Journal of Turkish Science Education, 2023, *20*(2), 356-368.
DOI no: 10.36681/tused.2023.020

Ecoliteracy's contribution to creative thinking: a study of senior high school students

Diana Vivanti Sigit[1], Rizhal Hendi Ristanto[2], Anisa Nurrismawati[3], Ratna Komala[4], Puji Prastowo[5], Abubakar Sidik Katili[6]

[1]*Faculty of Mathematics and Natural Science, Universitas Negeri Jakarta, Indonesia, ORCID ID: 0000-0002-1431-919X*
[2]*Faculty of Mathematics and Natural Science, Universitas Negeri Jakarta, Indonesia, ORCID ID: 0000-0001-8655-2030*
[3]*Faculty of Mathematics and Natural Science, Universitas Negeri Jakarta, Indonesia, anisanurrisma@gmail.com, ORCID ID: 0000-0003-2362-7052*
[4]*Faculty of Mathematics and Natural Science, Universitas Negeri Jakarta, Indonesia, ORCID ID: 0000-0002-1127-6235*
[5]*Faculty of Mathematics and Natural Science, Universitas Negeri Medan Indonesia, ORCID ID: 0000-0002-0085-487X*
[6]*Faculty of Mathematics and Natural Science, Universitas Negeri Gorontalo, Indonesia, ORCID ID: 0000-0002-7562-4833*

ABSTRACT
Ecological literacy (Eco literacy) along with creative thinking skills can be utilised to overcome environmental problems to achieve environmental sustainability. This research analyses the correlation between ecological literacy and students' creative thinking skills of environmental problems. The research method is quantitative with a correlational study. The research respondents include 281 pupils of Grade 11 MIPA (Science) from three areas in Indonesia: Jakarta, Sumatera, and Gorontalo. Data collection consists of a write test and an opinion-seeking questionnaire. Ecological literacy analysis consists of caring, practical competence, and knowledge dimensions. Creative thinking skills are analysed through fluency, originality, flexibility, and elaboration dimensions. The results indicate that ecological literacy and creative thinking skills levels in grade 11 MIPA in a medium category. Female students have a higher average score in ecological literacy and creative thinking skills than in male students. The research finds a positive relationship between ecological literacy and creative thinking skills.

RESEARCH ARTICLE

ARTICLE INFORMATION
Received: 30.06.2021
Accepted: 03.01.2022

KEYWORDS:
Environmental education, ecological literacy, environmental problems, 21st century skills.

To cite this article: Sigit, D. V., Ristanto, R. H., Nurrismawati, A., Komala, R., Prastowo, P., & Katili, A. S. (2023). Ecoliteracy's contribution to creative thinking: a study of senior high school students. *Journal of Turkish Science Education, 20*(2), 356-368.

Introduction

Twenty first century skills are widely discussed in various fields of life including education. Students are expected to acquire the 21st century skills so that they can compete globally. Twenty first

century skills include three aspects of basic skills (creative thinking – problem solving, creativity - innovation, communication - collaboration), literacy skills (information literacy, media literacy, ICT literacy), and survival skills (flexibility - adaptation, initiative - self-direction, social - cross-cultural skills, productivity accountability, leadership, and responsibility). In formal education, learning process integrate literacy and high order thinking skills. One of the high order thinking skills is creative thinking (Al-Muhdhar et al., 2021; Budsankom et al., 2015; Hargrove, 2013; Yusnaeni et al., 2017).

Creative thinking is also known as divergent thinking, where someone can produce useful ideas to solve problems from various perspectives (Kamarrudin et al., 2022; Kim, 2011; Sternberg & Sternberg, 2010; Treffinger et al., 2002; Yusnaeni et al., 2017). Everyone is born with different creative thinking skills; therefore, creativity is valued as a talent (Beghetto, 2010);(Yazar & Birgili, 2015). In the context of education, students need to acquire creative thinking skills to solve complex problems (Awang, H., & Ramly, 2008; Baran et al., 2021). According to the TIMSS (Trends in Mathematics and Science Study), the creative thinking skills of Indonesian pupils are low (Fitrianawati et al., 2020; Istiyono et al., 2020). Hence, creative thinking skills need improvement in their implementation in schools to create a new generation capable of competing globally (Irmita & Atun, 2018; Kan'An, 2018; Marni et al., 2020). The improvement of creative thinking skills requires several efforts, among others providing innovative learning models and learning media, education through mass media, and utilizing learning media through social media mostly used by the students.

