Genetics in socio scientific issues: measuring rebuttal abilities in scientific argumentation

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Abstract. Genetics is one of the most important concepts in understanding Biology. Even though it is now widely applied in various socio-scientific issues, often, it also causes debate in the society, especially in the learning process. Students’ argumentation in addressing socio-scientific issues that arise can be used as an assessment to see how students think in supporting or denying their claims. Utilize the case study on 21 high school students in one of West Java public school; the study aims to see students’ rebuttal ability and the genetic concept they use to support their denial. The results showed that 34.92% students giving rebuttals, with 14.29% of them provide conceptual support that relevant to genetics, while another 47.62% students provide a general Biology conceptual support, 14.29% students provide a misconception of genetics, and 23.81% using an irrelevant concept. It shows that it is important to do the learning that supports the growth of rebuttal ability in the learning process so that students’ critical thinking ability becomes better, especially in understanding the genetic concepts in school and social life.

1. Introduction
Socio-scientific is an issue used in strengthening the process of students' scientific ability in discussing, debating, and solving problems [1]. Decisions made to resolve the issue can be expressed while providing an accurate argument to emerge the critical thinking process in it [2]. Students in various schools in Indonesia are still not much use of socio-scientific issues in helping the learning process to grow their critical thinking skills [3]. The same thing is expressed by Kolarova, that the lack of socio-scientific themes to give students not honed critical thinking skills, especially in giving socio-ethical considerations in society [2]. Values about right and wrong, immoral and immoral, wrong or true, are a consequence that society faces when responding to the use of science, especially genetics in everyday life [4].

Genetics is a science that is still difficult to understand in school: some of the things that make it difficult to understand because of its abstract, complex, and too many unintelligible genetic-related terms [5]. One of the causes that cause genetics is difficult to understand is an improper teacher teaching strategy that the concept does not extend to students [5]. Genetic technology in the world’s industries in the fields of food, pharmaceuticals, agriculture, and others have influenced the state of modern society...
today. For example, a pharmacogenetic study demonstrating that sociological societies in the genetic field provide political considerations regarding xenotransplantation of stem cells [6]. The controversy that will arise later in the debate over whether or not a genetic technology is used will be determined by the appropriate rebuttal so that the best decision can be taken by the policy maker [7].

Studies have shown that using socio-scientific in classroom learning in addition to improving critical thinking skills [2], also helps students decide on the ethical behaviour that underlies a decision [7]. Scientific literacy abilities [8], decision making [1] with a grounded rebuttal. Students are helped to establish the ability to defend his opinions on the current socio-scientific finding a growing issue in the community, if in the classroom more often teachers can introduce the concepts of biology, especially genetics to his students. Genetics in socio-scientific can be studied comprehensively more comprehensive from the underlying concept to its application in the life of society. Maintaining an opinion as to whether or not a genetically socio-genetic issue used in society requires a deep and high understanding of the fundamental genetic concepts. This means that socio-scientific themes provide an opportunity for students to build their ability to argue and defend the arguments they have put forward, since the resulting scientific concepts have an impact on the social sphere [9], as they usually cause debate.

Debates can be done in writing or orally-dialogically [10], with refutations rejecting and maintaining the argument itself (the group) accompanied by data that can break other people's arguments while strengthening the initial arguments that have been made [11]. Topcu, Sadler, and Tuzun [12] revealed that to build informal reasoning abilities, namely the ability to negotiate individuals, make conclusions and provide solutions to SSI conflicts given [13], [14] rebuttal is one of the most important components of argumentation. When debating, it means that students must provide a rebuttal for approval and disagreement about the issues raised. Refutation and Rebuttal must have sufficient data and evidence so that the rebuttal is accepted and can change the mindset or opinion of the opponent to enter into the logic proposed [15]. Based on the background, it is important to know and be introduced to students how to understand genetics through socio-scientific themes as well as how students make a rebuttal in addressing emerging issues.

2. Methods
This study uses a case study method, with 21 students majoring in Natural Sciences consisting of 11 students of class XI and ten students of class X in a high school in West Java Indonesia. Students are given three pieces of socio-scientific discourse on GMO plants, avian influenza, and genealogies of the descendants of the Ancient Egyptians. Discourse is directed at exploring the concept of genetics that is possessed through arguments and support for claims of arguments in the discourse. The data obtained are then analyzed using simple statistics to determine the structure of the argument students have, the structure of the arguments raised, and what genetic concepts are used to support the objections and support expressed. Furthermore, interviews were conducted with five best results of the subjects studied, Biology teaching teachers, and subject homerooms. The interview contains extracting information about student achievement in Biology subjects and the achievement of the five best students in all subjects in the class.

