Ecoliteracy assessment using Q-methodology: Indonesian high school students' views on disaster and ecology

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Various environmental crises and natural disasters encourage educational curricula in all countries to accommodate epistemic processes intended to improve students' competency in environmental literacy. Awareness, skills, knowledge, and attitudes towards the environment are part of ecoliteracy competencies measurable using tools. This study aimed to assess the environmental literacy of high school students by means of *Q-methodology* as a tool. The assessment did not evaluate scores but rather emphasised the subjectivity of participants to demonstrate students' diverse ecoliteracy perspectives in the context of environmental and disaster issues. This study combined qualitative and quantitative research methods. It selected 51 participants (26 natural science students and 25 social science students) from three senior high schools in D. I. Yogyakarta Province, Indonesia. The Q-sorting process and data analysis used the *FlashQ (Flash*-based application) and *KADE Desktop*, respectively. The results discovered five factors in each group, with a cumulative percentage of explained variance of 64% in natural science students and 55% in social science students. The following factors have the same label because of the similarity of participants' opinions described in their answers: recognising positive and negative consequences; reflecting; and identifying problems. Using Q-methodology as an assessment tool can demonstrate which issues are of primary concern to students.

Introduction

Natural disasters are manifestations of damage, pollution, extinction of living things, and global climate change (Keraf, 2010). Environmental education appears as an alternative solution to promote changes in the interaction between humans and nature towards a better direction, ultimately saving humans from disasters. In relation to disaster mitigation due to climate change, environmental education becomes the basis for combining consistent adaptation options with environmental quality improvement (Krasny & DuBois, 2019; Suharko, 2014). Future uncertainty due to environmental changes urges the young generation to innovate and find sustainable solutions prioritizing ecological aspects. Therefore, it is important for teachers to integrate environmental issues into school subjects (Rhode Island Environmental Education Association, 2019). UNESCO considers environmental education a multidisciplinary education. In practice, it is interdisciplinary, cross-curricular, even transdisciplinary and hence requires integration of various learning approaches (Fauville et al., 2014; Selby & Kagawa, 2018).

The climate crisis is a priority in implementing education to raise awareness and improve the response capacity of schools to potential disasters. Curricula in all countries should prioritise climate change mitigation and adaptation at all levels of education (González-Gaudiano & Meira-Cartea, 2019). Environmental education programs are expected to

foster motivation for pro-environmental behaviours, indirectly playing a decisive role in reducing disaster risks. Environmental literacy and a holistic, interdisciplinary approach in education help to achieve such a goal. Environmental education curriculum can promote epistemic processes leading to improvement of students' competencies in environmental literacy (Kinslow et al., 2019; Darner, 2009; Dyer, 2007). The concept of environmental literacy emerges in response to "ecologically illiterate" human behaviour that pollutes the environment. It represents the capacity to be aware of the environment and take appropriate action to preserve, restore, and improve the system sustainability to foster harmony with nature (Roth, 1992; Hempel, 2014). Currently, the term "ecoliteracy" is commonly used to describe a condition of "environmentally literate" (McBride et al., 2013). Students with ecoliteracy are able to act and have a profound understanding of how humans and natural systems are connected and how to maintain such connections to be sustainable. Therefore, it is necessary to have awareness, skills, and attitudes to consider the environment in daily decisions and be involved in individual and collective actions (Rhode Island Environmental Education Association, 2019).

The scope of the ecoliteracy assessment covers local to global scale systems and involves personal to communal responsibilities. It includes biodiversity, population growth, natural resources, environmental and health qualities, natural disasters and extreme weather, and land use (Selby & Kagawa, 2018; Sund & Gericke, 2020; Hollweg et al., 2011). According to Rhode Island Environmental Education Association (2019), the ecoliteracy assessment tools commonly used are *ElectroCity-Genesis* (online computer game), *Citizen Science* (adventure puzzle game), *The Mystery of Taiga* (3D virtual park), *Web-based Inquiry Science Environment* (interactive scientific models), *ONPAR Middle School Science Test* (targeting cognitively content and skills), and *Local Environmental Modeling System* (web-based simulation of land-use decisions).

Understanding how humans consider the environment requires a social perspective to explore the main environmental issues. This study primarily aims to describe, identify, categorise, and compare various ecoliteracy perspectives of senior high school students from natural and social science majors. In Indonesia, senior high schools have been divided into these specialisations since grade 10. These two majors differ in the object being analysed. Differences in knowledge background and habits will also affect analysing and solving problems. The distributed questionnaires do not assess students' ecoliteracy through scores but instead focus on deepening students' perspectives. Also, the ecoliteracy assessment is in the context of environmental and disaster issues. The outcomes are expected to disclose which issues are of primary concern to students so that it contributes to reducing ecological-based disaster risks through school education.

This study employed *Q-methodology*. This method was developed by William Stephenson in the 1930s at the University of Oxford (Webler et al., 2009). Q has fundamental components in human social and behavioural research (Ramlo, 2021; Brown, 1996). This methodology explores distinct perspectives, discourses, or decision-making in dealing with an issue (Zabala, 2014). Q is often associated with quantitative methods using an established statistical component in measuring human subjectivity (Newman & Ramlo, 2015). Therefore, Q is receiving attention in social research. Q-method combines qualitative and

quantitative techniques (Brown, 1996; Akhtar-Danesh & Mirza, 2017). This method is used to understand how students deepen their understanding of the environment as part of constructivism-interpretivism (Webler et al., 2009).

