MEASURING THE LEVEL SCIENTIFIC ARGUMENTATION ABILITY OF BIOLOGY PROSPECTIVE TEACHER

Laras Firdaus[1]* and Ida Royani[2]

[1&2]Department of Biology Education, FSTT, Mandalika University of Education, Indonesia

E-Mail : larasfirdaus@undikma.ac.id

ABSTRACT: *This research is a descriptive study conducted at the Mandalika University of Education which aims to measure the level of scientific argumentation ability of biology prospective teacher at the Mandalika University of Education. A total of 20 respondents were involved in this study. The instrument used to measure the level of scientific argumentation ability is an open-ended question consist of 3 items. The data obtained were then analyzed descriptively. As a result and conclusion, that the level of scientific argumentation ability of biology prospective teacher is still low. Therefore, learning methods are needed that can help students to improve their scientific argumentation ability. There are several ways that can be taken to improve the scientific argumentation ability of biology prospective teacher. One of them is by using Socio-Scientific Issues (SSI). For further research using SSI, it must be done with good planning, preparing controversial themes or topics that will become a matter of debate during the learning process.*

Keywords: *Scientific Argumentation Ability, Biology Prospective Teacher.*

INTRODUCTION

Recently, science learning has focused on the formation of scientific arguments (Okumus & Unal, 2012) - or in other words, the goal of recent sciencce learning are centered on increasing the ability to build scientific arguments (Homburger *et al*., 2021); (Nam & Chen, 2017); (Telenius *et al*., 2020). In science education, scientific argumentation is the main part related to reasoning abilities (Hong & Talib, 2018). Then in relation to scientific thinking, scientific argumentation becomes the main component. Therefore, scientific argumentation is a part (component) that must be continuously improved (Bulgren *et al*., 2014). Both in the learning process and in everyday life, scientific arguments are needed, especially to evaluate information, whether scientific information or claims are valid or not (Mason & Scirica, 2006). In addition, scientific argumentation does not only have an impact on understanding concepts (Basel *et al*., 2013); (Kelly & Takao, 2002), the nature of science (Songsil *et al*., 2019) which ultimately leads to an increase in scientific knowledge (*Grooms et al*., 2015), but also becomes a skills and/or tools to evaluate various information (including scientific findings) and socio-scientific problems (Kim & Roth, 2019). Furthermore, (Telenius *et al*., 2020) explains some of the benefits of scientific argumentation, which can increase learning motivation. When students are involved in discussions or debates, it is very possible for them to be aware of both their own arguments and those of their friends - in this way, they will be more aware of whose arguments are more reliable.

The term argumentation comes from the Latin word (*argumentum*), referring to the activity of thinking to show (present) an argument that can be done orally or in writing accompanied by evidence to support a claim *(Meral et al.,* 2021). To argue means to give an argument. We often do this activity in our daily life, when we discuss or debate with friends or even with our parents when we sit together watching a television program. During discussion or debate, we present claim and evidence to support the claims we put forward-this is the general structure of an argument, consisting of premises or claims and evidence and/or reasons. For example, Plato brought an umbrella to campus because today is raining. In this example, the reason to strengthen the claim (*Plato brought an umbrella to campus*), that is *because today is raining*. Arguments like this, in logics are called causal reasoning. However, not all the words *because* it is a reason to support a claim. For this reason, it should be noted that if the word because is followed by an event that is currently or has occurred, then the word because is called a reason, but if it is followed by an event that has not yet occurred, a claim will remain a claim, not an argument (Moore & Parker, 2015).