Learning methods such as brainstorming can be chosen to develop students' creative thinking. Brainstorming provides the right environment for students to express themselves in generating ideas (Abdullah Mirzaie et al., 2009). The use of effective learning media will also create more lively learning and provide easiness for students and teachers to access and evaluate information acquired (Al-Muhdhar et al., 2021; Mcginn, 2014; Sigit et al., 2019; Zubaidah et al., 2017). Creative thinking skills must be trained to prepare the upcoming generation to be able to solve complex problems such as environmental problems. Environmental problems are one of the problems that happened in Indonesia (Prastiwi et al., 2020a). Environmental problems can be decreased with a skill related to environmental. This skill is an important component of pro-environmental attitude competence that needs to be possessed as a form of environmental awareness of the increasing number of environmental problems (Sigit et al., 2019; Daskolia & Kampylis, 2012). Environmental problems can be addressed if it is supported by ecological literacy or ecoliteracy (Prastiwi et al., 2020a). Students acquired ecological literacy in environmental learning and media both printed and digital media (McBride, 2011; Schimek, 2016).

The goal of ecological literacy is to improve individual awareness and enthusiasm to act on environmental issues in a sustainable way. The current research focuses on the relationship between ecological literacy and students' creative thinking skills to overcome environmental problems. Another research conducted by (Nadiroh et al., 2019) showing there's an interaction between ecological literacy and critical thinking which also related to creative thinking. The previous research focused on students who came from the same locations and environmental conditions. Meanwhile, this study aims to analyse the level of creative thinking in environmental problems in terms of ecological literacy in students who come from schools with different locations and environmental conditions.

Methods

Research Design

The research consisted of an independent variable (X_1) of ecological literacy and a dependent variable (Y) of student's creative thinking skills.

Population, Sample, and Procedure

The research population included of grade 11 students majoring in science from three provinces in Indonesia, namely DKI Jakarta, Sumatera, and Gorontalo. The population was selected using purposive sampling. Purposive sampling was chosen because the three provinces are in a different island and different locations conditions than previous research that had been done. The research samples consisted of 281 students consist of male and female of grade 11 science selected using purposive sampling because grade 11 already learnt about environmental subject in grade 10. The samples were homogeneous and representative of the population. The ecological literacy variable was measured using questionnaire and a multiple-choice test, whereas creative thinking skills were measured using an essay instrument.

Research Instrument

The ecological literacy instrument used consisted of a test and a questionnaire developed from (Mcginn, 2014; Orr, 1992; Rizal et al., 2019)*).* As for the questionnaire were being translated from original version (Mcginn, 2014) and being modified according to conditions in the research area. Dimensions of awareness and practical competence were measured using questionnaire in the form of a Likert Scale with 24 question items, whereas the knowledge dimension was measured using a multiple-choice test.

Table 1

Instrument Grids of Ecological Literacy and Question Items

Dimension of Awareness	
Indicator: Awareness to be responsible to reduce negative impacts on the environment	
No.	Questions items
Scale: strongly agree, agree, disagree, strongly disagree	
1.	Small actions performed by one person has no significant impact on environmental problems this item involves a double negative which can be very problematic for respondents
2.	Electricity must be produced from renewable sources to reduce the use of fossil fuel
3.	Activities of environmental conservation seminar are one of the useful activities
4.	I will not use recycled products because they are expensive
5.	Separating wet and dry waste is necessary
6.	I do not care about the waste produced by industrial because it does not disturb me
Dimension of Practical Competence	
	Indicator: Actions conducted to reduce negative impacts on the environment
No.	Question items
Scale: always, often, sometimes, rarely, never	
1.	I pretend not to know if there is garbage scattered around
2.	I use air conditioning (AC) continuously
3.	I prefer using public transportation rather than personal vehicles.
4.	I turn off the electricity when not in use
5.	I clean the class according to the cleaning picket schedule
Dimension of Knowledge	
	Indicator: The basic concept of ecology and understanding of human activities on ecosystems

No.	Question Items (multiple choice)
1.	Based on the parameters of air pollution and population increase, the analysis of the relationship between both parameters is….
2.	Based on the parameters of natural resource availability and population density, the analysis of the relationship between both parameters is….
3.	What will happen if the pollutant level in an environment exceeds the threshold?
4.	Components of an ecosystem are inorganic things such as plankton, fish, fish-eating birds, and guano. If there is large-scale fishing, the consequences are….
5.	A plot of land consists of the following components: corn crops, small birds, caterpillars, rats, chickens, and snakes. These components will depend on each other in a food chain in the ecosystem. The form of the composition is…
6.	Activities that can be conducted to reduce environmental problems are …
7.	Flood disasters often occur in various regions in Indonesia; to your knowledge, what are the causes of floods….
8.	Depends on the news is, as a good citizen and students who cares for the environment the appropriate actions are…
9.	Plastic takes 50 – 600 years to degrade; an appropriate way to manage plastic waste is ….
10.	Why is nondegradable plastic waste harmful to living things ….
11.	Other efforts that can be done to reduce global warming in addition to the development of green open spaces (RTH) are ….
12.	One way to protect endangered species in Indonesia is ….
13.	Environmental carrying capacity is the ability of the environment to meet the needs of living things. The following human activities that could reduce the environmental carrying capacity are….

