



The Use of Scientific Writing Heuristics (SWH) to Build Rebuttal Abilities in Scientific Argumentation

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article info

Article history:

Received: 4 September 2019

Received in revised form: 1 November 2019

Accepted: 4 November 2019

Available online: 31 December 2019

Keywords:

Argumentation

Rebuttal

Scientific writing heuristic

Socio Scientific Issues

TAP revised framework

abstract

The research aims to build and measure students' abilities in rebuttal using the Scientific Writing Heuristic (SWH) approach. This mixed-method research method was carried out for 5 months on 38 students, at a high school in West Java, Indonesia. The issue of socio-scientific genetics is given the theme of Genetic Modified Organisms with rebuttal measurements using the updated Toulmin argumentation framework. Qualitative and quantitative data are taken in this article in the form of argumentation before, during, and after treatment; coupled with deep interviews and questionnaires as well as observation of discussions. The results showed there were changes and improvements in rebuttal ability by 27.15% (30 students). The distribution of the strength of evidence is at most level 2 at 48.7% with a weak category, at level 3 at 30.8% with a strong enough category, at level 4 at 20.5% with a strong category.

2019 Scientiae Educatia: Jurnal Pendidikan Sains

1. Introduction

Argumentation in the last twenty years has been seen as a way to deepen understanding of issues developing in society. Social and scientific issues are undeniably a trigger for debate in ordinary people and academics. Each as a representative of the people who have concern for the development of the world as if competing to give their opinions on support or rejection of the issue (Rapanta & Macagno, 2016).

Researchers in the field of argumentation (Braund, Scholtz, Sadeck, & Koopman, 2013) state that argumentation is the center of coordinating theory and evidence for a problem to find conclusions. Cetin and Horng reveal that the argumentation can encourage inquiry knowledge in understanding science with data and evidence as a basis so that a connection can be established (Horng, Lu, Chen, & Hou, 2013). The same thing was expressed by Larrain that the argument raises an independent desire to ask questions, criticize, strengthen opinions using appropriate and strong evidence, so that an appropriate assessment will be

obtained in accepting differences in the knowledge that is correlated with ethical and social issues (Larrain, Freire, & Howe, 2014).

Specifically regarding rebuttal, is part of the argument (Anisa, Widodo, & Riandi, 2017), even rebuttal is the argument itself which arises when students defend their opinions from the attacks of opponents. Personal decisions are taken in producing claims to respond to an argumentative matter that certainly goes through various stages of consideration. Someone will evaluate various evidence or accurate data so that it can be used as a strength in giving a rebuttal to the claims made (Lee, Chao, & Chen, 2011; Pabuccu & Erduran, 2017; Weng, Lin, & She, 2017). The ability to reason will develop (Kim, 2014) and be able to connect data elaboratively with other opinions that arise (Nussbaum & Schraw, 2007). That is, a person in submitting a counter argument must include rebuttal by providing a lot of supporting evidence must also have engagement or engagement with the decisions he made (Tschida, 2012) (Harland, Wald, & Randhawa, 2017).

Accuracy of observation to collect data and facts that can support a rebuttal conducted by students in the learning process in the classroom and outside the classroom (Chen, Lin, Hsu, & Lee, 2011). This observation activity can be carried out through the inquiry process (Khishfe, Alshaya, BouJaoude, Mansour, & Alrudiyan, 2017). Students will understand and understand that an argument in science will be strong if it is supported by facts and data obtained through research. The process of inquiry in building a rebuttal makes students get new concepts and helps them make interconnections between old concepts and new concepts they obtain even in a hypothetical framework (Wu & Tsai, 2007).

The teacher can provide an assessment of students' argumentation abilities by determining certain criteria based on a framework. Many researchers in the field of argumentation have provided a framework for assessing arguments, but to assess rebuttal abilities are a rare thing. Walton is one of the argumentation experts, who provided a basic framework to develop rebuttal ability, and that framework is from the analogy of arguments by Pollock and the refutation procedure by Goodwin (Metaxas, Potari, & Zachariades, 2016). Pollock does not reveal the existence of a critical question (also referred to as refutation) in conducting rebuttal, but the example that he revealed can be used as a foothold (Walton, 2010). Toulmin (Toulmin, 2003) as the forerunner of the argumentation observer who has recorded his thoughts in the field provides the basic pattern of arguments consisting of claims, data, warrant, backing, qualifier, and rebuttal.

