

The Profile of High School Students' Reflective Judgment and Argumentation Skills in Biology

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ABSTRACT

Critical thinking skills are one of the 21st-century skills and a basis to form a reflective judgment and argumentation on an issue. The aim of this study was to determine the profile of reflective judgment and argumentation skills of high school students in biology learning. The subjects of this study were students of SMAN 2 Tasikmalaya. 288 Grade-10 students were involved as sample who examined by purposive sampling technique. The instrument was a descriptive test which comprised of 2 questions about issue of burning waste and a rice field project on peatlands. Analysis of the test results was carried out descriptive quantitative. The results showed that the reflective judgment and argumentation skills was still low with the mean of students' reflective judgment skills in the non-appearing category of 34.38%, 47.22% pre-reflective, 12.15% quasi-reflective, and 6.25% reflective. The average written argumentation skills of students were level 0 (3.47%), level 1 (58%), level 2 (33.33%), and level 3 (5.21%). Students' reflective judgment and argumentation skills need to be trained and accustomed to the biology learning process used appropriate learning models or strategies.

Keywords: *Reflective judgment, Argumentation, Biology learning*

1. INTRODUCTION

The 21st century is marked by the development and improvement of technology, encouraging the creation of quality human resources. Problem-solving, critical thinking, creative thinking, communication, collaboration with others, adaptable, and entrepreneurship are skills that students need to work in the 21st century [1]. Basically, education is an important pillar for the increasing of the quality human resources. Education in Indonesia is inseparable from the challenges of 21st-century skills. A good learning process would be able to develop the abilities and competencies that needed in the 21st century, such as creativity, critical thinking, communication, and collaboration (4Cs). The challenges of the global era are increasingly advanced so that the needs of education today require students to be able to interact and communicate with others, with critical thinking and creativity as provisions in facing global challenges that are increasingly advanced and compete in life.

The critical thinking skills makes someone think openly to find the truth of the problem and make a wise decisions based on the information obtained. Critical thinking becomes a person's foundation for making the reflective judgment. The reflective judgment shows the level of a person's ability to collect and analyze information from various sources so that it becomes the basis for a person in making decisions [2]. Reflective judgment is a model that used to measure changes in perspective or critical thinking that a person uses in making decisions about an issue [3]. The thing that underlies the emergence of reflective judgment is the uncertainty of a person's knowledge in a phenomenon that can affects in making decisions. As time goes by, a person's epistemic knowledge or assumptions will change, starting in adolescence and continuing into adulthood [4], [5]. Reflective judgment has seven levels that are grouped into three categories, namely pre-reflective, quasi-reflective, and reflective. The first category, pre-reflective has the first three levels (1-2-3), which is a concrete truth where there is only one assumption that is believed or

considered to be the most correct regardless of other points of view. The next two levels are the quasi-reflective category (4-5), which is the uncertainty of the belief system [3]. That is, the assume that the expert subject is not always right, which is indicated by the existence of other possibilities. The third category, reflective includes two levels (6-7), an individual has turned as recipients of information (passive) to information makers (active) who are based on evidence and belief [5]. The reflective level shows that science can develop with the emergence of facts so that it can analyze and interpret it into a cohesive knowledge. Reflective judgment can be realized with attitudes and arguments that support thinking and analysis of the problem.

The ability to give an argumentation is part of critical thinking skills [6]. Communication skills include argumentation are one of the skills needed by students in the 21st century. Argumentation skills are needed in learning science, especially biology because students can be actively involved in providing opinions based on data, evidence, or theories that support their opinion on problems [7]. Argumentation becomes the main basis for students in learning how to produce evidence, examine, evaluate theories, and communicate like a true scientist [8]. Science involves the theories that underlie an event and these theories are open to being refuted or challenged. That is at the center of the discourse of scientists every day that makes scientists involved in the argumentation process. Argumentation can also develop students' ability on reasoning, thinking, and improving scientific literacy [9]. The argumentation component refers to a simplified Toulmin's Argumentation Pattern (TAP), which consists of claims, evidence, and reasoning [10]. Claim means a statement to identify an argument. Evidence is data or information to support claims. The reasoning is the justification that connects claims and data.

