

Analysis of ecological literacy level and creative thinking skills of college students

Diana Vivanti Sigit¹, Rizhal Hendi Ristanto¹, Ratna Komala², Anisa Nurrismawati¹, Puji Prastowo³,
Abubakar Sidik Katili⁴

¹Department of Biology Education, Faculty of Mathematics and Natural Science, Universitas Negeri Jakarta, East Jakarta, Indonesia

²Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Negeri Jakarta, East Jakarta, Indonesia

³Department of Biology Education, Faculty of Mathematics and Natural Science, Universitas Negeri Medan, Medan, Indonesia

⁴Department of Biology Education, Faculty of Mathematics and Natural Science, Universitas Negeri Gorontalo, Gorontalo, Indonesia

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ABSTRACT

Higher education institution is one of educational institutions that serve as a place of cultural values, and norms expected to become a foundation to foster caring attitudes toward the environment. These attitudes are accordingly meant to develop ecological literacy in order to overcome environmental problems which are likely to be minimized by combining ecological literacy and creative thinking skills. A quantitative descriptive with correlational study was employed in this research. There were 275 college students from three areas in Indonesia, namely Jakarta, Sumatera, and Gorontalo involved as respondents of the research. Data was collected by means of Google Forms consisting of tests and opinions. The ecological literacy was analyzed using dimensions of caring, practical competence, and knowledge while the creative thinking skills were analyzed using dimensions of fluency, originality, flexibility, and elaboration. This research is limited to students in the Department of Science and Non-Science. Findings of the research indicates that the ecological literacy level is in the medium category, whereas the creative thinking skills are good. Female students have a higher average score in ecological literacy and creative thinking skills compared to that of male students. Thus, there is a positive relationship between ecological literacy and creative thinking skills.

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Corresponding Author:

Diana Vivanti Sigit

Department of Biology Education, Faculty of Mathematics and Natural Science, Universitas Negeri Jakarta
Rawamangun Muka Street, East Jakarta-13220, Indonesia

Email: dianav@unj.ac.id

1. INTRODUCTION

Developing creative thinking skills is necessary as a prerequisite of individuals for entering the modern and global worlds [1], [2]. The modern world is full of rapid progress and competition, and continues to move forward in global mobility, social transformation, democracy, and industrial revolution [3]–[6]. Progress must be made by preparing individuals, especially college students, who will enter the working world, for being globally and competently competitive. A survey by the American Management Association (AMA) states that competencies required in the industrial world are critical thinking, collaboration, communication, and creative thinking [7]. Creative thinking skill is a mental process that involves cognitive process and thinking skills divergently in which someone could produce an idea useful for solving problems from different perspectives [8]–[11]. Everyone is born with different creative thinking; hence, creativity is not only valued as gifted but also a human natural need and competence possessed [12], [13].

Creative thinking is an important component to facilitate individuals to succeed in the working world, family life, and community, and increase academic achievement [14]–[16]. In educational context, it is deemed crucial for learners and college students to possess creative thinking skills because the level of students creative thinking in Indonesia remains low [2], [17]. Creative thinking is one of ways to solve complex problems [18]. Common problems that occur are environmental problems emerging in almost all parts of Indonesia [19]. Efforts to prevent and rectify environmental problems have been made from primary school to higher education institutions, such as the Adiwiyata program, environmental education, or school culture in the implementation of the environment. Environmental damage, however, often occurs in Indonesia's areas due to the lack of knowledge and awareness about the environment. The low environmental awareness taking place at schools and higher universities indicates that the implementation of programs and integration of environmental content are less optimum. Educators only teach students how to address environmental problems according to textbooks with the absence of direct implementation toward the problem solving. This applies in schools; therefore, it requires further actions for implementing the strategies for solving the environmental problems. One of them can be carried out by the help of the universities.

College students as an agent of change are expected to have innovation for solving the environmental problems by developing creative thinking skills that consequently require a creative mindset. Creative thinking skill is an important component in the competence of pro-environmental attitudes [20], [21]. A pro-environmental attitude is necessary as a form of environmental awareness. Having this sort of awareness, environmental problems can be solved with the support of ecological literacy [19]. The goal of ecological literacy is to enhance individual awareness to act on developing environmental issues so that they can be sustainable human beings. Moreover, an individual who has ecological literacy skills will have the ability to involve in environmental problems [20], [22]. To overcome environmental problems requires creative thinking skills to achieve the environmental sustainability [23], [24].

A study [19] showed that high school students still have a basic ecological literacy level and thus require an improvement to maximize their understanding of the environmental conditions. Previous studies were conducted in schools located in the same areas and under similar environmental conditions. A research indicates a relationship between ecological literacy and critical thinking, which involves creative thinking skills [25]. The eco-literacy level of college students is of a medium level [26]. A research study [1] suggested that college students' creative thinking skills need improvement. The improvement of environmental awareness can be done in many sectors including in the universities. Universities as one of higher education institutions have a big role in educating young people, who will become future leaders, in various fields such as education, economics, technology, and the environment. Universities need to prepare students from various fields to participate in solving environmental problems. Previous studies [26]–[28] showed that students have had good understanding of but lacked implementation in the environmental conditions. In addition, research on the level of ecological literacy and creative thinking of students from various majors in Indonesia has not widely been carried out [2], [28].