Koeneman said (Koeneman, Goedhart, & Ossevoort, 2013) that the weakness of the Toulmin Argumentation Pattern (TAP) is that the pattern is only based on the appearance of the argument structure, but does not pay attention to the evaluation of the argument. Toulmin does not provide an analogy of logical validity as an evaluation of argumentation. This means that TAP cannot give a picture of how reasoning in students' thinking in giving birth to the arguments they put forward. Especially for rebuttal, in TAP is a situation that is contrary to claims, does not provide reinforcement. Osborn sees that if the TAP is added to the criticism, strong criticism will emerge and explore students' inquiry experiences (Osborne et al., 2016)

Toulmin also gives direction that rebuttal is a claim that presents conflicting data (Du, 2017), it's just that Toulmin's example and pattern of rebuttal is too simple and cannot comprehensively reveal that rebuttal is also an independent claim. The rebuttal has a complex structure from the aspect of proof so that claims that are different from the opponent's claims can be accepted and understood. Without strong and correct evidence, rebuttal cannot refute an opponent's attack on the initial claim that is supported or raised. Weaknesses in this TAP have led to the need for a new framework based on the validity of the opinion (arguing) of students in addressing the existence of pros and cons arguments regarding socio-scientific issues, especially in this research in the field of genetics. Next in this article, the arguments put forward by students are a form of rebuttal in the form of rebuttal or refutation. Kuhn argues that when the opponent's argument is followed directly by another counter-argument introduced by the original speaker, the second counter-argument serves as a refutation that removes or reduces the strength of the opponent's argument at the beginning (Kuhn & Udell, 2003).

Disclaimer of an argument can be in the form of refutation that attacks certain aspects in an argument, such as attacking claims, data warranties, backing, and even counter-arguments. Someone who refutes, of course, must defend the previous opinion by enriching and strengthening the building of arguments accompanied by correct evidence and related to the context of the refutation, this is what is called a rebuttal. Rebuttal strengthens the argument building that has been made before. A person who is refuted will likely be convinced that his argument is wrong or incorrect so that the initial argument becomes defeated and recognizes the truth or strength of the evidence presented by the opponent. That is, rebuttal made opponents are still weak and easily defeated in the proof. The difference between the two is

that rebuttal must provide evidence while refutation merely criticizes many aspects of conflicting opinions.

Of course, to be able to practice the ability to argue requires away as a bridge that makes it easy for teachers to get used to it to students. The scientific writing heuristic (SWH) approach is seen by some experts as being able to bridge this. SWH was developed by Brian Hand who guide students to think inquiry (Erkol, Kişoğlu, & Büyükkasap, 2010). The steps in SWH help students carry out the negotiation and exploration phases in the process of understanding various empirical findings to find concepts. Claims are made based on observations made, so students can develop the widest investigation to find data and evidence so that it is possible to refute the claims of other students.

The SWH approach is very structured so that students can be attracted to the situation of reasoning and transform evidence into claims (Akkus, Gunel, & Hand, 2007). This evidence can then be used as a platform to accept or refute a claim. This approach has provided a template that guides students and teachers in carrying out scientific activities and writing down their reasoning, so said by Hand and Keys in Akkus (Hand, Norton-Meier, Gunel, & Akkus, 2016) that SWH is a bridge between formal and informal writing skills that accelerates the construction of scientific understanding and reasoning. The template used in SWH as used by Akkus in his research can be seen in the following table 1 (Akkus et al., 2007):

Table 1. SWH Templates for Teachers and Students

Teacher Activities	Students Activities
1. Exploration before learning through concept mapping individually or in groups	1. Giving / asking questions
2. Pre-learning activities (writing observations, brainstorming, and asking questions)	2. Preparing for an investigation, what will (must) be done 2. Preparing for an investigation, what will (must) be done
3. Learning activities	3. Observations
4. Phase I negotiations: Write a learning journal	4. Make a claim
5. Phase II negotiations: Compares data obtained from observations in groups of students	5. Prepare, establish and interpret the evidence and claims supporting data
6. Negotiations phase III: Compare ideas from sourcebooks with students' discussion results	6. Comparing the claims made with the claims of other friends (groups).
7. Negotiation phase IV: Reflections individually or in groups	7. Reflecting the results of self-investigation and other people (groups)
8. Explore students' understanding through mapping concepts that have been discovered	8. Write an appropriate explanation as a clarification of the understanding that has been obtained

