**Enhancing Students’ Argumentation Skill**

**Using an Argument Driven Inquiry-Based Module**

**Shinta Devi Amielia1, Suciati2, Maridi\*3**

1Master Program of Science Education, Sebelas Maret University

2,3Faculty of Teacher Training and Education, Sebelas Maret University

|  |  |  |
| --- | --- | --- |
| **Article Info** |  | **ABSTRACT** |
| ***Article history:***  Received Jun 12, 201x  Revised Aug 20, 201x  Accepted Aug 26, 201x |  | Argumentation skills as a form of communication to externalize ideas through scientific discourse is a very important in learning of science. As an integral part of the science, argumentation skills should be integrated as a component of learning science. The purpose of this study is to determine the effectiveness of argument driven inquiry-based module in enhanching the students’ argumentation skills. This study was conducted at one of the State Senior High School in Surakarta academic year 2016/2017. The pre-test and post-test research pattern with treatment and control class groups were used throughout the study. While the treatment group taught by using module based on argument-driven inquiry, the control group was taught by a module that commonly used in the school. As the study concluded, using argument driven inquiry-based module in the learning process is effective to enhance the quality of students’ argumentation skills. |
| ***Keywords:***  Argumentation  Rebuttals  Inquiry  Teaching materials  Science Education |
| *Copyright © 2017 Institute of Advanced Engineering and Science.  All rights reserved.* |
| ***Corresponding Author:***  Shinta Devi Amielia,  Master Program of Science Education,  Sebelas Maret University,  36A Ir. Sutami Road, Jebres, Surakarta 57126, Central Java, Indonesia.  Email: [shinta.d.amielia@gmail.com](mailto:shinta.d.amielia@gmail.com) | | |

1. **INTRODUCTION**

The increasingly rapid development of science and technology in 21st century impacts on various aspects of life, including in education aspect [1]. Education plays an important role in improving human resource quality. Education is required to prepare and to produce high-quality human resource in order to process information well and correctly [2]. High quality human resource should have necessary skill or competency in 21st century. One of skills necessary in dealing with digital era in 21st century is communication skill [3]. Communication skill is a competency in delivering message (ideas, thoughts) from one party to another to allow interdependency between both of them [4]. The important part of communication skill in science field is argumentation skill [5].

Argumentation skill is an individual’s skill of organizing a statement accompanied with evidence and logical reason aiming to justify belief, attitude or value, to maintain it, and to influence others [6]. Argumentation, according to Simon, Erduran, & Osborne [7] is a process of collecting a variety of components necessary to build an argument. The components of argument, according to Toulmin (1958) in Chan & Esther [8], consist of claim, evidence, warrant, backing, qualifier, and rebuttal. The components of argumentation, according to Toulmin (1958), are adjusted by McNeill & Krajcik [9] with the students’ ability of understanding the definition of individual components, and yield 4 components: claim, evidence, reasoning, and rebuttal. Claim is an idea, a conclusion, hypothesis, or opinion on an event or phenomenon [10]. Evidence is a scientific data to support claim [11]. Reasoning is a reason given to connect evidence to claim. Rebuttal is an alternative answer to refuse claim as claim given is considered as less appropriate [9].

Argumentation skills is an important requirement that must be mastered in science because science studying not only sees how natural law works, but also to be able to explain how natural phenomena occur and how it goes in the future. Osborne, Erduran, and Simon [12] states that learning science allows the discussion about the facts obtained and the theory prevailing in the nature that argument is very important in constructing science knowledge. As an integral part of the science, argumentation skills should be integrated as a component of learning science. Socio-cultural view emphasizes on the social interaction in the process of learning and thinking, the ability of thinking critically honed through discussion, argument and experience exchange among students [13], [14]. This requires the argumentation skill to be taught in a structured learning science, and implemented in the science learning activities as an argument in science has a unique character distinguishing it from other disciplines. In the perspective of social activity, argumentation focuses on the interaction between individuals where someone tries to expresses statement or particular matter. What matters is how he can convince others that his opinions are acceptable reason, evidenced by the relevant proof and reason, because it is the skill of looking at a multi-perspective problem by using as much as possible supporting evidence. This is usually an obstacle for students and teachers of science. In addition, argumentation skill can help improve scientific knowledge because through argumentation process, students can construct the answer appropriate to the concept of science [15]. Considering the elaboration above, argumentation skill is important to develop in learning process.

The fact shows that learning in Indonesia has not facilitated the students yet to develop their argumentation skill. The learning process is still teacher-centered. It leads to a less conducive learning circumstance for the students to develop their argumentation skill. When students are put on the position of exchanging thoughts or ideas rarely, their argumentation skill will be poor [16]. Tama’s [17] and Pritasari’s [18] studies mentioned that argumentation skill of Senior High School students in Surakarta still belongs to low category. It can be seen from the students’ answer having no strong foundation when they have discussion. The answer the students give is still in statement form without followed with supporting evidence and reasoning, so that the gain score of individual argumentation skill aspects is still low.

