Students' Cognitive Ability: Its Relationship with Ability in Scientific Literacy and Student Self-efficacy

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Abstract. This research aimed to show the relationship between ability in scientific literacy and self-efficacy of students with their cognitive capabilities. The population in this research were students of biology education at the Siliwangi University who attended a vertebrate zoology class. The samples were 30 students from one class and chosen by random sampling. The data were collected by measuring the students' cognitive abilities through a test and inventory. The normality test and data homogeneity of variance were conducted before testing the hypothesis using multiple regression. The results showed that there is an intense relationship between ability in scientific literacy and self-efficacy with cognitive ability. The ANOVA results showed that there is an influence of the ability in scientific literacy and self-efficacy on the cognitive abilities. Therefore, there was a relationship between ability in scientific literacy and self-efficacy with student cognitive ability.

Keywords: cognitive ability · scientific literacy · self-efficacy

1 Introduction

Scientific literacy is an important knowledge that the students should learn and master. It will help the students to understand the modern issues which are related to the development of technology and knowledge since the science education aims to improve the students' competence to achieve what they need in various situation. A person who has scientific literacy can use the scientific concept and understand the interaction between science, people, and technology and also the development of social and economic [1, 2]. Scientific literacy is defined as a capacity to use the scientific knowledge, identify the questions and make a conclusion based on the facts and data to understand the universe and make a decision based on the change caused by human activity [3].

Scientific literacy is also defined as an understanding what science is and everything related to science [4], the contents of science and the ability to differentiate science and non-science [5]. The other definition of scientific literacy is the ability to use the knowledge to solve the problems [6], to think scientifically [7], to have critical thinking

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about science [3], to have freedom in learning about science [8]. These definitions assume that scientific literacy is multidimensional, not only knowing scientific knowledge but also more complicated than this. Scientific literacy can build an environment that is fraught with the intellectual and cultural, as well as the desire to be involved in recent scientific issues as a reflective human. Also, scientific literacy urges the development of an ability to be proficient in decision-making [2].

In Indonesia, especially in the University of Siliwangi, the understanding of science which leads to the formation of scientific literacy of the students has not been understood yet by the science lecturer. As a result, the learning process is still conventional and focuses on the conceptual mastership of the students. According to that rationality, it will implicate to lack of cognitive ability. Cognitive ability is a result of the activity or the process to get the knowledge from their own experience [9].

In several opinions, scientific literacy is very important to be mastered [10]. However, scientific literacy will be more meaningful when self-efficacy which is needed by the students have been trained like what tells about how to deal with the difficulties, to grow the confidence and hope and also to deal with all the possibilities in a different situation [11]. In science education, the perception of self-efficacy is related to science, the ability of science processing and defined as the important factor which affects the students learning [12].

Self-efficacy is defined as an individual opinion of the ability or conviction to perform desired actions. An individual who has high self-efficacy will put a lot of effort into reaching a life goal and will not give up easily [13]. The opinion was supported by the experiment carried out by Namaziandost and Cakmak [14], which showed a positive change of self-efficacy along the learning process. Those who believe in their ability tend to have strong motivation and push themselves strongly to be successful people. Self-efficacy concerns an opinion about an individual ability to organize and implement the action for presenting specific skills [15]. This means that self-efficacy is an individual conviction regarding self-ability to organize, to complete tasks, to reach goals, to produce something and implement actions to demonstrate specific skills to reach a certain purpose.

Occasionally, belief and conviction reduce individual self-confidence. The reliance level of a student depends on the difficulty level that is owned by students in a consequence of their confidence level. A weak efficacy opinion is an internal obstacle to the advancement and inhibits the ability to face an external obstacle effectively. A low self-efficacy inhibits individual effort and causes one to easily give up.

The theory of self-efficacy has been noted by several researchers as an important academic point. It refers to the social cognitive theory which describes that every person can learn from their social environment [16]. This theory is still recognized as a new concept. However, this concept has been demonstrated to strongly influence learning results [17]. Besides, self-efficacy can influence learning outcomes [18]. According to that statement, it means that having high self-efficacy is proportionate with learning results. Self-efficacy as presumably contributing a significant effect in the cognitive aspect, in this matter is the learning outcomes [11, 19]. In the previous experiment performed by Dissanayake et al. [20], showed that there was a significant relationship

between self-efficacy and environment matter. A good environment will support an improvement in students' self-efficacy.

The concept of scientific literacy explains how fundamental the understanding of scientific literacy is. When students learn and control the environment around them, they control themselves indirectly. The principle of self-controlling will be more effective when it is related to the academic content. Meanwhile, self-efficacy will lead the students how to think, to motivate and to behave based on their or other people's experiences. Thus, this research aimed to show the relationship between ability in scientific literacy and self-efficacy of students with their cognitive capabilities.