Therefore, this study aims to analyze the level of ecological literacy and creative thinking of students from various majors which are classified into science and non-science students. This classification is based on research [29] pointing out that students with a science background tend to care more about the environment. Therefore, this research aimed at analyzing creative thinking levels in environmental problems in terms of ecological literacy among college students from different locations and environmental conditions, and the relationship between ecological literacy and college students' creative thinking skills in overcoming environmental problems.

2. RESEARCH METHOD

A descriptive method with a correlational study was employed in this research consisting of an independent variable (X1) of ecological literacy and a dependent variable (Y) of college students' creative thinking skills. Students from universities in DKI Jakarta, Sumatera, and Gorontalo were selected as population of the research by means of a purposive sampling, namely based on science and non-science majors. They were 275 students consisting of 97.09% science students and 2.91% nonscience students with 16.36% male and 83.64% female of gender classification. The purposive sampling was employed because previous research [29] noted that students of science tend to care more about the environment compared with students of non-science. The selected samples were calculated using McClave's formula and the result generated a standard error of $0.531 < 1$; thus, the samples were homogeneous and representative for the population.

Data of the research was collected by distributing instruments from each variable. A questionnaire and a multiple-choice test were used to measure ecological literacy variable whereas an essay test was used to measure the creative thinking skills. The research was conducted in several stages: hypothesis testing, sampling, instrument creation and validation, data collection, data analysis, and research conclusion [30]. The

ecological literacy instruments consisted of tests and questionnaire [31]–[33]. The dimensions of caring and practical competence were measured using questionnaire in the form of a Likert scale with 24-item questions. Whereas the knowledge dimension was measured using a multiple-choice test with the score for correct answer=1 and wrong answer=0, as indicated in Table 1 [31]–[33].

Table 1. Sample of questions of ecological literacy indicator

Dimension	Question item
Dimension of caring	
Indicator:	1. Small actions by one person have no significant impact on environmental problems
Awareness to be responsible for reducing the negative impacts on the environment	2. Electricity must be produced from renewable sources to reduce fossil fuel utilization
Scale: strongly agree, agree, disagree, strongly disagree	3. Activities of environmental preservation seminars are useful activities
	4. I will not use recycled products because they are expensive
	5. It is necessary to separate wet garbage and dry garbage
	6. I don't care for waste produced by factories since it does not disturb me
Dimension of practical competence	
Indicator:	7. I pretend not to know if there is garbage scattered around
Actions conducted to reduce negative impacts on the environment	8. I use air conditioning (AC) continuously
Scale: always, often, sometimes, rare, never	9. I use public transportation to travel
	10. I save electricity usage
	11. I carry out class duties as scheduled
Dimension of knowledge	
Indicator:	12. Based on the chart, the information received is ...
The basic concept of ecology and understanding of human actions on the ecosystems	13. Information gathered from the above chart is ...
	14. Pollutant levels that exceed the threshold in an environment will cause ...
	15. These components will be interdependent if they are arranged into a food chain with an order of...
	16. Based on the above table, activities that can be done as an effort to reduce environmental problems are...
	17. Components in an ecosystem consist of inorganic compounds, plankton, fish, fish-eating birds, and guano. If excessive fishing occurs, the consequences are...
	18. Based on the above news, the causes of floods are...
	19. As a good citizen and learner who care about the environment, the appropriate action to respond to the news is...
	20. The above chart indicates the time needed for plastic waste to decompose in nature. Based on the chart, the right way to better manage plastic waste is...except...
	21. Based on the above article, why plastic waste is harmful to organisms...
	22. Besides developing RTH, things that can be done to reduce global warming are...
	23. One of the ways in endangered animal protection is...
	24. The following human activities that could reduce the environmental carrying capacity are...

The measurement of caring dimension used the Likert scale with scoring of 4-3-2-1 (strongly agree, agree, disagree, and strongly disagree), whereas the measurement of practical competence dimension also used the Likert Scale with scoring of 5-4-3-2-1 (always, often, sometimes, rare, never). The knowledge dimension was measured using a multiple-choice test with scoring of correct=1 and wrong=0. The criteria of ecological literacy assessment were categorized based on the criteria [33] as indicated in Table 2.

Table 2. Criteria of ecological literacy score

Criteria	Provision
Illiterate	<60
Low	60-70
Basic	71-80
Medium	81-90
High	91-100

The instruments of creative thinking skills comprised four dimensions, namely flexibility, fluency, originality, and elaboration. All the dimensions were measured using an essay question test that consisted of 10 questions as shown in Table 3 [11], [34], [35]. The criteria of creative thinking assessment were categorized as indicated in Table 4. The criteria for achieving creative thinking scores are divided into five criteria. These criteria include not creative, less creative, creative enough, creative, and very creative. Each category has its own score range as seen in Table 4.