Regarding the structure or model of an argument, Toulmin's model (Toulmin Argumen Pattern/TAP) is one of the most widely used argumentation models (Kelly & Takao, 2002); (Magalhães, 2020); (Walková & Bradford, 2022). According to Toulmin's model, an argument consists of several elements, including claims, grounds, warrants, backing, rebuttal, and qualifier (Dawson & Venville, 2009); (Duschl & Osborne, 2002); (Foong & Daniel, 2013); (Hong & Talib, 2018); (Kelly & Takao, 2002); (Nam & Chen, 2017); (Osborne *et al.,* 2004); (Songsil *et al.,* 2019); (Telenius *et al.,* 2020); (Walková & Bradford, 2022). An argument is a claim that is supported by reasons, data (evidence) (Larson *et al.,* 2009); (Telenius *et al.,* 2020), or a claim is the main proposition in an argument supported by ground or evidence (Walková & Bradford, 2022). Data or evidence that supports a claim can be in the form of expert opinion, research finding, observations (facts). Without a support (ground/evidence), a claim is still a premise or a claim is not an argument (Telenius *et al.,* 2020). The relationship between claims and evidence is called warrant (Dawson & Venville, 2009); (Osborne *et al.,* 2004); (Telenius *et al.,* 2020); (Walková & Bradford, 2022). Warrants are used when data or evidence is felt to be insufficient to support a claim, or an argument (claim and evidence) has not convinced by someone (the reader) (Osborne *et al.,* 2004). Backing is also referred to as second evidence after the first evidence, or referred to as evidence that strengthens warrants (Dawson & Venville, 2009); (Telenius *et al.,* 2020). A qualifier is a component or condition that supports an argument or claim (Dawson & Venville, 2009); (Hong & Talib, 2018) or warrants (Telenius *et al.,* 2020). A counter-argument or counter-claim is an argument or claim that contradicts the previous argument or claim, or simply, a counter-argument/counter-claim is a refutation of the previous argument/claim (Gronostay, 2016), while rebuttal is a refutation of the counter-argument or counter-claims (Gronostay, 2016); (Telenius *et al.,* 2020).

The importance of argumentation ability, both in life and in formal and academic settings, makes it an area that continues to receive attention from many

researchers. However, research on argumentation is an area of research that is rarely carried out (Telenius *et al*., 2020) - or in other words, research on scientific arguments is not completely evenly distributed in every region or country (not consistently done). For example, in Malaysia, research on argumentation skills has been a recently reviewed research topic (Songsil *et al*., 2019). Likewise with the Mandalika University of Education, the study of scientific argumentation is a new study. In our observations on scientific publications (Google Schoolar and Scopus), we did not find any publications by Mandalika University of Education lecturers (especially biology education lecturers) about scientific arguments. While in the biology education syllabus of the Mandalika University of Education, one of the emphasis is to improve scientific argumentation ability. In line with this goal, it is necessary to conduct an assessment of the ability of scientific argumentation. This study of the ability of scientific argumentation at biology prospective teachers can be seen as an initial action in an effort to meet the objectives in the biology education curriculum at the Mandalika University of Education. The purpose of this study was to determine the level of scientific argumentation ability of biology prospective teacher at the Mandalika University of Education. As a logical consequence, the results that will be obtained through this study will be very useful for the development of the learning process.

METHODS

This descriptive research was conducted at the Mandalika University of Education, on the second semester of biology prospective teacher in academic year 2021/2022. The number of respondents in this study were 20 people. The quality of the arguments given by the respondents in this study refers to the TAP model. The data collection process used 3 open-ended questions in the field of biology. We use these 3 items because the biology prospective teacher as respondents have knowledge in biology content, and the measured ability is the same (i.e scientific argumentation ability). According to Toulmin, basically an argument consists of claim, evidence, and warrant (Qin & Karabacak, 2010). Therefore, we compiled an argument scoring rubric as shown in Table 1 as a reference for assessing the quality of the arguments given by respondents (in terms of these are biology prospective teachers) with the criteria; 0–2 (poor); 3–5 (not good); 6–8 (good); and > 8 (very good/excellent).

Table 1. Rubric to Assess the Quality of an Argument.

Score	Description	Note
0	• Give no response. • The response are given does not match between the claim and the evidence	Poor
1	The response are given is only limited to claims and reasons, or data (facts)	Noot Good
2	The response given shows a relationship between claims and evidence (facts, expert opinions, and research finding), equipped with warrants.	Good
3	The response are given shows the relationship between claims and evidence, has been equipped with warrants, is supported by	Very Good/Excellent

qualifiers, backing—or at least contains most of the elements of the TAP model argument.