Measurement of the ecological literacy dimension is using Likert Scale and multiple – choice as shown in the Table 2.

Table 2

Measurement and Category of Scoring Ecological Literacy Dimension

Dimension	Measurement	Category	
		Positive statement	Negative statement
Caring	4 – 3 – 2 – 1	4 = strongly agree 3 = agree 2 = disagree 1 = strongly disagree	4 = strongly disagree 3 = disagree 2 = agree 1 = strongly agree
Practical competence	5 – 4 – 3 – 2 – 1	5 = always 4 = often 3 = sometimes 2 = rarely 1 = never	5 = never 4 = rarely 3 = sometimes 2 = often 1 = always
Knowledge	1 and 0	1 = correct answer; 0 = wrong answer	

Criteria of ecological literacy assessment are based on (Mcginn, 2014) as indicated in Table 3.

Table 3

Criteria of Ecological Literacy Score

Criteria	Provision
Illiterate	<60
Low	60 – 70
Basic	71 – 80
Standard (Medium)	81 – 90
High	91 – 100

Note. Mcginn, 2014

The creative thinking skills instruments comprised four dimensions, namely: flexibility, fluency, originality, and elaboration. The instruments were measured using an essay test that consisted of 10 questions. Scoring for each dimension are shown in the Table 4.

Table 4

Measurement and Category of Scoring Creative Thinking Skills Dimension

No.	Dimension	Indicator	Number of Question	Scoring Criteria
1.	Fluency	produce various ideas and similar answers in solving problems	3	4 = students fluently answer questions (give 3 ideas) 3 = students are not fluent answer and just give 2 ideas relating to questions 2 = students only give 1 idea relating to questions 1 = students give no answer the question
2.	Flexibility	provide various descriptions and interpretations of a picture, story, or problem	2	4 = students can interpret a problem at least 2 answers from different point of view 3 = students can interpret a problem at least 1 answer from different point of view 2 = can only interpret a problem but not related to a question 1 = students can't answer the question
3.	Originality	generate unique and different answers	2	4 = students can provide at least 2 new ideas/solutions 3 = students can provide at least 1 new ideas/solutions 2 = students can provide 1 general solution 1 = students can't answer the question
4.	Elaboration	derive ideas or detailed steps on an object or idea	3	4 = students can develop more than 2 ideas that is easy to understand, and logical 3 = students can develop 2 ideas that is easy to understand, and logical 2 = students can develop at least 1 idea that is easy to understand, and logical 1 = students can't answer the question
		Total	10	

Note. Modified from Treffinger et al., (2002)

Creative thinking skill dimensions that received the highest score were fluency and originality dimensions can be seen in Table 5.

Table 5

Example of Question Items of Creative Thinking Dimension

Dimension	Indicator	Question Item
Fluency	produce various ideas and similar answers in solving problems	1. How do you help reducing plastic usage? 2. Based on the article about air pollution in Indonesia, provide appropriate solutions to overcome air pollution problems 3. If you are the government, what kind of innovative policies that you would make to reduce air pollution?
Originality	generate unique and different answers	4. Currently, the utilization of plastic bags has been reduced and is replaced by environmentally friendly shopping bags. In your opinion, what are other environmentally friendly materials that can be used to replace plastic? 5. Flood is a common issue for almost all regions in Indonesia. To overcome floods, what are your action to prevent a flood to occur in the future? 6. One cause of flood is people's behaviour of throwing garbage into the river. As a student who understands the environmental condition, how do you promote the environmental activity so they could respect the existence of the rivers and get used to throwing garbage into a garbage bin?
Flexibility	provide various descriptions and interpretations of a picture, story, or problem	7. What do you think about the forest deforestation for plantation? Is it beneficial to people in general? 8. The government is currently conducting a Jurassic Park construction project on Komodo Island. The development triggers some controversies. What do you think about the program and the effect to the environment?
Elaboration	derive ideas or detail steps on an object or idea	9. Oil palm plantations are considered environmentally unfriendly due to the plantation development system that causes several problems. What do you think that can be done so that the oil palm plantations continue to contribute to the economic sector and remain environmentally friendly? 10. What are solutions you could offer to reduce waste problems and fishing using environmentally unfriendly tools?