Table 3. Instruments of creative thinking skills

Dimension	Indicator	Question item
Fluency	Produce various similar ideas and answers to solving a problem	1. How can you help reduce plastic use? 2. Based on the above articles, please provide the right solutions so that the air pollution issue can be handled! 3. If you were a government, what kind of innovative policies would you implement to reduce air pollution?
Originality	Generate unique and different answers	4. The use of plastic bags has currently been reduced and replaced by environmentally-friendly shopping bags. In your opinion, what are other environmentally-friendly materials that can be used to substitute plastic? Flood is a common issue that occurs in almost all parts of Indonesia. To overcome floods, what ideas can you create to prevent floods to occur in the future? 5. One of the causes of floods is people's behavior to throw garbage into the rivers. As a student who understands the environmental conditions, what things can you socialize so that people could pay more respect to the existence of rivers and get used to throwing garbage in the garbage bin?
Flexibility	Provide various descriptions and interpretations of an image, story, or problem	6. Give your opinion on the benefits or positive impacts of deforestation to be used as plantations! 7. The government is conducting a Jurassic Park project on Komodo Island. Give your opinion from various perspectives!
Elaboration	Produce ideas or detailed steps on an object or idea.	8. Oil palm plantations are deemed environmentally unfriendly since the development system of the plantations causes several problems. In your opinion, what can be done so that oil palm plantations could continue to contribute to the economic sector yet stay environmentally friendly? 9. What solutions could you give to reduce waste problems and decrease the activity of catching fish using environmentally unfriendly materials?

Table 4. Criteria for creative thinking score

Criteria	Provision
Not creative	0-20
Less creative	21-40
Creative enough	41-60
Creative	61-80
Very creative	81-100

Pearson's product moment for the dimensions of caring and practical competence were employed for the validity test of the ecological literacy instrument whilst Cronbach's alpha was used for the reliability. The reliability calculation for both dimensions resulted in a coefficient of 0.588 and 0.452, respectively. Biserial Point Formula was employed in the validity test for the dimension of knowledge whereas Kuder Richardson 20 was correspondingly used in the reliability.

Expert validation by validators was used in the validity test for creative thinking instruments. The validators were selected according to the following criteria: education, expertise, evaluation field, and relevant content expertise. The validation data were gathered by providing a validation assessment sheet to the validators. The total score generated was then calculated using Lawshe's formula in which a question is valid if the content validity index (CVI) is within the provision range of 0-1 [36]. The calculation of the question reliability employed Cronbach's alpha and resulted in a coefficient of 0.717; then, the items were reliable.

The data analysis consisted of descriptive statistical analysis in the form of mean, maximum score, minimum score, and standard deviation. The hypothesis prerequisite tests included the normality test of Kolmogorov Smirnov and the homogeneity test of Bartlett test. The linear regression test was selected for hypothesis testing, whereas Pearson's Product Moment was used in the calculation of the correlation coefficient. The hypothesis testing was followed by a linear regression test and correlation test and the calculation of the correlation coefficient and coefficient of determination.

3. RESULTS AND DISCUSSION

3.1. Data results

The data analysis of the ecological literacy instruments generated 24 valid items and the reliability calculation for the dimension of caring and practical competence using Cronbach's alpha obtained a coefficient of 0.588 (caring dimension) and 0.452 (practical competence dimension). The reliability for the knowledge dimension calculated using Kuder Richardson 20 (KR-20) produced 0.820 > r table (0.60); therefore, the items were reliable. The validity test for the creative thinking instruments used expert validation by validators. The validators were selected according to the following criteria: education, expertise, evaluation field, and relevant content expertise.

The validation data were gathered by providing a validation assessment sheet to the validators. The total score generated was then calculated using Lawshe's formula in which a question is valid if the content validity index (CVI) is within the provision range of 0-1 [36]. The result of the CVI calculation was 1, therefore the items were valid. The calculation of question reliability employed Cronbach's alpha and resulted in a coefficient of 0.717; thus, the items were reliable. Based on the data, the maximum score for creative thinking skills was 97.50 and the minimum score was 47.50. The average score of the creative thinking was 77.28 following 58.18% of the respondents categorized as creative as shown in Figure 1.

The scores percentages in each of four dimensions of creative thinking skills resulted that dimension fluency and originality with 26.32%. Whereas flexibility with 22.02% and elaboration dimension with 25.34%. The scores percentage in each of four dimensions of creative thinking skills resulted that dimensions with the highest score were fluency and originality and the lowest score was flexibility dimension with 22.02% as presented in Table 5 [11], [34], [35].

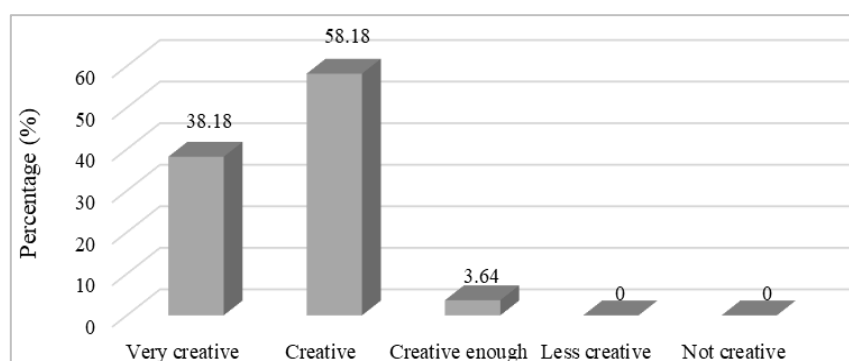


Figure 1. Percentage of criteria of students' creative thinking skill score

Table 5. The score of the creative thinking skill dimensions

Dimension	N	Mean	Standard Deviation	Percentage (%)
Fluency	275	81.91	14.19	26.32
Originality	275	81.91	11.75	26.32
Flexibility	275	68.52	11.41	22.02
Elaboration	275	78.86	16.93	25.34

Five indicators were used to categorize the score of ecological literacy namely illiterate, low, basic, medium, and high skills. Based on the research on ecological literacy, the maximum score was 95.83, the minimum score was 48.22, and the average score was 81. The data indicate five criteria of ecological literacy was illustrated in Figure 2.