RESULT AND DISCUSSION

This research focuses on measuring the level of scientific argumentation ability of biology prospective teacher. Based on the results of the analysis as shown in Figure 1, it is known that the scientific argumentation ability of biology prospective teacher is still low. These results are relatively the same as the findings of (Iordanou, 2010), that children and adolescents do not show good argument ability. Likewise with (Marttunen,1994), that argumentation skills at the university level are still low. The low ability of scientific argumentation in students is influenced by several factors, *first*; in this case, the biology prospective at the Mandalika University of Education cannot identify the components or elements in an argument-or in other words, the biology prospective teacher at the Mandalika University of Education does not have a good knowledge of how to compilling an argument because knowledge of the elements of an argument is very important to be able to construct a good argument (Kaewpet, 2018).
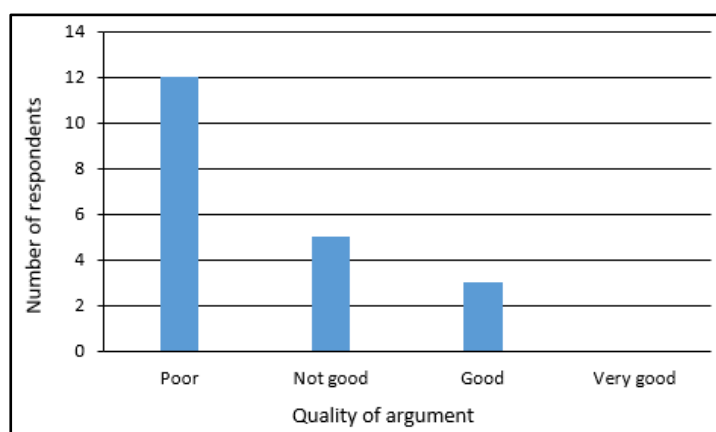

Figure 1. Level of Scientific Argumentation Ability.

Second; It is undeniable that in research on argumentation ability, researchers use different instruments-this is in accordance with the purpose of doing a study. Some use a questionnaire or a discourse, then the respondent is asked to determine the components of an argument in a discourse, but in the context of making an argument, not only knowledge about the elements of an argument, but also an understanding of specific content becomes very important in constructing an argument-in other words, constructing this argument is a complex process. In this case, argumentation skills are related to higher order thinking. Therefore, it is not surprising that higher order thinking skills as a learning goal will be very difficult to achieve (Crowell & Kuhn, 2014). Specific content refers to conceptual understanding of the scientific domain (in this case understanding of biological content). This low understanding of the biological content causes the low quality of an argument (Angeloudi *et al*., 2018); (Faize *et al*., 2018); (Kelly & Takao, 2002); (Khishfe, 2012); (Majeed & Kirmani, 2021).

Understanding this content will help students to identify and analyze facts or data that will be used to support a claims, helping them analyze the issues being analyzed (Yahia & Afifi, 2017). Therefore, his low understanding of the biological content will make it very difficult for him to support the claims that have been made (Songsil *et al*., 2019). The results of research conducted by (Basel *et al*., 2013) also showed a low ability to compose scientific arguments in the theory of evolution. Students do not understand the content about evolution-causing them to have difficulty assessing the claims and evidence used to support their claims.

Third: another factor that plays a role in scientific argumentation ability is epistemological beliefs (Greene, 2016); (Saad *et al*., 2017). For (Hofer, 2004), epistemological beliefs are the essence of knowledge and ways of knowing, so they are referred to as cognitive constructs that affect various academic performances. As a cognitive construct, epistemological beliefs have relationship with reasoning abilities (including scientific argumentation abilities) and decision-making skills (Akbay *et al*., 2018). The research findings show the strong relation between epistemological beliefs and argumentation ability. (Iordanou & Rapanta, 2021) show the relationship between epistemological beliefs with argumentation ability, and self-regulation (Demirbag, 2021). (Nussbaum *et al*., 2008) showed a strong relationship between epistemological beliefs related to various academic performances, such as ability in argumentation, problem solving, conceptual understanding, and interpreting controversial issues.

CONCLUSION

Based on the results of the analysis and the limitations of the discussion, it can be concluded that the level of students' argumentation skills is still very low. This indicates that biology prospective teacher at the Mandalika University of Education cannot recognize the elements in an argument, and this leads to their inability to construct arguments properly. In addition, the lack of understanding of the biological content is one of the factors that affect the quality of the argument. Refers to the results of this study, therefore the learning methods are needed that can help students to improve their scientific argumentation ability. There are several ways that can be taken to improve the scientific argumentation ability of biology prospective teacher. One of them is by using socio-scientific issues (SSI). For further research using SSI, it must be done with good planning, preparing controversial themes or topics that will become a matter of debate during the learning process.

