Analyzing socio scientific issues through algorithm

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Abstract. This study aims to reveal whether the use of a learning model Dialogical Argumentation Instructional Model (DAIM) can improve the student’s ability to argue by using the concept of genetics in maintaining opinion using socio scientific issues. The research method uses mixed method, with the number of students studied as many as 36 students and 1 Biology teacher. The socio-scientific issue rose was about the use of mutant organisms and the acceleration of evolution with the help of biotechnology on transgenic corn. The results obtained that the ability to understand material rose between 1 - 14 points; there is an increase in the complexity of the structure of argumentation to level 6, and although it is low, the use of the concept of genetics as a basis for opposing and defending opinions can be seen.

1. Introduction
Biology is considered difficult subjects [1,2]. Even though students consider Biology is easier than other science subjects such as Physics and Chemistry, but from the acquisition aspects of the test results, it turns out to be the same as the others [3]. If asked to students which is more difficult between the three subjects, almost all students say Biology is easier. Just Say that is true, but are students able to apply what they consider easy in the context of everyday life? Especially if the raised issues in the context of socio-scientific issues, it turns out that not many can answer these issues using the concept of Biology [3]. Biology cannot be separated from genetic concept, a concept which according to some studies is one difficult concept. Genetics provides information about how living things are formed, how cells control all metabolic functions of living things, even genetics helps predict what life will be today when certain possibilities occur to it. We should say that genetic are the core of biology.

Genetic characteristics are quite abstract and complex with various accompanying symbols are often regarded as the hardest part in Biology subjects [1,3,4]. In high school, the subject about viruses in class X to biotechnology in class XII seems impossible to separate from genetic studies. How absurd it is to understand Biology without mastering genetics. Genetic concept distribution in Indonesia curriculum at most of high school are in class XII. Among them are Heredity, Mutation, Evolution, and Biotechnology. The introduction of the genetics was introduced regarding genetic substances that explained about DNA, RNA, and Dogma Centers. Students often find difficulties in understanding genetics when the teacher gives actual cases of genetics (SSI) from the community [3,5]. Students give opinions logically about the cases without being able to provide the right theoretical foundation.

In biology textbooks in Indonesia, for example, there are cases of Genetics Modified Organism (GMO) crops (soybeans, corn, tomatoes, etc.). Such cases are discussed during study only with a biotechnological perspective. Only revolves around how to make it, what principles are used, for what, and the benefits in society [6]. But it is rarely found to discuss how GMOs are examined in terms of gene
expression, or how the donor DNA and recipient DNA adaptations are connected. Maybe the study is too deep for the high school level, but at least students can do logical reasoning if they are able to bring up the right data to support their opinions. What interesting thing that caused it are the one-way learning method in Indonesia are still a common thing to do during class session [7]. Frasser said that this type of learning prioritizes teachers as the only source of learning in the classroom and students are considered as objects that have low involvement in building their abilities [1]. If the teacher raises such of socio-scientific issues spoken before, students tend to wait the information from teacher to gain solution as their decision in solving the problems. One-way communication between teachers and students limit

Students’ reasoning in expressing opinions. Reluctance to the teacher and not normally speaking scientifically in class is an obstacle in understanding the lesson, especially in genetic material in Biology. The socio-scientific issues’ is actually very good in eliciting a comprehensive understanding of the genetic concept [8]. The case that often become headlines in the society are studied scientifically in the classroom from a genetic point of view, such as cases of mutations in down syndrome, cases of consanguinity marriage that have the potential to inherit dangerous diseases, or the safety of Genetics Modified Organisms’ (GMO’s) products. The use of dialogic learning models can be an alternative solution so that the ability to study concepts from factual cases arises in students. One of the learning models is the Dialogical Argumentation Instructional Model (DAIM) that can be used to make relevant decisions about socio scientific influencing their everyday experiences [9,10]. Through this paper, it could be seen how DAIM raises students’ understanding of genetics through socio-scientific issues.

2. Method
The method used in this study is mixed method [11], of the 3 schools studied at high school in West Java Indonesia, only one school will be discussed in this paper. The research conduct in 3 classes, one of them using DAIM as a method, the others are using Scientific writing heuristic (SWH) and combining method between DAIM and SWH. In this paper, only one class which using DAIM only will revealed the results. The study was conducted for 3 months with the support from the Biology teacher. The material is focused on Mutations, Evolution, and Biotechnology. Those materials were previously already given by the teacher, and this research aimed to sharpening students’ understanding by their genetic knowledge point of view. The learning model used is the Dialogical Argumentation Instructional Model (DAIM) [12], which is a dialogical argumentative learning model using socio-scientific issues. Socio-scientific issues rose in terms of mutations regarding the use of mutant organisms. The socio-scientific issue given for evolution and biotechnology material is about transgenic corn, the issue is raised from two sides of material because biotechnology is considered an agent that accelerates the process of speciation in the evolutionary process.

