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COGNITIVE BASIS AND SEMANTIC STRUCTURE OF PHENOMENOLOGICAL REASONING ON SCIENCE AMONG LOWER SECONDARY SCHOOL STUDENTS: A CASE OF INDONESIA

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Abstract. *A study had been conducted in qualitative design employing phenomenology approach to examine the cognitive basis and the semantic structure of phenomena based reasoning of lower secondary school students in Ambon. The data of the study were collected by using a test. Phenomena stimulus of science was given to the informants in the form of cognitive basis and semantic structure of phenomena based reasoning. This study concluded that (1) the cognitive basis of phenomena based reasoning were orientation, inferential abstraction, and inferential affirmation; (2) students were able to analyze phenomena by using systematic cognitive framework only if they had complete information of the phenomena; (3) inference validity related to the cognitive basis is heavily determined by the phenomena analysis ability; (4) the general semantic structures in phenomena based reasoning were definitional and assertional; (5) the semantic structure complexity was determined too by the phenomena knowledge availability which was analyzed.*

Key words: *cognitive basis, cognitive process, knowledge structure, phenomenological reasoning, semantic structure.*

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Introduction

An ability to practice reasoning is one of the essential skills that must be possessed by every person to be able to adapt to the rapid development and movement. Reasoning ability is a procedural thinking skill which aims at predicting a particular phenomenon that will occur or new concept based on the existing facts or evidences. Reasoning is a mental strategy, program, or rule used to process information and to draw conclusions beyond the empirical evidences (Lawson, 2004). Reasoning is a procedural or operative knowledge which is contrary to a declarative or figurative knowledge. According to Mercer & Sperber (2011), reasoning refers to a specific conclusion in a conceptual level which not only constitutes a new mental representation or conclusion but also refers to the preceding representations or premises. Reasoning is a most important principle and essential thing in daily knowledge. It is beneficial to evaluate arguments, test hypotheses, collect evidence, draw conclusions, and to make decisions in everyday life (Metallidou, et al., 2012).

Reasoning skill is extremely important for people to be able to adapt to surrounding environment filled with many complex problems. Moreover, a scientific reasoning is an essential skill which encourages the existence of scientific literacy society. It is explained by Galyam & Le Grange (2005); Dunbar & Fugelsang (2004) that adaptation ability towards rapid changes heavily depends on the ability to think and make decisions based on reasoning, analyzing, and information synthetizing. An awareness of the reasoning importance as the key goal of natural science learning is increasing.

This improvement is indicated by the increasing of research number in psychology and education related to scientific reasoning during these recent decades. The emergence of researches related to scientific reasoning in cognitive psychology can be divided into two major aspects, which are: (1) related to an investigative process of a procedural knowledge, and (2) related to an inferential process of a conceptual knowledge (Khun &

Pearsal, 2000; Zimmerman, 2000; Bao, et al., 2009). Besides, various studies begin to reconstruct the human being reasoning process. Several studies start to compare the reasoning process of scientists and that of non- scientists or children. The studies were conducted to map the cognitive basis, that underlays the reasoning process. There are some differences related to cognitive basis of scientific reasoning between a child and a scientist. It can be seen from the findings of a study conducted by Hogan and Maglienti (2001). Hogan and Maglienti compared an initial belief factor related to the prior knowledge of reasoning process of scientists and of non-scientists. They concluded that scientists tended to use data to evaluate their knowledge, while children or non-scientists tended to use their personal point of view.

Mapping the cognitive basis means diverging the mental model used by a reasoner in recognizing and formulating the inference. The mental model used by children in reasoning daily phenomena is very different from the mental model used by scientists in constructing a theory (Khun, 1989). The framework stated by Khun is applied by Tytler & Peterson (2003). Based on the findings, Tytler & Peterson identify 3 children reasoning characteristics: (1) an exploration origin or the way to connect theories and evidences, (2) response to some challenging ideas, and (3) identify and find relevant variables. Besides, they also utilized reasoning framework proposed by Driver, et al. (1996) to show reasoning process during an exploration and experimentation. The frameworks used were: (1) phenomena based reasoning, (2) relationship based reasoning, and (3) conceptual based reasoning. Regarding the natural science learning, the most reasoning used was phenomena based reasoning since it is considered more relevant to the natural science characteristics.