SUGGESTION

Students should be able to hone their argumentation skills so that students have logical reasoning, clear views, and rational explanations for the things being studied.

THANK YOU NOTE

The authors would like to thank all those who have provided assistance, both morally and materially, so that this research can be carried out properly and smoothly.

REFERENCES

Akbay, T., Akbay, L., and Başer Gülsoy, V.G. (2018). Causal Effect of Two Predominant Factors on Critical Thinking Disposition. *Mehmet Akif Ersoy Üniversitesi Eğitim Fakültesi Dergisi*, *15*(45), 88-104.

Angeloudi, A., and Papageorgiou, G. (2022). Primary Students' Argumentation Skills on Evaporation: A Teaching Intervention. *Preschool & Primary Education*, *10*(1), 1-24.

Angeloudi, A., Papageorgiou, G., and Markos, A. (2018). Primary Students' Argumentation on Factors Affecting Dissolving. *Science Education International*, *29*(3), 127-136.

Basel, N., Harms, U., and Prechtl, H. (2013). Analysis of Students' Arguments on Evolutionary Theory. *Journal of Biological Education*, *47*(4), 192-199.

Bulgren, J.A., Ellis, J.D., and Marquis, J.G. (2014). The Use and Effectiveness of an Argumentation and Evaluation Intervention in Science Classes. *Journal of Science Education and Technology*, *23*(1), 82-97.

Crowell, A., and Kuhn, D. (2014). Developing Dialogic Argumentation Skills: A 3-Year Intervention Study. *Journal of Cognition and Development*, *15*(2), 363-381.

Dawson, V., and Venville, G.J. (2009). High-School Students' Informal Reasoning and Argumentation About Biotechnology: An Indicator of Scientific Literacy? *International Journal of Science Education*, *31*(11), 1421-1445.

Demirbağ, M. (2021). Modeling the Relations Among Argumentativeness, Epistemological Beliefs and Self-Regulation Skills. *International Journal of Progressive Education*, *17*(4), 327-340.

Duschl, R.A., and Osborne, J. (2002). Supporting and Promoting Argumentation Discourse in Science Education. *Studies in Science Education*, *38*(1), 39-72.

Faize, F.A., Husain, W., and Nisar, F. (2017). A Critical Review of Scientific Argumentation in Science Education. *EURASIA Journal of Mathematics, Science and Technology Education*, *14*(1), 475-483.

Foong, C.-C., and Daniel, E.G.S. (2013). Students' Argumentation Skills Across Two Socio-Scientific Issues in a Confucian Classroom: Is Transfer Possible? *International Journal of Science Education*, *35*(14), 2331-2355.

Greene, J.A. (2016). *Handbook of Epistemic Cognition*. London: Routledge.

Gronostay, D. (2016). Argument, Counterargument, and Integration? Patterns of Argument Reappraisal in Controversial Classroom Discussions. *JSSE - Journal of Social Science Education*, *1*(8), 42-56.

Grooms, J., Enderle, P., and Sampson, V. (2015). Coordinating Scientific Argumentation and the Next Generation Science Standards Through Argument Driven Inquiry. *Summer*, *24*(1), 45-50.

Hofer, B.K. (2004). Exploring the Dimensions of Personal Epistemology in Differing Classroom Contexts: Student Interpretations During the First Year of College. *Contemporary Educational Psychology*, *29*(2), 129-163.

Homburger, S.A., Drits-Esser, D., Malone, M., and Stark, L.A. (2021). Building Argumentation Skills in the Biology Classroom. *The American Biology Teacher*, *83*(2), 104-111.

Hong, L.Y., and Talib, C.A. (2018). Scientific Argumentation in Chemistry Education: Implications and Suggestions. *Asian Social Science*, *14*(11), 1-16.

Iordanou, K. (2010). Developing Argument Skills Across Scientific and Social Domains. *Journal of Cognition and Development*, *11*(3), 293-327.

Iordanou, K., and Rapanta, C. (2021). "Argue with Me": A Method for Developing Argument Skills. *Frontiers in Psychology*, *12*(631203), 1-14.

Kaewpet, C. (2018). Quality of Argumentation Models. *Theory and Practice in Language Studies*, *8*(9), 1105-1113.