The problem of low argumentation skill also occurs in one of State Senior High Schools in Surakarta. The fact found in early observations shows that during the learning process only a few students express opinions related to the materials. When the teacher asks, the students answer is still in a simple statement without any support of evidence and reason. Discussion and interaction activities between the students and teachers are less intensive. The results indicate that the students have not been trained to argue. The result of observation conducted based on the measurement of argumentation skill according to McNeill & Kracjik [9], shows the percentage of students’ argumentation skill aspect as follows: claim 44.08 %; evidence 26.88 %; reasoning 20.43 %; and rebuttal 0%. The mean argumentation skill of students is 22.84%. Based on the results obtained, the ability of the student’ argument skills is still low.

The results of need analysis conducted in one of State Senior High Schools in Surakarta Indonesia indicate the low school achievement of competence in biology material with an average score, it was only 78.84%. Based on data from the national exam’s result shows that the excretory system matter gets the low score and has the decrease in its percentage for three consecutive years from 2013 to 2015: 56.84% in 2013; 66.31 % in 2014; and only 49.59% in 2015. The result of argumentation skills analysis on module and book commonly used in the school shows that the score is still low. Claim aspect gets score of 30.0% in book one and 22.0% in book two; evidence aspect gets score of 13.0% in book one and 12.0% in book two; reasoning aspect gets score of 16.0% in book one and 15.0% in book two; and rebuttal aspect gets score of 0.00% in book one and 0.00% in book two. Considering the result of analysis, it can be concluded that book and module used in one of Public Senior High Schools in Surakarta have not used argumentation skill optimally yet.

An alternative way to enhance students’ argumentation skills optimally is using suitable learning materials such as a module. The module is one type of teaching materials presented systematically, so that the user can learn with or without a facilitator or teacher. Module is a learning material that can encourage and give students a chance to study independently and to study appropriately according to students’ ability [19]. Septiani, et al. [20] states that the use of module leads the students to learn individually, meaning that they can adjust the speed of learning to their ability. Setyawan [21] states that the use of scientifically-based modules in learning effective at improving students' critical thinking skills. The learning using module allows the students with a high ability of learning to complete a basic competence faster than other students. In addition, through modules, students can measure the level of their material mastery.

The optimization of module development to empower the students’ argumentation skills can be done by integrating learning model that can accommodate the emergence of argumentation aspects in the module. One of alternative learning model appropriate to integrate into module is Argument-Driven Inquiry (ADI) learning model. This strategy was developed by Sampson & Gleim [22] as an integrated learning unit encouraging the students to participate in an interdisciplinary work, so it might improve the students’ understanding on important and practical concepts in Biology [22]. ADI is a laboratory-based learning which can improve the students’ knowledge and skill by participating in several scientific argumentations through reading and writing activities [23]. ADI learning strategy consists of a set of activities and is expected to be able to develop the students’ active participation in an argumentation discourse and improve the argumentation quality.

The efforts to increase the active participation of students in the learning process inspire the researchers to develop a module based on argument-driven inquiry in excretory system subject. The module developed is expected to support the learning process, to guide the students in doing their activities independently through structured activities in the module and to increase the argumentation skill of students according to the 21st century’s demands.

1. **RESEARCH METHOD**

The study research involved two (11th grade) classes consisting of 31 students in each class. The classes were selected by using a simple random sampling method. The equivalence of two groups was tested via a number of instruments. These were achievement test, probing questions and logical thinking test. Kolmogorov-Smirnov test results indicated that there were no statistical differences between the two classes in terms of the scores taken from each test/scales aforementioned. Therefore, the two groups of students were accepted as equivalent.

The research design used was *pre and post-test non-equivalent control group design*. Observation technique was conducted to find out the students’ argumentation skill in experimental and control class before and after learning using module in excretion system material. The research design is presented in Table 1.

Table 1. Research Design

|  |  |  |  |
| --- | --- | --- | --- |
| Class Group | Treatment | | |
| Experiment (N = 31) | O1 | X1 | O2 |
| Control (N = 31) | O1 | X2 | O2 |

O1 : Pretest (Observation on argumentation skill before treatment)

O2 : Posttest (Observation on argumentation skill after treatment)

X1 : Learning using an argument-driven inquiry-based module

X2 : Learning using module used in school

Considering Table 1, it can be seen that each of classes consists of 31 students. Experiment class was taught using argument-driven inquiry based-module developed by author, while control class was taught using existing module in school. Module based on argument-driven inquiry was conducted the activities using argument-driven inquiry syntax by Sampson and Gleim [22]. There are identification of the task, the generation of data, the production of a tentative argument, the interactive argumentation session, the creation of a written investigation report, double-blind peer review, the revision process, a reflective discussion. Validity of module based on argument-driven inquiry on the excretory matter to increase cognitive learning outcomes is valid based on the average score of validaion by experts. Module based on argument-driven inquiry gets score 90% by an expert of matter; 97.5% by an expert of module development; 100% by linguist; 78.25% by an expert of learning device; 88.75% by education practitioners; and 90% by students. Therefore module based on argument-driven inquiry on excretory system matter to increase cognitive learning outcomes was interpreted as valid and it was implemented to treatment class group. Research transactions ware carried out for 5 weeks with a summary of activities in Table 2.