Science is a term that describes two core points: the body of knowledge and the process of knowledge gaining (Zimmerman, 2005). However, Carin & Sund (1989) elaborate the term as science, that was not only a group of knowledge of a certain thing or living thing, but it also related to the way to do, to think, and to solve problems. Science or natural science is a branch of knowledge, of which the main concept is the nature and its content. The objects learnt in natural science are the cause-effect and the causal relationship of natural phenomena. Natural science learning, stressing on memorizing facts or concepts, is considered as a traditional learning. Teachers employing content based learning might think that this way helps students to develop their reasoning ability. Yet, in fact, many researches reveal that a teacher centered learning supported by student memorizing method are not effective to enhance students' reasoning (Bao, et al., 2009). Natural science learning should emphasize essential skill improvement and give priority to the process instead of memorizing, because it might give an implication to the improvement of other abilities (Galyam & Le Grange, 2005). Similarly, Staver (2007) suggests that a learning emphasizing on scientific findings and problem solving might trigger students to comprehend the knowledge deeper. Therefore, a learning should give priority to the activation of thinking and reasoning (Eskin & Bekiroglu, 2009).

Studies of the development of scientific reasoning ,especially in terms of natural science are rarely conducted in Indonesia, especially in Moluccas. Information tracing related to scientific reasoning reports more activation effort carried out by the implementation of particular learning strategies. Studies related to mapping and characterizing of reasoning in the form of cognitive performance and semantic structure are limited qualitatively. Therefore, it is necessary to conduct a comprehensive study, to analyze the cognitive basis and explain the semantic structure underlaying the phenomena based reasoning process of lower secondary school students in Ambon.

The purpose of the study is to map and depict the cognitive basis and the semantic structure of students in reasoning several phenomena related to scientific concepts. The research questions are formulated as follows: (1) what cognitive basis which underlays the students' phenomenological reasoning?, (2) what cognitive basis which influences the students' phenomenological reasoning?, (3) how is the look of the semantic structure in the students' reasoning description related to several scientific phenomena?.

Methodology of Research

General Blackgroud of Research

This study employs qualitative design with phenomenological approach. Generally, the focus of the study includes students' cognitive basis and semantic structure in phenomenological reasoning. The focus is based on Dawson's (2013) argumentation that thinking is a process involving operational knowledge manipulation within cognitive system. Therefore, the scope of the study is to map the students' operational knowledge within cognitive system used to practice reasoning of several given scientific phenomena. This study adopted Sibey's

(2009) framework, such as (1) orientation, (2) abstraction, (3) re-representation. Another focus of the study is the semantic structure depicted in the students' argumentation. According to Sowa (1992), semantic network is a graphic structure representing knowledge with a particular connection pattern among semantic units. This study was conducted to map the semantic structure types used by the students during reasoning several scientific phenomena. Classification of the semantic structure types was based on Sowa (1992) consisting of definitional system, assertion system, implication system, learning system, and hybrid system. The study was administered to eight grade students of lower secondary schools in Ambon, Indonesia. The study was conducted in three months, comprising: four weeks of designing items and validating the content together with some experts and science teachers, three weeks of administering the test in five schools, and five weeks of analysing data as well as writing the article for publication.

Sample of Research

Samples of the research were twenty students of the eighth grade of lower secondary school chosen from five lower secondary schools in Ambon. The samples were chosen through two stages. First, the five schools were chosen randomly out of lower secondary schools in Ambon, Indonesia. Second, the samples were chosen randomly by drawing four students from each chosen school. The subjects of the study are considered as valid and reliable due to the similar characteristics. The chosen schools implement the same curriculum on science. Furthermore, the tested materials have been taught by the science teachers in each school; and there is no significant age difference among the samples, indicating that the subjects are all in the same biological development phase. Therefore, the samples of the study were considered as homogenous, so the difference in the students' argumentation will reflect the distinction of the cognitive process in reasoning several scientific phenomena.