SWH Template as in Table 1 will be used as a bridge to training the argumentation of students in building rebuttal with socio-scientific issues at the source of Genetic Modified Organism (GMO) or genetically modified organisms. The choice of GMOs as an issue in learning in this study because the application of technological advances in genetic engineering to various products for human welfare has moved beyond selective breeding by manipulating the genetic material of an organism in ways that cannot occur naturally, and this has caused significant controversies including the loss of diverse biological and food safety concerns (Lederman, Antink, & Bartos, 2014). Using GMOs as an issue is not intended to bring students to reject or support the issue, but to provide opportunities for literacy so that the reasons put forward to support and or refute the opinions of others must be based on correct understanding.

Socio-scientific issues provide opportunities for students to crafting or form their ability to argue. The problems that exist in socio-scientific issues are based on scientific concepts that have an impact on the social realm because of their nature which causes debate (Ekanara & Rustaman, 2016). The existing debate will bring up considerations in the form of support and refutation of the issue to be able to make decisions objectively and rationally. It is very interesting to know whether this SWH can bring good rebuttal skills to students in addressing socio-s scientific issues regarding genetically modified organisms. A good measure of whether or not a rebuttal that appears on students will be analyzed using a new framework (see figure 2) Toulmin argumentation patterns that have been improved. Several levels of categories will group students according to their progress in the learning process.

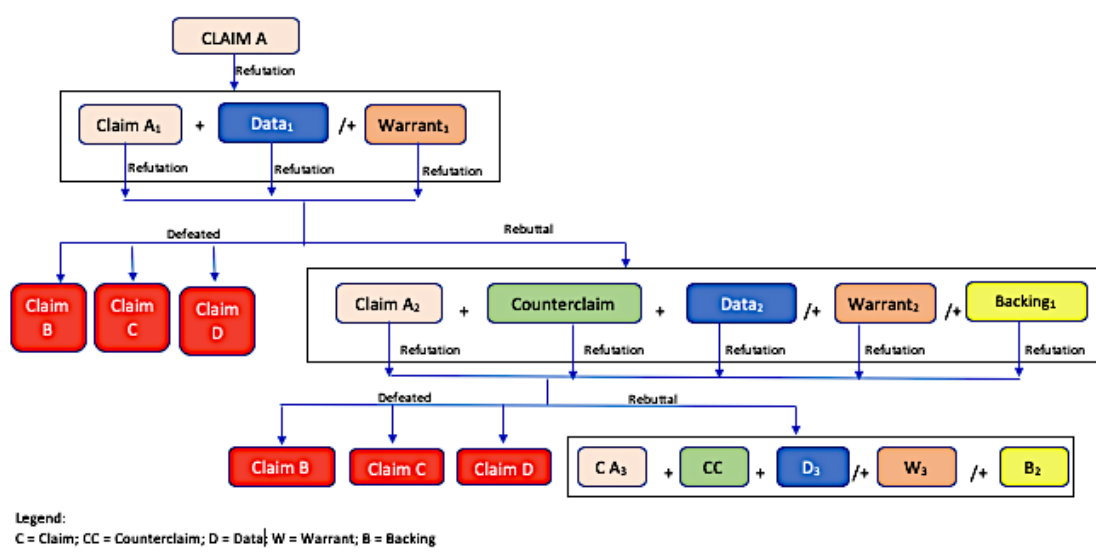


Figure 2. Improved Toulmin Argument Framework Scheme

2. Method

The method used in this research is a mixed-method embedded experimental model (Creswell, 2003). Exposed to the results to be discussed and discussed are the results of qualitative research alone about the level of change in students' rebuttal abilities in addressing the issue of GMOs. The study was conducted for 5 months in one of the state high schools in the West Java Province of Indonesia, with as many as 38 students in class XII Science and 1 Biology teacher. The research design can be seen in Figure 1. It can be seen in Figure 1 that the treatment was given to students after pre-testing the material content (mutation at the first meeting and evolution-biotechnology content at the second meeting) and written argumentation about GMOs (use of organisms' mutants at the first meeting and the use of transgenic corn at the second meeting). Next, after the pre-test is the treatment of the learning process with the SWH approach, ending with giving a post-test regarding the content of the material and written argumentation. The final step is to interpret the combined results of the pre-during-post during the learning process.

