Profile of High School Students’ Propositional Network Representation when Interpreting Convention Diagrams

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Abstract. The delivery of concepts in studying Biology often represented through a diagram to easily makes student understand about Biology material. One way to knowing the students’ understanding about diagram can be seen from causal relationship that is constructed by student in the propositional network representation form. This research reveal the trend of students’ propositional network representation patterns when confronted with convention diagram. This descriptive research involved 32 students at one of senior high school in Bandung. The research data was acquired by worksheet that was filled by diagram and it was developed according on information processing standards. The result of this research revealed three propositional network representation patterns are linear relationship, simple reciprocal relationship, and complex reciprocal relationship. The dominating pattern is linear form that is simply connect some information components in diagram by 59,4% students, the reciprocal relationship form with medium level by 28,1% students while the complex reciprocal relationship by only 3,1% and the rest was students who failed to connect information components by 9,4%. Based on results, most of student only able to connect information components on the picture in linear form and a few student constructing reciprocal relationship between information components on convention diagram.

1. Introduction

The delivery process of concepts in studying Biology often represented through a diagram. The teacher very dependent to diagram and graphic for teaching Biology material with well [1]. The diagram can be represented in two ways, spatial isomorphs and convention representation [2]. The spatial isomorphs diagram is a diagram which is resembles the form of actual source while the convention representation illustrates the form that is represented through symbolic features, color and icon. Someone will interpret the diagram with well if he/she able to identify the elements in the diagram by spatial isomorphism or convention representation [3]. One way to knowing the students’ understanding about the diagram can be seen from causal relationship which is constructed by student in form of propositional network representation.

Studying a meaningfulness, cognitive psychology develop the propositional representation. Proposition as representation concept play a role in information processing model (illustrating every kind of information) and often interpreted connect with picture [4]. Information processing involve working memory to get experience (knowledge) which is stored in long-term memory. Empirical
component that is stored the information according to experience can be explained in form of propositional network [4]. According to that opinion, propositional network representation can be a way to knowing student’s understanding about the diagram through causal relationship that is constructed by student. Proposition which is known by subject can be helping to choose information and factual that is relevant in combining cognitive units with appropriate way to solve the problem [5].

Symbolic knowledge representation is a rather neglected problem, especially studying network that can represent and study the infinite propositional rules [6]. Diagram interpretation can form the visual representation of person’s mental. The formation may be guided by previous knowledge that involve associative connection between mental visual representation and information that is triggered by diagram [3]. Propositional network representation explain declarative/conceptual knowledge which is represented in propositional network similar with semantic network representation [7]. Research about propositional network representation may never have been done. But the student’s mental visualization picture when they reads diagram was already done a lot [3]. In a section other than education, propositional network representation has been widely applied in Human Factors and Ergonomics Society section to illustrate knowledge object in a work system scenario. Propositional network consists of one set of nodes which are represented information source, agent, and objects that are connected in certain causal paths [8].

2. Methods
This research is a descriptive research which aims to give a student’s mental representation description and the causal relationship is represented in form of propositional network representation when interpreting convention diagram. This research also reveal the factors which are influence propositional network representation pattern that is constructed by student. The data was collected qualitatively to see the trend of propositional network representation pattern then it’s described in order to explain student’s mental representation description when interpreting diagram. The subject in this research was 32 students from one of senior high school in Bandung that was determined according to convenience sampling technic or willingness to involve in this research. Data collection is acquired by using written instrument in form of worksheet which aims to identify and analyze the trend of propositional network representation which is made in propositional network according to diagram that have been available.

Worksheet is developed according to 4 standards information processing [9] and adapted to be three standards that is information identification, information integration (interpretation and information synthesis) and information relevance analysis. Identification and information integration is made in form of question that is made in description form while information relevance analysis is explained in form of propositional network representation that is constructed by student. Worksheet instrument development is executed through judgment preparation step for validate the instrument by expert lecturer. Judgment implementation by expert lecturer about worksheet instrument aims to know the content of validity, conformity with framework indicator that is adopted, question conformity with answer key and language structure.

3. Result and Discussion
The research data is analyzed according to results of respondents answer in the worksheet and observation result according to questionnaire and findings obtained while in the field. The given of worksheet instrument have held in the moment after studying sense system material. Previous knowledge (prior knowledge) will very guides student to connect the connection of associative in mental visual representation with information that is triggered by diagram [3]. This also aligned with previous research that first knowledge influence interpretation diagram/picture ability [10]. Research finding that is presented in form of student’s propositional network representation pattern description when interpreting convention diagram according to student’s answer analysis result in the worksheet that have been given. The developed diagram in this research has gone through judgment step by expert lecturer. Something that is considered according to conformity analysis with curriculum that’s
used, conformity analysis of material concept according to information component indicator and completeness which are show the process mechanism. Diagram that is used in the research to get student’s representation information is a diagram about eyeball structure and mechanism of seeing process below.

