# PROCESS AND QUALITY DEBRIEFING IN SCIENTIFIC INQUIRY OF BIOLOGY TEACHER PROSPECTIVE THROUGH ARGUMENTATION

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## ABSTRACT

Scientific inquiry is the heart of science so it needs to be accommodated in science learning. The study was conducted in order to develop a model of scientific inquiry skills debriefing for biology teacher prospective by using a framework of argumentation. The focus of study is piloted argumentation framework prototype to promoting scientific inquiry skills for biology teachers prospective through general biology course. The study was conducted to describe quality and using process of scientific inquiry skills. Subjects were first year student participants of general biology course. Data of the quality and process of scientific inquiry skills obtained through observation by using audio-visual recording and student workbook analysis. Results of audiovisual recording and transcript of student workbook confirmed through interview. The results showed that using of the argumentation framework in debriefing scientific inquiry skills could increase scientific inquiry skills in investigation activity. The quality and process of scientific inquiry skills had been developed on the aspects: to formulate investigation problems, make hypotheses, identify variables, define variables operationally in the investigation, represent data of investigation results and make scientific explanation of investigation results based on data and supported theory.

***Keywords:*** *argumentation, quality and process of scientific inquiry, scientific inquiry briefing*

## Introduction

Development information and technology has changed the order of modern society. Significant changes occurred, ie from manufacturing jobs that rely on routine skills now turning more emphasis on information and knowledge services. Knowledge grows specialized and expanded exponentially. Decentralized of decision making, sharing information, collaboration and innovation were key of the current work. However, Riley (2006) suggested that the results of his study that graduation of secondary schools, polytechnics, and universities were lack of the skills (eg, oral and written communication, critical thinking and problem solving), professionalism and work ethic, teamwork and collaboration, working in diverse teams, applying technology, leadership and project management. These things was a skill that is needed to face the 21st century. Related to this, the universities must change its strategy by providing opportunities for students to acquire the

skills of critical thinking and creative, flexible in problem solving, as well as having the ability to collaborate and communicate.

Scientific inquiry is the scientific framework that gives students the opportunity to use critical thinking skills, communication as well as a chance to solve the problem, so it is relevant to the skills needed in the 21st century. NSTA recommend to the teachers to use scientific inquiry and committed to helping students develop a deep understanding of science and scientific inquiry. However, most of teachers were not prepared to teach science using scientific inquiry approach. Professional development of teachers were generally only intended to support teachers in improving student's knowledge, by changing the way of teaching (Capps and Barbara; 2009). Although the research results have shown the importance of scientific inquiry learning, but in its application in the learning process was still less. This is because of most teachers do not have the experience to develop scientific inquiry in the classroom. Krajcik, Mamlok and Hug (2000) suggested the application of scientific inquiry learning demand teachers skills to make adequate preparations to represent science inquiry. Meanwhile Crawford (2000) stated scientific inquiry learning was a complex and sophisticated way that requires significant professional development.

Walker, et al. (2010) stated that the argument driven inquiry (ADI) learning model has implications for the ability of reasoning and use of better evidence because it was obtained through scientific investigation. Scientific investigation carried out by using a framework of scientific inquiry. Bybee (2011) states that the mastery of how science was obtained to provide cognitive abilities supplies such as reasoning with data, building an argument, and making coherent logical explanation, exercising critical thinking, and improving communication skills.

Jim`enes et al. (2000) stated argument was reasoning strategies and critical thinking. Mason and Scirica (2006) stated the argument was reasoning associated advantages and disadvantages, pros and cons and causation based on alternative perspective. Based on these terms, the argument used by searching for scientific truth using reasoning to criticize the causal relationships, predictions, hypotheses and explanations to coordinate claims, data, evidence, and support as an argument.

Based on the background, this study aims to describe the quality and process of the learning with the argumentation discourse in exercising scientific inquiry skills biology teachers prospective.

**Methods**

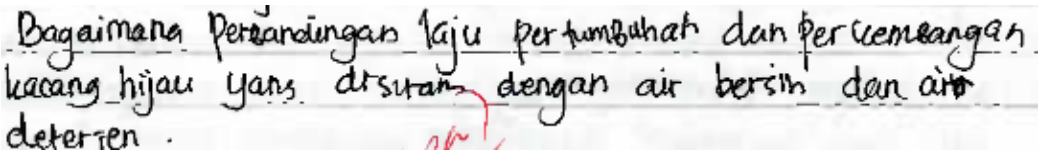
Qualitative study conducted in describing the development of the quality and process of scientific inquiry skills Biology of biology teachers prospective. Research subjects were biology education students of PGRI Semarang University who participated in general biology subject.

Data about the quality and process of scientific inquiry skills obtained through observation to the learning process of general biology. Observation done using an instrument in the form of audio-visual recording equipment. Results of audio-visual recordings made to the transcripts and analysis. The quality of scientific inquiry were analyzed by using arguments discourse, select and explain the reasons for implementing aspects of scientific inquiry. The performance of students in applying scientific inquiry skills were also analyzed by student work book. Interview did to obtain information of constraints which faced by biology teachers prospective in order to implement scientific inquiry skills aspects. Analysis results of audio visual transcripts, workbook analysis and the interviews were analyzed further by data triangulation approach to obtain a description of the scientific inquiry skills development by students.

Based on the analysis results of the qualitative data to the lectures process and student workbook document known that students have progress in implementing the scientific inquiry skills, especially in laboratory activities. For more details, it will be presented the development mastery of scientific inquiry on each indicator.