Data Analysis

The validity test for the instruments employed Pearson Product Moment and Biserial Point Formula for multiple choice questions. Whereas reliability questions were measured using Cronbach's Alpha and Biserial Point Formula for multiple choice questions. The reliability calculation using Cronbach's Alpha and Kuder-Richardson (KR-20) obtained values of 0.588 (caring dimension), 0.452 (practical competence dimension), and 0.820 (knowledge dimension). The validity test for ecological literacy instruments employed Pearson Product Moment (r. count > r table; α=0.05) and Biserial Point Formula resulted in 24 questions items were valid.

The creative thinking skill instruments were validated by experts. The total score derived was calculated using Lawshe's formula that resulted in a Content Validity Index (CVI) of 1; therefore, the

items were valid (Hendryadi, 2017). The score for creative thinking instruments validation using Lawshe's formula in a Content Validity Index (CVI) of 1; therefore, the items were valid.

The data analysis comprised analysis of descriptive statistics of mean, maximum score, minimum score, and standard deviation. The homogeneity employed the Kolmogorov-Smirnov normality test and Bartlett's homogeneity test. The results of the normality test for each variable generated a Kolmogorov-Smirnov (KS) value (0,838 > α=0,05) indicating that the data came from a normally distributed population. Therefore, parametric tests were preferred in the data analysis. Regression analysis was applied to understand the correlations among ecological literacy and creative thinking skills. The results of the homogeneity test (0,000 < α=0,05) for each variable suggest that the data from each variable came from a homogeneous population (Table 6).

Table 6

Results of Normality and Homogeneity Tests

Variables	Normality Test (Kolmogorov-Smirnov)	Homogeneity Test (Bartlett Test)
Ecological literacy (X_1)	0.838	0.000
Creative thinking (X_2)	0.838	0.000

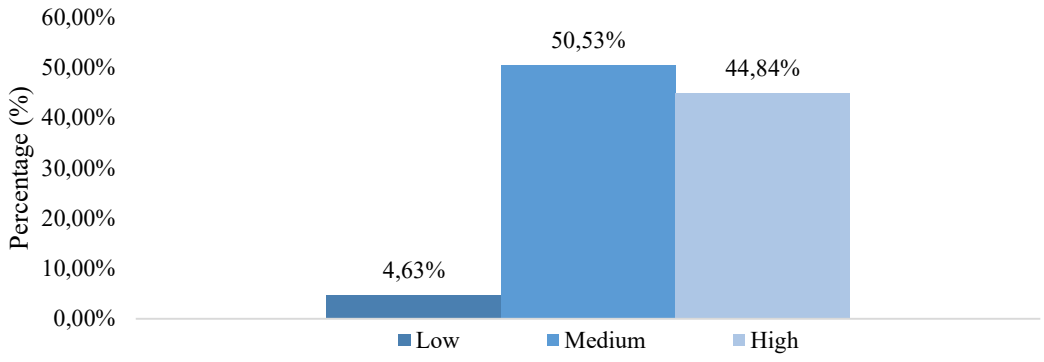
Findings

Creative Thinking Skills

The maximum score for creative thinking was 95 and the minimum score was 28 and average score was 71. The respondent frequency of above-average score was 146 respondents (52.00 %) and below-average score was 135 respondents (48.00%). The creative thinking skill is in medium level as shown in Figure 1.

Figure 1

Creative Thinking Skill Levels



The dimension with the highest score was fluency at 27.66% and the lowest was the originality dimension 22.20% (Table 7).

Table 7

Percentage of Creative Thinking Skill Dimension Score (Y)

Dimension	N	Mean	Standard Deviation	Percentage (%)
Fluency	281	78.74	16.88	27.66
Originality	281	63.20	13.27	22.20
Flexibility	281	74.51	14.50	26.18
Elaboration	281	68.19	17.19	23.96

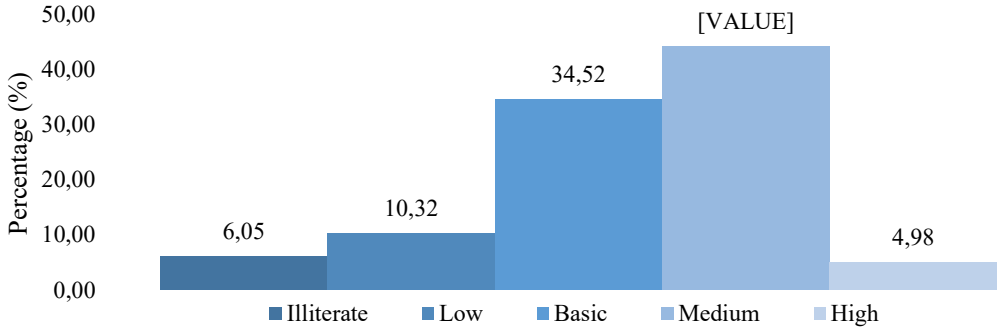
Note. Almeida et al., 2008; Kim, 2011; Torrance, 1966.

