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Relationship between Scientific Argumentation Skills and Students' Scientific Literacy Skills

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ABSTRACT

Learning models that develop students' argumentation and critical thinking skills are widely applied in senior high school. The purpose of this study was to verify the correlation between argumentation skills and scientific literacy skills of high school students on cell matter as the smallest structural and functional unit of life and cell bioprocesses. This research uses a correlational method. The sample of this research was the students of class XI MIPA SMAN 1 Batusangkar, numbering 34 people. Data on argumentation skill and scientific literacy skill were obtained from the test results in the form of an essay test using socio-scientific issues. Descriptive statistics, Pearson product moment correlation analysis techniques, and path analysis were used for data analysis. The results showed that there was a significant and positive relationship between argumentation skills and scientific literacy skills. In addition, argumentation skills have a statistically positive predictive effect on scientific literacy skills. It was revealed that argumentation skills acted as a partial mediating variable, so as stated in the theory, argumentation skills and scientific literacy skills were found to be very closely related. Thus, students' argumentation skills can be used to predict students' scientific literacy skills.

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PENDAHULUAN

The purpose of science education is not only mastery of theory but also learning how to be involved in scientific argument debate (NGSS, 2013). This form of applying the objectives of science education is indicated by the existence of scientific literacy documents that require science education to empower students, develop understanding and thinking habits, build scientific arguments using claims, evidence, and reasons and to negotiate their arguments when making decisions (AAAS, 1994). This educational document on scientific literacy, recommends that the involvement of students in scientific practices such as inquiry and evidence-based explanations or arguments

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can improve their scientific literacy and encourage them to engage in decision-making on socio-scientific issues (Rudolph & Horibe, 2016). Or in other words, there is a close relationship between argumentation skills and scientific literacy skills (Sengul, 2019; Aragão & Marcondes, 2018).

Argumentation in scientific learning can be interpreted as a process of connecting claims and data through justification or through evaluating knowledge claims based on empirical or theoretical evidence (Sampson & Clark, 2009). Arguments have three objectives that cannot be separated from one another, namely (1). to understand the phenomenon under study (ie by building claims and arguments), (2). articulate that understanding (presenting arguments), and (3) invite others to criticize our claims and arguments (criticizing claims, arguments and evaluating arguments while defending their own arguments) (Berland & Reiser, 2011). Scientific argumentation provides a way to improve understanding of scientific concepts as well as scientific literacy skills (Sengul, 2019). Students' low scientific argumentation skills show their low scientific literacy skills (Tsai, 2013).

There are quite a number of studies that examine students' argumentation and literacy skills (Chen et al., 2016; Nam & Chen, 2017; Anisa *et al.*, 2019), including in Indonesia. Several studies have shown that learning has been applied that is able to build argumentation skills and scientific literacy of students (Kusumastuti *et al.*, 2019; Rohmawati *et al.*, 2018), however, teachers rarely assess the students' argumentation and scientific literacy skills. Other studies generally examine the effect of differences in demographic and transnational cultural variables on scientific argumentation skills and scientific literacy (Basl, 2011; Tsai, 2013; Bybee & McCrae, 2011). Apart from that, information about students' argumentation skills and students' scientific literacy skills as well as the relationship between scientific argumentation and students' scientific literacy is also very limited. This limited information is unfortunate because the data on students' argumentation skills and scientific literacy are one of the basic considerations in choosing and implementing a learning strategy that is able to support the skills needed in the 21st century.

This study tries to confirm the correlation between scientific argumentation skills and students' scientific literacy on cell material as the smallest structural and functional unit of life and cell bioprocesses. The results of this study are expected to be one of the basic foundations in selecting and implementing an appropriate learning strategy to improve students' scientific literacy.

METHOD

Research design

This study on the relationship between argumentation and scientific literacy skills among high school students was designed as a correlational research model. It was carried out to reveal the relationship between two or more variables and to obtain results regarding cause-and-effect (Creswell, 2012). Argumentation skills were defined as the independent variable, while scientific literacy skills were the dependent variable.

Research sample

The population of this study were students of class XI MIPA at SMAN I Batusangkar, Tanah Datar, West Sumatra. This school was chosen because it has implemented literacy learning in classroom and the test questions already contained elements of scientific literacy. The research sample was determined through simple random sampling, consisting of class XI MIPA 1 class students and class XI MIPA 4 class students for instrument testing.

Research instrument

In this study, the researcher used a form of a written test as instrument. It was a student's scientific literacy test which contains socio-scientific questions/issues that occur in society in the form of an essay, to which the answers must be backed by valid reasons and

data in order to measure the students' argumentation and scientific literacy skills.