Table 2. Summary of Research Activity

|  |  |
| --- | --- |
| Week | Research Activity |
| 1 | Pretest (Observation on argumentation skill before treatment) |
| 2 - 4 | Treatment (learning using an argument-driven inquiry-based module in experiment class and learning using module existing in school in control class in the same material) |
| 5 | Posttest (Observation on argumentation skill after treatment) |

Table 2 shows that before treatment, all of students’ statements were observed and recorded during learning process to find out their argumentation skill in both experiment and control classes. After observation, both classes are given treatment in 3 weeks. After the treatment, all of students’ statements were observed and recorded to find out the change of students’ argumentation skill. All of statements were analyzed using the argumentation skill assessment rubric developed by McNeill & Krajcik [9], as shown in Table 3.

Table 3. The Argumentation Skill Assessment Rubric Developed by McNeill & Krajcik (2011)

|  |  |  |  |
| --- | --- | --- | --- |
| **Argumentation skills**  **aspect** | **Level** | | |
| 0 | 1 | 2 |
| **Claim**  It is a statement that is given as a response for a question asked or a conclusion | There is no claim or a false claim | There is a true but incomplete/ missing claim | There is a true, complete and accurate claim |
| **Evidence**  It is scientific fact that supports the claim. The data must be appropriate and sufficient to support the claim | Evidence is not provided or it is provided but it doesn’t support the claim | Appropriate but insufficient evidence is provided. It may contain some inaccurate evidence | Appropriate and sufficient evidence is provided to support the claim |
| **Reasoning**  It is a justification that allows evidence to be associated with the claim | Reason is not provided or a judgment is made that does not associate the claim with the evidence | A judgment is made that associate the claim with the evidence.  Evidence is repeated and / or it includes some more scientific principles which are insufficient. | It is a judgment that associate the claim and the evidence.  It contains appropriate and sufficient scientific principles |
| **Rebuttals**  Alternative explanations are given and explained.  Counter-evidence and reasoning are provided to show why alternative explanations are not appropriate. | Available alternative explanation is not given.  Rebuttal is not provided or a false rebuttal is given. | Alternative explanations are given.  Insufficient counter-evidence and reasoning which are proper but not sufficient to build a rebuttal are given | Alternative explanations are given.  Sufficient counter-evidence and reasoning which are proper and sufficient to build a rebuttal are given |

The arguments in the obtained data from the observation and voice recordings taken during the practices were analyzed according to the descriptive analysis. In descriptive analysis, the aim is to present the findings to the reader in an organized and interpreted way [24]. For this reason, the students’ arguments have been examined according to the rubric (see Table 3) developed by McNeill & Krajcik [9]. Arguments are coded in this direction by claim, evidence, reasoning and rebuttal. Claim, evidence, reasoning and rebuttal were scored according to the level of their situation. Scoring was done as following; 0 point was given to Level 0, 1 points to Level 1, and 2 points to Level 2. Then averages of the scores obtained from these components were calculated. In the process of coding the arguments, the opinions of a researcher who had previously worked on this subject were frequently referred to.

The difference of pre and post test scores between control and experimental class groups has been analyzed. During the data analysis, parametric tests were used because the normality assumptions were fulfilled. In data analysis, potential difference between control and experimental class groups before and after the module implementation in the learning process was assessed by using Independent Samples T-Test. After the learning process using module commonly used in the school and argument driven inquiry-based module, in both control and experimental class groups, the difference of pre and post test scores was analyzed using its N-gain. The criteria used in the N-gain value, according to Hake [25], are presented in Table 4.

Table 4. The Criteria of Gain Index and Its Interpretation

|  |  |
| --- | --- |
| N-Gain | Interpretation |
| g < 0,3 | Low |
| 0,7 > g ≥ 0,3 | Middle |
| g ≥ 0,7 | High |

1. **RESULTS AND ANALYSIS**

Module is developed by using eight steps of argument-driven inquiry model syntax that was integrated with four aspects of argumentation skills. Module is divided into three chapters of the excretory system subject. There are lungs as excretory organ, skin as excretory organ, kidney and liver as excretory organ.

The result of analysis on the argumentation skill aspect scores arising based on the result of observation is presented in Table 5.

Table 5. The Percentage Score of Argumentation Skill Aspect

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Aspect | Control Class | | Experimental Class | |
|  | Pretest | Posttest | Pretest | Posttest |
| *Claim* | 80% | 83% | 80% | 88% |
| *Evidence* | 9% | 12% | 9% | 26% |
| *Reasoning* | 32% | 34% | 39% | 58% |
| *Rebuttals* | 2% | 5% | 2% | 19% |
| Mean | 31% | 34% | 33% | 48% |

Table 5 shows that there is a significant difference of argumentation skill pretest scores between experiment and control classes. The mean pretest score of control class is 31%, including: 80% for claim, 9% for evidence, 32% for reasoning, and 2% for rebuttal aspects. Meanwhile, that of experiment class is 33%, including: 80% for claim, 9% for evidence, 39% for reasoning, and 2% for rebuttal aspects. The mean posttest score of argumentation skill in experiment class is higher than that in control class. The mean posttest score of experiment class is 48% including: 88% for claim, 26% for evidence, 58% for reasoning, and 19% for rebuttal aspects, while that of control class is 34%, including: 83% for claim, 12% for evidence, 34% for reasoning, and 5% for rebuttal aspects

The descriptive analysis results of pre-test and post test scores in treatment and control class groups are presented in Table 6 below.