Instrument and Procedures

The data of cognitive basis and semantic structure were obtained by utilizing a written test instrument. The instrument in the form of the test was validated and tried out beforehand. The test items were in the form of several scientific phenomena based on science materials taught to the students. The scientific phenomena in the test instrument were constructed based on science materials in the textbooks used by the schools. The test items were then validated in the sense of the content (content validation). The validation process involved some experts and science teachers in each sample school. The validation by the experts was aimed at determining the validity of the phenomena and the validation by the science teachers was aimed at reassuring that the materials have been taught and could be tested to the students. The validated instrument was then tried out to the ninth grade students of lower secondary schools. The try out samples were chosen due to an assumption that the ninth grade students have already passed the materials. The try out was aimed at reassuring that the students are able to provide proper argumentation responses. The try out results were proven proper so it could be used to record the research data related to cognitive basis as well as semantic structure of the students. Three scientific phenomena (see Table 1) were chosen out of the eighth grade of biology materials of lower secondary school.

Table 1. The test items of the phenomena-based reasoning.

Number	Case 1
1	In a cylinder aquarium, there are several organisms such as fishes, slugs, and water vegetation. **Question:** What might happen if the aquarium is entirely closed so there is no way for air circulation? **Answers:** a. The organisms will still be alive b. The organisms will be alive until there are no oxigen more c. The organisms will die directly **Why?**

	Case 2
2	Certain treatments are given to miyana plant (Coleus sp.). In the first treatment, the Coleus sp. is put in a topsoil polybag which is watered regularly every day. In the second treatment, the Coleus sp. is put in a clayful polybag which is watered regularly. **Question** What might happen to the miyama plant (Coleus sp.) in the first and the second treatments? **Elaborate your answer.**
	Case 3
3	A cabbage farmer plants the cabbages in two greenhouses. He is surprised that the harvest of the plants are different. The cabbage from greenhouse A are bigger than those from greenhouse B, whereas, he uses the same seeds and soil, and also he used the same amount and type of water and fertilization. He then asks a researcher to find out the reason of the difference. The researches takes data to test his hypothesis. Here are the data taken by the researcher.

Variable	Greenhouse A	Greenhouse B
The amount of CO_2 in the air	++++	+++
Air temperature	$32^0 - 32^0$ C	$32^0 - 32^0$ C
Light intensity	++++	+++

Question
Why does the researcher observe the three variables?
Give your explanation.

Data Analysis

The data analysis was started by recording some argumentation written on the given answer sheets by the students. The argumentation data were analysed to examine the appropriateness conceptually. The argumentation was correct if the students were able to analyse the variables within the given phenomena completely and explained the relation between variables so it arised valid responses conceptually. The correct answers were analysed qualitatively in order to map and explained the cognitive basis underlaying the students' reasoning. The characteristics of each proposition of the students' argumentation was analysed based on an analysis framework by Sibley (2009), namely (1) orientation, (2) abstraction, and (3) re-representation. Orientation is a process of recognizing and analyzing the observed phenomena. A problem orientation is generally depicted on the onset propositions in an argumentation. Abstraction is a generalization development phase of the observed phenomena. Re-representation is an affirmation process of a created mental model. The characteristic of each proposition reflects the cognitive process in the students' mind during the reasoning process of several scientific phenomena related to biology concept. The order of the proposition in an argumentation also reflects the cognitive stages of reasoning, beginning from orientation, abstraction, and re-representation.

The subsequent analysis phase was mapping the semantic structure of the students' argumentation. The written argumentation of the students was noted and depicted in the form of reasoning map. Concept mapping analysis had been implemented by White (2004) and Stolpe & Stromdahl (2007) to map students' reasoning pattern. In this study, the reasoning mapping is used to examine the semantic structure of the students' argumentation. The reasoning mapping is rechecked by utilizing the semantic structure types by Sowa (1992). The semantic structure types are: Definitional system, Assertion system, Implication system, Learning system, and Hybrid system. Definitional system emphasizes the subtype or a relation between a concept and a recent concept. Assertion system is a structure which emphasizes a particular proposition. Unlike the definitional system, the information in this system is considered correct. Assertion system is managed as a model of a conceptual structure functioning as a language semantic. Implication system uses implications as a primary relationship to connect systems. Implication system is used to represent belief, causality, or conclusion patterns. Learning system represents knowledge acquisition structure in which a new knowledge might replace the natural system by adding or deleting a concept or a structure. Hybrid system is a combination of two systems or more as explained previously.