*a. The development of the ability to formulate problems*

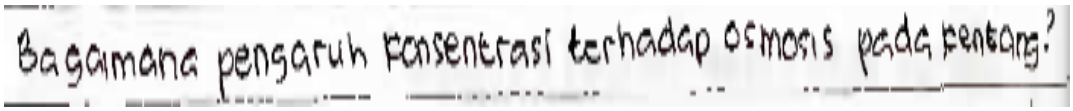
The ability of the students in formulating the problem was not clear, too general, did not fit with the theme. It can be seen from the formulation of the problem which proposed in the scientific work as follows:


Bagaimana Perbandingan laju pertumbuhan dan perkembangan kacang hijau yang disuram dengan air bersih dan air deterjen.

This indicates that the student formulated the problem was still based on the assumption and the focus in variables to be tested was not clear.

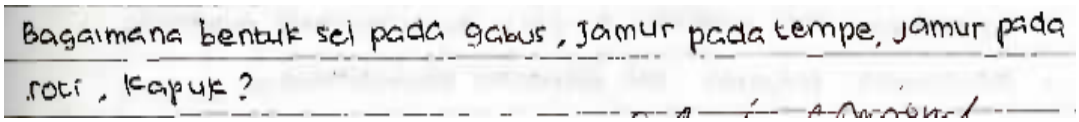
Based on the analysis result of course reports, formulation of the problem has been progressing and improving. Some students have been able to improve the formulation of the problem becomes clearer and the focus of the problem in accordance

with the theme, as well as describe the variables to be tested through the formulation of the problem. This is revealed as the problems formulation as follows:


Bagaimana pengaruh konsentrasi terhadap osmosis pada kentang?

Based on citation of formulation problem shows that there has been a pattern of independent variable and dependent variable, although it also shows less concentration.

Formulation of the problem in course with observation method also showed improvement. Formulation of the problem have shown the parameters that should be observed by students, as quoted from the formulation of the problems as follow:


Bagaimana bentuk sel pada gabus, jamur pada tempe, jamur pada roti, kapuk?

Development and improvement indicates that APSIS framework as a debriefing model of scientific inquiry skills to formulate the problem. This was revealed by the analysis results of the video transcript. Based on video transcript analysis shows the scaffolding process with an APSIS framework through argumentation discourse. For example, shown in the following dialogue between student and lecturers:

Lecturer : "How do you formulate the problem?"

Student : "How the comparison of the gas diffusion speed on HCL and NH4OH?".

Lecturer : "What do you mean with comparison of the gas diffusion speed?"

Student : "The speed of the gas diffuses from HCL and NH4OH".

Lecturer : "Do you think the type of substances will affect the speed of gas diffusion?

Student : "Yes".

Lecturer : "Why?"

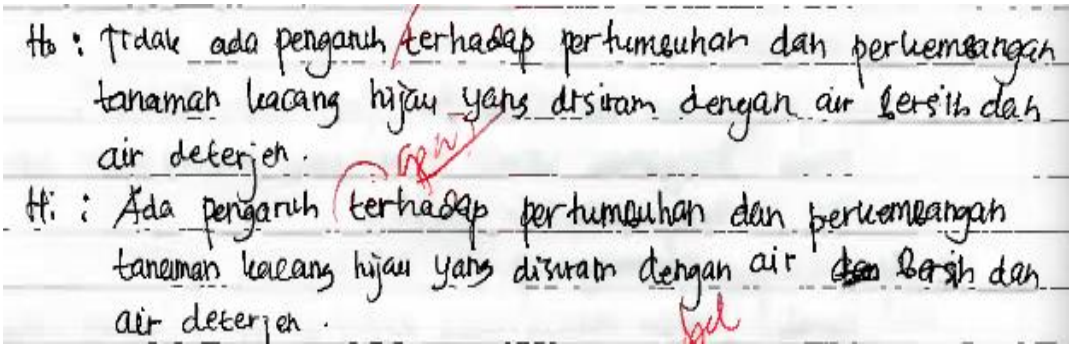
Student : "Because it composed of different elements and abilities".

Lecturer : "So, how do you formulate the problem?"

Based on its, the student was able to fix the problem formulation after getting scaffolding of lecturers, so that the problem formulation was more focused and related to things that will be tested.

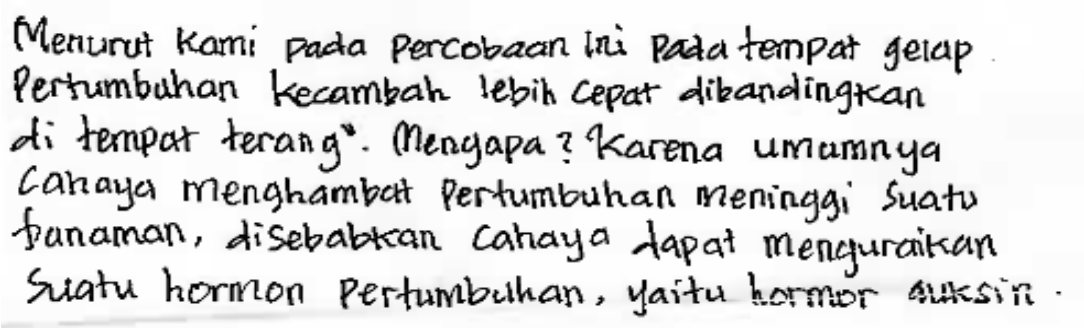
b. The development of the ability to formulate hypotheses

The ability of students in formulating hypothesis initially reaches 50% of the students have not been formulate hypotheses clearly and did not comply with the basic theory. Such as the following quote:

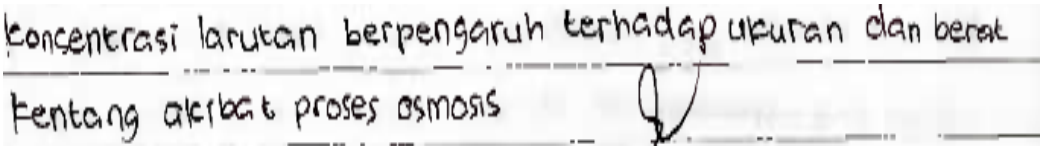

Ho : Tidak ada pengaruh terhadap pertumbuhan dan perkembangan tanaman kacang hijau yang disiram dengan air bersih dan air deterjen.
Hi : Ada pengaruh terhadap pertumbuhan dan perkembangan tanaman kacang hijau yang disiram dengan air ~~dan~~ bersih dan air deterjen.