Data sources used and discussed in this paper are the results of argumentation tests before, during and after treatment interventions using SWH. Other data sources are the results of the student worksheets, interviews with teachers, interviews with 10 students, questionnaires at the beginning and end of treatment, and observations of the learning process in class. The learning process is documented using video and audio then transcribed into writing to facilitate data analysis.

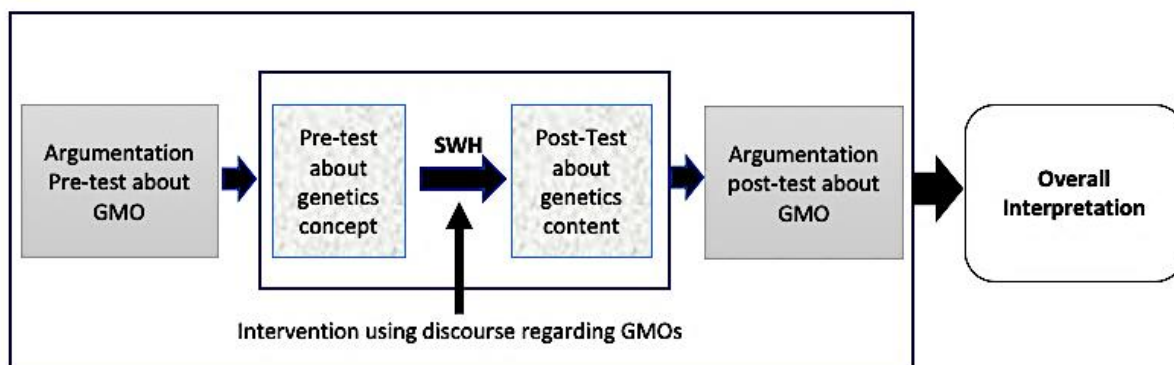


Figure 1. A mixed-method embedded experimental model research design that is used to build rebuttal capabilities

The discourse given to students is GMO-themed. The first meeting raised the use of mutant organisms and the second meeting regarding the use of transgenic corn. The final part of the

discourse, students are given two opinions pros and cons of the community, then students are asked to answer the following questions:

1. Which opinion do you prefer?
2. Why don't you agree with other people's opinions?
3. Tell us your reasons based on data!

2.1. Framework

The framework used is a revision of Toulmin's argumentation pattern (TAP) whose scheme can be seen in Figure 2. Based on the framework in Figure 2, leveling is carried out based on how much evidence (data, warrant, and backing) that students can express during the argumentation process take place. The lowest level if only able to make a claim only, the level will increase if students provide more evidence that defends (rebutting) or attack (refuting) the opposite arguments. The next analysis is seen from the strength of the evidence presented. If students only submit claims without reason, then the argument is at the first level, if it provides evidence in the form of opinions from personal subjective judgments and/or incorrect data and/or misleading data, then it is at the second level. The complete level of evidence strength can be seen in Table 2.

Table 2. Categories of strength levels of evidence presented in the argument

Level	Descriptors
1	If providing a claim without including evidence
2	If providing a claim with evidence in the form of one or both: <ol style="list-style-type: none"> a. Opinions based on personal judgment, and/or b. Incorrect data, and/or misleading
3	If providing a claim with evidence in the form of one or both of them: <ol style="list-style-type: none"> a. Opinions based on personal judgment, and/or facts b. Data: <ol style="list-style-type: none"> 1) wrong, and or; 2) misleading, and or; 3) true but not related
4	If providing a claim with evidence in the form of: Opinion based on facts alone, together with correct but unrelated data
5	If providing a claim with evidence in the form of facts and data that is true and related

2.2. Intervention

The first and second meetings each consist of 3 times face to face, each with 2 lesson hours. The first 2 hours of learning after the pre-test of students are conditioned to work on the worksheets that help students do the learning steps in the SWH approach. Worksheets contain guidance adapted from the SWH template as in Table 1. Scientific socio-scientific discourse is then given to each individual to be examined, then students are guided to fill in

Worksheets by the teacher. The teacher acts as a facilitator with the method of teaching questions and answers, so students do an inquiry to find answers to the questions they have written in the worksheet.