Kelly, G.J., and Takao, A. (2002). Epistemic Levels in Argument: An Analysis of University Oceanography Students' Use of Evidence in Writing. *Science Education*, *86*(3), 314-342.

Khishfe, R. (2012). Relationship Between Nature of Science Understandings and Argumentation Skills: A Role for Counterargument and Contextual Factors. *Journal of Research in Science Teaching*, *49*(4), 489-514.

Kim, M., and Roth, W.-M. (2019). *Dialogical Argumentation and Reasoning in Elementary Science Classrooms*. London: Routledge.

Larson, A.A., Britt, M.A., and Kurby, C.A. (2009). Improving Students' Evaluation of Informal Arguments. *The Journal of Experimental Education*, *77*(4), 339-366.

Magalhães, A.L. (2020). Teaching How to Develop an Argument Using the Toulmin Model. *International Journal of Multidisciplinary and Current Educational Research (IJMCER)*, *2*(3), 1-7.

Majeed, S., and Kirmani, N.S. (2021). Effect of Argumentative Discourse Based Intervention on Argumentation Ability: A Study of Demographic Factors. *Global Language Review*, *VI*(I), 114-124.

Marttunen, M. (1994). Assessing Argumentation Skills Among Finnish University Students. *Learning and Instruction*, *4*(2), 175-191.

Mason, L., and Scirica, F. (2006). Prediction of Students' Argumentation Skills About Controversial Topics by Epistemological Understanding. *Learning and Instruction*, *16*(5), 492-509.

Meral, E., Sahin, I.F., and Akbas, Y. (2021). The Effects of Argumentation-Based Teaching Approach on Students' Critical Thinking Disposition and Argumentation Skills: "Population in Our Country Unit". *International Journal of Psychology and Educational Studies*, *8*(1), 51-74.

Moore, B.N., and Parker, R. (2015). *Critical Thinking (Eleventh Edition)*. New York City: McGraw-Hill Companies, Inc.

Nam, Y., and Chen, Y.-C. (2017). Promoting Argumentative Practice in Socio-Scientific Issues Through a Science Inquiry Activity. *EURASIA Journal of Mathematics, Science and Technology Education*, *13*(7), 3431-3461.

Nussbaum, E.M., Sinatra, G.M., and Poliquin, A. (2008). Role of Epistemic Beliefs and Scientific Argumentation in Science Learning. *International Journal of Science Education*, *30*(15), 1977-1999.

Okumus, S., and Unal, S. (2012). The Effects of Argumentation Model on Students' Achievement and Argumentation Skills in Science. *Procedia - Social and Behavioral Sciences*, *46*, 457-461.

Osborne, J., Erduran, S., and Simon, S. (2004). Enhancing the Quality of Argumentation in School Science. *Journal of Research in Science Teaching*, *41*(10), 994-1020.

Qin, J., and Karabacak, E. (2010). The Analysis of Toulmin Elements in Chinese EFL University Argumentative Writing. *System*, *38*(3), 444-456.

Saad, M.I.M., Baharom, S., Eshah, S., and Setambah, M.A.B. (2017). Factors Affecting Reasoning Skills on Socio Scientific Issues (SSI). *International Journal of Academic Research in Business and Social Sciences*, *7*(2), 646-652.

Songsil, W., Pongsophon, P., Boonsoong, B., and Clarke, A. (2019). Developing Scientific Argumentation Strategies Using Revised Argument-Driven Inquiry (rADI) in Science Classrooms in Thailand. *Asia-Pacific Science Education*, *5*(7), 1-22.

Telenius, M., Yli-Panula, E., Vesterinen, V.-M., and Vauras, M. (2020). Argumentation Within Upper Secondary School Student Groups During Virtual Science Learning: Quality and Quantity of Spoken Argumentation. *Education Sciences*, *10*(12), 1-19.

Walková, M., and Bradford, J. (2022). Constructing an Argument in Academic Writing Across Disciplines. *ESP Today*, *10*(1), 22-42.

Yahia, M., and Afifi, M. (2017). Impact of (QCEJ) Strategy on Developing the Skills of Constructing Scientific Arguments Among Middle School Students: The Role of Familiarity with Science Content Knowledge. *International Journal of Educational Science and Research*, *7*(3), 45-60.