2 Materials and Methods

This study used a correlational research approach to relate the ability in scientific literacy and self-efficacy with cognitive ability. The population was 76 students of Department of Biology at University of Siliwangi, Tasikmalaya, West Java, Indonesia who attended vertebrate zoology class in the academic year of 2020/2021. The participants were 30 students (only 1 class). The participants were chosen by random sampling in the average age of 19 years old, including 18 females and 12 males.

The research was conducted for 4 months from February to May 2020. Data was collected after a 1 semester learning process in the final exam. The instruments were academic ability test, scientific literacy test and inventory of self-efficacy. The cognitive ability and scientific literacy consist of 10 essays (Table 1) which were tested based on a cognitive domain by Anderson [21]. The cognitive domain consists of analysis, synthesis, and creativity. The scientific literacy test was about the domain of context, content, and process which are adapted from Test of Scientific Literacy Skills (TOSLS) [22]. The items were about 30 items and re-tested to the students who were not the experiment samples. The test was a multiple-choice refers to the indicator of PISA 2012, including how to explain the scientific phenomenon, to evaluate and prepare a scientific investigation, and to interpret scientific data and evidence.

The self-efficacy inventory was adapted from General Self-Efficacy (GSE) by Weinman et al. [23], which was adjusted to the measured indicator in the study. These indicators refer to Bandura [24] about self-efficacy. The inventory consists of 30 statement items with alternate subject responses on a scale of 11 with 1–100 intervals starting from 0–49 (not sure), 50–89 (pretty sure) and 90–100 (very confident) at intervals of 10.

The validity and reliability of the test were determined by Cronbach's Alpha. The questions of the test have been validated by Pearson Correlation. The hypothesis test used multiple linear regressions. A normality test and the homogeneity of variance were carried out before testing the hypothesis with linear regression. The normality test used Kolmogorov-Smimov Test and the homogeneity used Lavene's Test. All data were tested by using SPSS version 23.0 for windows.

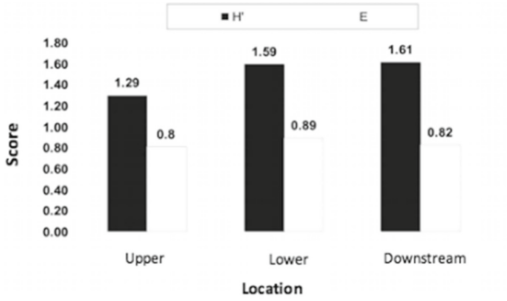
3 Results

The results of the experiment show the data of the beta-value is shown in Table 2.

Table 1. The example of questions for a scientific literacy test.

Indicator	Interpreting the data and evidence
Indicator Explanation	Creating the appropriate graph from data

Question No. 1



Amphibian diversity and equality dispersion in three location based on Shannon-Wiener diversity index and equality dispersion.

Based on the graphic above which statement is correctly described? indices of diversity in ecotourism areas

a. Kedung Kayang waterfall is a range of diversity indexes from 0.8 to 0.89.
b. The diversity and equilibrium of the same species indicate that the overall ecosystem in the habitat is still in good condition.
c. Ecosystems in underwater locations and downstream diagrams are better in conditions when compared to existing ecosystems at the site over waterfalls.
d. The surrounding of Kedung Kayang waterfall area of the upper part has been disturbed by human activity.

Table 2. The analysis of beta-value

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	85.997	29.771		2.889	0.008
Literacy	0.550	0.383	0.236	1.437	0.162
Efficacy	-1.132	0.412	-0.451	-2.747	0.011

Data analysis was conducted to determine the relationship between ability in scientific literacy and self-efficacy with cognitive abilities and the results are presented in Table 3. Meanwhile, the mean, standard deviations and variance are presented in Table 4. The results of the multiple correlation analysis showed that there was a relationship between ability in scientific literacy and self-efficacy with cognitive ability.

According to the results of the analysis of multiple regression linearities, the table showed the ability of scientific literacy and self-efficacy with an R of 0.535. This value indicated a significant relationship between ability in scientific literacy and self-efficacy with cognitive ability. The R2 (determination coefficient) was 0.233 or 23.3%, which represented the percentage of the effect of ability in scientific literacy and self-efficacy on cognitive ability as 23.3%. The remaining 76.7% was influenced by another variable, which was not included in this study.

Table 3. Summary of multiple correlation analysis

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.535	0.286	0.233	14.270

Table 4. Mean, standard deviations and variance

	N	Mean	Std. Deviation	Variance
Scientific literacy	30	47.33	6.975	48.644
Self-efficacy	30	51.57	6.484	42.047
Cognitive capability	30	53.67	16.293	265.471
Valid N (listwise)	30			

Table 5. Mean, standard deviations and variance

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	2200.417	2	1100.209	5.403	0.011
Residual	5498.259	27	203.639		
Total	7698.667	29			

The predictor affection on cognitive ability was also tested by using regression analysis (ANOVA). The details of the ANOVA results are presented in Table 5.