Environmental education contributes to stimulating sustainable development. An educated community is considered capable of finding solutions for sustainable resource management and reducing environmental degradation (Locke et al., 2013). Environmental education programs aim to prepare a generation that can understand the interconnection between humans and natural systems and has the knowledge, willingness, skills, and courage to act on preserving the environment (Stone, 2017). However, despite the UNFCCC's priorities, the education sector's response to climate change remains considerably limited. Based on a study conducted by the International Education Bureau, merely 35% of 78 countries have integrated the climate change topic into the curriculum (González-Gaudiano & Meira-Cartea, 2019). Therefore, this study seeks to provide insightful resources in ecoliteracy assessment in senior high school students, as well as promoting novelty in using different methods and tools.

Method

Research design

This mixed-methods research combined both qualitative and quantitative methods through the use of Q-methodology. It aims to assess participants' subjectivity and perspectives (Brown, 1996; Brown, 1980). Therefore, it is highly suitable for the assumption of the constructivism-interpretivism paradigm that strongly relies on participants' subjectivity. In Q, participants sort based on their experiences, perspectives, and knowledge; therefore, the results show diverse factors formed from the group of participants.

This study was conducted in January-April 2021 using a purposive sampling technique to obtain a limited number of participants (Bashatah, 2016). The participants were 51 twelfth-grade students from three senior high schools: State Senior High School 2 Sleman (SMAN 2 Sleman), State Senior High School 5 Yogyakarta (SMAN 5 Yogyakarta), and State Senior High School 1 Banguntapan (SMAN 1 Banguntapan). They were then divided into two groups, i.e., 26 students in the natural science major and 25 students in the social science major. This group division aimed to explore ecoliteracy from the perspective of two different majors. These schools were selected because of the specificity of their programs: *Satuan Pendidikan Aman Bencana* (Disaster-Safe Education Unit − a school that implements standard infrastructure as well as the culture that can protect the community and the surrounding environment from hazards) and *Sekolah Adiwiyata* (eco-school character education program where students learn about environmental care values) (Prasetiyo et al., 2020). Senior high school students were chosen considering that they have already been capable of grasping pure abstractions, e.g., philosophy and concepts. They are expected to comprehend the topics in the research questionnaires and explain the reasons more efficiently and complexly (Mutammam & Budiarto, 2013).

Q-methodology enables researchers to disclose perspectives and opinions, identify important criteria, and explain factors that construct students' ecoliteracy components on ecology and disasters. This methodology was implemented in six phases (Bashatah, 2016; Webler et al., 2009; Banasick, 2019) as follows:

1. Researchers developed a comprehensive set of statements called *concourse* that functions as the population. We arranged the statements in Indonesian (for the English version, see Table 2). The statement items (Q-statement) were developed into 46 ecoliteracy component units comprising 11 units of affective domain (environmental sensitivity and appreciation), 11 units of skills (cognitive: identifying and defining environmental problems), 12 units of knowledge (ecological, sociopolitical, and environmental issues), and 12 units of environmentally responsible behaviors (active participation in problem-solving, including locus of control, personal responsibility, and perception to bring about change).

2. The statements are based on literature related to climate change perception, disaster risk reduction, school-community preparedness, and school disaster management (Hollweg et al., 2011; Tuladhar et al., 2014; McBride et al., 2013). They are opinions in lieu of facts.

3. Researchers carried out the sampling (P-set) process, i.e., selecting participants to fill out the Q-sort. Participants differ from respondents as they are selected not as the representative of the population but as that of extensive opinion in the target population. On this basis, high school students were selected for they assumedly already have sufficient understanding and knowledge to explain the concept of ecology and disasters. They are expectedly able to provide compelling insights and facilitate collecting data. The number of participants should be less than the number of statements — generally, a 3:1 ratio is used.

4. Distributed the statements (Q-sort). Each participant was asked to distribute (forced distribution) a statement into the Q-set ranging from a scale of +5 (strongly agree) to -5 (strongly disagree) (Figures 1a and 1b). The ranking follows the Likert scale format using a quasi-normal distribution. The offline version of Macromedia *FlashQ*, a *Flash*-based application, was used in the Q-sort process. Researchers sent the application to participants. Afterward, each participant filled out the Q-sort and sent the results back to the researchers.

5. Conducted online interviews with participants representing each factor formed. The goal is to obtain an in-depth understanding of Q-sort profiles and relevant information by comparing participants' preferences to the factor analysis results.