The ability on reflective judgment and argumentation in the Biology lesson on the topic of Environmental Change is important to be studied further. The environmental change topic is inseparable from everyday life issues so that reflective thinking and argumentation are needed by students in connecting their understanding from various sources as a basis for expressing their opinions to solve problems. Before designing an appropriate model or strategy, information is needed especially about students' initial abilities so the mapping that obtained to determine what actions will be used in learning and how to overcome them. The aim of this study was to determine the profile of senior high school students'

reflective judgment and argumentation skills in biology learning.

2. RESEARCH METHODS

This research is a quantitative descriptive study. The data obtained were the results of the students' reflective judgment and written argumentation skills tests. This research was conducted at SMA Negeri 2 Tasikmalaya. In total there were 288 students of class X-MIPA selected through purposive sampling and participating in this research as sample. The instrument used to measure the skills of reflective judgment and argumentation was a test description compiled used google form.

The essay test consists of 2 questions and was an adjustment to the topic of environmental change by raising the issue of burning waste and a rice field project on peatlands. The quality of argumentation skills was identified which refers to the TAP (Toulmin's Argumentation Pattern) has been simplified by Mc. Neil et al. [10]. The students' argumentation levels were categorized into 4 levels in table 1. The skills to reflective judgment was analyzed descriptive based on the rubric model of Zeidler's reflective judgment [5].

Table 1. The category level of argumentation skills

Argumentation Level	Description
Level 0	There is no claim, evidence, and reasoning
Level 1	Include claim
Level 2	Include claim dan evidence
Level 3	Include claim, evidence, and reasoning

3. RESULTS AND DISCUSSION

The results of this research were conducted to analyze the initial profile of students' reflective judgment and argumentation skills. The results showed that the skills of reflective judgment and written argumentation at SMAN 2 Tasikmalaya had varied levels. Based on the answer analysis, an average of the categories of reflective judgment skills showed in figure 1. Examples of expressions for each level of reflective judgment expressed by students showed in table 2.

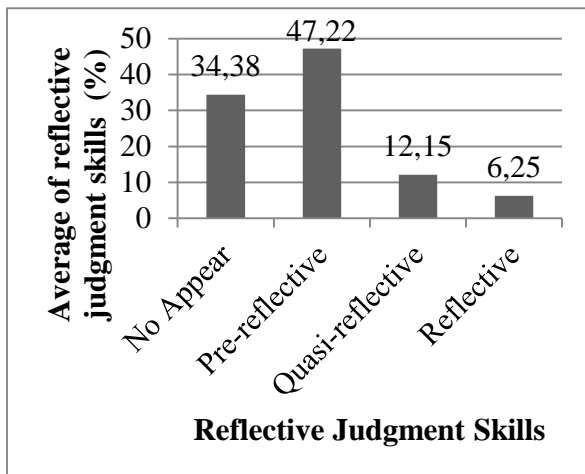


Figure 1 Average of reflective judgment skills

Based on figure 1 showed the reflective judgment skills in the pre-reflective category were the highest at 47.22%, compared to quasi-reflective and reflective categories. The results of this study indicate that the students' reflective judgment skills have not been maximized, seen from the number of students who are in pre-reflective. The written answers in the description questions have not shown deep thought on the issues being studied. The student still finds it difficult to connect the concepts or knowledge of Biology with the facts found to formulate and analyze a decision related to existing environmental issues. However, some students made conclusions based on their experiences and the information obtained. When

performing the test, students use their reflective judgment skills to dealing the issues that are on the questions, which are ill-structured problems. Students will try critical thinking, make reasonable conclusions and actions [19]. An ill-structured problem shows that there is no definite answer so that it tends to bring up various kinds of planned solutions in dealing with this issue.

Students' learning patterns or habits are a factor in the limited emergence of critical thinking skills so that they affect the development of reflective judgment skills, such as the lack of opportunities for students to learn to elaborate contextually on facts and problems [3]. The ability to think critically is a person's basic ability to make reflective decisions. The existence of limited critical thinking skills in students who have not developed optimally is a characteristic of pre-reflective and quasi-reflective individuals [5]. Students in the pre-reflective category have not been able to use evidence as a basis for making conclusions or decisions, only relying on personal opinions that have no basis and their beliefs are also supported by those who have conveyed this. Meanwhile, students in the quasi-reflective category begin to think that the existence of other possibilities and evidence is the key to a different perspective of a statement or problem, but they have not been able to integrate the existing evidence in providing conclusions. In the reflective category, students can compare evidence and opinions from other points of view to build solutions.