Quantitative assessment of understanding mutation, evolution and biotechnology material was carried out by giving pre-test and post-test before and after the learning treatment using DAIM. The pre-test and post-test questions about Biology concept as seen in Figure 1, were made with focus on the genetics concept. Though the problem is about mutations, the aspects that were asked are about genetics. Qualitative assessment is taken about the structure of the argument before intervention, during intervention, and after intervention. Questionnaires are given to students before and after treatment to see students’ assumptions about the learning process. Interviews were conducted on 15 selected students and on Biology teachers in the class. Data retrieval during learning using the DAIM model was recorded using a video recorder during group discussions and class discussions. More details about method, can be seen in figure 1.

3. Result and discussion
In this section, the results of quantitative and qualitative research will be displayed from the DAIM class studied. The pre and post-test are the quantitative result and the structure of rebuttal argumentation are the qualitative result. The qualitative result is focusing on how rebuttal structure improved by the data that contain genetically concept to strengthen their arguments. The research design method as seen on Figure 1, are clearly showed that the quantitative are embedded into qualitative research. The overall
result will discuss in other paper to complete all the analysis.

3.1. The result of pre-test and post-test scores
The results of the study are divided into 2 main parts, namely qualitative and quantitative results [11]. As stated in the methodology section, quantitative data taken regarding changes in students' cognitive knowledge results before and after the provision of learning using DAIM. The question of mutations is 30, the question of evolution is 15, and the question of biotechnology is 15. The results of the comparison of values before and after treatment can be seen in Table 1.

Table 1. The average result of the pre-test and post-test.

| Scores average | Mutation | Evolution | Biotechnology |
|----------------|----------|-----------|--------------|
| Pre-test       | 35.46    | 37.69     | 32.90        |
| Post test      | 38.43    | 39.07     | 53.89        |
| Sig. 2-tailed  | 0.573    | 0.041     | 0.000        |
| Mean           | -1.088   | -5.466    | -14.833      |

*Score scale between 0 – 100

Table 1 shows that the value of students has increased in each material with learning using DAIM. The results of different tests showed no significant differences for mutation material (sig. 2-tailed) of 0.573 with an average increase of 1.088 points better in the post test. The results of the different test showed that there was a significant difference for the evolution material (sig. 2-tailed) of 0.041 with an average increase of 5.466 points better in the post test. The results of different tests showed that there were significant differences in biotechnology material (sig. 2-tailed) of 0.000 with an average increase of 14.833 points better in the post test.

Early on, students were given learning using DAIM by being given a socio-scientific discourse regarding the use of mutant organisms, the teacher seemed to still not understand how to give discussion questions so that student arguments emerged. Students and teachers still appear to be in the old learning way even though there has been debate among students in the group. Students still find it difficult to make arguments because previously they were not used to arguing. The next lesson on the socio-scientific theme of evolution and biotechnology, students are more focused because the teacher has seen the shortcomings done before, so learning with DAIM is in accordance with the syntax.

Even though the post-test achievement rate is still far below the standard value applied (75 minimum) but the change in results from before and after the intervention shows an increase. This is because learning about mutation, evolution, and biotechnology takes actual cases in society. Students tend to have more interest if learning is thematic, with social issues that do occur in the community and contain controversy or debate [13].

Figure 1. The research design method.
3.2. Improved structure of argumentation

Qualitative summary results regarding the increasing complexity of the argumentation structure can be seen in Table 2. Table 2 shows that in SSI mutant’s organism there was a change in support of 11 people out of 23 students who expressed their opinions (13 other people did not give opinions). There are students who previously supported opinion A to support opinion B, or vice versa. Even then, there are students who turn to opinions A and B. The socio-scientific given asks students to determine whether they support A’s opinion that allows the use of mutant organisms, or supports opinion B which prohibits the use of mutant organisms. Each support must include reasons and data that strengthen the arguments. Similar result appears in SSI transgenic corn, out of 18 people who expressed opinions, at the end of the meeting there were 10 people whose opinions changed. That is, Table 2 shows that learning using DAIM can give rise to other considerations in students' thinking about the issues being discussed, that is what makes students then switch to supporting different opinions or remain firm on their initial support.