This indicates that some of the students in formulating hypothesis, have not been identified variables. It also shows an understanding of the theory has not been fully used as a basis for formulating hypothesis.

Hypothesis formulation improvements show that the formulation of hypotheses relevant to the formulation of the problem as well as the basic theory which used and indicate variables tested in the experiment. This is revealed as the formulation of the following hypothesis:


Menurut kami pada percobaan ini pada tempat gelap pertumbuhan kecambah lebih cepat dibandingkan di tempat terang". Mengapa? Karena umumnya cahaya menghambat pertumbuhan meninggi suatu tanaman, disebabkan cahaya dapat menguraikan suatu hormon pertumbuhan, yaitu hormon auksin.

Or


Konsentrasi larutan berpengaruh terhadap ukuran dan berat tentang akibat proses osmosis

Improvements of hypothesis structure shows that the APSIS framework as a functional debriefing model of scientific inquiry skills to exercise skills in formulating

hypotheses for biology teachers prospective. Based on the analysis of the video transcript shows that students get help and find arguments in formulating hypotheses.

Lecturer : "Why do you believe that the concentration will affect the weight of the potatoes?"

Student : "Because the concentration of the solution will affect osmosis".

Lecturer : "How the relation to the weight of potatoes?"

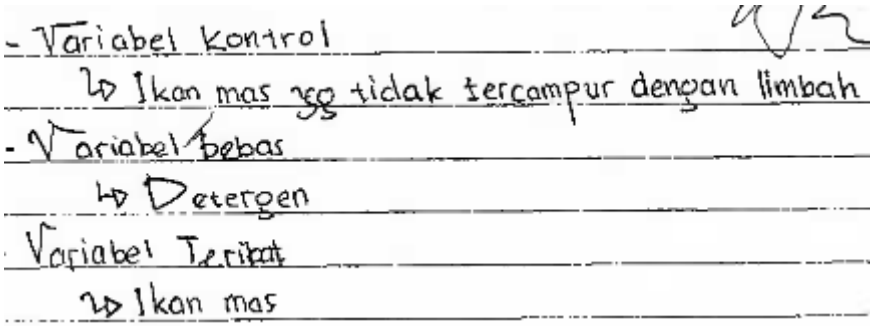
Student : "Because of the concentration means shows a comparison between the solute in this case sugar and the solvent is water.

... This will lead to the displacement of substances because potatoes consist of cells that have the cell membrane ... and thus will occurs the process of osmosis through the cell membrane .... As a result, the potatoes will decline or weight gain because of an osmosis ... Its depend on concentration ... ".

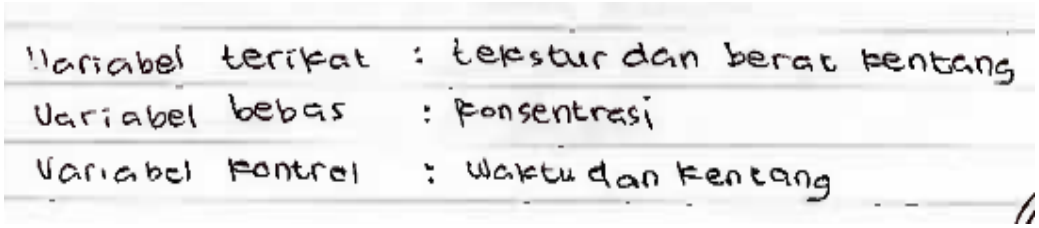
Based on this, students have been able to develop their arguments as a basis that is used to construct a hypothesis, that the theoretical basis of the concept and the principle of osmosis. This indicates that, based on the APSIS framework through arguments discourse will be able to promote the skills to formulate the hypothesis in scientific inquiry, including when the evaluation of the base used in building hypotheses.

*c. The development of the ability to identify the variables in the experiment.*

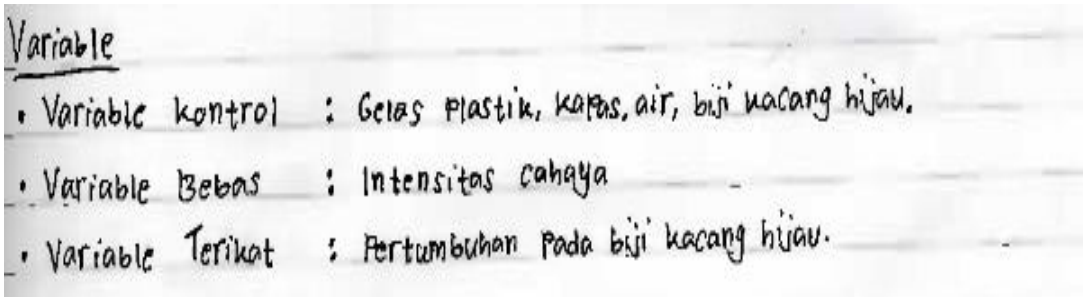
The ability of students to identify the variables are things that must receive attention in briefing scientific inquiry skills. Based on the analysis result to the formulation of the variables at the beginning of treatment found some facts that: 1) the variables have not been identified, especially for students who have not been able to focus on the problem formulation and hypotheses; 2) the student has not been able to determine the operational definition of variables. As the variables identification quote of the following:


- Variabel kontrol
  ↳ Ikan mas yg tidak tercampur dengan limbah
- Variabel bebas
  ↳ Detergen
- Variabel Terikat
  ↳ Ikan mas

Based on these quotations, parameters which used in each variable has not been clearly identified. Furthermore, after a briefing with the APSIS framework appears the lack of progress in identifying the variables, as seen in an excerpt of the variable identification results by student as follows:


Variabel terikat : tekstur dan berat kentang
Variabel bebas : konsentrasi
Variabel kontrol : waktu dan kentang

or


Variable
- Variable kontrol : Gelas plastik, kapas, air, biji kacang hijau.
- Variable Bebas : Intensitas cahaya
- Variable Terikat : Pertumbuhan pada biji kacang hijau.