Ecological literacy

The calculation of descriptive statistics indicates that the mean was 78 with the frequency of above-average scores was 167 respondents (59.40%) and below-average scores was 114 respondents (41.00%). The analysis results suggest that there were five criteria of ecological literacy skills, namely illiterate, low, basic, standard (medium), and high.

Figure 2

Students' Ecological Literacy Level



The dimension with the highest score was Caring at 35%, whereas the lowest was in the Practical competence dimension 33.00% (Table 8).

Table 8

Percentage of Ecological Literacy Dimension Score (X_2)

Dimension	N	Mean	Standard Deviation	Percentage (%)
Caring	281	81.4	8.60	35.00
Practical	281	76.00	11.00	32.40
Knowledge	281	77.00	20.00	33.00

Note. Mcginn, 2014; Orr, 1992; Rizal et al., 2019

The comparison score of male and female respondents are shown in Table 9.

Tabel 9

Comparison of Respondents' Average Score by gender

Gender	N	Average Score	
		Ecological Literacy	Creative Thinking Skills
Male	110	78.00	69.00
Female	171	78.00	73.00

Based on the correlation value of 0.158, the correlation between ecological literacy and creative thinking skills was at a low level. The determination coefficient (R_{y12}) resulted in a value of 0.025; hence, ecological literacy gave a contribution of 2.5% to the students' creative thinking skills (Table 10).

Table 10

Result of Regression Calculation between Ecological Literacy and Creative Thinking Skills

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	56.238	5.697		9.871	.000
	Ecological literacy	.194	.073	.158	2.678	.008
a. Dependent Variable: creative thinking						

Discussion

The research shows that students' ecological literacy score was in a medium category (standard) 0f 44.5%. The medium category (standard) indicates that students had understood and possessed a sense of caring for and knowledge of environmental problems and how to overcome them as an implementation of their knowledge by learning environmental subjects. Individuals within the standard category are categorized as ecologically literate and they understand how to implement them. Ecologically literate means that individuals can make their own decisions regarding actions and their impacts on the environment.

The ecological literacy dimension with the highest score was the caring dimension. At this level, individuals will feel that their actions can have an impact on the environment; therefore, people with a high caring level will consider their actions and select the most efficient way to prevent impact on the environment. On the contrary, individuals with a low level of caring for the environment tend to feel that their actions have no impact on the damage to the environment (Mcginn, 2014).

Caring for the environment occurs with the amount of information acquired during education at school, in activities conducted in the environment, from experience, and from various media. The second level dimension was knowledge. Knowledge can be obtained from education at school through environmental learning and from activities related to the environment conducted at school or outside of school.

Moreover, they also acquire knowledge by accessing them through internet media on environmental topics. The knowledge is not merely related to the ecological system and its component; the knowledge, however, is made as a basis for caring and being responsible for the environmental conditions (Mcginn, 2014). The dimension that received the lowest score was the practical competence dimension. In this case, individuals who have a high level of practical competence will try not to participate in activities that have negative impacts on the environment. Moreover, they will invite people in their surroundings to perform environmentally friendly life habits. Low practical competence can be caused by the knowledge possessed has not been fully implemented or following the behaviour of others who do not care about the environment (Hartono, 2020; Nurfajriani et al., 2018). Practical competence occurs from individuals' experiences to reduce the negative impacts of human behaviour on the environment (Orr, 1992; Prastiwi et al., 2020a).

The acquisition of dimension scores in ecological literacy are affected by several factors, one of them is age. Human generally achieve the highest level of knowledge and understanding of ecology at the age of 35-74 (Pitman & Daniels, 2016). This indicates that ecological knowledge develops with experiences in contributing to the environment to form good ecological literacy. The respondents had an average age of 16-17 years, students who have ecological understanding tend to be moved to contribute to solving various environmental problems. The environmental problem can be addressed

with problem-solving skills (Prastiwi et al., 2020a). Environmental problem solving requires high order mindset and creativity to produce better ideas. Moreover, it not only demands a thinking process and memorising but also higher thinking levels, namely critical thinking, and creative thinking (Rizal et al., 2019; Rofiah et al., 2013).