The scores percentages in each of three dimensions of ecological literacy skills showed that the dimension with the highest score was the knowledge dimension with 34.39%. As for the practical dimensions with 32.92%, and the lowest was the caring dimension with 32.69%. The percentage of ecological literacy dimensions scores were shown in Table 6 [31]–[33].

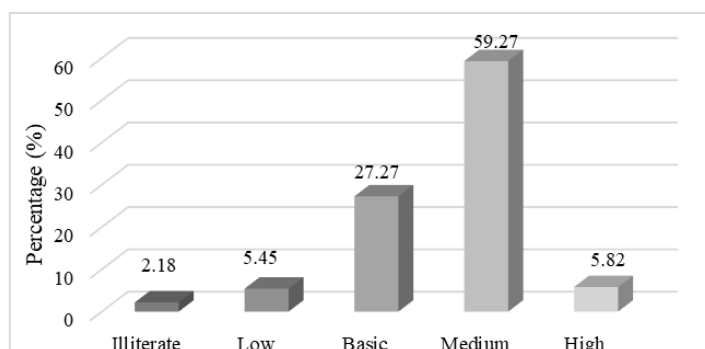


Figure 2. Percentage of ecological literacy score criteria

Table 6. The percentage of ecological literacy dimension score (X_2)

Dimension	N	Mean	Standard deviation	Percentage (%)
Caring	275	79.65	6.83	32.69
Practical	275	80.23	9.15	32.92
Knowledge	275	83.81	16.08	34.39

The average scores in ecological literacy and creative thinking skills were higher among women than men. This could occur due the disproportionate number of respondents from science and nonscience programs with more science program. The comparison of average scores between males and females are presented in Table 7.

The results shows that the students from science and nonscience programs are different. The science program students showed a good ecological understanding and tended to contribute to various environmental problem solving. That is indicated with the higher score compared to those of nonscience program. This could occur due the disproportionate number of respondents from science and nonscience programs, in which more students of science program occupied the number as shown in Table 8.

Table 7. Comparison of average score of respondents

Gender	N	Average score	
		Ecological literacy	Creative thinking skills
Male	45	80.85	76.56
Female	230	81.30	77.42

Table 8. Score comparison between students science and nonscience programs

Gender	N	Average score	
		Ecological literacy	Creative thinking skills
Science	269	82.54	77.42
Non-science	6	82.00	71.25

The result of normality test calculation for each variable resulted in a Kolmogorov-Smirnov (KS) of 0.084 or greater than $\alpha=0.05$; therefore, the data were from a normally distributed population. The result of homogeneity test for each variable indicated a significance value of 0.000 or smaller than $\alpha=0.05$; hence, it can be concluded that the data for each variable were originated from a homogenous population. The calculation of regression for the relationship between ecological literacy and creative thinking skills generated a regression model $\hat{Y}=56,921+0,251X_2$ with a linear and significant relationship form. Based on the correlation value of 0.196, the relationship level between ecological literacy and creative thinking was low. The result of the calculation of the coefficient of determination (R_{y12}) was 0.039; hence, ecological literacy contributed 3.9% to the student's creative thinking skills as shown in Table 9.

Table 9. Calculation of correlation coefficient and coefficient of determination

Model	R	R Square	Adjusted R Square	Std. Error of the estimate	R Square change	Change statistics				
						F Change	df1	df2	Sig.	F change
1	0.196 ^a	0.039	0.035	9.34539	0.039	10.953	1	273		0.001

*Sig. ($\alpha \leq 0.05$)

3.2. Discussion

The ecological literacy scores of the students from the three universities were in the medium category. This indicates that students have already had an understanding of and care for the environment. Moreover, they have had knowledge about environmental problems and how to find solutions. An individual with a medium literacy level is included in the "ecologically literate", which means the individual has understood the environmental conditions and is capable of applying appropriate actions in managing the environment. The calculation of the dimensions shows that the knowledge dimension received the highest score. Knowledge can be obtained from education in school, campus communities, or through environmental learning or environment-related activities inside or outside the campus. Knowledge of the environment is accumulated since students receive learning about environment-related content in school. Additionally, students could acquire knowledge from access to the internet media by browsing around environmental topics.