Results of Research

There are three phenomena presented to the informants to be analyzed. Generally, the three phenomena are adopted and modified from several observable phenomena in daily life. The informants' cognitive basis and semantic structure of the three phenomena are presented below.

Case 1

Related to the phenomenon 1, the answers and the explanation given by the twenty informants can be grouped into two, those who chose an option (a) the organisms will still be alive and an option (b) the organisms will be alive until there is no more oxygen. The following is the analysis result of the cognitive basis and the semantic structure of the informant related to phenomenon 1.

Cognitive Basis

The open ended answers were analyzed to see the cognitive basis underlying the reasoning process about the aquarium ecosystem phenomenon. The students were asked to analyze the aquarium total blocking effect to the organisms. The cognitive basis explanation which represents an option (a) is presented in Table 2.

Table 2. The cognitive basis of an informant named Dandi.

Proposition	Type	Validity	Cognitive Process
A fish uses gills to breathe instead of lungs	Categorical	Valid	A phenomenon orientation
			⩔
It does not matter if the aquarium is totally blocked	Conditional	Invalid	Inferential Abstraction
			⩔
A fish does not need oxygen	Categorical	Invalid	Affirmation

The analysis result of the cognitive basis in Table 2 shows that the informant used two types of proposition in stating an argumentation of the aquarium blocking impact to the organisms. The two propositions are named categorical and conditional proposition. Categorical proposition is used when the informants orient the analyzed phenomenon. Meanwhile, conditional proposition is used to do abstraction or generalization to a phenomenon which might happen to the organisms if the aquarium is totally blocked. The other categorical proposition is used to affirm the result of the generalization. Table 2 also shows that the propositions do not meet the valid assumption. The analysis result indicates that even though the scientific reasoning stages are in line with the stages theoretically described, yet the fault lies on the materials validity of each stage. The informant stated invalid inference since they were wrong in recognizing and defining the phenomenon conceptually. The invalid initial model in recognizing a phenomenon might ignite invalid inferential abstraction too.

Semantic Structure

The students' answers are also mapped in the form of the graph from which the semantic structure is then analyzed. The following Figure 1 shows the semantic structure of analysis result of the informants related to the aquarium organisms' phenomenon.

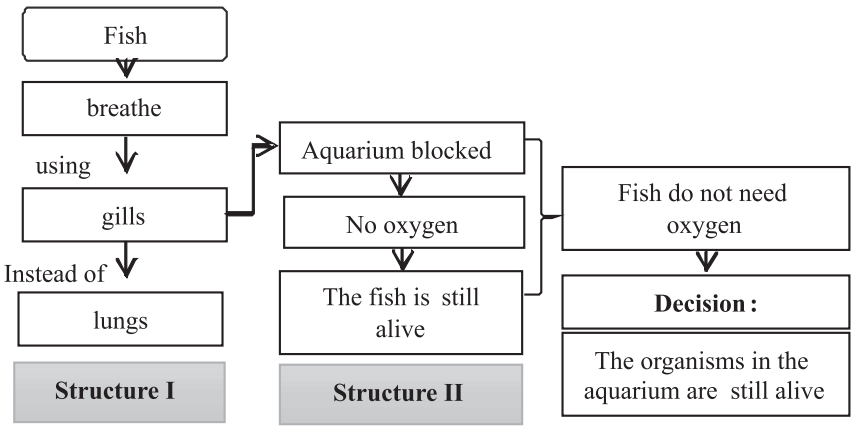

Figure 1: Dandi's semantic system.

The semantic structure mapping result showed in Figure 1 indicates that there are two structures used by the informant. Structure 1 is called definitional structure which explains the respiratory process of fish. The informant defines that fish breathe by using gills instead of lungs. In structure 2, the informant uses the assertion model in the form of cause-effect relationship to explain the impact of oxygen unavailability in the aquarium for the fish. The informant's argumentation who used the semantic structure of a hybrid model is presented in Table 3.

Table 3. Dandi's semantic structure.