Based on these quotations, it show the progress in identifying variables. However, developments in identifying variables has not kept with operational of each variable. The ability of students to operationalize variables that have not been clearly will lead experiment procedure. This was revealed in the transcript of the lecture following:

Lecturer : "Do you use the same potato?"
Student : "Yes ...".
Lecturer : "What about the size? ... is it same?"
Student : "Yes ....
Lecturer : "Why ... ..?"
Student : "I don’t know, Sir”

Lecturer : "What will be happen to the potatoes? Will the potatoes submerged all or partly submerged?"

Student : "Maybe ... .Yes."

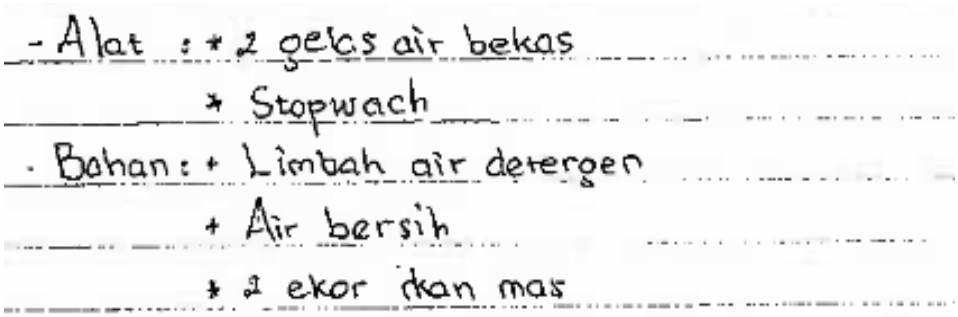
Lecturer : "How can you believe that only concentrations which affect osmosis if one potatoe fully submerged and the other partially submerged ...?"

Students : "It should pay attention to other variables that allow the influence of the trial should be controlled or conditioned in order to remain the same for all treatments ...

Based on these quotations, the lecturer has been working to provide scaffolding as argumentative use APSIS models. So the ability to identify the variables had improved. However, the student's ability to formulate operational definitions of the variables were not optimally growing. It was also revealed by the tests results of understanding and reasoning to the skills to operationalize the variables which was generally lowest among other scientific skills. Thus APSIS framework in exercised to operationalize variables still requires argumentative scaffolding framework more detailed.

*d. The development of the ability to design an experimental procedure.*

APSIS model framework develop the ability to design experimental procedures include registering the need for tools and materials as well as designing and implementing work procedures. Here is a list of tools and materials which prepared students are as follows:


- Alat : * 2 gelas air bekas
  * Stopwach
- Bahan : * Limbah air deterjen
  * Air bersih
  * 2 ekor ikan mas

List of tools and materials showed that the tools and materials which needed have not been accompanied by a unit, specification, size, and completeness of tools and materials clearly. Analysis video transcripts of some students confuse to deciding specification tool that should be used as follows:

Lecturer : "How many drops of substance that you need ..?"

Student : "25 drops".

Lecturer : "If 25 drops, is it right when using the pipette?"

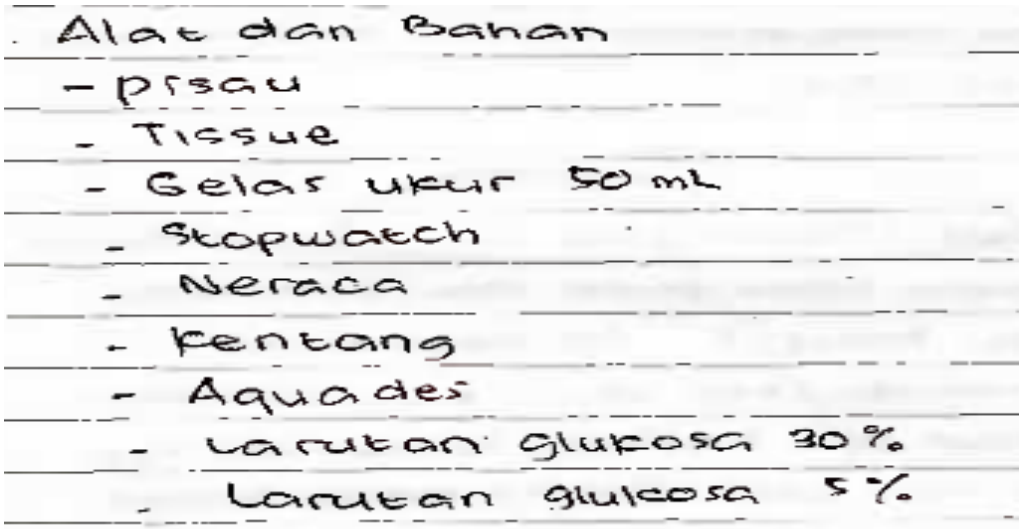
Student : "....."

Lecturer : "Approximately 25 drops of it, is there one milliliter?

Student : "More ...."