Table 6. The Pre-test and Post test Scores of the Treatment and Control Class Groups

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Class Group | Score | Minimum  Score | Maximum Score | | Mean | | N-gain | | |
|  | Min | Max | Average |
| Eksperimental | Pretest | 6 | | 15 | | 2.35 | 0 | 0.34 | 0.85 |
| Posttest | 10 | | 44 | | 10.41 |  |  |  |
| Control | Pretest | 4 | | 11 | | 0.74 | 0 | 0.16 | 0.32 |
| Posttest | 8 | | 16 | | 3.93 |  |  |  |

Based on Table 6, it can be seen the average score of pre-test in experimental class and control class is not much different, where the pre-test score average of each class are respectively 2.35 and 0.74. The results of the post-test as presented in Table 6 can be seen that the average score of posttest in experimental class is higher than that in control class, where the post test score average of experimental class is 10.41 with N-gain score is 0.85 (high criteria) and the post test score average of control class is 3.93 with N-gain score is 0.32 (low criteria).

The argument driven inquiry-based module in the excretion system subject increases the students' argumentation skills significantly and effectively. The effectiveness of module can be seen from the increase in the posttest score of argumentation skill after the learning using argument driven inquiry-based module. The increasing of argumentation skills post-test was calculated by the score of the N-gain. The result of analysis presented in Table 6 shows that the mean N-gain of argumentation skill in experimental class is higher than the control class, 0.85 belonging to high category.

Module is a learning material that can encourage and give students a chance to study independently and to study appropriately according to students’ ability [19]. Setyosari [26] said the advantages of using module in learning are that students’ motivation can be increased, students’ task can be identified quickly, students’ learning outcomes can be adjusted with students’ ability, and it is more effective and efficient in learning. Learning using the module is more effective than conventional learning, because through using the module students can learn independently, so that students can develop learning steps, needs, and ability affecting the students’ learning outcomes in the class taught using the module as a student teaching material [27]. Howard & Miskowski [28] added that 79% students were helped to understand Biology Cell topic using Inquiry Module-based Laboratory. Howard & Miskowski [28] also mentioned that students’ performance after using the module was better than before. Hatzikraniotis et al. [29] reported that there was an increase from the pretest to the post-test scores after using an inquiry module. Using a module in learning as compared to the traditional method of using a textbook is meant to increase active learning and improve critical thinking, as well as problem solving skills. It also gives the teacher the opportunity for conducting formative assessment in the classroom. Standardized textbooks have their own styles, and their contents, depth of coverage of materials, and organization, may affect the teaching and learning environment. Thus, the use of a module presents a more flexible learning environment for both teachers and students.

The results of the activity in the module, presented in Table 5, shows that the activities the students did using syntax of argument driven inquiry can practice the students’ argumentation skill aspects. The results during the research supported by Sampson, et al. [30] shows that the application of ADI has a positive impact on the learning process in the classroom, especially in creating a conducive atmosphere for the students to argue. The students had better disciplinary engagement and produced better arguments after the intervention. The interaction within the group push the students to submit opinions more freely without fear. ADI learning model practices students to construct explanation or knowledge and share ideas in small groups in class discussion, thereby creating a class circumstance providing “process” culture in science learning [23]. It is in line with Zohar and Nemet [31], Myers [32], Okumus and Unal [14], Demircioglu and Ucar [33], Hasnunidah, et al. [34], Farida and Gusniarti [35], and Ginanjar, et al. [36] concluding that the learning process involving ADI model activities can improve the students’ argumentation skill. Walker, et al. [37] added that the activities in ADI model can improve the students’ ability significantly in giving evidence and reasoning to support claim, thereby creating a good and correct argumentation.

The argument driven inquiry-based module used in the learning process can enhance students' argumentation skills because it presents the activities structured in the form of experiments and observations using the syntax of argument driven inquiry, in which every aspect of argument driven inquiry is integrated into aspects of argumentation skill. The first stage of ADI model is task identification containing problem or phenomenon presented in the form of discourse and picture. Based on discourse and picture, the students are directed to identify problem so that they can formulate problem and develop hypotheses or temporary answer to the problem statement. The syntax of task identification is integrated into claim aspect in the form of hypothesis formulation as temporary answer to the problem later proved for its truth in data collection and analysis stage [22]. Research data show that the students’ achievement in the pretest and posttest aspects claim is the highest compared to the achievement aspects of the evidence, reasoning, and rebuttals. The results were supported by the results of the research Cho and Jonassen [38] which states that students are more focused in making a claim (statement) because it is a basic part of the solution to a problem. Kaya, Erduran, & Cetin [10] adds that claim is the aspect that most often arises because the claim is only a simple idea, statement, hypothesis, or opinion of an event or phenomenon without supported by evidence and reason.

In data collection and analysis stage, students work in group to design experiment, conduct experiment and investigation, collect data, and analyze data resulting from experiment. In the syntax of data collection and analysis, potential aspect of argumentation skill arising is evidence. Through experiment and investigation activity in data collection and analysis stages, the students collect evidence and data to support initial statement or temporary answer that has been made. Evidence the students find in investigation or experiment process can support the statement the students give, thereby can be accepted by other students. It is in line with Walker, et al. [37] study finding that the students’ ability of giving evidence supporting claim improves after conducting investigation in ADI model.