Semantic unit	Structure I	Structure II
	Respiratory system	Oxygen need of organisms
Semantic model	Definitional	Assertion
	Hybrid model	

Table 3 shows that there are two semantic units used by the informant in constructing conceptual system about organisms' phenomenon in the aquarium. The semantic units described in structure I and structure II are the respiratory system and the oxygen need of aquatic organisms, respectively. He connected the respiratory system to the aquatic organisms' need of oxygen. The relationship means that fish breathe by using gills and thus they do not need oxygen. The informant made mistakes in constructing the semantic systems of fish respiratory system and the effect to their lives if the aquarium is blocked. Respiratory system is a mechanism of an individual to inhale oxygen for the metabolic purpose. Breathing through either gills or lungs is aimed at obtaining oxygen, so the meaning formed by the informant in the semantic structure was wrong.

Beside the reasoning given by Dandi, Juniar provides a different conclusion after analysing the phenomenon related to the organisms blocked in the aquarium. The conclusion and it's reasoning related given by Juniar are different from those given by Dandi.

Cognitive Basis

The informants' open ended answers were analyzed to determine the cognitive basis that underlays the reasoning process of the aquarium ecosystem phenomenon. The students were asked to analyze the effect that might happen to the organisms if the aquarium were totally blocked. The explanation of the cognitive basis by Juniar represents some informants who chose option B as it is presented in Table 4.

Table 4. The cognitive basis of an informant named Juniar.

Proposition	Type	Cognitive Process
Before blocking the aquarium, there is already oxygen inside the aquarium	Categorical	Phenomenon orientation
The organisms will die after there is no oxygen more	Conditional	Inferential abstraction
Every organism needs oxygen	Categorical	Affirmation

The analysis result of cognitive basis in Table 4 shows that the informant used two types of proposition in stating an argumentation related to the effect of blocking aquarium on the organisms. Both propositions are named categorical proposition and conditional proposition. Categorical proposition is used when the informants oriented the analyzed phenomenon. While conditional proposition is used to do abstraction or generalization to a phenomenon which might happen to the organisms if the aquarium were totally blocked. Categorical proposition is used to affirm the result of the generalization.

Formally, the cognitive framework structure made by Juniar in reasoning the aquarium organisms' phenomenon is in line with the theoretical explanation. However, the informant failed stating the proper inferential abstraction because he did not recognize and identify the phenomenon carefully. The informant only focused on the relationship identification between the fish and the need of oxygen. The informant did not realize the existence of other organisms in the aquarium like the vegetation, which can conduct photosynthesis and produced oxygen for the sake of other organisms. Thus, it can be concluded that the inferential validity in the phenomenon based reasoning depends heavily on the ability to recognize, define, and see the phenomenon.

Semantic Structure

The students' answers were also mapped in the form of the graph then the semantic structures were analyzed. The following Figure 2 shows the semantic structure analysis result of the informant named Juniar related to the aquarium organisms' phenomenon.

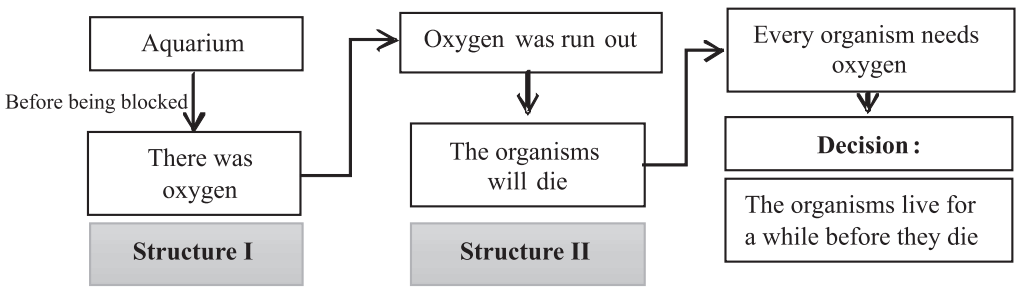

Figure 2: Juniar's semantic system.

The mapping result of semantic structure in Figure 2 shows that there are two structures used by the informant. Structure 1 called definitional structure explains the condition of oxygen in the aquarium before it is blocked. The informant identified that there was oxygen remained in the aquarium before being blocked. In the structure 2, the informant used assertion model in the sense of cause-effect relationship to explain the effect of oxygen unavailability for fish in the aquarium. Thus, it can be seen that the informant's argumentation employed the semantic structure of hybrid model as presented in Table 5.

Table 5. Juniar's semantic structure.