Knowledge is not merely related to the ecological systems and their components, but it can also be used as a basis for caring and being responsible for environmental conditions [33]. The research data shows that the participating respondents had an average age of 18-20 years old. The highest level of knowledge and understanding of ecology is achieved by humans when they are around 35-74 years old [37]. This indicates that ecological knowledge is developing with experience in contributing to the environment to form a good ecological literacy. The score of the caring dimension was the lowest compared to that of the other dimensions. This can be related to the level of the student's awareness that tends to lead them to feel if their actions will give no impact on the environment. Moreover, they have knowledge that has not been applied entirely nor follow others' behaviors of having no care about the environment [38], [39].

The college students tend to care yet they decide to have someone else do the action to overcome environmental problems. An individual with a good caring level will feel that all actions could have an impact on the environment. Therefore, an individual with a high level of caring will consider all actions and select the most efficient way to prevent impacts toward the environment. In contrast, an individual that has a low level of caring for the environment will tend to feel that all actions in his/her life have no impact on the damage occurring in the environment [33]. The participating students came from science and non science programs. They showed a good ecological understanding and tended to contribute to various environmental problem solving. Students of science programs have better score because they have courses in relation to environment compared to students of non science programs. The higher score derived from science students could be made due to disproportionate number of respondents from science and nonscience programs in which more students of science program occupied the number.

Environmental problems can be addressed with problem-solving skills [20]. Environmental problem-solving requires a high-order mindset and creativity to generate better ideas. Problem-solving not only requires a thinking process and memorizing but also a combination of higher thinking levels such as critical and creative thinking [32]. A creative mindset is used as action and desire to solve environmental problems. Creative thinking is a component of environmental education that is used to solve environmental problems to achieve a sustainable lifestyle [21]. This is consistent with a study [23] stating that individual creativity gained from being trained in creative thinking and authentic experiences of the environment could influence individual perspectives on the environment so that environmental sustainability can be achieved.

In the current research, students' creative thinking skill is considered creative. A good creative thinking level indicates that the students have easy access to information; thus, they have references that stimulate creativity to ease them when encountering the environmental problems. Creativity in thinking is developed in three components, namely people, field, and domain. People means the actors, in this case, students; the field is the knowledge learned by students in an institution, either in schools or in colleges; and the domain is the place where the students learn, such as colleges. Therefore, the role of the university as a place to learn for students is imperative to foster students' creativity.

The highest score in the creative thinking dimension was fluency and originality. The fluency dimension explains the students' ability to elaborate answers and solutions to overcome environmental problems. The fluency in expressing ideas and alternatives occurred in problem-solving will develop into other usable solutions [9], [11], [35]. Fluency in answering questions indicates that students are used to hearing or seeing solutions that are well-conveyed through environmental education in schools, teacher's roles, campus activities or social activities, parents' roles, or information through mass media [33], [40]–[42].

The originality dimension suggests the level of students' ability in creating and producing good new ideas. Ideas that emerge in research are innovative and applicable. The originality level of a good idea indicates that students understand and have sufficient knowledge of environmental problems and their solutions. Media that are easily accessed by students tend to enable them to adapt answers from the internet and modify them into a useful and acceptable solution [16]. The formed relationship between ecological literacy and creative thinking skills has been indicated low. This is different from previous studies [19], [20] on the level of ecological literacy among students in Adiwiyata school and indicates no relationship between ecological literacy and critical thinking that is included in the higher-order thinking [25]. The ecological literacy level of university students indicates a medium category [1]; however, no further research about the relationship between ecological literacy and higher-order thinking has been conducted.

The current research gathered demographic data on the respondent's gender. The average scores in ecological literacy and creative thinking skills were higher among women than those of men. This could occur due to disproportionate number of respondents between men and women in which more women occupy the number. The ecological literacy score among women was higher than that of men. This was due to the women's tendency of having better care feeling for the environmental conditions. Although women are at a lower level than men in terms of knowledge, they learn faster about the environment; thus, their knowledge level develops. Moreover, as women get older, they tend to have a better attitude toward and greater caring for the environment [43], [44].

Gender is still debated in terms of creative thinking. This occurs owing to many studies indicating different results when connecting gender to creative thinking [10], [45]. In the current research, there was a difference in the score of creative thinking between men and women. This contradicts other research results [10], [44], [46] stating that men have higher creative thinking levels. Men have better creative thinking levels than women since they tend to be interested in such fields as sciences, engineering, technology, and problem-solving skills at which they are better than women. Problem-solving skill is closely related to creative thinking [10], [43]. Since the need of today is unpredictable and complicated and demands that people be able to apply their creativity, it is commonly acknowledged that higher education plays a crucial role in encouraging students' creative thinking skills. Creative thinking skills can be trained periodically through implementation of appropriate curricula in schools or through environmental awareness actions in universities. Education institutions, both schools and universities, are a place for the transfer of knowledge, cultural values, and norms that are expected to become a foundation to foster attitudes of caring for the environment among their students [47].

4. CONCLUSION

This research aims to fill the gap and inform academics and other researchers in the context of creative thinking and ecological literacy in higher education. While other research focuses on developing creative thinking and environmental awareness in students in high schools. The results indicate that ecological literacy level is in the medium category, whereas creative thinking skills are good. Female students score higher than male students in ecological literacy and creative thinking. This paper is limited to analyzing the level of creative thinking and ecological literacy of students from science and nonscience programs; thus, this paper could be used as a reference for other research related to creative thinking and environmental problems.