Negotiations are conducted between the teacher and students, and between individual students. The reference sources offered by teachers are in the form of the internet (which can be accessed using their respective smartphones), and/or Biology textbooks that have been provided previously. Students will take notes in the worksheet regarding the reasons behind their support, until an individual conclusion is obtained about the reasons for supporting claim A or claim B, or even supporting both claims.

The next 2 hours of learning students conduct group discussions following group claim A, claim B, or claims that support A and B. The negotiation process is also carried out with the facilitation of teachers who do scaffolding from group to group. The final results of the group conclusions will be brought and used as the group claims to conduct open class discussions between the two (or third) large groups using a debate system. The last 2 hours were carried out post-tests regarding the content of the material and the arguments

3. Result and Discussion

The discussion will begin by looking at changes in the level of argumentation and the strength of rebuttal evidence to further explain the level of distribution achieved by students in building rebuttal.

3.1 Changes in Argumentation Level and Strength of Rebuttal Evidences

The results of changes in the level of argumentation of students obtained can be seen in Fig. 3 which shows a fairly large change in the decrease in the level of argumentation from the first intervention. The results of the first intervention's post-test argument showed that there was a decrease in the level of argumentation by 48,4% from high to low level and only 3,2% who leveled up.

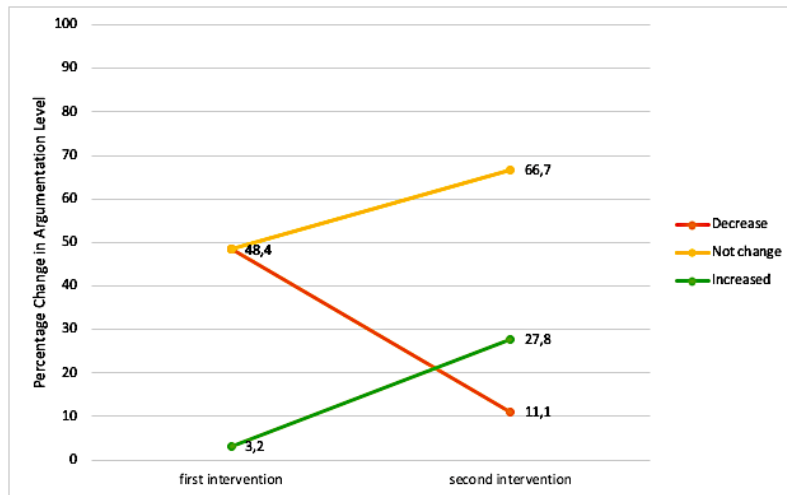


Figure 3. Percentage changes in the level of argumentation of students at the first and second meetings

The second intervention in Fig. 3 shows that the change is quite drastic, only 11,1% whose level of argument dropped, 27,8% who went up and 66,7% who's not changed their level.

The distribution of the level of argumentation can be seen in Fig. 4, most were still at level 2 of 80,6% in the first intervention and then began to shift to 59,0% in the second intervention. There are no more students whose arguments are at level one. The shift can be seen in Figure 4 going up to levels 3 and 4 at the second intervention. A shift to a higher level occurs because in the learning process using SWH, there are negotiations between themselves and the environment (teachers and peers) in confirming the truths of the various data obtained.

