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Correlation of students' environmental literacy and scientific literacy after students' involvement in wetlands-based stem educational approach

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Abstract. Environmental Literacy is considered as one of the few perspectives necessary for SDGs to be achieved. At the same time, the concept of environmental literacy is often discussed with the concept of scientific literacy as basic requirement of environmental literacy. Scientific literacy is defined as the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity. This study investigated the correlation between students' environmental literacy and students' scientific literacy after their scientific literacy has been improved using wetlands-based STEM educational approach. The results shows' that there is no significant correlation between students' scientific literacy and environmental literacy ($p = 0.085$; $\text{sig.} = 0.519$; $\alpha = 0.05$). This study discusses how environmental literacy should be a joint effort between educators from all different fields for it to be cultivated within student's life.

Key words: Scientific literacy, wetlands, environmental literacy, STEM

1. INTRODUCTION

Environmental literacy has often been associated with science education. Evidently, environmental literacy has been mentioned along with scientific knowledge about environment in Programme for International Student Assessment (PISA) report about students' environmental literacy [1]. It implies that science teacher might bear big the responsibility when it comes to achieving the aims of environmental education through the practice of science teaching.

Environmental Literacy Task Force defined environmental literacy (EL) as "an ability to act individually and with others to support healthy, prosperous, and equitable ecology for present and future generations". Outlining four strands of environmental literacy: knowledge, skills, affect, and behaviour [2–4]. Environmental literacy was considered as the important skill in the 21st century to support of sustainable development [5]. Previous research on environmental literacy is more often associated with science subjects, as shown by article search result using SCOPUS database with keywords "Environmental literacy" and "science". A mapping of those search results also shows that when the article discusses about science, it implies natural science instead of social science.

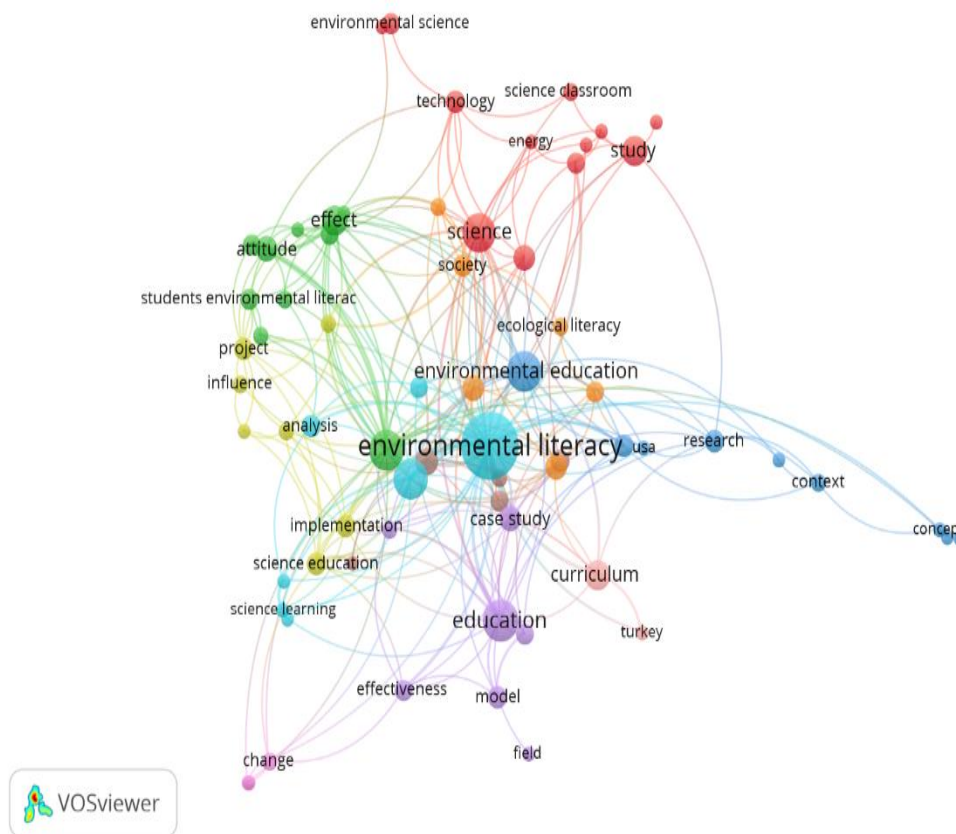


Figure 1. Visualization of other topics that are discussed alongside "Environmental Literacy" and "Science" (data obtained from Scopus Index)

For example, research conducted by Gayford [6] highlight the need for science teachers to have understanding about environmental education. There were 16 articles that is indexed in Scopus that discuss about similar topics, meanwhile, no articles that shared the same urgency that focus on social teachers.