The results of the ANOVA showed that ability in scientific literacy and self-efficacy simultaneously affected cognitive ability. It was demonstrated by the significant value of the calculation results at 0.011 which was less than the significance level of 0.05. It means that there was affection from scientific literacy and self-efficacy to cognitive ability.

4 Discussion

Students' scientific literacy ability would be clearly present if they had good own self-efficacy. The concept of self-efficacy placed an emphasis on the cognitive aspect [25]. Self-efficacy influences the understanding of science and knowledge [26]. Self-efficacy is the best indicator of the learning process. According to Rafiola et al. [27], self-efficacy was the most influential in academics and achievements. Self-efficacy was an intense paradigm that operated based on motivation [15]. Self-efficacy is believed to predict motoric skill use and is related to the completion of tasks. Self-efficacy as an individual conviction regarding the ability to accomplish certain life goals [5, 6].

The learning system has components that should support each other to achieve a comprehensive outcome in carrying out its role. A system will get a good achievement if its components are fully empowered. All the components involved in each learning system should understand the role and contribution in improving student competence. If a learning-oriented system is oriented to scientific literacy, then literacy should be referred to the learning. In PISA, not only knowledge and acumen are needed to answer the challenges of the 21st century but also the scientific ability and scientific attitude are needed.

Scientific literacy has been viewed as the competence needed to improve the thinking ability of science in terms of personal, social, political, economic and other issues. Everyone has different scientific literacy skills based on knowledge, understanding, skills, and values. To conclude a novel solution to solve the issues, the students should learn how to work with others and combine the ideas [22].

Every individual should have self-efficacy due to the important value of self-efficacy to support their future. Self-efficacy is assumed as one of the necessary competencies needed to think about science, social, political and economic problems, as well as life issues. Every person has a different scientific literacy level, depend on the self-understanding of science, skills and other aspects of life. In science, scientific literacy is one of the learning results for all students.

Scientific literacy could be developed through science education [28]. Science education is an education that explains the use of science and scientific skills creatively implemented in daily life based on scientific phenomena [29]. Science is not only the accumulation of evidence that can be observed directly but also needed for further interpretation and inference.

Scientific phenomena that can be directly accessed and observed by the five senses are the result of the mental process and its facts can be collected through various abilities. For example, after obtaining the observed data in laboratories, students could conduct an inference through explanations and make conclusions. Students could construct the knowledge gained by the experience. Constructive learning could be regarded as meaningful learning. An experiment conducted by Alismail and McGuire [30]. showed that the teamwork, communication, critical skills, and academic ability will improve if the teacher could create meaningful learning focused on resources, strategies, and context according to student life.

Scientific literacy can be generated not only through the competence of explaining the phenomenon scientifically but also requiring scientific evidence. Therefore, a scientific statement must be in harmony with the empirical evidence and new evidence may revise pre-existing scientific knowledge. But it is very difficult to make objective observations and interpretations. A scientist is personally committed to a theory, belief, prior knowledge, experience and hope which really affect their work [9, 30]. The inclusiveness of scientific literacy as a major competency for science learning tends to develop in terms of scientific questions. The attainment of scientific literacy refers to the process of science in which the mental process involved answering a question or solving a problem.

Self-efficacy is a part of the mental process that was helping or hindering to achieve the goals. Self-efficacy could be as high as the establishment of purpose and could be a stronger commitment to achieving the final goal. When individuals have to face

a complex situation, they will have to show strong confidence to solve the problems and maintain the efficiency of analytical thoughts. An individual who hesitated to solve the problems is usually inefficient in analytical thoughts. People with high self-efficacy tend to be more adept at learning and reaching an achievement than those with low self-efficacy. In other words, when several individuals have the same capabilities, those who are confident in completing the task are more likely to succeed than those who are not confident. The students with high self-efficacy could achieve extraordinary levels of being involved in cognitive processes such as paying attention to enhance learning, elaborating, organizing, etc. [31].

Self-efficacy is related to anticipate the types of constructive pictures and repeated pictures. Individuals who have self-efficacy have a picture of success as manifested in the appearance and behavior of the positive and effective. Individuals who are not able to have this picture tend to feel a failure. Self-efficacy is associated with cognitive functions through motivational and information processes. The stronger an individual's beliefs, the more powerful the effort deployed to process cognitive memory and increase the memory capacity of the individual. This was evidenced by statistical tests that showed the strong relationship between ability in scientific literacy and self-efficacy with cognitive ability.

5 Conclusion

In conclusion, there was a relationship between ability in scientific literacy and self-efficacy with student cognitive ability. The percentage of the effect of ability in scientific literacy and self-efficacy on cognitive ability was 23.3%. The remaining 76.7% was influenced by another variable, which was not included in this study.

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