3. Results and Discussion
3.1. Results
The results of the research obtained three aspects, the first is about the composition of arguments constructed by students. The second is about the depth of rebuttal presented by the students. The third is analyzing the data or genetic concepts used by students to support and strengthen the rebuttal it put forward. The results of the first study can be seen in table 1 below.
Table 1. Composition of arguments structure constructed by students

|                | SSI  | Basic Argumentation | Advance Argumentation |            |          |          |
|----------------|------|---------------------|-----------------------|------------|----------|----------|
|                | Claim| Grounds             | Backing               | Warrant    | Rebuttal | Counterclaim |
| Pedigree       | Sum  | 21.00               | 21.00                 | 8.00       | 17.00    | 12.00     | 7.00     |
|                | %    | 100.00              | 100.00                | 38.10      | 80.95    | 28.57     | 33.33    |
| GE*            | Sum  | 21.00               | 18.00                 | 6.00       | 9.00     | 24.00     | 11.00    |
|                | %    | 100.00              | 85.71                 | 28.57      | 42.86    | 57.14     | 52.38    |
| Virus          | Sum  | 21.00               | 19.00                 | 6.00       | 11.00    | 8.00      | 8.00     |
|                | %    | 100.00              | 90.48                 | 28.57      | 52.38    | 19.05     | 38.10    |
| Average        | %    | 100.00              | 92.06                 | 31.75      | 58.73    | 34.92     | 41.27    |

*GE=Genetic Engineering

Based on table 1, it can be seen that from 21 subjects of this research, it was obtained only 34.92% that rebuttal appear in statements presented socio-scientific discourse. This means that only about seven people who can provide a rebuttal. The largest percentage of rebuttal was raised in the SSI genetic engineering discourse on transgenic crops. That is to say; transgenic crops have been more widely understood and known by the subject (in this case representing an educated society of the same age) as compared to the genealogical tree of genealogies of the Egyptian king's disease and bird flu. Bird flu is a socio-scientific issue that has recently graced the news in the mass media but has the lowest average among the three SSI discourses put forth. The subject's answer spreads are within the scope of the class X that has just received the Biology material about the virus, while class XI is less able to rebuttal the virus-related. The second research result can be seen in table 2 below.

Table 2. The category of rebuttal presented by the students

| Socio Scientific Issues | Category of Rebuttal | Attacking | Indicating an error in | Providing additional data |
|-------------------------|----------------------|-----------|------------------------|--------------------------|
|                         | Refutation | Claim | Claim | Ground | warrant | conclusion | data |
| Pedigree                | Sum        | 3     | 5     | 3      | 2       | 1          | 3    |
|                         | %          | 14.3  | 23.8  | 14.3   | 9.5     | 4.8        | 14.3 |
| GE*                    | Sum        | 5     | 6     | 5      | 2       | 2          | 2    |
|                         | %          | 23.8  | 28.6  | 23.8   | 9.5     | 9.5        | 9.5  |
| Virus                   | Sum        | 2     | 6     | 2      | 5       | 0          | 1    |
|                         | %          | 9.5   | 28.6  | 9.5    | 23.8    | 0.0        | 4.8  |
| Average                 | %          | 3.33  | 5.67  | 3.33   | 3.00    | 1.00       | 2.00 |

*GE=Genetic Engineering

Based on table 2, it can be seen that the rebuttal was raised by approximately 7 students. It is a small number from 21 students, but this can give an idea of how students are capable of rebuttal. The category of rebuttal seen is to attack the refutation or claim on the discourse; indicates an error in the claim, ground, warrant, and / or conclusion of the opinion expressed in the discourse; and providing additional data to support the rebuttal that has been put forward, based on these three criteria, only 15.87% attacked the refutation, and 26.98% attacked the claim; 15.87% indicates an error in opinion in the discourse, 14.29 indicates an error in the data, 4.76% indicates a warrant error, and 9.52% indicates an error in the conclusion; then from 7 students, only about 25.40% of students who provide additional data to support rebuttal it. The results of the third study can be seen in table 3, table 4, and table 5 as follows.
Table 3. The genetic concept of DNA and RNA used in rebuttal

| Respondents | Genetics | Bio General Knowledge | Wrong concept | Irrelevant |
|-------------|----------|----------------------|---------------|-----------|
| 2           |          |                      |               |           |
| 5           |          |                      | 1             |           |
| 8           | 2        |                      |               |           |
| 9           |          | 2                    |               |           |
| 11          |          |                      |               |           |
| 13          | 1        |                      |               |           |
| Sum         | 0        | 6                    | 2             | 0         |
| Percentage (%) | 0      | 50                   | 33.33         | 16.67     |

Based on Table 3 it can be seen that discourse on avian influenza with emphasis on the concept of viral replication involving DNA and RNA given to the students as many as 21 people. Only 6 out of 8 students included support data to strengthen their rebuttal. Distribution of data that support no one uses the conceptual data genetics; even there is two incorrect data concept. More data are expressed in the form of biological knowledge about viruses in general. It means that the student has not been able to associate or do not have knowledge in the field of genetics to be used in support of the rebuttal he proposed.