The instrument used for measuring students' scientific literacy and argumentation skills came in the form of essay questions. It contains aspects of a scientific literacy test and validated by two experts in the field of biology education in the context of PISA questions. The validated questions (amounting to 10 questions) were tested in other classes and resulted in five valid questions. These five questions were used to measure students' argumentation skills and scientific literacy. Students must answer the questions with proper reasons and data. The following are question examples:

Question 1: We are advised to drink 1 liter of water every day. Almost 70-95% of the human body consists of water. Sufficient consumption of water can prevent various physical problems, such as dry skin, chapped lips, and even dehydration. Dehydration poses a fairly serious problem for the body, because water is one of the chemical components of the human body's cells. If dehydration occurs, what will happen to the other chemical components of the cell?

Question 2: Consumption of healthy foods is critical to maintaining a healthy physique so that the body is always in top condition. The four main functions of food for human life are maintaining body processes in growth or development and replacing damaged body tissues. In addition, food also provides energy to carry out daily activities, regulate metabolism and balance of water, minerals and other body fluids. Based on the above discourse, human activities cannot be separated from food, as well as cells. In your opinion, is there a connection between the above and cell metabolism?

Data analysis

To determine the relationship between students' argumentation and scientific literacy skills, calculations were carried out using SPSS 21. Before starting an analysis of the relationship between argumentation skills and students' scientific literacy, the scores for each skill were calculated.

The score of argumentation skill was determined using the student's argumentation skill assessment sheet, which adapts the Toulmin's Argumentation Pattern (TAP), with argumentation assessment components in the form of claims, warrants and backings (Khusnayain, 2013). Each argumentation component has a maximum score of 2, with the minimum score being 0. Thus, the maximum score is 6 after all components are added up, with a minimum score of zero for each item. The score is 2 if the component is correct and in accordance with the data presented, 1 if the component is correct but does not match the data, and 0 if the component is not true nor match the data.

The relationship between argumentation and scientific literacy skills was analyzed using the Pearson Product Moment Correlation. The argumentation skill score can be determined using the following formula:

$$Avg.Score = \frac{Number\ of\ argumentation\ skill}{Total\ students}$$

$$\%\ Argumentation\ skills\ = \frac{Total\ score}{Max.score}\ x\ 100$$

Assessment for scientific literacy skills, researchers used a rubric of the characteristics of scientific literacy. The science literacy skill score can be searched using the following formula:

$$Avg.Score = \frac{Number\ of\ scientific\ literacy\ skill}{Total\ students}$$

$$\%\ Science\ literacy\ skills\ = \frac{Total\ score}{Max.score}\ x\ 100$$

RESULTS AND DISCUSSION

Argumentation skills

Argumentation skills were measured using an instrument in the form of an assessment sheet to assess students' arguments, where scientific literacy questions were given after the learning session. This student argumentation skill assessment sheet adapts Toulmin's Argumentation Pattern (TAP). The results showed that the average

student's argumentation skills were 49.6% in the high category (Table 1).

Table 1. Student argumentation skills

No	Classification	Score Range	Frequency	Percentage (%)
1.	Very High	≥ 63,00	9	26.47
2.	High	50≤ Xi ≤ 62	5	14.71
3.	Medium	37 ≤ Xi ≤ 49	12	35.29
4.	Low	24≤ Xi ≤ 36	7	20.59
5.	Very Low	≤23	1	2.94
		Total	34	100
		Average		49.6

This data shows that in general, students of class XI MIPA SMAN I Batusangkar have argumentation skills, especially in the matter of cells as the smallest structural and functional unit of life and cell bioprocesses are good. They are able to explain natural phenomena and questions by connecting theory with evidence. In other words, they already have argumentation and critical thinking skills which are very necessary in building scientific literacy.

Scientific argumentation skills are communication skills in building and criticizing knowledge through arguments, questions, claims, evidence, and reasons (Bjørkvold & Blikstad-Balas, 2018). These argumentation skills are a critical component of scientific literacy, and students need to understand what constitutes a good argument and know how to use arguments to communicate with their peers (Chen, 2019).

There are quite a number of studies that examine students' argumentation and literacy skills (Chen *et al*., 2016; Nam & Chen, 2017; Anisa *et al*., 2019), including in Indonesia. Several studies have shown that learning has been applied that is able to build argumentation skills and scientific literacy of students (Kusumastuti *et al*., 2019; Rohmawati *et al*., 2018), but rarely does the teacher assess the student's argumentation and scientific literacy skills.

Science literacy skills

Students' scientific literacy skills are known to be in the high category, with the average being 79.56 (Table 2). This shows that the students of class XI MIPA at SMAN I Batusangkar generally already have good scientific literacy skills, especially on cell material as the smallest structural and functional unit of life and cell bioprocesses. They have critical thinking and discourse to understand the dynamic relationship between science and technology in society and its impact on the development of science and problem solving skills. They already have good knowledge, concepts and attitudes in solving problems related to socio-scientific issues.