This research shows that the creative thinking skills of students is in medium level. In the calculation of dimension scores, the fluency dimension received the highest score of 22.60%. The dimension explains students' abilities in describing answers and solutions in solving environmental problems. Fluency in expressing ideas and alternatives that emerged in problem-solving will develop into other relevant solutions (Kim, 2011; Torrance, 1966; Treffinger et al., 2002). Fluency in answering questions indicates that students were used to hearing or seeing solutions stated in environmental education at school, from the role of teachers and parents, and information in mass media (Latta et al., 2018; McBride, 2011; Mcginn, 2014; Miller, 2018; Sigit et al., 2019).

The dimension that received the lowest score was the originality dimension. This suggests that students' ability level to be creative and produce new ideas was still low compared to other dimensions in creative thinking. Ideas that occurred in the research were relatively general, whereas to acquire a high originality level, the answers and solutions that emerged must be rare and different yet solve the problem. This was due to the students were not accustomed to being trained to create innovative ideas or stock of knowledge that adolescents are unlikely to possess. The ease of accessing various mass media leads students to adapt their answer from the internet instead of creating their own ideas (Baran et al., 2021).

This study shows that the level of ecological literacy of students is in the medium category and shows that there is a significant relationship between ecological literacy and students' creative thinking skills. This is different from previous (Prastiwi et al., 2019, 2020b) regarding the level of ecological literacy in Adiwiyata school students and research from (Nadiroh et al., 2019) which showed no relationship between ecological literacy and critical thinking which was also involving creative thinking.

The association between gender and creative thinking is still much debated. The average score of ecological literacy and creative thinking skills was higher for female respondents (Table 10). Female respondents obtained a higher average score in ecological literacy than the male respondents because women tend to have a better sense of caring for the environment. Women, however, usually have a lower level of knowledge than men do, yet they learn quickly about the environment thus their knowledge is developing (Schimek, 2016; Stevenson et al., 2013). In addition to the number of comparisons between men and women, generally men are more interested in science than women especially in terms of science, technique, and technology and they have better problem-solving skills than women. (Ambusaidi et al., 2021; Schimek, 2016; Yusnaeni et al., 2017). Moreover, as women get older tend to have a better attitude towards the environment and a greater level of caring for the environment (Schimek, 2016; Stevenson et al., 2013).

Creative thinking skills in the context of education can be trained through environmental studies in the school curriculum (Diki, 2013). The curriculum in Indonesia specifically aims to prepare the Indonesian people to have the ability to survive globally by becoming productive, creative, innovative, and effective citizens (Irmita & Atun, 2018). These can be generated by training students to have a creative mindset to make a move in environmental action and improvement (Ahmad, 2020; Astuti, 2017).

Conclusion and Implications

This research is limited to the subject of environmental issues taught to senior high school students in Indonesia. The research found that students' ecological literacy and creative thinking skill level were in a medium category. There was a difference level of ecological literacy and creative thinking between females and males, where females score higher than males. Ecological literacy gave a contribution of 2.5% to the students' creative thinking skills. Research can be done on other subject matter with samples from junior high school students or college students. Future research can also

focus on other higher order thinking skills such as critical or metacognitive thinking and other literacy skills.

Acknowledgement

We would like to thank Eka Putri Azrai, B.Ed., M.Sc. and Erna Heryanti, B.S.F., M.Sc for validating the creative thinking instruments, the Research and Community Service Institution for the research funding under a contract number 13/PKN/LPPM/IV/2022. We also thank the Department of Biology Education Universitas Negeri Medan and Universitas Negeri Gorontalo for the research collaboration.

References

Abdullah Mirzaie, R., Hamidi, F., Anaraki, A., & Rajaee, S. (2009). A study on the effect of science activities on fostering creativity in preschool children. *Journal of Turkish Science Education*, *6*(3), 82–90. http://www.tused.org

Ahmad, D. N. (2020). Pengaruh kemampuan berpikir kreatif terhadap kemampuan mengelolah lingkungan hidup dengan pendekatan berbasis masalah pada matakuliah pklh (effect of creative thinking skills on ability to manage the environment with problem-based approach in pklh course). *SEJ (Science Education Journal)*, *3*(1), 45. https://doi.org/10.21070/sej.v3i1.2227

Almeida, L. S., Prieto, L. P., Ferrando, M., Oliveira, E., & Ferrándiz, C. (2008). Torrance test of creative thinking: the question of its construct validity. *Thinking Skills and Creativity*, *3*(1), 53–58. https://doi.org/10.1016/j.tsc.2008.03.003

Al-Muhdhar, M. H. I., Basaroh, A. S., Prasetyo, T. I., Sumberartha, I. W., Mardiyanti, L., & Fanani, Z. (2021). Improvement of creative thinking skills and environmental literacy through the e-module of surrounding nature exploration. *AIP Conference Proceedings*, *2330*(March). https://doi.org/10.1063/5.0043102