6. Analysed and interpreted the data using *KADE Desktop* 1.2.0.

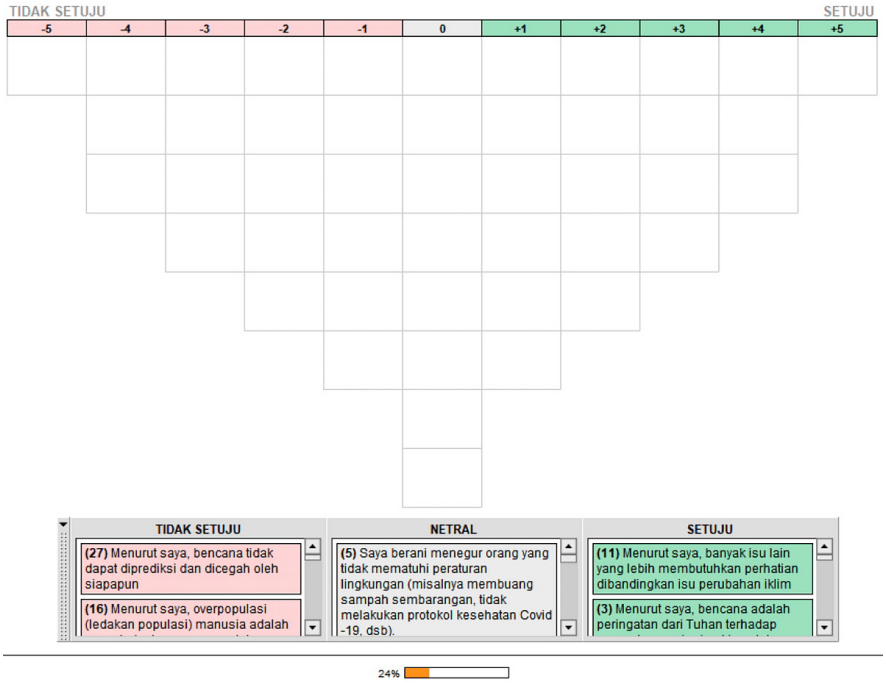

Figure 1a: Placing items in the forced distribution in FlashQ (Table Q consisting of 46 columns) - first step (use web or PDF reader 'zoom in' function to view)

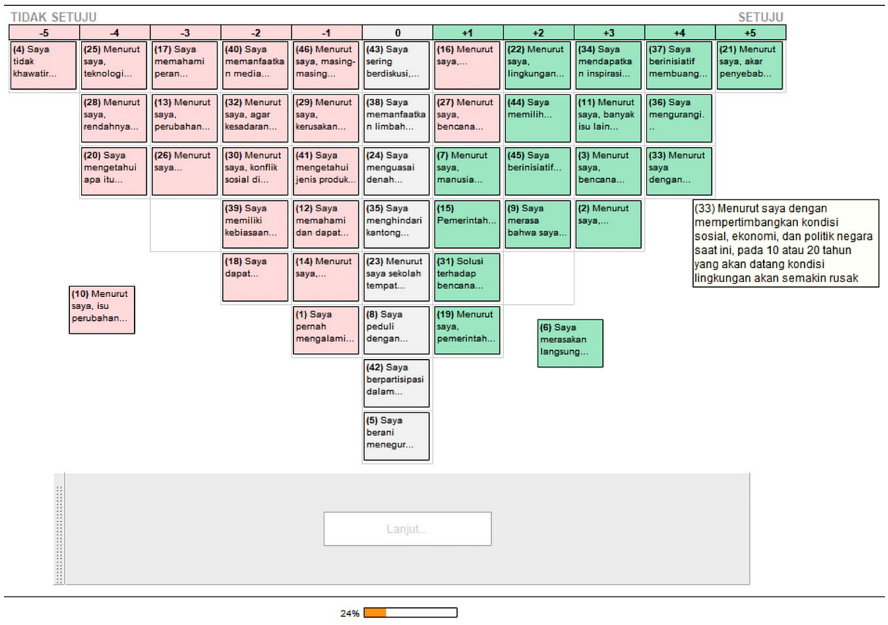

Figure 1b: Placing items in the forced distribution in FlashQ (Table Q consisting of 46 columns) - approaching last steps (use web or PDF reader 'zoom in' function to view)

Data analysis

Q-sort data were analysed using KADE (*Ken-Q Analysis Desktop Edition*) version 1.2.0 (Banasick, 2019). The stages included data input, matrix correlation, factor extraction (using principal component analysis), factor rotation (using varimax rotation), factor loadings, and display data output. Factor analysis (PCA) was used to create clusters of participants with similar views. The goal is to find a pattern where the Q-statement appears in a different Q-sort (Webler et al., 2009). Each factor represents a distinctive perspective on the subject studied (Akhtar-Danesh & Mirza, 2017). Factor analysis represents the heterogeneity of attitudes that can interpret why they come up with such notions. The final stage was interpreting interviews based on the Q-sort results. The results were then verified and communicated to participants (Nijnik et al., 2013). The Q-method analysis is also called discourse analysis (Webler et al., 2009).

Q-methodology does not highlight data validity as there are no external criteria to assess an individual's perspective. Each statement item was interpreted individually and deemed valid to express participants' opinions (Valenta & Wigger, 1997; Brown, 1980). Nevertheless, in the preparation, researchers asked for careful consideration and valuable advice from experts, i.e., senior high school teachers in physics, biology, chemistry, and geography. In addition, the instrument has been prior piloted in a preliminary study on the university students of the Environmental Geography Department at Universitas Gadjah Mada (Rahma et al., 2020). KADE has already included reliability and eigenvalue calculations in determining the factor (Banasick, 2019). An eigenvalue indicates the number of variables capable of elaborating a factor. Extractable factors must have eigenvalue > 1. Highly reliable factors are generally represented by five participants with composite reliability > 0.8 (Ramlo, 2021; Brown, 1980).

Results

Based on the table of factor characteristics, the cumulative proportion of explained variance for natural science students was 64%, whereas that for social science students was 55% (Table 1). These results are acceptable as the extractable factors in social research generally explain 50-60% of the variance (UCLA Statistical Consulting Group, 2020). Extraction results from both groups generated five factors each. These factors represent and explain the distinctive perspective of the representative participants (Newman & Ramlo, 2015). Based on Table 1, the composite reliability was above average, ensuring that each factor is highly reliable (Brown, 1980). Table 2 is a factor array that describes distinguishing statements among factors. The interpretation of each factor is based on the factor array, including rationales put forward by participants associated with the representative factor (Ramlo, 2021).

Tables 3 to 7 summarise factor descriptions representing participants from the natural science major, whilst Tables 8 to 12 list those from the social science major. Factors were named based on the environmental literacy categories from Rhode Island Environmental Education Association (2019). The comparison between factors is presented in the discussion section.