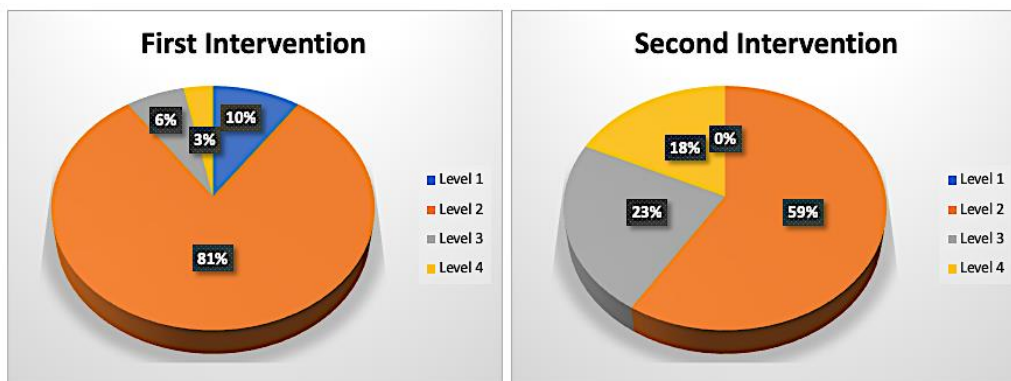


Figure 4. The percentage distribution of students' argument level at the first and second interventions

Some data written in Student worksheet shows improvements in the number and source of information, from tertiary sources such as blogs, wikis, and even from WhatsApp messages; at the second intervention, it became a secondary source from quotations of research results in the form of clipped articles or paper reports. In addition to improved data sources, students hold discussions three times, in individual activities, group activities, and class discussion

activities. Students during the discussion can get new information and data to enrich what they have obtained individually.

Improvements can be seen in the student worksheet, there is data that was ultimately decided not to be taken because it weakens the arguments it supports. This means that students reconcile the data obtained to maintain their arguments. Class discussion in a debating atmosphere does not allow all students to express their opinions, but it is enough to provide additional information for students to continue to support the initial argumentation or move on to the opposite argument, or some later do not want to take sides, there are even students which support the positive aspects of public opinion that are pros and cons.

This process is strengthened by the results of the analysis of changes in the level of evidence strength of students' arguments, the results of changes in the level of evidence strength expressed by students can be seen in Fig. 5 which shows the progress in the second meeting that students who have a reduced strength level of evidence only 22,2% (compare with the first meeting which reaches 51,6%).

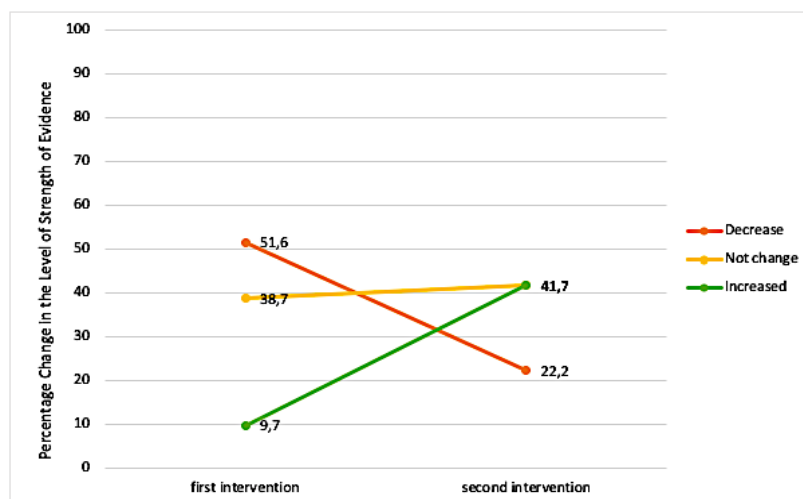


Figure 5. Changes in the level of evidence strength of students' arguments at the first and second meetings

The shift was dominant in students who were able to increase the level of evidence strength from only 9,7% in the first intervention to 41,7% in the second intervention. This shows that the learning process encourages students to carry out rebuttal with stronger and more relevant evidence so that their arguments are not defeated by opposing groups. Excerpts from research results and opinions from experts in the field of GMOs (pros and cons) color the utterance of arguments when discussing debates in class. Not only quoting the opinions of

experts and the results of their research, but students can also express the source of information from the data obtained.

Although the strength of evidence as seen in Fig. 6 is still dominated by level 2 by 48.7% but there are no more students who make claims without evidence. This level distribution can be seen in Fig. 6 and clearly shows a level shift towards a higher direction. The highest percentage addition was in students who were able to present factual and true evidence (level 4), even though it had not been directly related to the content of genetic material. Level 4 is up from the first meeting at 6.5% to 20.5% at the second meeting. Although no one reached level 5 at the second meeting, in general, it moved to a better level.