Semantic unit	Structure I	Structure II
	Oxygen availability	Oxygen need
Semantic model	Definitional	Assertion
	Hybrid model	

Table 5 also shows that there are two semantic units used by the informant in constructing conceptual system about organisms' phenomenon in the aquarium. The semantic units described in structure I and structure II are the oxygen availability and the oxygen need, respectively. The informant related the oxygen availability to the aquatic organisms' need of oxygen. The relationship means that fish need oxygen, so if there is no more oxygen, they cannot live. Even though the informant employed hybrid semantic model, it did not make the meaning of the structure valid. The informant failed to identify the role of other organisms in the aquarium that might produce oxygen, thus, it causes the semantic system to be invalid.

Case 2

Cognitive Basis

The open ended answers were also mapped in the form of the graph, then the semantic structures of the answers were analyzed. The students were asked to analyze the types of soil effect to the plantation growth. The cognitive basis explanation is presented in Table 6.

Table 6. The cognitive basis of an informant named Resta.

Proposition	Type	Validity	Cognitive process
Topsoil contains many mineral substances for the vegetation growth	Categorical	Valid	Phenomenon orientation
If the polybag is filled with clay, the plant cannot grow	Conditional	Valid	⩛ Effect abstraction
Clay does not contain mineral substance for plant to grow	Categorical	Valid	⩛ Affirmation

The analysis result of the cognitive basis in Table 6 shows that the informant used two types of proposition in stating argumentations of the different plant growth in two different types of soil. The two propositions are named categorical and conditional proposition. Categorical proposition is used when the informant orients the characteristics of the soils. Meanwhile, conditional proposition is used to do abstraction or generalization to a phenomenon which might happen if the plant were put in the clay polybag. Other categorical propositions are used to affirm the result of the generalization.

Semantic Structure

The students' answers were also mapped in the form of the graph then the semantic structure were analyzed. The following Figure 3 shows the semantic structure analysis results of the informant related to the plant's growth in two different types of soil.

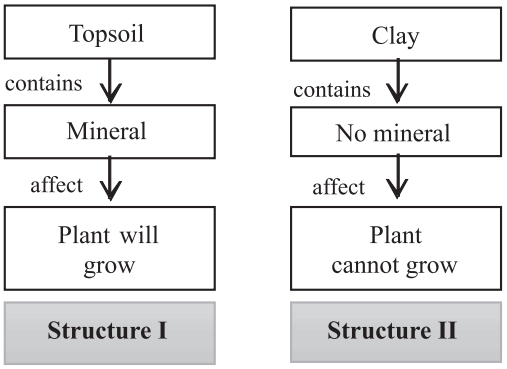

Figure 3: Resta's semantic system.

The mapping result of semantic structure in Figure 3 shows that there are two structures used by the informant. Structure 1 is called assertion structure that explains the characteristics of topsoil and its effect to the plant growth. In the structure 2, the informant also used assertion model to explain the characteristics of clay and its effect to the plant growth. The informant's argumentation using the semantic structure of assertion model is presented in Table 7.

Table 7. Resta's semantic structure.

Semantic unit	Structure I	Structure II
	Soil characteristics	Soil characteristics
Semantic model	Assertion	Assertion
	Assertion model	

Table 7 also shows that there is one semantic unit used by the informant in constructing a conceptual system about the different plant growth in two different types of soil. The semantic unit which is described is that the soil characteristic is heavily supporting the plant growth. The informant can recognize and define both phenomena so well that valid arguments can be built formally and materially. The informant can explain the characteristic differences between topsoil and clay in the sense of the mineral substances contained, so they can construct a valid mental model related to the effect of both types of soil to the plant growth. The informant makes a valid generalization by using valid characteristics.

Case 3

Cognitive Basis

The open ended answers were mapped in the form of the graph, then were analyzed to see the cognitive basis underlying the reasoning process of the different growth of cauliflower plants in different greenhouse conditions phenomenon. The following Table 8 is the cognitive basis explanation.

Table 8. The cognitive basis of an informant named Jihan.