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REFERENCES

- [1] T. Borodina, A. Sibgatullina, and A. Gizatullina, "Developing creative thinking in future teachers as a topical issue of higher education," *Journal of Social Studies Education Research*, vol. 10, no. 4, pp. 226–245, 2019.
- [2] A. Saregar, U. N. Cahyanti, Misbah, N. E. Susilowati, A. Anugrah, and N. Muhammad, "Core learning model: Its effectiveness towards students' creative thinking," *International Journal of Evaluation and Research in Education (IJERE)*, vol. 10, no. 1, pp. 35–41, Mar. 2021, doi: 10.11591/ijere.v10i1.20813.
- [3] J. Knight, "GATS, trade and higher education perspective 2003-where are we? Regionalization of African higher education view project," *The Observatory on Borderless Higher Education*, 2003, doi: 10.13140/RG.2.2.14347.62243.
- [4] S. C. Noh and A. M. A. Karim, "Design thinking mindset to enhance education 4.0 competitiveness in Malaysia," *International Journal of Evaluation and Research in Education (IJERE)*, vol. 10, no. 2, pp. 494–501, Jun. 2021, doi: 10.11591/ijere.v10i2.20988.
- [5] M. Baygin, H. Yetis, M. Karakose, and E. Akin, "An effect analysis of industry 4.0 to higher education," *2016 15th International Conference on Information Technology Based Higher Education and Training (ITHET)*, Istanbul, Turkey, Sep. 2016, doi: 10.1109/ITHET.2016.7760744.
- [6] P. A. Bourne and V. M. S. Peterkin, "Academic leadership and governance of higher education-book review," *International Journal of Research in Business Studies and Management*, vol. 4, no. 9, 2017, [Online]. Available: <https://www.ijrbmsm.org/papers/v4-i9/3.pdf>.
- [7] American Management Association (AMA), "AMA 2010: Critical Skills Survey Executive Summary," American Management Association, 2010. [Online]. Available: www.amanet.org.
- [8] R. J. Sternberg, "The nature of creativity," *Creativity Research Journal*, vol. 18, no. 1, pp. 87–98, Jan. 2006, doi: 10.1207/s15326934crj1801_10.
- [9] D. J. Treffinger, G. C. Young, E. C. Selby, C. Shepardson, and F. Sarasota, "Assessing Creativity: A Guide for Educators," The National Research Center on the gifted and talented, 2002.
- [10] Y. Yusnaeni, A. D. Corebima, H. Susilo, and S. Zubaidah, "Creative thinking of low academic student undergoing search solve create and share learning integrated with metacognitive strategy," *International Journal of Instruction*, vol. 10, no. 2, pp. 245–262, Apr. 2017, doi: 10.12973/iji.2017.10216a.
- [11] K. H. Kim, "The creativity crisis: the decrease in creative thinking scores on the Torrance tests of creative thinking," *Creativity Research Journal*, vol. 23, no. 4, pp. 285–295, Oct. 2011, doi: 10.1080/10400419.2011.627805.
- [12] R. A. Beghetto, "Creativity in the classroom," in *The Cambridge Handbook of Creativity*, Cambridge University Press, 2012.
- [13] B. B. Yazar Soyadi, "Creative and critical thinking skills in problem-based learning environments," *Journal of Gifted Education and Creativity*, vol. 2, no. 2, pp. 71–71, Dec. 2015, doi: 10.18200/jgedc.2015214253.
- [14] S. Bolandifar and N. Noordin, "Investigating the relationship between creativity and academic achievement of Malaysian undergraduates," *Jurnal Teknologi (Sciences and Engineering)*, vol. 65, no. 2, pp. 101–107, Nov. 2013, doi: 10.11113/jt.v65.2355.
- [15] M. Hilton, "Preparing students for life and work," *Issues in Science and Technology*, no. 4, 2015. [Online]. Available: <https://issues.org/preparing-students-for-life-work/> (accessed Dec. 21, 2022).