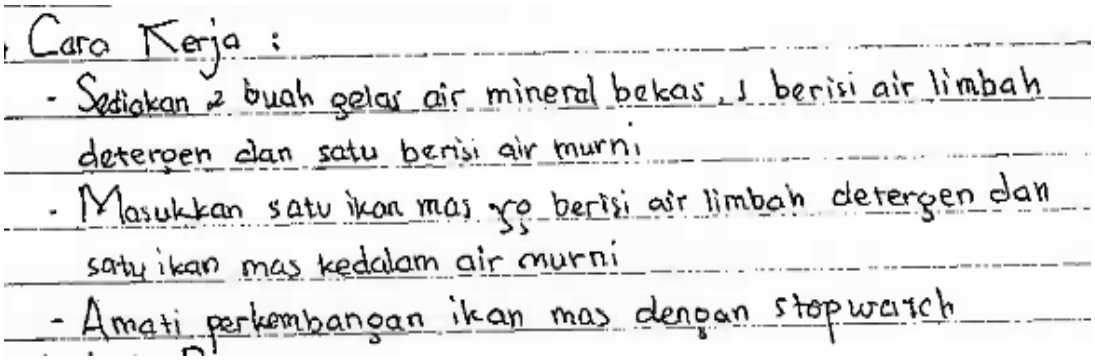
Lecturer : "So, what kind of tool that must be used?"

Based on the list of tools and materials in the course showed the following topics:

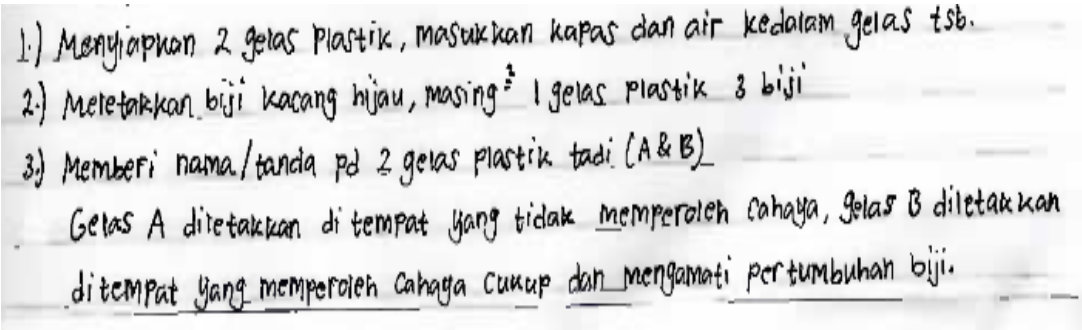

Alat dan Bahan
- pisau
- Tissue
- Gelas ukur 50 mL
- Stopwatch
- Neraca
- Pentang
- Aquades
- Larutan glukosa 30%
- Larutan glukosa 5%

List of tools and materials showed that the tools and materials needed have been accompanied by the unit, specification, size and completeness of tools and materials clearly. Thus indicates progress in registering the tools and materials used in the experiments that regard specifications, sizes and units that will be used.

Defined work steps were still too general, treatment was not clearly identified in each group, the procedures has not operationally yet and did not perform repetition. As shown in the following passage:


Cara Kerja :
- Sediakan 2 buah gelas air mineral bekas, 1 berisi air limbah deterjen dan satu berisi air murni
- Masukkan satu ikan mas ke berisi air limbah deterjen dan satu ikan mas kedalam air murni
- Amati perkembangan ikan mas dengan stopwatch

Results of improvements to the procedures after discussion in the argument presented in the following figure:


1.) Menyiapkan 2 gelas plastik, masukkan kapas dan air kedalam gelas tsb.
2.) Meletakkan biji kacang hijau, masing² 1 gelas plastik 3 biji
3.) Memberi nama/tanda pd 2 gelas plastik tadi (A & B)
Gelas A diletakkan di tempat yang tidak memperoleh cahaya, gelas B diletakkan di tempat yang memperoleh cahaya cukup dan mengamati pertumbuhan biji.

Examples of scaffolding process through APSIS framework to exercise skills to compose experimental procedures, as well as the analysis results in the following video transcript:

Lecturer : "Why the potatoe is only one? if the potatoe is only 1 compared with 5 potatoes, which will be more valid?"

Student : "5 ...".

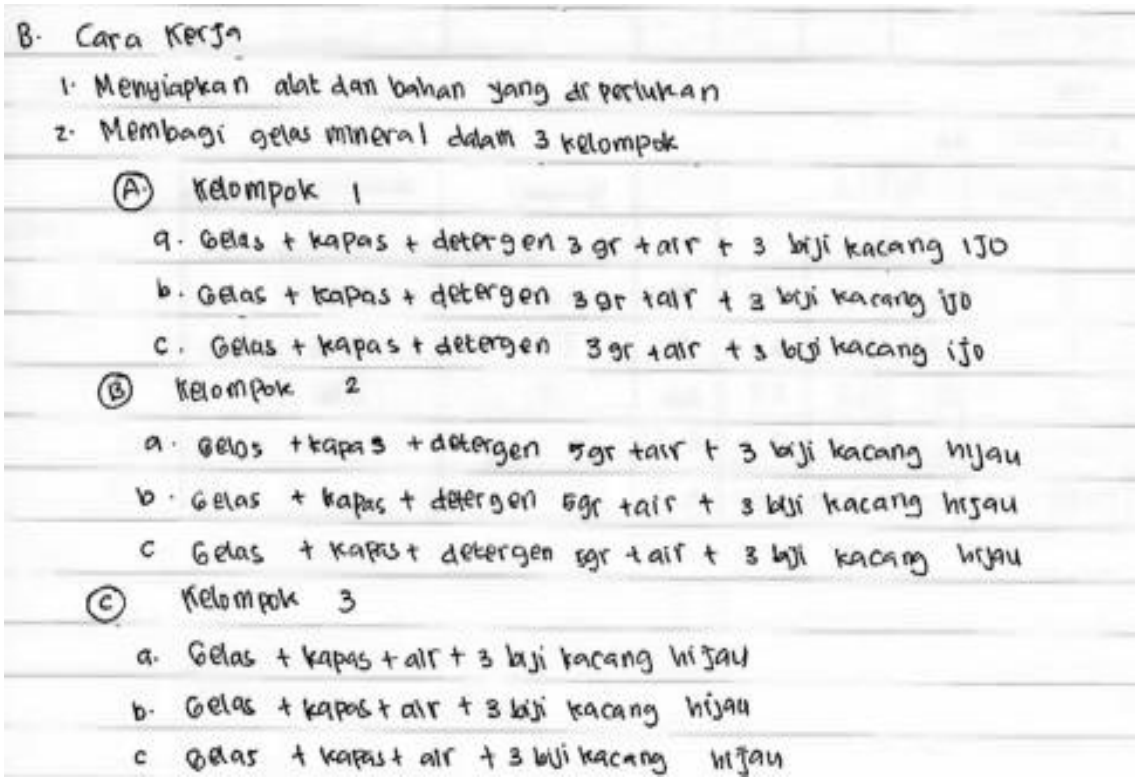
Lecturer : "Why?"