Table 1: Comparison of factor characteristics for natural science students and social science students in D.I. Yogyakarta Province

	Factor characteristics natural science major					Factor characteristics social science major				
	F 1	F 2	F 3	F 4	F 5	F 1	F 2	F 3	F 4	F 5
No. of defining variables	9	6	3	2	2	13	2	1	2	1
Avg. rel. coeff.	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Composite Reliability	0.97	0.96	0.92	0.89	0.89	0.98	0.89	0.81	0.89	0.81
S.E. of factor Z-scores	0.16	0.2	0.27	0.33	0.33	0.14	0.33	0.45	0.33	0.45
Eigenvalues	9.60	2.54	1.85	1.40	1.30	6.69	2.1	1.88	1.61	1.42
Cum. % explained var.	37	47	54	59	64	27	35	43	49	55

Table 2: Factor array of each group
(Natural science students and Social science students; Z = Z-score variance)
(Use 'zoom in' function on web or PDF viewer to facilitate reading)

No.	Statement	Natural science major						Social science major					
		F.1	F.2	F.3	F.4	F.5	Z	F.1	F.2	F.3	F.4	F.5	Z
1	I have been in an emergency and am capable of assisting as many people as possible.	0	-1	-2	2	3	0.615	-1	0	0	1	-4	0.473
2	In my opinion, human safety against disasters is more important than environmental conservation.	-2	0	-4	0	0	0.382	-2	-5	-2	4	-1	1.652
3	In my opinion, disaster is God's way of warning humans who cause harm.	2	1	2	-2	2	0.442	2	-3	4	0	-4	1.478
4	I am not concerned about the environment's future because current technological advancements can address environmental issues.	-5	-4	-3	-3	-5	0.189	-5	3	-1	2	2	1.487
5	I dare to reprimand those who violate environmental regulations (e.g., littering, not following the Covid-19 health protocol, etc.).	2	0	4	0	-1	0.544	1	2	1	1	-3	0.523
6	I am personally affected by the effects of climate change on both myself and the environment around me.	0	2	2	2	5	0.238	2	0	0	-2	5	0.767
7	In my opinion, humans have the right to exploit and modify nature to meet their needs.	-3	-1	-3	-1	-1	0.176	-2	-4	0	-1	0	0.471
8	I'm concerned about environmental issues and want to learn about them, even if I am not in the area where they occur.	2	0	2	5	1	0.424	1	-1	0	-3	-2	0.319
9	I feel compelled to leave the next generation with a decent, healthy, and secure environment.	3	4	0	3	-4	1.371	5	1	3	-1	1	0.743
10	In my opinion, global climate change is merely an environmentalist campaign tactic.	-3	-5	-4	-5	-3	0.143	-4	-2	-1	3	0	1.255
11	In my opinion, numerous other issues req-uire greater attention than climate change.	-3	-3	-5	-1	-4	0.266	-3	-3	2	-2	1	0.806
12	I am aware of and capable of explaining a variety of environmental issues and their consequences.	0	-1	-4	1	0	0.466	-2	2	-2	4	-2	1.172
13	In my opinion, climate change is the primary contributor to global disasters.	-1	1	-1	0	1	0.158	0	2	-3	-4	0	0.803
14	Disaster mitigation knowledge should be a mandatory component of each academic unit (elementary to higher education).	1	1	-2	-2	-2	0.407	2	4	4	-2	0	0.703
15	The government is responsible for natural resou-rce conservation, pollution control, and increasing public awareness of environmental issues.	0	3	-1	3	-3	0.803	3	-1	1	-2	1	0.434
16	In my opinion, human overpopulation is the primary source of environmental problems.	1	1	-3	-2	-2	0.629	1	-2	2	5	-3	1.301
17	I am aware of keystone species' significance. If it perishes, an imbalance in the ecosystem will result, potentially precipitating a disaster.	-1	2	0	-1	3	0.466	-2	0	-5	-1	1	0.718
18	I can explain natural processes (for example, biogeochemical cycles, food chains, and the movement of the earth's plates) and what occurs when their components are disturbed.	-1	-3	0	-4	0	0.322	-3	4	-4	2	4	2.015

No.	Statement	Natural science major						Social science major					
		F.1	F.2	F.3	F.4	F.5	Z	F.1	F.2	F.3	F.4	F.5	Z
19	In my opinion, the government is responsible for regulating natural resource use to ensure that no one falls below the poverty line.	-1	3	1	1	-1	0.5	1	-4	0	3	-3	0.993
20	I am aware of and utilise "environmental services" daily.	-2	-2	-2	-4	1	0.654	-4	0	-3	0	-4	0.639
21	In my opinion, the root cause of environmental problems is the belief that humans are the center of nature (anthropocentrism) and that their needs are more important than those of other living things.	-2	3	0	0	0	0.45	-2	-4	-2	-4	-5	0.469
22	In my opinion, the immediate environment (school and home) can serve as a conservation area for biodiversity.	1	2	-1	3	-2	0.596	1	1	3	0	0	0.237
23	I believe my school is prepared in an emergency or disaster, both technically and non-technically.	2	0	-1	1	2	0.177	0	-1	1	1	3	0.281
24	I am proficient with building plans, familiar with signs and instructions, and know how to conduct an emergency evacuation at school.	1	-2	2	-4	-1	0.875	0	2	-1	-2	-3	0.454
25	In my opinion, advanced technology is the answer to dealing with environmental issues and disasters.	-2	-2	3	-1	-4	0.916	-1	-1	-2	3	2	0.664
26	In my opinion, Indonesia handled the Covid-19 pandemic better than other countries.	-4	-4	-3	-3	2	0.909	-4	0	2	0	-1	0.971
27	In my opinion, disasters are beyond anyone's ability to predict or prevent.	-4	-1	-2	2	-2	0.653	-3	-1	-2	1	3	0.774
28	In my opinion, a lack of education contributes to a person's lack of environmental awareness.	-4	0	3	1	-3	1.172	4	-3	-1	-1	2	0.96
29	In my opinion, environmental degradation in Indonesia will continue to occur as long as Indonesia prioritises economic interests.	-1	2	1	-3	4	1	1	-3	-4	2	0	0.833
30	In my opinion, many social conflicts in Indonesia arise as a result of environmental issues.	-3	0	0	-1	4	0.717	-1	-1	2	-1	3	0.517
31	Solutions to disasters and environmental probl-ems can be found by deepening religious, moral, and artistic concepts, revitalising indigenous knowledge, and instilling environmental ethics begins at the elementary school level.	3	1	3	0	2	0.11	4	0	1	0	4	0.407
32	In my opinion, to ensure that disaster and enviro-nmental awareness are not merely discursive, these components must be included in the assessment category (e.g., school accreditation).	0	3	1	-1	1	0.289	3	-2	-3	0	-2	0.538