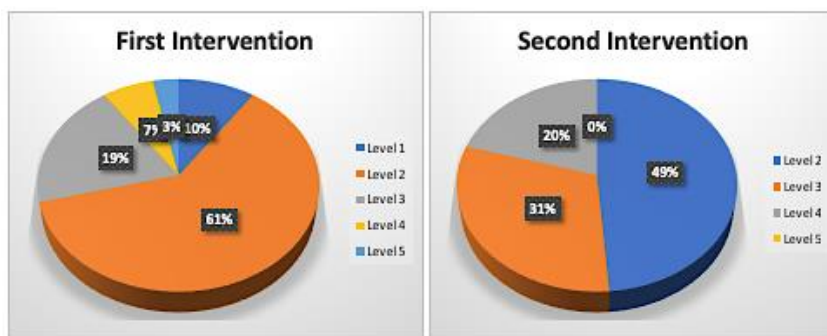


Figure 6. Percentage distribution of the evidence strength level of students' arguments at the first and second interventions

Previous studies showed that the involvement of the environment (learning atmosphere, teachers, and peers) in helping students to have an inquiry can build their ability to criticize the truth of an opinion or evidence so that students can make decisions about which arguments are the most appropriate to support and which arguments are the most unfounded or even unreasonable in his view (Chen, et al., 2016; Hand & Norton-Meier, 2011).

3.2 Distribution of Levels of Strength of Argument Evidence

Interesting findings can be seen in Fig. 7 which shows the distribution of groups that have increased the level of strength of evidence, it turns out to be in the group of claim A that supports the use of GMOs. Based on the record when group A discussed at the 2nd meeting, group members tended to obtain more evidence from group B (rejecting GMO) and AB (supporting positive things from claims A and B). The evidence obtained is used when a class argument in expressing rebuttal to strengthen his argument. This shows that group A dominated the level increase in the second meeting. This means that in defending his opinion to support GMO products, evidence based on facts, data and research results from various

sources are used to strengthen his rebuttal while breaking the opponent's reputation. This information can be seen on the worksheet in the results of the group discussion.