Proposition	Type	Cognitive process
The amount of CO2 in the air, air temperature, and the light intensity accepted by the plants affect the photosynthesis activity.	Categorical	Orientation

The analysis result of the cognitive basis in Table 8 shows that the informant used one type of proposition in stating an argumentation of the different plant growth in two different greenhouses. The proposition is categorical proposition. Categorical proposition is used when the informant orients the characteristics of the plant in two different greenhouses' condition. The analysis result shows that there is only one stage in the cognitive framework used to explain the plant growth phenomenon in the greenhouses. The informant identified three variables that might influence the photosynthesis process of the cabbage. The informant did not explain the correlation between the photosynthesis and the biomass of the cabbage.

Semantic Structure

The students' answers were also mapped in the form of the graph then the semantic structures were analyzed. The following Figure 4 shows the analysis result of the semantic structure of the informant related to the different plant growth in two different condition phenomenons of the greenhouses.

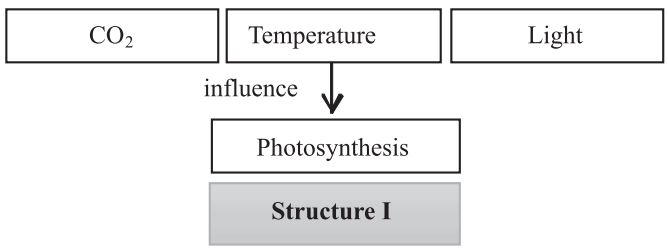

Figure 4: Jihan's semantic system.

The mapping result of semantic structure in Figure 4 shows that there is one structure used by the informant. The structure is definitional assertion structure which describes that CO_2, temperature, and light influence on the plant photosynthesis activity, as presented in Table 9.

Table 9. Jihan's semantic structure.

	Structure I
Semantic structure	Greenhouse characteristics
Semantic model	Definitional

Table 9 also shows that there is one semantic unit used by the informant to construct the conceptual system about the plant growth difference in two different greenhouses. The semantic unit described is the characteristics of the greenhouses which influence the plant growth. The analysis result of semantic structure shows that the informant used a simple structure to explain the effect of the greenhouse to the plant. It can be concluded that the simple structure might represent the informant's knowledge structure related to the given phenomenon. Based on the cognitive basis and the semantic structure explanations of the three given phenomena, the finding construction is summarized in Table 10.

Table 10. The findings construction.

Focus of the study	Case 1	Case 2	Case 3	Conclusions
Cognitive Basis	In general, there are three stages used by the students in analyzing phenomenon 1. The stages are phenomenon orientation, inferential abstraction, and inferential affirmation, respectively.	There are three stages used by students in analyzing phenomenon 2. The stages are phenomenon orientation, inferential abstraction, and inferential affirmation, respectively.	There is only one stage used by the students in analyzing phenomenon 3. The stage is phenomenon orientation.	The cognitive basis of phenomena based reasoning are (1) orientation, (2) inferential abstraction, and (3) inferential affirmation. The students can analyze the phenomena by using a systematic cognitive framework if they have complete knowledge of the given phenomena.
	The students demonstrate the orientation stage when they analyze the given phenomenon even though the inference is not valid.	The students are able to analyze the differences and infer well.	The students are able to orient the given phenomenon well, although it is not followed by further cognitive framework.	The inference validity in the cognitive basis is determined by the ability to analyze the phenomenon
Semantic Structure	The students are able to provide structured argumentation in two semantic models, named definitional and assertional model.	The students are able to provide structured argumentation in two semantic models, named definitional and assertional model.	The students are able to provide an argumentation in one semantic model, named definitional model	There are two general semantic structures in phenomena based reasoning, named definitional and assertional model. The semantic structure complexity is determined by the availability of knowledge related to the analyzed phenomenon.

Discussion

Reasoning is a thinking process which is based on the facts or a concept to create a certain conclusion related to new facts or concepts never existed before. Reasoning is a linear thinking process having a beginning and an ending point, yet it is subsequent. The final conclusion of a particular reasoning process of a concept might be the beginning of another reasoning process of other concepts. Therefore, reasoning process consists of some stages that need to be done by a reasoner in analyzing a particular phenomenon. The stages of reasoning are considered as a cognitive process, which is determining the overall reasoning activity. Each stage of reasoning process also has a certain characteristic.