The following tables describe each factor obtained from interviews with representative participants. Tables 3 to 7 describe the ecoliteracy factors of natural science students, while Tables 8 to 12 describe that of social science students. The numbers encoded at the end of each sentence, e.g., (#2, +4), indicate that the participant agrees (+) to statement 2 (#2); conversely, the negative sign (-) indicates that the participant disagrees with the statement. The +/- symbol is followed by a number that indicates the participant's degree of agreement or disagreement with the statement.

Table 3: Factor 1 for natural science students
(recognising positive or negative consequences)

No.	Factor descriptions
2	Students prioritise environmental conservation over human safety, as considered in the long-term context. Shall the environment be sacrificed, humans will also be affected. They provided an example: floods would not occur if humans did not throw garbage carelessly. This attitude reflects pre-disaster action. The environment must be managed in advance to avoid disasters (#2, -2).

21	God created nature for the use of humans and other living creatures. *"It is such an atypical notion to believe that nature is damaged because of being used to meet the life needs. Nature is damaged only if it is overexploited for personal gratification. Man is the caliph (leader) on earth capable of taking care of the environment once they do not put forward their personal egoism"* (#21, -4).
27	Through advances in technology and science, several disasters can be predicted, albeit not always accurately. As an example, students pointed out the Agency for Meteorology, Climatology, and Geophysics (BMKG) which often issues information and disaster warnings to increase public vigilance. Natural disasters, such as volcanic eruptions, tsunamis, and tornadoes, may not be preventable but can sometimes be predicted. Other disasters, e.g., floods and landslides, can still be prevented by behavioural changes, including not throwing garbage and cutting down trees carelessly (#27, -4).

Table 4: Factor 2 for natural science students (empathy)

No.	Factor descriptions
21	The opposite of Factor 1. Participants agreed to statement #21. Humans feel like the holders of control over nature and therefore are often unaware of the existence of other living creatures. Their ambition to fulfill their never-satisfied needs does not go hand in hand with their sense of responsibility towards the environment, so damage and disasters occur everywhere (#21, +3).
40	Students were worried about the data accuracy because of various circulating hoax news. Social media are platforms accessible for many people; hence, students were often concerned about the spreading news that turned out to be deceptive and caused mass panic. They preferred to be passive users and did not participate in spreading disaster information (#40, -2).
38	Students felt unskilled in recycling used goods. They asserted not being well-informed of recyclable goods; thus, they were worried about unpredictable impacts that might be dangerous or even toxic. They did not stick to the 4R principles as a habit (#38, -3).

Table 5: Factor 3 for natural science students (taking action)

No.	Factor descriptions
34	Students said that there was a garbage bank in their area that local mothers used as materials for various works, including dresses, mats, and numerous plastic waste crafts. For students, this activity is deeply inspiring. *"The surrounding environment affects an individual's mindset, personality, and life. So, I think this statement is true because I often get inspiration from nature to create many economic-valued works. It also evokes* 'the mood' *to learn"* (#34, +5).
41	Environmentally friendly products are considered safer and do not harm the environment. Students avoid using disposable cutlery products, start using an *eco-bag* to replace plastic bags, and reuse product packaging. *"The current trend right now is disposable cosmetics, such as 'sheet mask'. I was informed that the production process of these products damages the environment. Likewise, the more luxurious product packaging is, the more natural resources it used"* (#41, +4).
12	Students understood various environmental issues but could not elaborate on them comprehensively. They felt it was not their capacity (in terms of expertise) to explain. *"For the same environmental issues, the impacts can be different and very complex. I find it difficult to explain the relationship between phenomena that occur"* (#12, -4).

Table 6: Factor 4 for natural science students (reflecting)

No.	Factor descriptions
8	It is important to know environmental problems occurring in other regions because they could impact human life in the area. Besides, an incident can be an experience (in terms of preparation) if the same event happens in another region (#8, +5).
27	Participants had the opposite opinions of Factor 1. Regarding beliefs, a disaster occurrence is God's will that human's technologies cannot resolve. *"Disasters that ever happen always come suddenly, inflicting many casualties"* (#27, +4).
24	The schools once carried out a simulation, but the student concerned did not attend. Those attending it forget the procedures since it was only held once (#24, -4).
20	Students did not know the definition of environmental services. *"I just heard the term' environmental services'"* (#20, -4).