**Table 2.** Comparison the number of students who make changes in support and the level of student argumentation structure after intervention.

| SSI            | Change of support | Level argument structure |
|----------------|-------------------|-------------------------|
|                | Change | The same | Better | The Same | Less |
| Mutant’s Organism | 11     | 12       | 18     | 3        | 2    |
| Transgenic Corn  | 10     | 8        | 5      | 9        | 5    |

This result is reinforced by the high complexity of the argument structure that was built after the intervention. The complexity of the argument structure has increased for 18 students. Structure complexity is on average at level 3, which has the structure of claim, grounds, and warrant. Previously the average was in the structure of claim and ground, with ground only in the form of logic thinking, not data obtained from other people's research results or other literature. Even among them, there were 2 student who achieved level 6, with structures of claim, grounds, warrant, backing, rebuttal, and counterclaim. Although this level 6 cannot be maintained until the final results, but students have shown that they are able to gain reasoning to higher level. More details can be seen in Table 3.

Chris Reed and Douglas Walton show the results of their research that the structure of the arguments held by high school students tends to revolve around claims, ground, and warrant [14-16]. Backing tends to be difficult to express especially during oral discussions directly in class, because it was hard to find an evidence instantly after the question from the opposite group [17]. This is related to the time or opportunity to seek strong and grounded data support to be logically narrated [18]. As is known, that the time of learning Biology with the density of the curriculum, limited teacher resources and the large number of students in Indonesia, does not allow to expand the scope of the discussion [7,19]. Therefore, DAIM can be used to help dialogically argumentative thinking processes through social scientific issues.
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In Table 3, it can be seen that there is an improvement in the structure of argumentation from SSI mutation to SSI transgenic corn. The interesting thing in the SSI transgenic corn discussion are the absence of students who can reach the complexity of argumentation at level 5 and 6. Even though there were only 4 students at level 1 (claim and ground) it seems that DAIM has not been able to optimally build the complexity of argument structure. Seems students have insufficient verbal ability and less courage to expressing their opinions with providing opinions that are grounded and explained through good logic. Dore said that to make an argument, the thing to do is to limit the topic, choose material that fits the theme of the discussion, arrange the discussion material in order, write what will be delivered (after going through revisions) and read the main literature related to the theme [20]. Students when conducting arguments through DAIM, without being trained and not trained to limit discussion and write reviews of data search results. So that in response to the opinions of opponents, students are less able to strengthen with the right data and backing.

Another important finding is when exploring the ability to argue among students during class discussion between opposing and supporters’ group. The summary results can be seen in Table 4, which shows that when arguing and answering the questions from teachers and other students, compared to SSI mutation, there are 6 students who are able to express their opinions in highest level (claims, grounds, warrant, backing, rebuttal, and counterclaim). Of the 36 students, while discussing evolution and biotechnology in SSI transgenic corn, there was 15 students were able to provide their arguments with warrants and backing and 7 people could give rebuttal on opposing arguments. Research conducted by Muller, Gleason, and Dore showed more or less similar results, that when arguing in scientific debates with social scientific issues or other actual things, students tended to maintain their opinions by using the support of data from various literature they had read or summarized [20–22].

**Table 3. Comparison of the argumentation structure level.**

| Level | Pre test | Post test | Pre test | Post test |
|-------|----------|-----------|----------|-----------|
| 6     | 0        | 1         | 1        | 0         |
| 5     | 0        | 3         | 0        | 0         |
| 4     | 1        | 4         | 2        | 3         |
| 3     | 5        | 10        | 8        | 12        |
| 2     | 8        | 6         | 3        | 11        |
| 1     | 11       | 0         | 6        | 4         |

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**Table 4. Comparison of the argument structure level during treatment.**

| Level | SSI | 6 | 5 | 4 | 3 | 2 | 1 |
|-------|-----|---|---|---|---|---|---|
|       | Mutants Organism | 1 | 1 | 5 | 5 | 3 | 0 |
|       | Transgenic Corns  | 6 | 2 | 3 | 4 | 2 | 0 |

Table 4 also shows that the ability to understand biological concepts can be explored by being given the appropriate socio-scientific issues. Foresight of teachers in helping to expel students' potential logic does provide an important role. Without teachers’ ability to lead students into deep discussions, students will not be able to bring out their best potential in argumentation [23]. This can be seen in the discussion of the socio-scientific issue regarding mutations, during the class discussion, the teacher was more passive in giving questions, more of which served as moderators of the discussion. Most dialogues between are around the concept of mutation, not yet deep onto why and how. The results of the interview with the teacher showed that she still did not understand well how to give the questions so the argumentative discussion would proceed. The same research result is delivered by Abdul Rahman that mechanistic
world influence to help student gain the better understanding are culture, school condition, teacher characteristic, and learning activity [24]. The syntax in DAIM as Diwu explain in his dissertation, requires the existence of a teacher review, not just inviting opposing groups and supporters to argue [12,25]. These difficulties are overcome by reviewing the learning process with the researchers, so that better results can emerge at the discussion session on SSI transgenic corn.