In the present study, the researchers use a framework of cognitive process by Sibley (2009). Ideally, a reasoning process needs to follow 3 essential stages, namely orientation, abstraction, and re-representation. However, those three cognitive processes cannot guarantee the validity of a particular reasoning conclusion. The informant named Dandi drew a valid conclusion for the first phenomenon, yet the supporting propositions were not valid. Fish are indeed able to live in a blocked aquarium not because they do not need oxygen, but because the vegetation inside the aquarium can provide the oxygen needed by producing it. The informant named Juniar drew an invalid conclusion based on the incomplete problem orientation. The informant did not recognize and define the role of the organisms in the aquarium.

This result shows that orientation of phenomena is a very important stage in the cognitive process of reasoning activity. A certain phenomenon might have a particular structure, consisting of several interrelated variables. In orienting a certain phenomenon, a reasoner needs to consider and understand the variables related. Well understanding of each variable might facilitate the reasoner to analyze the problem correctly and reconstruct the problem in order to make an appropriate conclusion. The phenomenon recognizing process needs a long term memory activation to define the elements of the phenomenon. Thus, the ability to recognize a certain phenomenon heavily depends on the availability of memory of the elements. It is in line with Goldvarg & Johnson-Laird's (2001) opinion that the ability to describe a reality beyond someone's mind is determined by the ability to construct meaning of prior knowledge. One's mind creates a semantic structure that is spatial-temporal in nature to recognize outside objects.

Another important ability in conclusion-making is an ability to reconstruct the phenomenon. The phenomenon reconstruction process is a process of mind to build a mental model based on the previous recognition. This reconstruction process needs an ability to interpret the semantic meaning of a certain element. If a reasoner can

understand the semantic meaning of each element properly, the construction process might utilize rational logic, otherwise it might utilize his intuition. A supporting fact of this statement can be found in the study, especially in the phenomenon 1, in which the informant made a generalization that fish breathed by using gills so they did not need oxygen. It indicates that the informant is bias in understanding the meaning since the informant utilizes intuition. It is in line with Alter et al.'s (2007) opinion that if a child tends to use his intuition during thinking process, it might be caused by the lack of capacity and motivation to analyze a certain phenomenon comprehensively. Another assumption is that most children have a limited capacity of working memory to process information.

The result of the study also shows that children are able to deliver their argumentation in a complex structure. Most of the participants of the study are able to deliver their argumentation in a hybrid semantic structure since it is found that more than one structure is having different types. It shows that children are able to construct a mental model related to the phenomenon analyzed. This result is not in line with the results of Vosniadou *et.al*, (2001), Nicollini *et.al*, (2007), Jonassen *et.al*, (2005) that children's knowledge structure is constructed based on concrete experiences and is very limited, yet it has been structured as theory like. Although the result of this study verifies Perkins et al.'s (2000) study that children in the age of 11-12 show difficulty in detecting concept invalidity in their daily thinking process. It means that even though children are able to state their well-structured and complex argumentation, yet the material truth of each proposition within the argumentation is not valid. In other words, there is invalid proposition used to construct a semantic network that they do not realize. Conceptually, it might be caused by the lack of control to the cognitive processes which take part in the reasoning process. Khun & Pearsall (2000) explained that the development of scientific thinking during childhood and adolescent age was indicated by the increasing of cognitive control to theoretical coordination and evidences.

Conclusions

Based on the result of the data analysis and discussion, it can be concluded that the cognitive basis of reasoning based on phenomena consists of (1) orientation, (2) inferential abstraction, and (3) inferential affirmation. The students who deliver accurate argumentation are the ones that are able to recognize a particular phenomenon well. Hence, one of the cognitive basis factors that influences the phenomenological reasoning process is phenomenon orientation. Generally, most students are able to deliver well-structured argumentation using hybrid pattern. However, the validity of the proportions that construct the semantic network is not valid. The result of this study indicates that the students who are not taught specifically to use reasoning norms can deliver their argumentation logically by using well-structured cognitive basis. The delivered argumentation also has complex semantic network structure.

Nonetheless, this study has a limitation in the sense of the scope, which does not include higher level education such as upper secondary school or university. Moreover, this study also does not describe the factors that influence the reasoning process in detail such as learning, metacognition, and motivation. Therefore, it is necessary to conduct further study in order to map the cognitive basis of upper secondary school and university students so that the result can be compared to the result of this study or other further studies to see the effect of learning, metacognition, and motivation factors to the reasoning process.

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