Table 7: Factor 5 for natural science students (identifying problems)

No.	Factor descriptions
30	Students argued that the mining industries often cause social conflicts. Conflicts occur between the community protesting mining activities—for they are considered environmentally harmful—and the community supporting them for economic reasons. Another student gave an example: in his/her region, the residents have the habit of disposing of garbage into the river even though the river is used to irrigate rice fields. Initially, it appears to be a simple thing; however, as time goes on, it leads to a conflict among residents. Another case is related to slums that the government often evict. Students are convinced that residents there do not opt to stay. This often provokes clashes with the authorities. Those examples illustrate how environmental problems often create social conflicts within the community (#30, +4).
9	Reflecting on the current situation, the condition of the environment does not show improvement; instead, it has worsened considerably. Students felt that the individual's action would not make a real impact on environmental improvement. There must be cooperation and a shared commitment to passing on a viable environment to the future generation (#9, -4).
25	Advances in technology do not guarantee that environmental issues and disasters can be addressed. Artificial technology has drawbacks, and technological developments actually aggravate environmental degradation. Human consciousness is paramount in sustaining and managing the environment (#25, -4).

Tables 8 to 12 describe the ecoliteracy factors of the social science students.

Table 8: Factor 1 for social science students (constructing justification)

No.	Factor descriptions
33	Not all people are willing to protect the environment, even for simple things such as separating garbage by type. In the economic sector, many industrial actors dump waste into the environment without being priorly processed. Students ever visited one of the batik industry centers to research batik waste. They found out that wastewater from batik dyeing was simply disposed of in the waterways. Likewise, in political activities, campaign equipment waste pollutes the environment. Politicians also rarely show concern for the environment. On this basis, students felt that the environmental conditions would be much worse in the future.

26	Students considered that the Covid-19 management seemed only to rename the same old regulations. The government has the authority to strengthen regulations in the community, but in reality, the implementation is unclear because of a lack of coordination. Students viewed the government's approach to the community as repressive, not persuasive. In addition, it was worsened by a lack of public adherence to health protocols—people often obey the regulations because of sanctions rather than self-awareness. Once unsupervised, they tend to be disobedient. This keeps happening over and over again (#26, -4).
4	Students expressed their concerns about technology. Despite the increasing advances over time, its impacts gradually damage the environment. Regardless of how advanced innovations are introduced to tackle environmental issues, environmental conditions will never improve if humans are unwilling to protect the environment (#4, -5).

Table 9: Factor 2 for social science students (recognising +/- consequences)

No.	Factor descriptions
12	Students gave examples of and explained global warming, i.e., the condition in which the overall average temperature of the earth's atmosphere, oceans, and lands rises because of greenhouse effects resulting from increasing gases emissions, such as CO_2, CH_4, N_2O, and CFC. These effects keep most of the sun's heat energy trapped in the earth's atmosphere and cannot be reflected out. *"I can elaborate on the environmental issues along with their impacts. I have gained this knowledge since elementary school"* (#12, +2).
2	Students looked from a preventive point of view on the pre-disaster context. Humans and nature need each other. By conserving nature, humans will avoid potentially arising disasters. The environment is part of resources. Once humans sacrifice the environment for the sake of their interests, the impact of the loss will backfire on them, including the possibility of fatalities (#2, -5).

Table 10: Factor 3 for social science students (explicit environmental domain knowledge)

No.	Factor descriptions
17	Students quite understood the basics of ecology. For instance, if the ecosystem has missing components, its balance can still be maintained as long as a substitute is available. Nevertheless, students disagreed with this statement because of their incomprehension of the term "keystone species". They assumed keystone species are rare living creatures or '*missing link' species* in the evolution theory (#17, -5).

Table 11: Factor 4 for social science students (identifying problems)

No.	Factor descriptions
16	The earth's space remains while the population increasingly grows. Population increase is directly proportional to the life needs that must be addressed. This will trigger the rise in natural resource extraction leading to inevitable damage. Pervasive settlement development often blocks water absorption, causes land conversion, or disrupts other ecosystem-balancing functions (#16, +5).
2	Students associated the occupation of space with one of the human rights, i.e., the right to life. Hence, the safety of human life is essential. Humans will be more aware of their actions to nature once they survive a disaster. This expectedly becomes a lesson to conserve the environment. Students highly prioritised human safety in an emergency (#2, +4).

38	Students felt they were not creative and therefore had no idea how to implement the 4R principles in everyday life. They supported this effort but still respected each individual's preference to buy new items or recycle old ones. *"It is too much trouble for something like this, and I do not know how to do it either"* (#38, -4).
46	The impact will be insignificant for an individual to act. It requires a collective effort to do so. For instance, floods still occur despite individuals' obedience not to dispose of garbage carelessly. Floods will continue to occur regardless of the myriads of campaigns promoting not to do so. It necessarily takes awareness and communal participation in reducing disaster impacts (#46, -5).

Table 12: Factor 5 for social science students (reflecting)

No.	Factor descriptions
6	Students felt immediate changes, such as hotter temperatures and volatile weather. They also got the impression that many health issues, e.g., allergies and skin disorders, are due to weather changes. The increasingly hotter daily temperature is due to the number of motor vehicles, ozone leakage, air pollution, and loss of vegetation. *"Discomfort due to weather changes makes me in no 'mood' for activities"* (#6, +5).
5	The disagreement comes from the students' personal experiences. *"I once reprimanded someone who tossed out the garbage but instead was snapped. It makes me afraid to rebuke others who are wrong"* (#5, -3).
1	The reason why students are unwilling to help others is not because of their lack of willingness but rather their sudden panic in an emergency. They provided an example in the context of the Covid-19 pandemic. Helping others is important, but it is way more important to ensure self-safety prior to doing so. Students expressed their utter confusion if faced with the condition in which they are obliged to help Covid-19 patients (#1, -4).