Table 4. Genetic concepts of virus used in rebuttal

| Respondents | Genetics | Bio General Knowledge | Wrong concept | Irrelevant |
|-------------|----------|----------------------|---------------|-----------|
| 1           |          | 2                    |               |           |
| 2           |          |                      | 1             |           |
| 3           |          |                      |               |           |
| 8           | 3        |                      |               |           |
| Sum         | 6        | 64                   | 37.33         | 16.67     |
| Percentage (%) | 66.67  | 33.33                | 0.00          | 33.33     |

Based on Table 4 it can be seen that the Concept of Genetics is quite good appears in the discourse on pedigree in the case of the Egyptian King Tutankhamun. Although from 7 people who mentioned rebuttal only four people who include data, two students of them provide data using genetic concept. One other student provided irrelevant data support, and one student gave data in the form of Biology knowledge in general.

Table 5. Genetic concepts of gene expression used in rebuttal

| Respondents | Genetics | Bio General Knowledge | Wrong Concept | Irrelevant |
|-------------|----------|----------------------|---------------|-----------|
| 1           |          |                      | 1             |           |
| 4           |          |                      |               |           |
| 6           | 2        |                      |               |           |
| 7           |          | 2                    |               |           |
| 11          |          |                      | 2             |           |
| 12          |          | 2                    |               |           |
| 19          |          |                      |               |           |
| Sum         | 3        | 12                   | 1             | 0         |
| Percentage (%) | 14.29 | 85.71                | 14.29         | 0.00      |

Table 5 shows that the SSI discourse on the inheritance of traits in genetically engineered Genetics Modified crops led to 12 students giving rebuttals with 7 students among them providing the support data for the rebuttal presented. 14.29% of them provide data using the concept of genetics, 14.29%
provide data with the wrong biological concepts, and 85.71% provide data with the concept of various knowledge of general biology.

3.2. Discussion

The research that has been done shows some things, that can be seen in table 1 that the students in general in argumentation is still on the basic argumentation structure of Toulmin [14], i.e., claim, grounds, backing, and a warrant. While the advanced argumentation structure of Rebuttal and Counterclaim is still rare in students [15], other studies have pointed out that, in students, the structure of the argument is still not well established, one of which is rebuttal and counter claim [16]–[18]. Rebuttal plays an important role in improving students' abilities in their cognitive, affective, and subtle psychomotor aspects. Studies of the concept of genetics using socio scientific issues will be more profound if the students in the discussion can use the rebuttal to strengthen the claims it expressed, as well as to confront even break the claim of the opponent [19].

The results of the study in Table 2 illustrate that of 21 subjects, only about five people can get rebuttal. This shows that the student is still weak in giving rebuttal against counter-arguments with his opinion. More refutation is a statement of disapproval of the counter claim but has not been able to show on what aspects of counter claims that have fatal aspects or missteps. Students also cannot provide additional data that can strengthen the denial. Only five students who presented rebuttal equipped with additional supporting data. What is worth noting is whether the additional data is correlated with the concept of genetics, or misconceptions of genetics, or in the form of general biological knowledge, or even data unrelated to the expected content.

The concept of genetics raised in the three discourses of socio-scientific issues does not necessarily make the students who made rebuttal can use the concept of genetics in as supporting data. Similarly, it has been shown in this study that content knowledge is rarely prominent compared to the social and ethical considerations of socio-scientific issues emerging [20]. The concept of genetics that emerges in table 4 can be seen in the following sentence:

"...as mentioned, that the inheritance of the nature to every offspring that was born only about 3.125%, so not necessarily every inheritance of the nature will exist in every birth line. Can be found other traits which will improve the offspring of other genetics" (Respondent number 2).

These students provide rebuttal support that although there is a possibility of 3.125% of recessive gene abnormalities inherited in the child from cousin marriage, it is most probably not lowered because it may be corrected from other genes (recessive genes do not meet with other recessive genes).

Other findings obtained from this research is, compared to other socio-scientific themes, students are more familiar with the discourse about transgenic crops, to provide rebuttal against counter claims that they did not think appropriate. The concept of genetics that emerged in one of them is as follows:

"...but what if the transgenic crops are actually contributing to the effect of changes in the nature of the consumer? It will be dangerous because the effects given can continue to increase" (Respondent number 12).

The student argues that there will be a change like a consumer who consumes transgenic maize in the future, although in detail not yet in-depth about genetics but is already a basic knowledge of gene expression and decreased properties.

4. Conclusion

The importance of rebuttal in the scientific argument seems to have not been much realized by the teachers in teaching the concepts of genetics. The low quantity and quality of rebuttal have been seen from research conducted using the discourse on the socio-genetic theme of genetics. On average it can be seen that the use of genetic concepts to support the rebuttal only ranged 14.29%, using general Biological knowledge of 47.62%, put wrong concepts in the genetics of 14.29%, and put an irrelevant concept of 23.81%. The research tells us that it is necessary to do a teaching or educational strategy to
be able to build and practice rebuttal in scientific arguments so that their critical thinking skills become honed.

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