- [16] M. A. Runco and G. J. Jaeger, "The standard definition of creativity," *Creativity Research Journal*, vol. 24, no. 1, pp. 92–96, Jan. 2012, doi: 10.1080/10400419.2012.650092.
- [17] J. Jumadi, R. Perdana, M. H. Hariadi, W. Warsono, and A. Wahyudi, "The impact of collaborative model assisted by Google Classroom to improve students' creative thinking skills," *International Journal of Evaluation and Research in Education (IJERE)*, vol. 10, no. 2, pp. 396–403, Jun. 2021, doi: 10.11591/ijere.v10i2.20987.
- [18] A. Halizah and R. Ishak, "Creative thinking skill approach through problem-based learning: pedagogy and practice in the engineering classroom," *International Journal of Human and Social Sciences*, vol. 3, no. 1, pp. 18–23, 2008.
- [19] D. V. Sigit, L. Prastiwi, R. H. Ristanto, and M. Rifan, "Adiwiyata school in Indonesia: A correlation between eco-literacy, environmental awareness, and academic ability with environmental problem-solving skill," *IOP Conference Series: Earth and Environmental Science*, vol. 1796, no. 1, Feb. 2021, doi: 10.1088/1742-6596/1796/1/012068.
- [20] L. Prastiwi, D. V. Sigit, and R. H. Ristanto, "Ecological literacy, environmental awareness, academic ability and environmental problem-solving skill at Adiwiyata School," *Indonesian Journal of Science and Education*, vol. 3, no. 2, Oct. 2019, doi: 10.31002/ijose.v3i2.1114.
- [21] M. Daskolia, A. Dimos, and P. G. Kamyliis, "Secondary teachers' conceptions of creative thinking within the context of environmental education," *International Journal of Environmental and Science Education*, vol. 7, no. 2, pp. 269–290, 2012.
- [22] M. Davidson, "Social sustainability and the city," *Geography Compass*, vol. 4, no. 7, pp. 872–880, Jul. 2010, doi: 10.1111/j.1749-8198.2010.00339.x.
- [23] V. M. Y. Cheng, "Views on creativity, environmental sustainability and their integrated development," *Creative Education*, vol. 9, no. 5, pp. 719–743, 2018, doi: 10.4236/ce.2018.95054.
- [24] R. W. Howe and J. F. Disinger, "Environmental Activities for Teaching Critical Thinking (Environmental Education Information Report)," 1990.
- [25] N. Nadiroh, U. Hasanah, and V. Zulfa, "Behavioral geography: An ecoliteracy perspective and critical thinking skills in men and women," *Indonesian Journal of Geography*, vol. 51, no. 2, pp. 115–122, Aug. 2019, doi: 10.22146/ijg.36784.
- [26] A. Muliana, E. Maryani, and L. Somantri, "Ecoliteracy level of student teachers (study toward students of Universitas Syiah Kuala Banda Aceh)," *IOP Conference Series: Earth and Environmental Science*, vol. 145, no. 1, Apr. 2018, doi: 10.1088/1755-1315/145/1/012061.
- [27] S. Jusoh, M. K. A. Kamarudin, N. A. Wahab, M. H. M. Saad, N. H. Rohizat, and N. H. N. Mat, "Environmental awareness level among University Students in Malaysia: a review," *International Journal of Engineering and Technology*, vol. 7, Dec. 2018, doi: 10.14419/ijet.v7i4.34.23575.
- [28] Z. B. Ningrum and H. Herdiansyah, "Environmental awareness and behavior of college students in regards to the environment in urban area," *E3S Web of Conferences*, vol. 74, 2018, doi: 10.1051/e3sconf/20187410004.
- [29] S. Choudhary, A. R. Saha, and N. K. Tiwary, "The role of compulsory environmental education in higher learning: A study in the University of Delhi," *Applied Environmental Education and Communication*, vol. 19, no. 4, pp. 389–401, May 2020, doi: 10.1080/1533015X.2019.1605946.
- [30] V. A. Ayedun, O. Ajibade, and B. J. Folyan, "Research in Methods in Communication & Media Studies," in *Quantitative Data Collection Methods*, Franklin International Publisher, 2018, pp. 188–189.
- [31] D. W. Orr, *"Ecological literacy: Education and the transition to a postmodern world."* Suny Press, 1992.
- [32] M. Rizal, D. V. Sigit, and R. H. Ristanto, "The relationship between the new environmental paradigm and ecological literacy with environmental responsibility behavior," (in Indonesian), Undergraduate Thesis, State University of Jakarta, 2019.
- [33] A. E. McGinn, "Quantifying and understanding ecological literacy: a study of first year students at liberal arts institutions," *Dickinson College Honors Theses*, 2014.
- [34] L. S. Almeida, L. P. Prieto, M. Ferrando, E. Oliveira, and C. Ferrándiz, "Torrance test of creative thinking: the question of its construct validity," *Thinking Skills and Creativity*, vol. 3, no. 1, pp. 53–58, Apr. 2008, doi: 10.1016/j.tsc.2008.03.003.
- [35] E. P. Torrance, *Torrance Test of Creative Thinking*. Princeton: N.J. Personal Press, 1966.
- [36] H. Hendryadi, "Content validity: initial stages of questionnaire development," (in Indonesian), *Jurnal Riset Manajemen dan Bisnis (JRMB) Fakultas Ekonomi UNIAT*, vol. 2, no. 2, pp. 169–178, Jun. 2017, doi: 10.36226/jrmb.v2i2.47.
- [37] S. D. Pitman and C. B. Daniels, "Quantifying ecological literacy in an adult western community: The development and application of a new assessment tool and community standard," *PLoS ONE*, vol. 11, no. 3, Mar. 2016, doi: 10.1371/journal.pone.0150648.
- [38] N. Nurfajriani, E. P. Azrai, and D. V. Sigit, "The relationship between ecoliteracy and pro-environmental behavior of junior high school students," (in Indonesian), *Florea: Jurnal Biologi dan Pembelajarannya*, vol. 5, no. 2, Nov. 2018, doi: 10.25273/florea.v5i2.3126.
- [39] R. Hartono, "Evaluating sustainable education using eco-literacy," *Habitat*, vol. 31, no. 2, pp. 78–85, Aug. 2020, doi: 10.21776/ub.habitat.2020.031.2.9.
- [40] B. B. McBride, C. A. Brewer, A. R. Berkowitz, and W. T. Borrie, "Environmental literacy, ecological literacy, ecoliteracy: What do we mean and how did we get here?" *Ecosphere*, vol. 4, no. 5, pp. 1–20, May 2013, doi: 10.1890/ES13-00075.1.
- [41] M. M. Latta, K. Hanson, K. Ragoonaden, W. Briggs, and T. Middleton, "Accessing the curricular play of critical and creative thinking," *Canadian Journal of Education*, vol. 40, no. 3, pp. 191–218, 2017.
- [42] A. L. Miller, "The role of creative coursework in skill development for University Seniors," *Global Education Review*, vol. 5, no. 1, pp. 88–107, 2018, [Online]. Available: <https://files.eric.ed.gov/fulltext/EJ1177632.pdf>.
- [43] M. J. Schimek, "How an experience in nature affects ecoliteracy of high school students," *School of Education Student Capstone Theses and Dissertations*, vol. 4133, pp. 1–88, 2016, [Online]. Available: https://digitalcommons.hamline.edu/hse_all/4133.
- [44] K. T. Stevenson, M. N. Peterson, H. D. Bondell, A. G. Mertig, and S. E. Moore, "Environmental, institutional, and demographic predictors of environmental literacy among middle school children," *PLoS ONE*, vol. 8, no. 3, Mar. 2013, doi: 10.1371/journal.pone.0059519.
- [45] W. J. He and W. C. Wong, "Gender differences in the distribution of creativity scores: domain-specific patterns in divergent thinking and creative problem solving," *Frontiers in Psychology*, vol. 12, Mar. 2021, doi: 10.3389/fpsyg.2021.626911.
- [46] D. Proudfoot, A. C. Kay, and C. Z. Koval, "A gender bias in the attribution of creativity: archival and experimental evidence for the perceived association between masculinity and creative thinking," *Psychological Science*, vol. 26, no. 11, pp. 1751–1761, Sep. 2015, doi: 10.1177/0956797615598739.
- [47] D. Diki, "Creativity for learning biology in higher education," *LUX: A Journal of Transdisciplinary Writing and Research from Claremont Graduate University*, vol. 3, no. 1, pp. 1–12, Nov. 2013, doi: 10.5642/lux.201303.03.