Table 2. Students' scientific literacy skills.

No	Classification	Score Range	Frequency	Percentage (%)
1.	Very High	≥ 81,00	14	41.18
2.	High	76≤ Xi ≤ 80	2	5.88
3.	Medium	71≤ Xi ≤ 75	8	23.53
4.	Low	66≤ Xi ≤ 70	9	26.47
5.	Very Low	≤65	1	2.94
		Total	34	100
		Average		79.56

Scientific literacy is a skill in applying scientific knowledge by interpreting information critically using common sense, making scientific decisions based on evidence, and managing uncertainty of ideas and negotiating ideas according to claims (Nam & Chen, 2017). Someone who has scientific literacy skills will have organized knowledge, intellectual abilities that continue to develop and have manipulative skills and a deep understanding of ideas and values (Towbridge, Bybee, & Powell, 2004), so that they have the skills to respond and act in dealing with problems in society. For that, every school should equip students to know what they should know, understand it and then appreciate it so that the knowledge gained at school is useful in solving the problems of their lives.

Scientific argumentation is a communication skill that involves the process of cognitive-individual development through tentative arguments against scientific phenomena, the validity of which can be determined by each individual through claims based on evidence and is considered relevant to scientific theory (Chen, 2019). Argumentation also involves a process of social interaction in which students offer, evaluate, criticize, challenge, and defend arguments through discourse (Washburn & Cavagnetto, 2013). With this argumentation process that involves both the private and the public, students use oral and written communication to understand and learn science and at the same time improve their scientific literacy. Recently, NGSS Lead States NGSS (2013) even supports argumentation as a core practice for building scientific literacy. Someone who has scientific argumentation skills will have communication skills and metacognitive awareness, critical thinking, understanding of science culture and practice, and scientific literacy (Cavagnetto, 2010). Thus, there is a very close relationship between argumentation skills and scientific literacy, even being a critical component of scientific literacy (Dawson & Venville, 2009). Although argumentation skills affect communication, metacognition, and critical thinking skills, not all forms of argument support an understanding of scientific practice and literacy.

Relationship between argumentation skills and scientific literacy skills

The Pearson correlation test in this study was used to predict the level and direction of the relationship between argumentation skills and students' scientific literacy skills. In this correlation test, scores are used to test scientific literacy from a research sample of 34 people. The results showed that there was a positive relationship between argumentation skills and scientific literacy skills with a correlation value of 0.75. Argumentation skills have a contribution of 56.25% to students' scientific literacy skills. That is, the higher the student's argumentation ability, the higher the student's scientific literacy ability. In other words, students who have high scientific argumentation will have high scientific literacy skills.

Scientific literacy is a skill in applying scientific knowledge by interpreting information critically using common sense, making scientific decisions based on evidence, and managing the uncertainty of and negotiation of ideas according to problem claims (Nam & Chen, 2017). Someone who has scientific literacy skills will have organized knowledge, intellectual abilities that continue to develop and have manipulative skills and a deep understanding of ideas and values (Towbridge, Bybee, & Powell, 2004), so that they have the skills to respond and act in dealing with problems in society. For this reason, every school should provide students with what is important to know and understand, and to appreciate the knowledge as such to render it useful in solving their daily problems.

Argumentation and scientific literacy skills are influenced by many factors. Important factors include intervening arguments regarding nature and aspects of science, intervening arguments about value pressures in society and social and cultural factors as well as understanding of the relationship between science and society in learning (Cavagnetto, 2010). The argumentation and scientific literacy skills of students in this high research were due to the intervention of arguments about nature and about value pressure in learning. The school has implemented learning that is able to build students' argumentation and scientific literacy skills.

Research that examines the relationship between argumentation skills and scientific literacy in the field is still limited in information. Generally, research related to argumentation and scientific literacy skills relates to learning models to build them and the effect of different demographic and transnational cultural variables on scientific argumentation skills and scientific literacy (Basl, 2011; Tsai, 2013; Bybee & McCrae, 2011). They did not report whether or not there was a relationship between argumentation and scientific skills when tested

in schools. However, information that confirms the truth of the relationship between scientific and literacy arguments in the field so far as the search for new references has just been reported. This study has a weakness that it has not tested the quality of arguments and the level of students' scientific literacy skills.

CONCLUSION

The results showed that there was a significant and positive relationship between argumentation skills and scientific literacy skills. Thus, this research has confirmed the truth of the theory that there is a close relationship between scientific argumentation skills and scientific literacy skills. Therefore, students' argumentation skills can be used to predict students' scientific literacy skills.

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