Moreover, the concept of environmental literacy is often mentioned alongside with scientific literacy. Scientific literacy is perceived to be a key competency which is defined in terms of the ability to use knowledge and information interactively [7]. In other words, scientific literacy includes an understanding of how a knowledge of science changes the way one can interact with the world and how it can be used to accomplish broader goals. When discussing scientific literacy, environmental issues often comes up as the context of discussion, and people who are scientifically literate were expected to be able make decision that is aligned with pro environmental behaviour [8].

Evidently, environmental literacy aspects and scientific literacy were reported and discussed side-by-side in Programme for International Student Assessment (PISA), a global assessment of students competence conducted by Organisation for Economic Co-operation and Development (OECD) in OECD countries [8]. Besides that, PISA scientific literacy questions also often involve environmental related issues. Environmentally friendly actions were also included in scientific literacy assessment in PISA 2018 [9]. As a comparison, author conducted a quick search in Scopus indexed articles to compare the amount of article which contains scientific literacy and certain school subjects. The results shows taht there were competing number of articles on environmental literacy in biology subject and economic subject. However, PISA chose to include environmental related context as part of science subject, but not as part of financial literacy assessment (which is also measured in PISA 2018). This situation implied that scientific literacy has a close connection with environmental literacy compared to other subjects [9].

Another evidence which strengthen the relation between science subject, scientific literacy, and environmental literacy is the global competence assessment in 2018 PISA [9]. Global competence assessment which examine various topic, also examine students' mastery on environmental sustainability. The questions used to assess students' mastery on environmental sustainability are mostly covered in natural science subjects such as the concept of air pollution, soil degradation, natural disaster, and contamination of pesticides to environment. These concept are taught taught to students in elementary to high school, such as in Indonesia [10].

Meanwhile other topics that also falls in the topic of environmental sustainability are about policies, practices, and behaviours of environmental sustainability. Those knwoledge were not a familiar concept for 15 years old student. For example, in Indonesia 15 years old students were in junior high school, and have not being taught of the concept of media communication, policy, how government weigh actions, and taxes in practice [10]. It becomes apparent that when talking about environmental sustainability, it is not only science knowledge that is expected to support it, but other knowledge too.

National Environmental Literacy Assessment (NELA) project administered by North American Association for Environmental Education (NAAEE), one of the leading institutes in environmental education, use 8 variables to assess students' environmental literacy. Those variables are: ecological knowledge, verbal commitment; actual commitment; environmental sensitivity; general environmental feelings; environmental issue and action skills [11]. Meanwhile, there were 3 main competences of scientific literacy that was assessed by PISA. Those are: explaining phenomena scientifically, evaluating and designing scientific enquiry, and interpreting data and evidence scientifically [9]. To make sure both literacy is facilitated in science classroom that discuss about environment or sustainability, a certain teaching approach is needed.

STEM is an instructional approach mostly used in science education, which combines five different disciplines namely Science, Technology, Engineering, and Mathematics. STEM Education develops students' skills into better problem solvers, independent, innovators, inventors, creators, logical thinkers, and technology literate [12]. . STEM education allows students to gain experience in finding answers to questions, carrying out scientific investigations, design techniques related to STEM disciplines, so that students can develop their identity as STEM learners through science, mathematics, technology, and engineering. STEM education can relate to scientific inquiry, by formulating questions that are answered through investigation to notify students before they engage in the engineering design process for solving problems [13]. Research by Rusyati, Pernamasari & Ardianto [14] and Syahmani & Hafizah [15] shows that STEM/STEAM-based teaching materials could provide of a self-contained concept characteristic and rich in teaching materials which can improve the scientific literacy and environmental literacy of the students.

This article is a report that was created as a part of a bigger research that focus on creating a learning resource using Wetlands-Based STEM Educational Approach [15]. Authors used STEM in this research as an effort to create a science learning experience that integrate many aspects of science, to ensure that the students have the sufficient knowledge to take real action by implementing science knowledge through technology, engineering and mathematical practice. However, the core of this article is not in the treatment that is given to the students, but whether the treatment itself, which already resulted in the significantly higher scientific literacy score ($z=-4,731$; $p\text{-value}=0,000<0,05$) correlates with students' environmental literacy. This study was conducted to seek whether environmental literacy has correlation with scientific literacy.

2. Material and Methods

This study was a survey research in its core. An experimental setting was previously created, to improve students' scientific literacy, and which the results already showed that students' scientific literacy significantly have improved (Syahmani et al., 2020). With this result, authors conducted a further examination to students using instrument to data about student's environmental literacy and scientific literacy (Table 1).

Table 1. Instrument indicator to measure environmental literacy and scientific literacy

Enviromental literacy			Scientific literacy	
Indicator:	Sub-Indicator	N items	Indicator:	N items
Environmental Affect	Environmental Sensitivity	6	Explaining phenomena scientifically	6
	General Environmental	6		
Cognitive Skills	Issue Identification	6	Evaluating and designing scientific enquiry	4
	Issue analysis	6		
	Action skills	9		
Behavior	Verbal Commitment	3	Interpreting data and evidence scientifically	10
	Actual Commitment	6		
Total		42	Total	20

The questionnaire consisted of 42 questions about environmental literacy, adapted from NELA according to *Middle School Environmental Literacy Survey (MSELS)* instrument. The questionnaire observes seven variables of environmental literacy, those were: verbal commitment; actual commitment; environmental sensitivity; general environmental feelings; environmental issue and action skills. There were a total of six questions for each variable, except for verbal commitment that only has 3 questions and action skills that has nine questions. The questions use 5-point Likert scale to assess students' environmental literacy for each question, with one being the lowest score and 5 as the highest score.