In argument development stage, students discuss in group to associate the data resulting from experiment in order to organize an argument. In syntax of argument development, potential aspect of argumentation skill arising is reasoning. Through group discussion, students can exchange ideas and collaborate to solve problem [39]. During discussion activity, the students convey the reason (reasoning) of each statement by giving justification connecting the claim to the evidence used. The reason given by the students is the result of thinking and understanding of the problems. Students' understanding is obtained through interaction during group discussions. Akcay [40] states that working in a group makes students more active in discussing and exchanging ideas with friends about the information obtained so as to help in understanding the information better than just reading the literature.

Argumentation session stage is the one in which the students communicate argument developed by giving the students the opportunity of proposing, supporting, criticizing, and maintaining their argumentation, explanation, and opinion through class presentation and discussion. Argumentation session facilitates the students to explain and to justify the argumentation developed and to give the students rebuttal against other students’ opinion considered as inconsistent with the concept of science. Argumentation session process, according to Lyewellyn [41] can facilitate the students construct scientific argumentation by means of giving other students the opportunity of expressing opinion and giving rebuttal against the opinion considered as inconsistent with the concept of science. During the argumentation session many students asking his opinion. Kaya et al. [10] also stated that the arguments on high school students greater arise when they engage in the discussion and argumentation session.

Report writing stage is the activity in which the students communicate the result of experiment and data analysis in the form of written report. In report writing stage, potential aspects of argumentation skill arising are claim, evidence, and reasoning. For the experimental group students, there was a section for answering the question “What is your argument?” in which students presented a good explanation for precisely answering the research question. Students asserted valid and reliable evidences to support their explanation. The next stage is peer review, in which the students evaluate and apply the knowledge acquired to the real life context. The students evaluate and assess their friends’ report and decide whether the report is acceptable or needs revision based on criteria enclosed in the peer review sheet. In peer review stage, potential aspect of argumentation skill arising is rebuttal. Revision process stage is the one in which the students rewriting the report based on reviewer’s feedback. This activity serves to encourage the students to improve their writing ability based on reviewer’s feedback. In revision process stage, the potential aspects of argumentation skill arising are claim, evidence, and reasoning. The last stage is reflective discussion in which the students conclude the result of research and apply the concept resulting from the experiment. In reflective discussion stage, the potential aspects of argumentation skill arising are claim, evidence, and reasoning.

Overall, the results of the analysis have shown that the use of argument driven inquiry based-module in excretion system material is more effective in enhancing students' argumentation skills.

1. **CONCLUSION**

The argument-driven inquiry-based module is effective to enhance the students’ argumentation skill, as indicated with N-gain score of 0.85 in the experimental class higher than that in control class using the book, 0.32. The assessment in this study is limited to aspects of argumentation skills; therefore the following suggestions are given:

1. In addition to assessing argumentation skill, the assessment in the learning process that should be included into this aspect of skills (psychomotor) is an assessment of knowledge (cognitive) and attitude (affective) aspects.
2. The use of argument driven inquiry-based module should be adjusted with the prevailing syllabus and curriculum, so that learning can take place properly.

**ACKNOWLEDGEMENTS**

Researcher would like to thank to all of those who have helped this research completion, especially to the students and the teachers of State Senior High School in Surakarta.