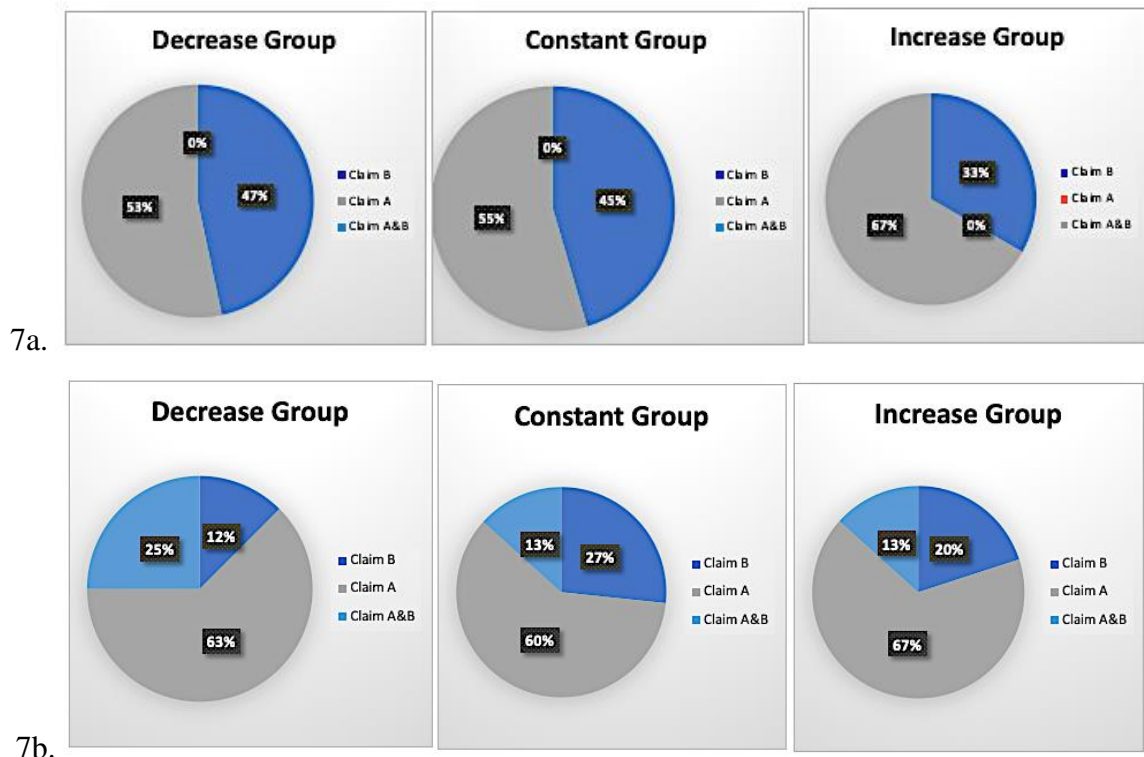


Figure 7. Distribution Group of evidence strength level (7a. First intervention) (7b. Second intervention)

Two discourse on sociocultural issues given to students is still in the realm of GMOs. The first and second meetings although the issues in the discourse look different, but the main theme is the same. Placement of pros and cons arguments are made in reverse to see the consistency of support at the second meeting. Another word is if student X chooses to support claim A at the first meeting and ends with type A at the end of the first meeting, students are predicted to support B at the second meeting (Kuhn, 2001; Kuhn & Udell, 2003; Kuhn, 2010) because claim A in the first meeting has the same purpose as claim B in the second meeting and vice versa. Even though the prediction was not proven to significantly sweep all claim voters, it can be seen in Table 3 that 34.2% of students showed consistent alignments from the first meeting to the second.

Interesting as a finding to note is the change in claims from refusing at the first meeting to supporting the use of GMOs at the second meeting, as many as 31.6% of students at the first meeting who opposed the use of GMOs became convinced to support.

Table 3. Percentage change in claims support for students from the first and second meetings

Change of support	Total	Percentage
Claim A to B	4	10,5
Claim B to A	9	23,7
Claim A to A	12	31,6
Claim B to B	4	10,5
Claim A to AB	2	5,3
Claim B to AB	3	7,9
Claim AB to A	3	7,9
Claim AB to B	0	0,0
Claim AB to AB	1	2,6
Total	38	100,0

The results of personal, group and class negotiations can shift the evidence of GMO rejection and convince voters of the claim to move in favor. If we pay attention to the strength of the evidence provided by the rational arguments of GMO supporters at the first meeting and the discussion process at the first meeting, this group holds the key evidence in the form of government regulation no.21 of 2005 (Estiati & Herman, 2015) and international regulations *United Nations Convention on Biological Diversity* 1992, dan *Cartagena Protocol on Biosafety to the Convention on Biological Diversity* 2000.

Evidence of the GMO's opponents despite being at the right level and related to genetic content, but this did not help GMO supporters change their decision-making decisions. Concerns about changes in genes that cause mutations in the next generation to the possibility of speciation do not make supporters doubt or move. Indeed, for predictions regarding speciation in animals that breed quickly can be known based on many phenotypic and genotypic features (Stern & Orgogozo, 2009) but for the evidence of speciation in humans not many provide the correct data source so that students who support are not convinced that speciation in humans is possible. This means that students are more likely to choose according to emotional reasons rather than intuitive (Widodo, Saptarani, Riandi, & Rochintaniawati, 2018). Besides, the molecular discussion of genetics has not been dealt with deeply by students at the high school level.

4. Conclusion

Expressing the pros and cons of a socio-scientific issue for students at the high school level is not easy. This study illustrates that the scientific writing heuristic (SWH) approach can direct how to help students think argumentatively to address differences of opinion while providing persuasion so that their opinions are accepted, as well as doubting the opponent's support so that the opponent supports his argument. Negotiations in his mind determine where

the end of support ultimately boils down. Evidence that according to him is relevant to his opinion will certainly be used as the main reference whether it will remain in its original claim or change to a previously contradictory claim. The influence of the environment of the teacher and the discussion between students is also a determinant of whether or not an argument change. Students will prefer the most logical evidence, satisfying their misunderstanding, easy to understand, meaningful and not violating the rules even though the concept of the material is still shallow.

Acknowledgments

Many thanks to 38 students in a high school in West Java along with Mrs. DK who diligently and patiently became part of this research. Hopefully, all the processes that go through bring benefits and blessings to the world of education in the future.

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