Table 2. Examples of expressions for each category reflective judgment skills

Stage	Examples of Expressions
Pre-reflective	In my opinion, the existence of the rice field project on peatlands also has positive impacts on life, such as overcoming the food crisis due to Covid-19, not entirely negative impacts. So it doesn't hurt to try it first.
Quasi-reflective	I believe that the rice field project on peatland is inappropriate because it has a high failure rate. Peatlands are not suitable for planting rice. If you do this, it will cause a lot of loss to the State and will only damage the ecosystem. Peatlands are one of the ecosystems that have an important function for the climate of Indonesia and the world.
Reflective	I am sure that the rice field printing project on peatlands is not appropriate, considering that the project was carried out in the previous administration and experienced a failure. Peatlands will dry out and burn easily, damaging the environment. Peatlands are one of the most important ecosystems for climate balance and biodiversity protection, even to avoid sources of zoonotic diseases that originate from natural destruction. Currently, the government should diversify food and develop local food, intensify it on suitable lands, and not peatlands that have proven to be low productivity and require expensive technology.

Another factor that causes their poor reflective judgment was because they have just entered class X which and still in the transition period from junior high school to high school. This is related to their personal epistemology and scientific reasoning which later can develop with age and educational experience [11], [12]. The development of scientific reasoning and personal epistemology can be conceptualized as a two-way process [11]. The development of reflective reasoning corresponds to the development of personal epistemology. Personal epistemological beliefs support the performance of reasoning and scientific mastery. Reflective reasoning requires students to reflect on and review their own experiences with an issue and critically examine opinions from various sources. Personal epistemology and reasoning require time and educational experience. It is expected that over time the students' reflective judgment abilities can increase.

The advantage of students having reflective judgment skills is that students are able to consider and evaluate evidence and opinion related to existing issues to reach a decision by looking at the problem objectively [5]. Reflective judgment does not only play a role in dealing with structured problems but also play a role of decision making in every day [13]. The investigative process carried out by students in seeking information and discussing with friends who have different points of view can develop reflective judgment abilities as well as developing views of their knowledge. When students cannot perform the reflective judgment, students tend to be difficult to dealing ill-structured problems. They find it difficult to consider and reflect on both acquired and known information to make decisions, solutions, and actions in dealing with problems logically.

The teachers need to facilitate group discussions among students regarding socio-scientific problems that occur in everyday life and from the internet. This could improve critical thinking skills in finding and evaluating information include from the internet [13], [14]. Group discussion, debate, role-playing can enable students to examine and evaluate their views or beliefs on knowledge, other people's opinions, and information from various sources. The teachers also need to show respect and be open to various opinions given by students.

Based on the answer analysis, the percentage of the categories of students' written argumentation skills for each class showed in figure 2. Examples of

expressions for each level of argumentation expressed by students showed in table 3.

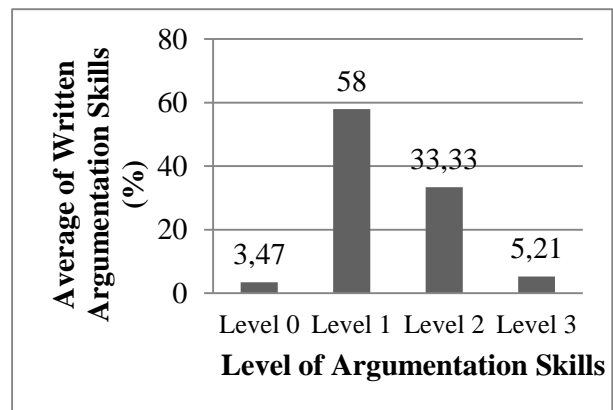


Figure 2. Average of Written Argumentation Skills

Based on figure 2 showed written argumentation skills in level 1 were the highest at 58%, compared to level 0, level 2, and level 3. The results of this study indicate that the students' written argumentation skills have not been maximized as seen from the number of student arguments that contain claims, but contain little evidence and reasoning.