The main purpose has come from this research, what about the concept of genetics in the results of this study? Does it arise in strengthening the argument? Although low, but in Table 5 it can be seen that after the intervention using DAIM, the complexity of the structures at levels 4, 5 and 6 emerged that had a backing, counterclaim, and rebuttal structures. Students who give rebuttal tend to provide additional data in the form of statistical data, expert opinion, or the results of the research obtained at the time of exploring information about SSI being discussed. Christenson on her dissertation revealed that the distribution of the different supporting reasons founded in the data they search to support reasoning about SSI from different subject area. On this case that was when they change them though from A to B or vice versa [26]. There’s a gap time between pre-test, intervention, and post-test time, and researcher found interview data that during the post test, students reconsider previous support by comparing data during discussion (during intervention).

### Table 5. Comparison of rebuttal levels.

| Level | SSI Mutants Organism | SSI Transgenic Corn |
|-------|----------------------|---------------------|
|       | Pre-test | Post-test | During Intervention | Pre-test | Post-test | During Intervention |
| 1     | -        | -        | 4                   | -        | -        | -                   |
| 2     | -        | -        | -                   | -        | -        | -                   |
| 3     | -        | 1        | -                   | -        | -        | 1                   |
| 4     | -        | 1        | 2                   | -        | -        | 1                   |
| 5     | -        | 1        | 4                   | -        | 1        | 7                   |

Post-tests regarding SSI mutation organisms were only able to bring up 3 students, each of whom were in rebuttal levels 3, 4, and 5; even at SSI regarding post-test transgenic corn only gave rise to one student at level 5. The distinguishing characteristics of rebuttal level 1 to 5. Note that the rebuttal level that appeared at the time of the intervention using DAIM showed that 2 at level 4 at SSI mutants’ organism and 1 student at SSI transgenic corn. That is, these students are able to provide additional data on genetics in general to support their objections to claims, data, warrant, and even the backing of opposing groups. An example that can be taken is the rebuttal given by student number 30:

> From the data that I got, humans have eaten different kind of organism, but for thousands of years, humans have never turned into other organisms, indeed mutants are not native organisms, but in fact the DNA those consisting of 5 nitrogen base (adenine, guanin, cytosine, thymine, and uracil) the same DNA we had. That mean it will not cause any harm, because humans also have the same nitrogen base”

The underline sentences are clearly an irrefutable concept of genetics, that humans like other organisms have the same 5 nitrogen bases. It's just that the composition and expression of the genes are different which causes different species differences.

Other sample we can use are rebuttal from student number 29: “Why do I stand both in groups A and B, because the support has advantages, and opponents also have advantages. Because of every opponent and supporter of evolution, they have their own reasons. The problem is that A, it is (transgenic corn) safe, does not harm another organism. We (I) agree that genetic engineering is safe but detrimental to the engineered organism because the organism does not know itself as a whole, because it has been engineered so that the expression of the gene’s changes from the original.” The underline sentences are also said the genetic ground and backing as student no 30 in a different case of SSI and in a different stand point. Those mean that DAIM can help teacher reveal student’s ability to expressing their opinion or argument in the socio-scientific issue with a genetic point of view.
4. Conclusion

The conclusion that can be drawn from this study is that the use of the DAIM learning model is able to encourage students to provide complex arguments in terms of structure and supporting data to maintain the stand points they hold. The results of mastery the concepts of mutation, evolution, and biotechnology also show an increase in the average value of 1 to 14 points. Although low, the concept of genetics that emerged during the intervention using DAIM can be seen and can be used as a reference basis for future research. The short time learning in class, to many students and the unfamiliar teacher with DAIM make those the obstacles in this research. It is necessary to find a solution to this problem, perhaps by providing teaching assistance in 1 class beside the main teacher (collaborative teaching) or by thematic learning using other socio-scientific issues that are more appropriate.

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