BIOGRAPHIES OF AUTHORS






Diana Vivanti Sigit    completed her Bachelor of Environmental Biology from IKIP Jakarta in 1989, while the Ecology Master's Program was completed in 1995 at Universitas Gadjah Mada and Doctoral Program focusing on environmental education from Universitas Negeri Jakarta in 2013. Currently serving as a lecturer at Universitas Negeri Jakarta. The focus of research that has been carried out is related to ecological and environmental research, especially biodiversity, ecology, and environmental issues. She can be contacted at email: dianav@unj.ac.id.






Rizhal Hendi Ristanto    completed his Bachelor of Biology Education from Universitas Muhammadiyah Surakarta in 2009 while the Biology Master's Program was completed at Universitas Sebelas Maret in 2010, and Doctoral Program from Universitas Negeri Malang in 2017. He is currently serving as a lecturer at Universitas Negeri Jakarta. The focus of research that has been carried out is related to education development, especially instructional design, Science instructional design, and instructional methods. He can be contacted at email: rizhalhendi@unj.ac.id.






Ratna Komala    completed her Bachelor of Environmental Biology from Universitas Jenderal Soedirman in 1988, while the Biology Master's Program was completed in 1994 at the Institut Pertanian Bogor (IPB) and Doctoral Program in Marine Bioecology from IPB in 2012. Currently serving as a lecturer at Universitas Negeri Jakarta. The focus of research that has been carried out is related to ecological research, especially zoology, marine ecology, and environmental issue. She can be contacted at email: ratna_komala08@yahoo.co.id.






Anisa Nurrismawati    received the bachelor's degree in education from the Universitas Negeri Jakarta in 2021. Her current research interests include students' creative thinking, digital literacy, and ecological literacy at various levels and areas of education. She can be contacted at email: anisanurrisma@gmail.com.



Puji Prastowo    completed his Bachelor of Biology Education from IKIP Medan in 1994, while the Biology Master's Program was completed in 2000 at the Bandung Institute of Technology (ITB). Currently serving as a lecturer at Universitas Negeri Medan, Medan since 2005. The focus of research that has been carried out is related to ecological research, especially insect ecology and bird ecology. For the field of education, research focuses on environmental-based biology education. He can be contacted at email: prast71@gmail.com.



Abubakar Sidik Katili    is an Associate Professor in ecology at the Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Negeri Gorontalo. Active as a lecturer in courses of ecology, biodiversity and conservation, environment, food ecology, coastal ecology, and coastal resource management. As a researcher in the fields of Ecology, Environmental Education and Biology Education. Receive his education in the biology education IKIP Negeri Gorontalo in 2003, master program in biology (ecology) faculty of biology UGM Yogyakarta in 2009 and Doctor of Science Education at Gorontalo State University in 2022. Publication topics include ecology, environmental education, biology education, biodiversity and conservation. He can be contacted at: abubakarsidik@ung.ac.id.