The majority of students in the level 1 category have difficulty providing evidence and reasons to support the claims. A good argument is not only a logical thought about theory but a claim that is supported by the justification that a theory is true [15]. Students in the level 2 category have been able to provide evidence, and some evidence provided based on students' daily experiences, but have not been able to support claims so that between claims and data seems no connection. Students in the level 3 category can explain the relationship of the claim with the data or evidence obtained.

The difficulty experienced by students in making arguments because they are not used to making an argument, and in the previous learning did not provide opportunities for them to express their opinions. Students who are accustomed to learning through the argumentation process will have the ability to argue. The basis for argumentation is reasoning. This means that it involves high-level thinking skills, especially critical thinking make decisions or conclusions from existing facts.

Table 3. Examples of Expressions for Each Level Written Argumentation Skills

Level	Expressions of Argumentation
0	I don't know yet, because burning garbage has become a common thing in society. This is a practical effort to reduce waste.
1	In my opinion, managing waste by burning is indeed a problem and contributes to the number of pollution that is dangerous to the health of living things.
2	Managing waste by burning garbage is not the best way because it causes air pollution, depletes the ozone layer, changes the global climate, and can interfere with breathing, such as shortness of breath. Besides, if the waste was burned plastic waste, the chemicals from that plastic will later turn into smoke and inhaled by humans, this is very dangerous.
3	Burning garbage increases the number of air pollutants. We can imagine that every house disposes of garbage by burning it, so any pollutants in the form of combustion smoke will form very much in the air. The smoke from burning waste contains CO ₂ and chlorine which causes damage to the atmosphere and global warming. The activity of burning trash also creates problems for health. If we breathe in CO, the hemoglobin in the blood which should function to circulate oxygen throughout the body will be disturbed so that the body will be deprived of oxygen.

Basically, students already have argumentation skills, but they have not been developed in the school curriculum. Therefore, the ability of scientific argumentation is important to be taught to students, especially in learning biology, so that they have logical reasoning from what they have learned so that they can explain the scientific phenomena that exist in everyday life. Also, students not only master scientific concepts, but students can learn to be actively involved in scientific argumentation [16]. Teachers can involve students in problem-based discussions to practice student argumentation. With students practicing argumentation, their critical thinking skills will develop [17], [18].

The students' understanding of the issue of burning rubbish and the project rice fields on peatlands seems still limited, even though this issue is familiar to them. This shows that students have not been able to analyze in-depth to get complete conclusions. Reflective judgment and argumentation skills must be trained and familiarized in the learning process so that students consciously decide to resolve an issue and communicate with a scientific explanation of the issues found with strong reasons or evidence. It is hoped that the results of this study can become a basis for teachers to apply appropriate learning models or strategies for students to optimize and incorporate reflective judgment and argumentation into biology learning.

4. CONCLUSION

Based on the results of the study, it can be concluded that the reflective judgment and argumentative skills of students in SMAN 2 Tasikmalaya class X-MIPA are still low. The reflective judgment skills in the pre-reflective category were the highest, compared to quasi-reflective and reflective categories. The written argumentation skills in level 1 were the highest, compared to level 0, level 2, and level 3. Students' learning habits are a factor in the limited emergence of critical thinking skills so that they affect the development of reflective judgment and argumentation skills. Students' reflective judgment and argumentation skills need to be trained and accustomed to the biology learning process using appropriate learning models or strategies.

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REFERENCES

- [1] R.S. Malik, Educational Challenges in 21st Century and Sustainable Development, *Journal of Sustainable Development Education and*