Student : "Yes ... as much as 5 times repetition of each treatment ..."

Lecturer : "What does it mean ...?"

Student : " Every treatment should have repetition ... so it will get valid data".

It describes that at first the students planning have not pay attention yet to did repetition in each treatment. By using the framework of APSIS, students realize the importance of clarity and working procedures to do with the validity of the data produced. Repair result of work procedures as the following quote:


B. Cara Kerja
1. Menyiapkan alat dan bahan yang di perlukan
2. Membagi gelas mineral dalam 3 kelompok
A. Kelompok 1
a. Gelas + kapas + detergen 3 gr + air + 3 biji kacang ijo
b. Gelas + kapas + detergen 3 gr + air + 3 biji kacang ijo
c. Gelas + kapas + detergen 3 gr + air + 3 biji kacang ijo
B. Kelompok 2
a. Gelas + kapas + detergen 5 gr + air + 3 biji kacang hijau
b. Gelas + kapas + detergen 5 gr + air + 3 biji kacang hijau
c Gelas + kapas + detergen 5 gr + air + 3 biji kacang hijau
C. Kelompok 3
a. Gelas + kapas + air + 3 biji kacang hijau
b. Gelas + kapas + air + 3 biji kacang hijau
c Gelas + kapas + air + 3 biji kacang hijau

Based on the citations, the students have included experiment design in experimental work procedures. In addition to these in the design can also be observed that the students designing with 3 kinds of treatments with 3 repetitions for each treatment. Improvements that have been done show that APSIS framework can be used to exercise skills in preparing work procedures or experiment methods. Arguments discourse in APSIS proved capable to direct students to have a framework to think how to design experiments.

*e. The development of the ability to interpret the data*

One indicator of scientific skills was the ability to interpret the data. Several modes of representation can be used to assist in interpreting the data, for example through tables, charts and graph or statistical calculations. The limited trial results in initial treatment showed that the majority (85%) initially using the table to represent the patterns observed experimental data. As shown in the following passage:

Tabel Pengamatan I

| No. | Jenis Media | Berat kentang | |
|---|---|---|---|
| | | Sebelum percobaan | Setelah percobaan |
| 1 | Aquades | 2,1 gram | 2,25 gram |
| 2 | larutan glukosa 5% | 2,1 gram | 2,05 gram |
| 3 | larutan glukosa 30% | 2,1 gram | 1,9 gram |

This phenomenon shows that present data in tabular form is the easiest mode and common in presenting the data. The outcome was a student having difficulty in doing inference. Through table mode, student was hard to see the pattern of the data tendency will thus have difficulty in attracting inference anyway. This indicates that the student has not fully consider the mode appropriately represent data that can help in interpreting data.

After the lecture give the APSIS models treatment appears the development of the students in interpreting the data. Results analysis of course report was also supported by the fact of the lecture transcripts showed its phenomenon. The following transcript showing student progress after receiving a briefing by APSIS framework. As illustrated lecture transcript of excerpts follow:

Lecturer : "Based on observations, what can you conclude?"

Student : "Potatoes were soaked in distilled water have more weight".

Lecturer : "Is the only soaked with distilled water which have more weight?"

Student : "No, but also at a concentration of 5%

Lecturer : "Why?"

Student : .....

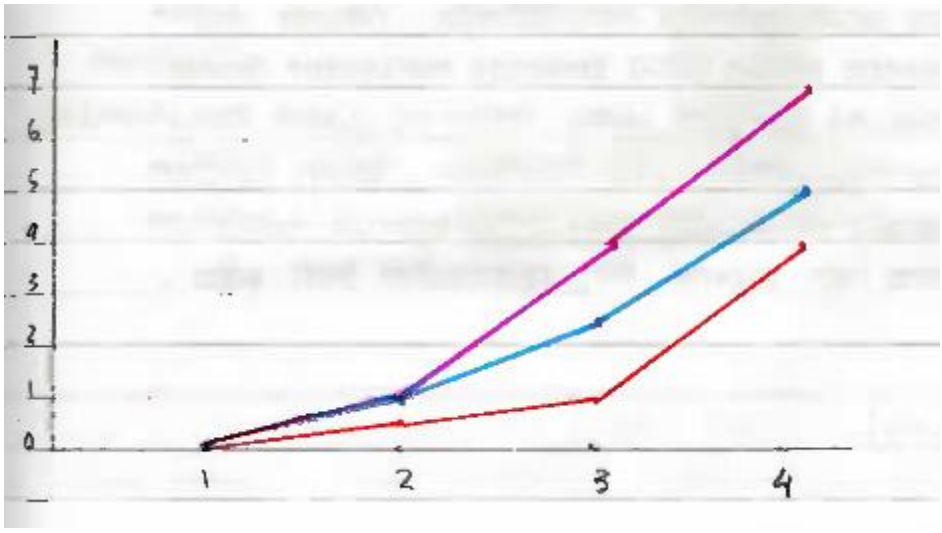
Lecturer : “How do you make your data is easily read and interpreted? Could use other means for example chart?”