Ambusaidi, A. K., Al-Hajri, F. H., & Al-Mahrouqi, M. K. (2021). Gender differences in omani students' perception of the pedagogical content knowledge of their science teachers as appeared in reality and students' preferences. *Journal of Turkish Science Education*, *18*(4), 781–797. https://doi.org/10.36681/tused.2021.103

Astuti, P. (2017). Peningkatan motivasi dan kemampuan berpikir kreatif siswa pada materi pencemaran lingkungan melalui media fotonovela. *Refleksi Edukatika : Jurnal Ilmiah Kependidikan*, *8*(1). https://doi.org/10.24176/re.v8i1.1783

Awang, H., & Ramly, I. (2008). Creative thinking skill approach through problem-based learning: pedagogy and practice in the engineering classroom. *International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering*, *2*, 334–339.

Baran, M., Baran, M., Karakoyun, F., & Maskan, A. (2021). The influence of project-based stem (pjbl-stem) applications on the development of 21st-century skills. *Journal of Turkish Science Education*, *18*(4), 798–815. https://doi.org/10.36681/tused.2021.104

Beghetto, R. A. (2010). Creativity in the classroom. *The Journal of Creative Behavior*, *2*(4), 239–241. https://doi.org/10.1002/j.2162-6057.1968.tb00110.x

Budsankom, P., Sawangboon, T., Damrongpanit, S., & Chuensirimongkol, J. (2015). Factors affecting higher order thinking skills of students: A meta-analytic structural equation modeling study. *Academic Journals: Educational Research and Reviews*, *10*(19), 2639–2652. https://doi.org/10.5897/ERR2015

Daskolia, M., & Kampylis, P. G. (2012). Secondary teachers' conceptions of creative thinking within the context of environmental education. *International Journal of Environmental & Science Education*, *7*(2), 269–290.

Diki, D. (2013). Creativity for learning biology in higher education. *Lux*, *3*(1), 1–12. https://doi.org/10.5642/lux.201303.03

Fitrianawati, M., Sintawati, M., Marsigit, & Retnowati, E. (2020). Analysis toward relationship between mathematical literacy and creative thinking abilities of students. *Journal of Physics: Conference Series*, *1521*(3), 6–11. https://doi.org/10.1088/1742-6596/1521/3/032104

Hargrove, R. A. (2013). Assessing the long-term impact of a metacognitive approach to creative skill development. *International Journal of Technology and Design Education*, *23*(3), 489–517. https://doi.org/10.1007/s10798-011-9200-6

Hendryadi, H. (2017). Validitas isi: tahap awal pengembangan kuesioner. *Jurnal Riset Manajemen Dan Bisnis (JRMB) Fakultas Ekonomi UNIAT*, *2*(2), 169–178. https://doi.org/10.36226/jrmb.v2i2.47

Irmita, L., & Atun, S. (2018). The influence of technological pedagogical and content knowledge (tpack) approach on science literacy and social skills. *Journal of Turkish Science Education*, *15*(3), 27–40. https://doi.org/10.12973/tused.10235a

Istiyono, E., Widihastuti, W., Supahar, S., & Hamdi, S. (2020). Measuring creative thinking skills of senior high school male and female students in physics (ctsp) using the irt-based phystcrets. *Journal of Turkish Science Education*, *17*(4), 578–590. https://doi.org/10.36681/tused.2020.46

Kamarrudin, H., Talib, O., Kamarudin, N., Ismail, N., Azmin, A., & Zamin, M. (2022). Examining the trend of research on active engagement in science education: bibliometric analysis. *Journal of Turkish Science Education*, *19*(3), 937–957. https://doi.org/10.36681/tused.2022.157

Kan'An, A. (2018). The relationship between jordanian students' 21st century skills (cs21) and academic achievement in science. *Journal of Turkish Science Education*, *15*(2), 82–94. https://doi.org/10.12973/tused.10232a

Kim, K. H. (2011). The creativity crisis: the decrease in creative thinking scores on the torrance tests of creative thinking. *Creativity Research Journal*, *23*(4), 285–295. https://doi.org/10.1080/10400419.2011.627805

Latta, M. M., Latta, M. M., & Ragoonaden, K. (2018). *Accessing the Curricular Play of Critical and Creative Thinking*. *January 2017*.

Marni, S., Aliman, M., Suyono, S., Roekhan, R., & Harsiati, T. (2020). Students' critical thinking skills based on gender and knowledge group. *Journal of Turkish Science Education*, *17*(4), 544–560. https://doi.org/10.36681/tused.2020.44

McBride, B. B. (2011). Essential elements of ecological literacy and the pathways to achieve it: perspectives of ecologists. *Graduate Student Theses, Dissertations, & Professional Papers*, *380*, 1–309.