- Research 2 (2018) 11. DOI: <https://doi.org/10.17509/jsder.v2i1.12266>
- [2] K.S. Kitchener, P.M. King, Reflective Judgment: Concepts of Justification and Their Relationship to Age and Education, *Journal of Applied Developmental Psychology* 2 (1981) 92. DOI: [https://doi.org/10.1016/0193-3973\(81\)90032-0](https://doi.org/10.1016/0193-3973(81)90032-0)
- [3] A.W. Subiantoro, N.A. Ariyanti, Sulisty, Pembelajaran Materi Ekosistem dengan Socio-Scientific Issues dan Pengaruhnya Terhadap Reflective Judgment Siswa, *Jurnal Pendidikan IPA Indonesia* 2 (2013) 42-46. DOI: <https://doi.org/10.15294/jpii.v2i1.2508>
- [4] P.M. King, K.S. Kitchener, Reflective Judgment: Theory and Research on The Development of Epistemic Assumptions through Adulthood, *Educational Psychologist* 39 (2004) 6. DOI: http://doi.org/10.1207/s15326985ep3901_2
- [5] D.L. Zeidler, T.D. Sadler, S. Applebaum, B.E. Callahan, Advancing Reflective Judgment through Socioscientific Issues, *Journal of Research in Science Teaching* 46 (2009) 75–93. DOI: <https://doi.org/10.1002/tea.20281>
- [6] V. Dawson, K. Carson, Introducing Argumentation About Climate Change Socioscientific Issues in A Disadvantaged School, *Research in Science Education* 50 (2020) 865. DOI: <https://doi.org/10.1007/s11165-018-9715-x>
- [7] B. Robertshaw, T. Campbell, Constructing Arguments: Investigating Pre-Service Science Teachers' Argumentation Skills in A Socio-Scientific Context, *Science Educational International* 24(2) (2013) 195–196.
- [8] S. Erduran, S. Simon, J. Osborne, TAPping into Argumentation: Developments in The Application of Toulmin's Argument Pattern for Studying Science Discourse, *Science Education* 88 (2004) 916. DOI: <https://doi.org/10.1002/sce.20012>
- [9] D. Lazarou, S. Erduran, R. Sutherland, Argumentation in Science Eduaction as An Evolving Concept: Following The Object of Activity, *Learning, Culture and Social* 14 (2017) 51. DOI: <https://doi.org/10.1016/j.lcsi.2017.05.003>
- [10] K.L. McNeill, D.J. Lizotte, J. Krajcik, R.W. Marx, Supporting Students' Construction of Scientific Explanations by Fading Scaffolds in Instructional Materials, *Journal of the Learning Sciences* 15 (2006) 189. DOI: https://doi.org/10.1207/s15327809jls1502_1
- [11] F.-Y. Yang, C.C. Tsai, Reasoning About Science-Related Uncertain Issues and Epistemological Perspectives among Children, *Instructional Science* 38 (2010) 347. DOI: <https://doi.org/10.1007/s11251-008-9084-3>
- [12] F.-Y. Yang, Exploring High School Students' Use of Theory and Evidence in An Everyday Context: The Role of Scientific Thinking in Enviromental Science Decision-Making, *International Journal of Science Education* 26 (2004) 1356. DOI: <http://dx.doi.org/10.1080/0950069042000205404>
- [13] B.K. Hofer, Epistemological Understanding as A Metacognitive Process: Thinking Aloud during Online Searching, *Educational Psychologist* 39 (2004) 52. DOI: http://doi.org/10.1207/s15326985ep3901_5
- [14] C.-C. Tsai, Beyond Cognitive and Metacognitive Tools: The Use of The Internet as An 'Epistemological' Tool for Instruction, *British Journal of Educational Technology* 35 (2004) 527. DOI: <https://doi.org/10.1111/j.0007-1013.2004.00411.x>
- [15] S.E. Toulmin, *The Uses of Argument*, Cambridge University Press, 2003.
- [16] D. Kuhn, Teaching and Learning Science as Argument, *Science Education* 94 (2010) 810. DOI: <https://doi.org/10.1002/sce.20395>
- [17] N. Hasnunidah, H. Susilo, M. Irawati, H. Suwono, The Contribution of Argumentation and Critical Thinking Skills on Students' Concept Understanding in Different Learning Models, *Journal of University Teaching and Learning Practice* 17 (2020) 1.
- [18] A. Zohar, F. Nemet, Fostering Students' Knowledge and Argumentation Skills through Dilemmas in Human Genetics, *Journal Research in Science Teaching* 39 (2002) 35–62. DOI: <https://doi.org/10.1002/tea.10008>
- [19] C.P. Dwyer, *Critical Thinking: Conceptual Perspectives and Practical Guidelines*, Cambridge University Press, 2017.