The transcript describes the mode of representing the data that was important to help students in interpreting data. The facts according to the results of the data analysis is based on excerpts from the report made the following:

• Pada tempat gelap.

| Hari | Panjang 1 | Panjang 2 | Panjang 3 | Warna daun |
|---|---|---|---|---|
| 1 | - | - | - | |
| 2 | 0.5 cm | 1.0 cm | 1.0 cm | |
| 3 | 1.0 cm | 2.5 cm | 4.0 cm | Kuning |
| 4 | 4.0 cm | 5.0 cm | 7.0 cm | Pucat |
| 5 | 8.0 cm | 13.5 cm | 15.0 cm | |
| 6 | 12.5 cm | 16.0 cm | 17.0 cm | |
| Rata" | 4.3 cm | 6.3 cm | 7.3 cm | |

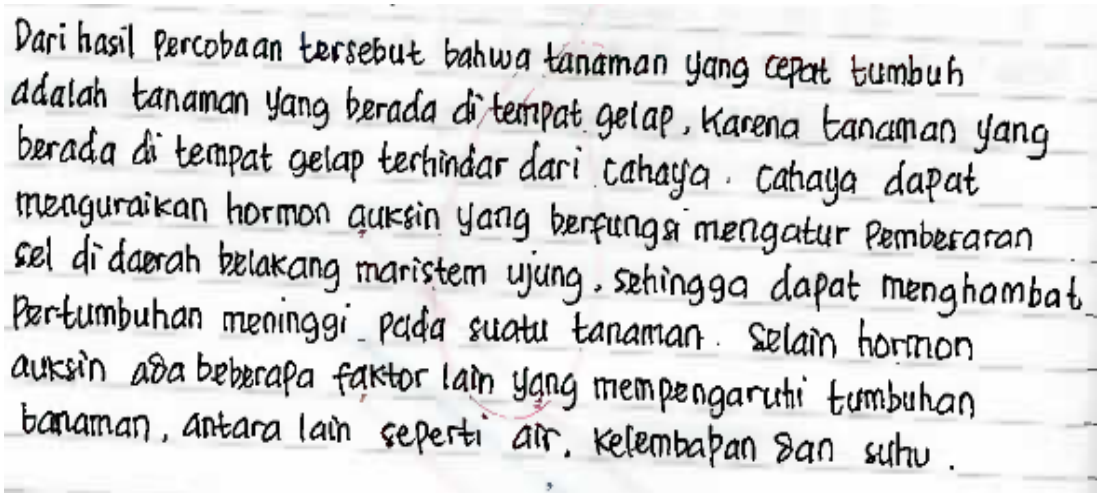
The following table was based on the students create a graph as observations data representation. Data of representation observation results as shown in the following passage:




Based on the improvements that have been done show that the APSIS framework through arguments discourse proved capable to direct students in selecting and using multiple ways of interpreting the data. Based on the interpretation of the data presented in this mode was expected to make some students make a scientific explanation for the observed data as well as alternative explanations for the phenomenon of pattern data.

*f. The development of skills to develop and formulate conclusions*

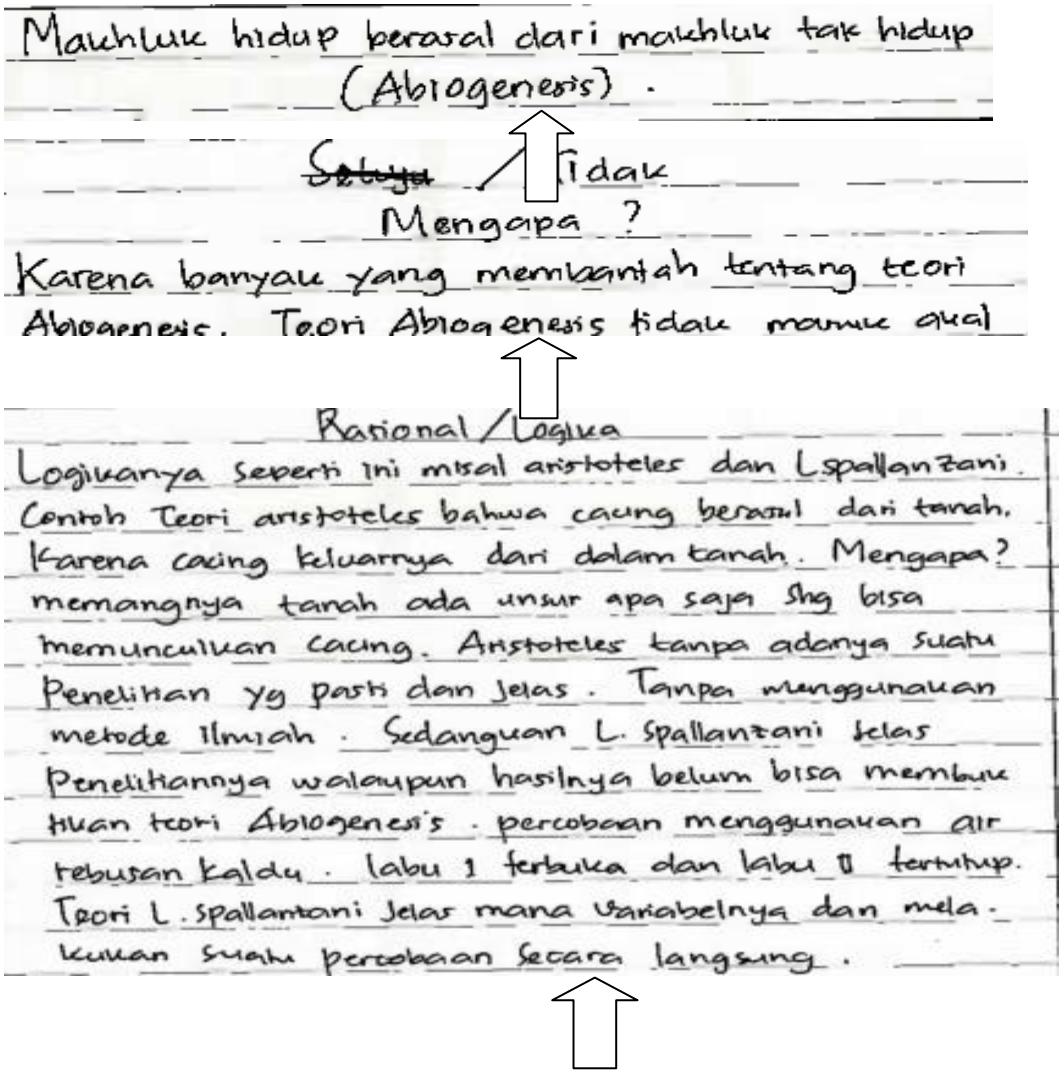
APSIS framework in promoting the ability to develop explanation and to formulate conclusions students are expected to be able to build a scientific explanation, critical and in-depth on the results of the data analysis. Pattern of discussion conducted by students to the experiment results illustrated in the following discussion excerpt:



Dari hasil percobaan tersebut bahwa tanaman yang cepat tumbuh adalah tanaman yang berada di tempat gelap, Karena tanaman yang berada di tempat gelap terhindar dari cahaya. cahaya dapat menguraikan hormon auksin yang berfungsi mengatur pemberaran sel di daerah belakang maristem ujung, sehingga dapat menghambat pertumbuhan meninggi pada suatu tanaman. selain hormon auksin ada beberapa faktor lain yang mempengaruhi tumbuhan tanaman, antara lain seperti air, kelembapan dan suhu.

Based on these quotes, show that the structure of the discussion which presented by students have used theoretically support to make explanation. However, the support was made based on experiment has not been fully used.

Efforts to improve the use of APSIS in promoting the ability to make an explanation on the data analysis is using Toulmin argument scheme. Toulmin argument schemes use quotation appears in the following spreadsheet



Mahluk hidup berasal dari mahluk tak hidup (Abiogenesis).

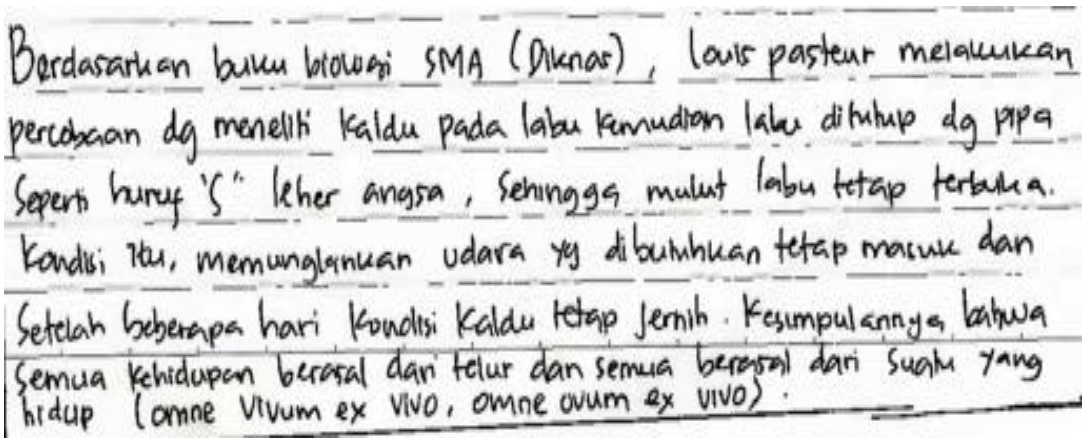
~~Setuju~~ / Tidak

Mengapa ?

Karena banyak yang membantah tentang teori Abiogenesis. Teori Abiogenesis tidak masuk akal

Rasional / Logika

Logikanya seperti ini misal aristoteles dan L.spallanzani. Contoh Teori aristoteles bahwa cacing berasal dari tanah, Karena cacing keluarnya dari dalam tanah. Mengapa? memangnya tanah ada unsur apa saja shg bisa memunculkan cacing. Aristoteles tanpa adanya suatu Penelitian yg pasti dan jelas. Tanpa menggunakan metode Ilmiah. Sedangkan L. Spallanzani jelas Penelitiannya walaupun hasilnya belum bisa membuktikan teori Abiogenesis. percobaan menggunakan air rebusan kaldu. labu 1 terbuka dan labu II tertutup. Teori L. Spallanzani jelas mana variabelnya dan melakukan suatu percobaan secara langsung.


Berdasarkan buku biologi SMA (Dikmas), louis pasteur melakukan percobaan dg meneliti kaldu pada labu kemudian labu ditutup dg pipa seperti huruf "S" leher angsa, sehingga mulut labu tetap terbuka. Kondisi itu, memungkinkan udara yg dibutuhkan tetap masuk dan setelah beberapa hari kondisi kaldu tetap jernih. Kesimpulannya, bahwa semua kehidupan berasal dari telur dan semua berasal dari suatu yang hidup (omne vivum ex vivo, omne ovum ex vivo).

Based on Tolmin argument scheme, encouraging students to think deeply and critically using multiple guarantors and supporters. By using scheme the student can collect scientific facts and theories, both the concept and scientific principles to be used as the basis for building a claim. Therefore it was recommended to exercise scientific inquiry skills, especially in building an explanation based on the interpretation of the data then used Toulmin scheme as a template.

## Conclusion

The results showed using of the argumentation framework in debriefing scientific inquiry skills showed an increase using of scientific inquiry skills in investigation. The quality and process of scientific inquiry skills had been developed on the aspects to formulate investigation problems, make hypotheses, identify variables, define variables operationally in the investigation, represent data of investigation results and make scientific explanation of investigation results based on data and supported theory.

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