Discussion

The factor category is based on the epistemic frame of the Environmental Literacy Assessment proposed by Shaffer (2012) (Rhode Island Environmental Education Association, 2019), covering five domains: Skill, Knowledge, Identity, Values and Epistemology (SKIVE). This section discusses the characteristics of each factor as well as the comparison between factors.

Factor 1 for natural science students and Factor 2 for social science students (recognising positive or negative consequences)

These factors prioritise the cognitive skill domain and evaluate how human decisions change ecosystems.

Recognising positive and negative consequences relates to skills in (1) evaluating environmental problems and formulating their solutions; (2) thinking critically; (3) assessing how human actions (or decisions) affect the environment through potentially arising impacts; and (4) explaining the causal relationships, stability, and changes. Factor 1 for the natural science students and factor 2 for the social science students share the same components. Students of both groups disagreed with statement #2. There is a resemblance of opinion, "shall humans preserve nature, nature will protect back humans." In response to this statement, students tended to prioritise long-term human safety. This notion

illustrates how they are inclined to altruistic values and pro-environmental attitudes (Ojea & Loureiro, 2007). Statements #27, #21, and #12 describe students' perspectives on the consequences of human behaviours towards the environment. Students demonstrated their cognitive skills to explain greenhouse effects in detail, distinguish between the causes of various disasters, and formulate viable solutions (i.e., preventing floods and landslides by not disposing of garbage and cutting trees carelessly).

Factor 1 for social science students (constructing justification)

This factor covers the domains of skills and epistemology to explain the arguments behind decisions.

This factor shows how students (1) acquire, evaluate, and communicate information, (2) develop evidence-based arguments, (3) propose possible solutions, and (4) justify actions on environmental issues. Based on statements #33 and #4, it can be inferred that students justify that the environment's future would not be better based on the evidence they obtained. Students deliberately observed the environment (visiting batik waste disposal sites) and events in the surrounding environment (commenting on campaign equipment waste, the attitude of political elites that do not show environmental concern, and technologies aggravating environmental conditions). Students had the ability to analyse problems based on data evidence. In response to statement #26, they were able to evaluate phenomena occurring in the surrounding community, even at the national level. Students elaborate in detail on the possibilities of why the Covid-19 management in Indonesia had not improved. They evaluated it through various facets ranging from public behaviours to government policies in disrupting the pandemics. Students concluded that the key to improving the environment is human awareness and behaviours. Students' rationales prove their competencies to identify *eco-crisis,* i.e., environmentally damaging human behaviours (Li & Lang, 2015).

Factor 3 for natural science students (taking action)

This factor covers the domains of skills, identities, values, and epistemology.

"Taking action" means (1) active participation in activities that lead to solving the environmental issues, (2) willingness to act, (3) locus of control, (4) environmentally responsible behaviors, and (5) efficacy development. Statements #34 and #41 describe students' participation in "taking action" to improve the environment. Students had a locus of control because of the influence of the external environment. A healthy environment shapes human characters and behaviors to be more environmentally responsible. Likewise, people with well-shaped attitudes will act to save the environment. Students had personal values toward the environment; therefore, they were willing to act and be environmentally responsible (King & Franzen, 2017). Students were even aware of and preferred to use environmentally friendly products for environmental safety reasons.

Factor 4 for natural science students and Factor 5 for social science students (reflecting)

These factors cover the domains of skills, identities, evaluation, and problem-solving process.

"Reflecting" includes defining problems, decision-making (including actions), evaluating problems and solutions, and developing efficacy. In factors 4 for natural science and 5 for social science, students used their skills to explain statements #27 and #6. They identified and evaluated environmental issues by describing the impacts of weather changes on their health as well as possible causes. They also believed that disasters are God's will; thus, however advanced artificial technologies are, they cannot prevent them from occurring. Students evaluated themselves and the environment through statements #8, #24, #20, #5, and #1. They thought that it is important to care about the environmental conditions in other regions to anticipate the same events possibly occurring in their region. Regardless, they felt unprepared once faced with an emergency (#1, #5, #24). In this context, it takes routine training and disaster mitigation drills or simulations to exercise vigilance against emergencies, especially in schools. In addition, the goal of such habituation is to increase the school's resilience to disasters.

Factor 2 for natural science students (empathy)

This factor covers the domains of skills, identities, and values.

Students were able to consider various perspectives, develop characters, reflect on the relationship between their attitudes and choices, and assess their actions and consequences on the environment. They were willing to act and had locus of control, beliefs, interests, morals, attitudes, and values towards nature, concern for environmental quality improvements, and sensitivity to the environment. Regarding statement #21, students considered the perspective of human-nature interaction, assuming that humans are the dominant factor causing disasters and environmental damage. This typical anthropocentric ethic over-exalts the notion that ethics only apply to humans, whereas other creatures are only tools to meet human interests (Keraf, 2010). In statements #40 and #38, students had a locus of control, a sense of responsibility, and prudence in acting. They evaluated that much information has unknown sources and unverified truth and chose to refrain from disseminating it to others because of potential negative impacts. Likewise, in statement #38, students also decided to be careful with their actions and preferred not to implement the 4R principles (Reduce, Reuse, Recycle, and Replace). It seems understandable because they are still in the character development phase towards the environment. Besides, it is entirely about the individual's preference for using goods.

Factor 5 for natural science students and Factor 4 for social science students (identifying problems)

These factors cover the domains of skills, values, and epistemology in identifying and defining environmental issues.