**REFERENCES**

|  |  |
| --- | --- |
| [1] | P. Turiman, J. Omar, A. M. Daud and K. Osman, "Fostering the 21st Century Skills through Scientific Literacy and Science Process Skills," *Procedia - Social and Behavioral Sciences 59 ,* p. 110 – 116 , 2012. |
| [2] | BSNP, Paradigma Pendidikan Nasional Abad XXI, Jakarta: Badan Standar Nasional Pendidikan, 2010. |
| [3] | A. A. C. T. E, 21st Century Knowledge and Skills in Educator Preparation, New York: Pearson, 2010. |
| [4] | Mashudi, Keterampilan Komunikasi, Jakarta: Wacana Prima, 2013. |
| [5] | J. Wellington and J. Osborne, Language and literacy in science education, Philadelphia: Open University Press, 2001. |
| [6] | E. Inch and B. H. Warnick, Critical Thinking and Communication: The Use of Reason in Argument, Boston: Pearson, 2006. |
| [7] | S. Simon, S. Erduran and J. Osborne, "Learning to Teach Argumentation: Research and development in the science classroom," vol. 28, no. 235-260, 2006. |
| [8] | F. Chan-Choong and G. S. D. Esther, "Assessing Students' Arguments Made in Socio-Scientific Contexts: The Considerations of Structural Complexity and The Depth," *Procedia Social and Behavioral Sciences,* p. 1120–1127, 2010. |
| [9] | K. L. McNeill and J. Krajcik, Suporting Grade 5 – 8 Students in Constructing Explanation in Science: The claim, evidence, reasoning and rebuttal framework for talk and writing, New York: Pearson Allyn & Bacon, 2011. |
| [10] | E. Kaya, S. Erduran and P. S. Cetin, "Discourse, Argumentation, and Science Lessons: Match or Mismatch in High School Students’ Perceptions and Understanding?," *Mevlana International Journal of Education (MIJE),* vol. 2, no. 3, pp. 1-32, 2012. |
| [11] | C. D. Wilson, J. Taylor, S. M. Kowalsk and J. Carlson, "The relative effects and equity of Inquiry-based and commonplace science teaching on students knowledge, reasoning, and argumentation," vol. 47, no. 3, 2010. |
| [12] | J. Osborne, S. Erduran and S. Simon, "Enhancing the quality of argumentation in school science," *Journal of research in science teaching,* pp. 994-1020, 2004. |
| [13] | S. Norris, L. Philips and J. Osborne, Scientific inquiry:The Place of interpretation and argumentation.Science as inquiry in theSecondary Setting, VA: NSTA, 2007. |
| [14] | S. Okumus and S. Unal, "The effects of argumentation model on students acheivement and argumentation skills in science," *Procedia - Social and Behavioral Sciences 46,* p. 457 – 461 , 2012. |
| [15] | C. v. Aufschnaiter, S. Erduran, J. Osborne and Shirley, "Arguing to learn and learning to argue: Case studies of how students' argumentation relates to their scientific knowledge," *Journal of Research in Science Teaching,* 2008. |
| [16] | L. K. Berland and K. L. McNeill, "Using a Learning Progression to Inform Scientific Argumentation in Talk and Writing," in *Learning Progressions in Science (LeaPS) Conference*, Iowa City, IA , 2009. |
| [17] | N. B. Tama, R. M. Probosari and S. Widoretno, "Penerapan Project Based Learning untuk Meningkatkan Keterampilan Argumentasi Tertulis Siswa Kelas X MIPA 2 SMA Negeri 5 Surakarta pada Materi Ekosistem," *Jurnal Inovasi Dan Pembelajaran Fisika,* vol. 2, no. 2, pp. 170-176, 2015. |
| [18] | A. C. Pritasari, S. Dwiastuti and R. M. Probosari, "The Argumentation Capacity Improvement Through the Problem Based Learning Implementation in Class X MIA 1 SMA Batik 2 Surakarta," *Jurnal Pendidikan IPA Indonesia Indonesian Journal of Science Education,* vol. 4, no. 2, pp. 158-163, 2015. |
| [19] | J. Mbulu, Pengajaran individual (Pendekatan, metode, dan media pedoman mengajar bagi guru dan calon guru, Malang: Yayasan Elang Mas, 2001. |
| [20] | D. Septiani, D. Sumarni and Saptorini, "The Effectiveness of Inquiry Learning Model with Module to Increase the Understanding of Concept and Generic Science Skills," *Jurnal Inovasi Pendidikan Kimia,* vol. 8, no. 2, pp. 1340-1350, 2014. |