On the other hand, the scientific literacy test measured using scientific literacy test. It was created to observe students' scientific literacy in form of 20 scientific literacy multiple choice questions. There were three competences in scientific literacy that was observed. Those are explaining phenomena scientifically, evaluating and designing scientific enquiry, and interpreting data and evidence scientifically. Respondent who are able to give correct answer for one question receive a score of 5, meanwhile respondent who failed to answer correctly receive no score. If a student answered correctly to all the scientific literacy test questions, respondent receive 100 score.

Each item in the instrument was created using wetlands ecology as the question context. The environmental literacy questionnaire involved evaluation to problems that can occur in wetlands area and how it is related to students' daily life. The scientific literacy test also wetlands as the context for the questions. Both instruments were administered online to the participants.

The participants of this study were 59 university students from the 5th semester in science education program study who participated in environmental education class. To mimic the classroom situation, another experiment has been conducted, where the students receive a treatment where they participate in learning where the teaching instructor used wetland-based teaching materials [15]. This treatment has proven to improve students scientific literacy (z-score=0,4; p-value=0,000) [16].

The students answer the questionnaire survey after they took the scientific literacy test. For the analysis, this study use Spearman-rho test to check correlation between the two variables, using IBM SPSS test [17]. Spearman-rho test is a correlation test that could be used to check the correlation between to data when if the data is not normally distributed as with the case of this study's data [18].

3. Results and Discussion

The result of Spearman rho's test when applied to scientific literacy and environmental literacy data could be seen in the Table 2.

Table 2. Spearman rho's result for correlation between Scientific Literacy and Environmental Literacy

		Correlations		
			Scientific Literacy	Environmental literacy
Spearman's rho	Scientific Literacy	Correlation Coefficient	1.000	0.086
		Sig. (2-tailed)	0.00.	0.519
		N	59	59
	Environmental literacy	Correlation Coefficient	0.086	1.000
		Sig. (2-tailed)	0.519	0.00.
		N	59	59

Note: (Sig. = 0.519, α = 0.05)

The tables indicate that there is no significant correlation between scientific literacy and environmental literacy (Sig. = 0.519, α = 0.05). This finding aligned with studies which argued that knowledge alone, in this case represented by scientific literacy test score, is not sufficient to make impact to someone's attitude, which in this case being assessed by the environmental literacy questionnaire.

Being an environmentally literate person means become a person that act in a pro-environmental stance. Meanwhile, previous study such as by Zsóka, et al. [19] where an environmental education was implemented, they found that although students environmental knowledge significantly increased "...the range of aspects which influences the behaviour of high school and university students is very wide and the interrelationship of those aspects is rather complex.". Rees [20] argued that it is human nature, cognition, and denial that block pro-environmental action in sustainable developments. It implied that although blockage in cognition aspect is already cleared, there would be two more blockages that cannot be unblocked simply by science education as we know it today: human nature and denial.

This study's result shows that students' scientific literacy does not correlate with students' environmental literacy. This result means when teachers want to develop students' scientific literacy teachers need to find a different approach, that is focused on developing the environmental literacy. Teachers cannot hope that by teaching students to think critically, it would immensely affect students' worldview about the environment or sustainable development [19,20].

This finding and previous studies also implied that if education in general aims to develop students' who could take action that actively supports the sustainable development, developing environmental literacy in science class should be accompanied with more subject other than knowledge about the environmental context and thinking skills. Furthermore, teaching about environment only in science education class alone might not sufficient. This situation should be handled by considering other approach to environmental education which might need more than education that is given by science teacher. Previous study conducted by Nurwido et. al. (2020), suggested that a behavioural change could be found in school that implement Adiwiyata Program (green school program in Indonesia). Further study on this matter might need to involve not only science teacher but all educators in the school, followed by a systemic change to school system that could support the cultivation of students' environmental literacy.

Environmental education should not be leaved only to the hands of science teachers. Educators from all fields should collaborate to create an education that is not only heavy on science subject but also filled with social aspect that could influence students' action and behaviour. It requires insight from various perspective and might require a bigger effort to ensure that the cultivation of environmental literacy should be is easy to introduce to students as early as possible [21].

4. Conclusion

This found that scientific literacy did not correlate with environmental literacy. It strengthens the arguments that having knowledge alone is not sufficient enough for someone to change their action in

daily life. Science teacher should pay a special attention to cultivate students' environmental literacy in science class, such as a collaborative project between educators within school.

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