Students identified, determined, and described various cases broadly associated with environmental issues as illustrated in statements #30, #9, #25, #16, and #46. Not only did students define an issue, but they also explained the complexity of a domino effect arising from a simple issue. Complexity is part of students' competencies in recognising the complexity of social problems by evaluating causes and their interrelationships (Kinslow et al., 2019). In this factor, students showed attitudes, concerns, and values towards environmental issues occurring in their surroundings or elsewhere. In statements #9, #25, #38, and #46, students voiced their scepticism over the future environmental situation that they perceived as no better than the current one. Nevertheless, scepticism reflects the scientifically critical attitude required to evaluate emerging evidence or biases (Kinslow et al., 2019).

Factor 3 for social science students (explicit environmental domain knowledge)

This factor covers the domains of skills and knowledge in investigating environmental issues.

Students were able to draw up explanations and solutions and had knowledge on environmental issues; ecosystems; sociopolitics; local, regional, and global environments; ecosystem dynamics; biodiversity; concerns and attitudes towards environmental issues. Only one single statement is explained in the factor regarding keystone species in #17. Students tended to disagree with statements whose definitions they did not recognise. Similar to statement #20, students did not know the term "environmental services" and therefore put this statement in the "disagree" column. From the interview results, students just heard the term *keystone species;* however, apart from that, they understood the basics of ecology, e.g., ecosystem balance and food chain, and were able to elaborate on what would happen if the balance is disrupted.

A consensus agreement is a statement consented by all participants, both agreed and disagreed statements. In other words, consensus becomes a statement that all participants are considerate. Based on Table 2 with green highlights, all participants of the natural science group disagreed with statement #7 and agreed to statement #31. Meanwhile, those of the social science group agreed to statements #22 and #36 and disagreed with statement #40.

Q-methodology offers a holistic model to represent the breadth of participants' perspectives (Valenta & Wigger, 1997). This assessment does not use scores and thus cannot determine the precise level of students' ecoliteracy competencies. Instead, it can be used as a tool for assessing those competencies in depth. Each individual's response is assumed to come from their subjective experience reflected in the description they provided. The same statement, even a contradictory one (agree or disagree), can be explained through various perspectives. The emerging pattern of factors leads to students' social perspective in addressing the environment and disasters (Webler et al., 2009).

Students often provided examples of contextual events that they see and experience directly in the neighbourhood and schools or from information written in the mass media and everyday interaction. Students never gave theoretical and definitive arguments. Rarely did

participants explicitly relate environmental phenomena to school subjects, learning experiences, and materials they learned in school. There was no relationship between students' majors and their ecoliteracy perspectives, especially related to disasters and ecology. Two topics, "floods" and "waste problems" were mostly set as examples to describe the impact of human behaviour on the environment. This answer pattern illustrates students' tacit knowledge acquired from their understanding and experience-based actions (Oktari et al., 2015). Tacit knowledge assists individuals in considering a particular event they ever experienced that will be adapted or adjusted to respond to other events (Tan & Md. Noor, 2013).

Although participants were students in different majors, the pattern of argument descriptions they put forward is not much different. It was likely that ecological and disaster knowledge was not considered as a school subject. In addition, this knowledge is interdisciplinary so that the information can be obtained from anywhere. From the description, senior high school students could understand, analyse, and evaluate the consequences of actions they and others did on the environment— whether it made for better or worse. These findings are input for schools, especially teachers, to integrate ecoliteracy in school subjects more thoroughly to provide broader scientific perspectives for students. Besides, it is vital to use the surrounding environment as a more contextual learning resource so that students can have direct experiences. It takes an effort to change the educational paradigm from transmissive models into transformative ones (Dyer, 2007). The goal is to prepare a generation to understand the interconnection between social systems and natural systems to ensure sustainable living in the future.

Conclusion and limitations

Based on the results, the ecoliteracy of students from both groups showed no significant differences. Several factors have the same label because of the similar opinion patterns in both groups, i.e., Recognising positive and negative consequences, Reflecting, and Identifying Problems. Q-methodology can demonstrate which issues are of primary concern to students. The dominant domains include analysing skills and attitudes towards environmental issues and disasters. Students were willing to act by showing environmentally responsible behaviours. This assessment highlighted the breadth of students' ecoliteracy perspectives in addressing various environmental issues and disasters. It did not use scores and thus could not determine the precise level of students' ecoliteracy competencies.

This study was conducted amid the Covid-19 pandemic through online interviews. Most Q-sortings were performed face-to-face with participants to dig up directly the reasons for placing the statements in the table (Q-Grid) (Ramlo, 2021). Despite interviews having to be online, communication with participants could still be maintained. The emerging challenges were as follows: (1) the application was not compatible with the participant's device; and (2) participants did not understand how to operate it and were confused by the table's interface (Q-Grid) as they had never done Q-sorting before. This study suggests that future researchers make shorter and simpler statements and use programs that can be operated using smartphones. Because of limited facilities, this study used the offline version of *FlashQ* that could only be operated using a personal computer. Thus, future researchers are

also encouraged to use the online version of *FlashQ* or *Easy Html-Q* (https://github.com/shawnbanasick/easy-htmlq) for ease of sorting. This study merely assessed students' ecoliteracy and did not compare it to the teaching and learning process; therefore, the gap between tacit and explicit knowledge is yet unknown. Further research on explicit knowledge is necessary to determine which learning processes need improvement.

The development of environmentally responsible behaviours in schools has been well-established because of the support of relevant facilities and programs. However, pandemic conditions limit all activities, including those of school students. Environmental programs, including the *Adiwiyata* and *Satuan Pendididkan Aman Bencana* programs, came to a halt during this study. It takes feasible solutions to address this, e.g., how to improve ecoliteracy through habituation in the home environment.

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