| [21] | D. N. Setyawan, N. S. Aminah and Sarwanto, "The Using of Scientific Based Physics Module in Learning to Enhance High School Students’ Critical Thinking Skills on Rotation Dynamics and Equilibrium of Rigid Body," *Journal of Education and Learning,* vol. 11, no. 2, pp. 213-218, 2017. |
| [22] | V. Sampson and L. Gleim, "Argument Drivent Inquiry to promote the understanding of important concept & practices in biology," *The American Biology Teacher Journal ,* vol. 8, pp. 465-472, 2009. |
| [23] | V. Sampson, J. Grooms and J. P. Walker, "Argument-Driven Inquiry as a Way to Help Students Learn How to Participate in Scientific Argumentation and Craft Written Arguments: An Exploratory Study," *Science Education,* pp. 217-257, 2011. |
| [24] | A. Yıldırım and H. Şimşek, Sosyal bilimlerde nitel araştırma yöntemleri, Ankara: Seçkin Yayıncılık, 2013. |
| [25] | R. R. Hake, "Interactive-engagement vs traditional methods: A six thousand-student survey of mechanics test data for introductory physics courses," vol. 66, no. 1, 1998. |
| [26] | P. Setyosari, Pengajaran modul, Malang: UM Press, 1991. |
| [27] | M. Ali, Guru dalam Proses Belajar Mengajar, Bandung: Percetakan Sinar Baru, 2007. |
| [28] | D. R. Howard and J. A. Miskowski, " Using module-based laboratory to incorporate inquiry into a large cell biology course," *The American Society for Cell Biology,* vol. 4, pp. 249-260, 2005. |
| [29] | E. Hatzikraniotis, M. Kallery, A. Molohidis and D. Psillos, "Students’ design of experiments: An inquiry module on the conduction heat," *Journal of Physic Education,* vol. 45, no. 4, pp. 335-344, 2010. |
| [30] | V. Sampson, J. Grooms and J. P. Walker, "Argumet Driven Inquiry as a way to Help Students Learn How to Participate in Scientific Argumentation and Craft Written Arguments:An Exploratory Study," *Science Education,* pp. 217-257, 2010. |
| [31] | A. Zohar and F. Nemet, "Fostering Students' Knowledge and Argumentation Skills Through Dilemmas in Human Genetics," *Journal of Research in Science Teaching,* vol. 39, pp. 35-62, 2002. |
| [32] | C. P. Myers , "The Effect of Argument Driven Inquiry on Student Understanding of High School Biology Concepts," MONTANA STATE UNIVERSITY , Montana, 2015. |
| [33] | T. Demircioglu and S. Ucar, "The Effect of Argument-driven Inquiry on pre-service science teachers' attitudes and argumentation skills," *Procedia-Social and Behavioral Sciences 46,* pp. 5035-5039, 2012. |
| [34] | N. Hasnuidah, H. Susilo, M. H. Irawati and H. Sutomo, "Argumen-Driven Inqury with Scaffolding as the Development Strategies of Argumentation and Critical Thinking Skills of Student In Lampung Indonesia," *American Journal of Educational Research,* vol. 9, no. 3, pp. 1185-1192, 2015. |
| [35] | I. Farida and W. F. Gusniarti, "Profil Keterampilan Argumentasi Siswa Papa Konsep Koloid yang Dikembangkan Melalui Pembelajaran Inquiry Argumentatif," *EDUSAINS,* vol. 6, no. 1, pp. 32-40, 2014. |
| [36] | W. S. Ginanjar, S. Utari and Muslim, "Penerapan Model Argument-Driven Inquiry dalam Pembelajaran IPA untuk Meningkatkan Kemampuan Argumentasi Ilmiah Siswa SMP," *Jurnal Pengajaran MIPA,* pp. 32-37, 2015. |
| [37] | J. P. Walker, v. Sampson, J. Grooms, B. Anderson and C. Zimmerman, "Argument driven ınquiry: An instructional model for use in undergraduate chemistry labs," Philadelphia, 2010. |
| [38] | K. L. Cho and D. H. Jonassen, "The effects of argumentation scaffolds on argumentation and problem solving," vol. 50, no. 3, 2002. |
| [39] | H. G. Schmidt, J. I. Rotgans and E. J. Yew, "The process of problem-based learning: what works and why," *Medical Education,* vol. 16, no. 3, pp. 85-96, 2011. |
| [40] | B. Akcay, "Problem Based Learning in Science Education," vol. 6, no. 1, 2009. |
| [41] | Llewellyn, Teaching High Scholl Science Through Inquiry and Argumentation, USA: Corwin, 2013. |