Mcginn, A. E. (2014). Quantifying and understanding ecological literacy : a study of first year students at liberal arts institutions. *Dickinson College Honors Theses*.

Miller, A. L. (2018). The role of creative coursework in skill development for university seniors. *Global Education Review*, *5*(1), 88–107.

Nadiroh, N., Hasanah, U., & Zulfa, V. (2019). Behavioral geography: an eco-literacy perspective and critical thinking skills in men and women. *Indonesian Journal of Geography*, *51*(2), 115–122. https://doi.org/10.22146/ijg.36784

Orr, D. W. (1992). Ecological literacy: Education and the transition to a postmodern world. In *Suny Press* (Vol. 3, Issue 4). Suny Press. https://doi.org/10.1111/j.1523-1739.1989.tb00238.x

Pitman, S. D., & Daniels, C. B. (2016). Quantifying ecological literacy in an adult western community: The development and application of a new assessment tool and community standard. *PLOS ONE*, *11*(3), 1–18. https://doi.org/10.1371/journal.pone.0150648

Prastiwi, L., Sigit, D. V., & Ristanto, R. H. (2019). Ecological literacy, environmental awareness, academic ability and environmental problem-solving skill at adiwiyata school. *Indonesian Journal of Science and Education*, *3*(2), 82. https://doi.org/10.31002/ijose.v3i2.1114

Prastiwi, L., Sigit, D. V., & Ristanto, R. H. (2020a). Hubungan antara literasi ekologi dengan kemampuan memecahkan masalah lingkungan. *Jurnal Pendidikan Matematika Dan Sains*, *11*(1), 47–61. https://doi.org/10.26418

Prastiwi, L., Sigit, D. V., & Ristanto, R. H. (2020b). Hubungan antara literasi ekologi dengan kemampuan memecahkan masalah lingkungan. *Jurnal Pendidikan Matematika Dan Sains*, *11*(1), 47–61. https://journal.uny.ac.id/index.php/jpms/article/view/21223/pdf

Rizal, M., Sigit, D. V., & Ristanto, R. H. (2019). *Hubungan antara paradigma lingkungan baru dan literasi ekologi dengan perilaku tanggung jawab lingkungan*. State University of Jakarta.

Rofiah, E., Nonoh, s. A., & Ekawati, E. Y. (2013). Penyusunan instrumen tes kemampuan berpikir tingkat tinggi fisika pada siswa smp. *Jurnal Pendidikan Fisika*, *1*(2), 17–22.

Schimek, M. J. (2016). How an experience in nature affects ecoliteracy of high school students. *School of Education Student Capstone Theses and Dissertations.*, *4133*, 1–88.

Sigit, D. V., Heryanti, E., Ayu, D., Pangestika, W., & Ichsan, I. Z. (2019). Pembelajaran lingkungan bagi siswa : hubungan kemampuan berpikir kreatif dengan kemampuan pemecahan masalah. *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, *4*(1), 6–12.

Sternberg, R. J., & Sternberg, R. J. (2010). he nature of creativity the nature of creativity. *Creativity Research Journal*, *18*(1), 37–41. https://doi.org/10.1207/s15326934crj1801

Stevenson, K. T., Peterson, M. N., Bondell, H. D., Mertig, A. G., & Moore, S. E. (2013). Environmental, institutional, and demographic predictors of environmental literacy among middle school children. *PLoS ONE*, *8*(3). https://doi.org/10.1371/journal.pone.0059519

Torrance, E. P. (Ellis P. (1966). *Torrance tests of creative thinking.* (Personel P). Personel Press.

Treffinger, D. J., Young, G. C., Selby, E. C., & Shepardson, C. (2002). *Assessing Creativity: A Guide for Educators* (Issue December).

Yazar, S., & Birgili, B. (2015). Creative and critical thinking skills in problem-based learning environments. *Journal of Gifted Education and Creativity*, *2*(2), 71–71. https://doi.org/10.18200/jgedc.2015214253

Yusnaeni, Y., Corebima, A. D., Susilo, H., & Zubaidah, S. (2017). Creative thinking of low academic student undergoing search solve create and share learning integrated with metacognitive strategy. *International Journal of Instruction*, *10*(2), 245–262. https://doi.org/10.12973/iji.2017.10216a

Zubaidah, S., Fuad, N. M., Mahanal, S., & Suarsini, E. (2017). Improving creative thinking skills of students through Differentiated Science Inquiry integrated with mind map. *Journal of Turkish Science Education*, *14*(4), 77–91. https://doi.org/10.12973/tused.10214a