**BIOGRAPHIES OF AUTHORS**

|  |  |
| --- | --- |
|  | Shinta Devi Amielia, S.Pd. was born in Rembang, on August 01, 1992 with the following history of education: graduated from SD Negeri 1 Woro in 2004, from SMP Negeri 1 Kragan in 2007, from SMA Negeri 1 Rembang in 2010, from Biology Education Study Program of Graduate Program of Teacher Training and Education Faculty of Surakarta Muhammadiyah University in 2014, and still studying at Master of Science (Biology) Education in Sebelas Maret University (2015 up to now). She has job experience in education field as the tutor in Science Class Learning Institution of Surakarta from 2016 up to now.  The works ever published:   1. 1 national proceedings and papers |
|  |  |
|  | Dr. Suciati, M.Pd. was born in Kediri, on July 23, 1958, with the following history of education: graduated from Education Graduate Program of Teacher Training and Education Faculty of Bandung Pasundan University in 1992, from Master of Science Education Program of Universitas Pendidikan Indonesia (Indonesia Education University) in 1999, Science Education Doctorate Program of Universitas Pendidikan Indonesia in 2005. Dr. Suciati, M.Pd. is now occupying the positions of permanent lecturer in Biology Education of Teacher Training and Education Faculty of UNS Surakarta, permanent lecturer in Science Education Postgraduate program of UNS, lecturer assuming Natural Science Course in Doctorate Study Program of FKIP UNS, Coordinator of Indonesian Natural Science Educator Association of UNNES Semarang for Central Java Area, Coordinator of Quality Guarantying in Biology Education Study Program of FKIP UNS, Lead Auditor Audit Internal in Mathematics Education of FKIP UNS Surakarta, Member of World Association of Lesson Study (WALS) UPI Bandung, member of Indonesian Biological Educator and Researcher Association, Member of Pusat Studi Jepang (PSJ) (Japanese Study Center) of UNS. Dr. Suciati, M.Pd. has participated in 175 activities and 10 services in education field.  The works ever published are as follows:  During 2005-2016, Dr. Suciati, M.Pd. has published 89 scientific works and 7 journals consisting of:   1. 32 international proceedings and papers 2. 57 national proceedings and papers 3. 7 national journals: 4. “*Model PROSTAD Pada Pembelajaran Biologi Untuk Memberdayakan Kemampuan Berpikir dan Interaksi Kelompok Peserta Didik (PROSTAD* Model in Biology Learning to Empower the Students’ Thinking Ability and Group Interaction”, *Jurnal Pengajaran MIPA*. 2014 Volume 19, No. 1: ISSN 1412-0917 5. *“Implementasi Pendekatan Kontekstual dengan Variasi Metode Berbasis Masalah untuk Meningkatkan Kualitas Pembelajaran Biologi* (The Implementation of Contextual Approach using Varying Problem-Based Method to Improve the Quality of Biology Learning)”. *Jurnal Pendidikan IPA Indonesia* 2013 volume 2, no. 1ISSN 2089-4392 6. “*Pembelajaran Biologi Model POE (Prediction, Observation, Explanation) Melalui Laboratorium Riil dan Laboratorium Virtuil ditinjau dari Aktivitas Belajar dan Kemampuan Berpikir Abstrak* (Biology Learning with POE Model through Real and Virtual Laboratory Methods Viewed from Learning Activity and Abstract Thinking Ability)”. *BIOEDUASI*. 2013 Volume 6, no 1. ISSN 1693-2654. 7. “*Penerapan Model Science Technology Society Melalui Eksperimen Lapangan dan Eksperimen Laboratorium ditinjau dari Sikap Peduli Lingkungan dan Kreativitas Verbal Siswa* (The Application of Science Technology Society Model through Field and Laboratory Experiments Viewed from Students’ Environment Caring Attitude and Verbal Creativity)” *BIOEDUKASI*. 2013 Volume 6,no 1ISSN 1693-2654 8. “*Mengenalkan Sains pada Anak Usia Dini Melalui Permainan Berbasis Sains* (Introducing Science to Early Age Child Through Science-Based Game). *Jurnal Attarbiyah*. 2013. No. 2ISSN 02159996. 9. “*Integrasi Pendekatan Konstruktivisme dalam Model Problem Based Learning Berbasis Kooperatif untuk Meningkatkan Kompetensi Mahasiswa pada Mata Kuliah Strategi Pembelajaran Biologi Tahun Akademik 2009/2010* (Integration of Constructivism Approach into Cooperative-Based Problem-Based Learning Model to Improve Students’ Competency in Bio*logy Learning Strategy Course in Academic Year of 2009/2-2010)”.* BIOEDUKASI. 2011Volume 4, No 2 ISSN 1693-2654. 10. “*Bimbingan Praktik Mengajar dengan Metode Pemodelan Bermakna untuk Mengembangkan Keterampilan Calon Guru dalam Mengajar IPA sebagai Upaya Peningkatan Kualitas Pendidikan IPA* (Teaching Practice Guiding with Meaningful Modeling Method to Develop the Prospect Teachers’ Skill in Teaching Natural Science as an Attempt of Improving the Quality of Natural Science Education)”. *BIOEDUKASI* 2005. Volume 2, No.2ISSN 1693-265X. |
|  |  |
|  | Prof. Dr. Maridi, M.Pd. was born in Karanganyar, on July 24, 1950, with the following history of education: graduated from Biology Education Graduate Program of Teacher Training and Education (FKIP) of Sebelas Maret University (UNS) in 1981, from Master of History Program of IKIP Negeri Jakarta in 1991, from Ecology Doctorate Program of Sebelas Maret University in 2012. Title of His Inauguration Speech is: Peran Sains dan Ilmu Lingkungan untuk Mewujudkan Pembangunan Berkelanjutan (The Role of Science and Ecology in Realizing a Sustainable Development). Prof. Dr. Maridi, M.Pd. is currently occupying some positions: as permanent lecturer in Biology Education of FKIP UNS Surakarta, UP PPL FKIP UNS, and a member of Indonesian Environment Health Expert Association. Prof. Dr. Maridi, M.Pd. has written 6 books.  The works ever published are as follows:  During 2004- 2016, Prof. Dr. Maridi, M.Pd. has published 89 scientific works and 7 Journals consisting of:   1. 4 International Proceedings 2. 8 National Proceedings and Papers 3. 2 International journals and 4 National Journals: 4. “Vegetation Analysis of Samin Watershed as Water and Soil Conservation Efforts”. BIODIVERSITAS”, Journal of Biological Diversity 2014(15) ISSN:1412-033X, E-ISSN: 2085-4722 5. “Fighting Through Conservation Wonogiri Reservoir Sedimentation Basin Keduang Approach Sub Vegetative Community-Based”. International Institut Science Technology and Education /IISTE, Hongkong. 2012 6. “*Modal Manusia Untuk Konservasi Waduk Wonogiri* (Human Capital for Wonogiri Dam Conservation)”. *BIOEDUKASI*. 20114 NO 2. ISSN 1693-2654. 7. “*Efektifitas Teknik Remidial untuk Menanggulangi Kesulitan Belajar IPA / Biologi Siswa SMP Negeri 3 Sragen* (The Effectiveness of Remedial Technique to Cope With Natural Science/Biology Learning Difficulty in the Students of SMP Negeri 3 Sragen)” *Jurnal BIOEDUKASI FKIP UNS*. 2005. ISSN: 1693-2654 8. “*Pengaruh Cara Belajar dan Motivasi belajar Terhadap Prestasi Belajar Biologi Siswa Kelas II SMA Negeri Colomadu Karanganyar* (The Effect of Learning Style and Learning Motivation on Biology Learning Achievement in the 2nd Graders of SMA Negeri Colomadu Karanganyar)”. *Jurnal BIOEDUKASI FKIP UNS*. 2005. ISSN: 1693-2654. 9. “*Variasi Cangkang Gastropoda Ekosistem Mangrove Cilacap* (Variation of Gastropod Shell in Cilacap Mangrove Ecosystem)”. *Jurnal BIOEDUKASI FKIP UNS*. 2004. ISSN: 1693-2654 |