Figure 1. Diagrams of the eyeball structure and the mechanism of seeing process

Figure 1 describing information component of structure which is compile the eyeball and seeing process mechanism from the beginning, light that is came in to the eye as an object which is seen till the object’s shadow is translated by brain to be a real object. Some question in worksheet guide student to connect between information component concepts in form of propositional net pattern. The question require respondent to identify information component on the diagram that is related with seeing process mechanism only (light as object, cornea, aqueous humor, pupil, iris, lens, vitreous humor, retina, fovea, photoreceptors that is consists of stem cells, cone cells, bipolar cells, interneuron, ganglion cells, inverted shadow from object, optical nerve, brain, objects real picture) and describing the function of every information component with a truly concept and connecting between information component concept to build propositional network representation.

3.1. The trend of student’s propositional network representation pattern when interpreting convention diagram

Based on research finding, from 32 respondent which are filling the worksheet instrument, it is found three student’s propositional network representation big pattern on the eyeball structure diagram and seeing process mechanism according to complexity level of the relationship between information component concepts that is used. The three patterns are linear form (simple), reciprocal relationship form (causal) with medium level and complex causal relationship form. Propositional network representation pattern is related with causal network formation that is constructed by student. Causal network illustrate all of the student’s knowledge to object/diagram that is useful to rate the student’s way taking decision to the information [11]. So, can be seen the variation of relationship pattern between information components in propositional network because the student’s comprehension to the information about diagram that is interpreted also different.
The linear pattern is a pattern that is very dominating in this research and constructed by students by 59.4% from all of respondent. Based on analysis result from linear pattern, student construct the propositional network with a different information component number and also the relationship number between the information component concepts. In the second pattern, 28.1% student already able to construct reciprocal relationship between the concept from information component that is found on picture, although a few student only. Meanwhile, on the third pattern, 3.1% student already able to connect the information element concepts to be more complex. The complex form which is formed is interpreted as a relationship which is involved information component number that is connected one to another so much compared with previous pattern. Besides of the three pattern, the rest is student that is failed to connect between information component by 9.4% and in detail, the student percentage in every pattern can be seen on figure 2.

![Figure 2. Student percentage on every trend of propositional network representation](image)

Three pattern which are represented student propositional network representation description on figure 2 above also have an ability to processing the different information in every pattern. This information processing represent from visual form and verbal become verbal system. On this worksheet, student not only asked to find and synthesize important information component on the convention picture, but also able to describe with causal relationship form from information component. Information processing center in working memory is different between visual and verbal information [4]. When the information component is interpreted, information processing in working memory every student to do the activity will also different. Working memory that is recorded in form of mental representation can give implication to studying activity if it able to choose a better method that will be used in studying process [12]. This is known from student’s answer when identifying information, describing information on the eyeball structure diagram and seeing process mechanism and then connecting it in form of propositional network. The following is representation pattern that is elaborated according to information interpretation on picture 1.

3.1.1. 1st pattern: propositional network in linear form (simple). On propositional network pattern in linear form show the relationship between concepts with one-way traffic. Average respondent in this pattern, in minority (31%) already able to identify the information component that is expected (light as object, cornea, aqueous humor, pupil, iris, lens, vitreous humor, retina, fovea, photoreceptors that is consists of stem cells, cone cells, bipolar cells, interneuron, ganglion cells, inverted shadow from object, optical nerve, brain, objects real picture) while by 42.1% of respondent also writing the information component that is not too necessary in seeing process mechanism (ciliary muscles, artery and vena and also ligament). Meanwhile about 26.3% of respondent writing some important information component, but less than complete. This is caused by the student firstly knowledge is very react in student to know a concept and new information on diagram, so they do a wrong interpreting
Aligned with previous research, someone cannot interpret and represent information component in diagram without knowing and understanding that information [3].

Table 1. Ability to process student information on the 1st pattern (linear)

| No | Information Identification                                                                 | Respondent Percentage |
|----|-------------------------------------------------------------------------------------------|-----------------------|
| 1  | Writing almost all of the information components on diagram                               | 42,1%                 |
| 2  | Writing important information component about seeing process mechanism                    | 31,6%                 |
| 3  | Less complete in writing information component on diagram                                  | 26,3%                 |

| No | Information Integration                                                                  | Respondent Percentage |
|----|-------------------------------------------------------------------------------------------|-----------------------|
| 1  | Less complete in describing information component but the concept is already correct      | 94,7%                 |
| 2  | Describing information component completely and the concept is correct                    | 5,3%                  |

| No | Information Relevance Analysis                                                           | Respondent Percentage |
|----|-------------------------------------------------------------------------------------------|-----------------------|
| 1  | Connecting information component properly and correctly                                  | 73,7%                 |
| 2  | Connecting most of information component with incorrect concept                          | 26,3%                 |

Based on table 1, student already able to identify all of important information component and able to describe the role in seeing process mechanism in the first pattern. But still, linear pattern that was described by student unable to connect from every information component that is already identified and described previously, so the trend that has been formed be in the same direction. The assumption that can be reported is because student assume a process that happen in mechanism, only shows the process from coming of the light till it’s translated by brain. Information component that can be connected also limited light lane through eyeball structure to brain, without thinking about function linkage from every information component on the convention diagram. Information component that is described and connected in propositional network representation by student are still found the incorrect concept in explaining seeing process mechanism. Even though, most of students already correct and properly in interpreting the information component and explaining seeing process mechanism on figure 1. Propositional network pattern is linear form (simple) that is constructed by student can be an example to figure 3.
3.1.2. 2
d Pattern: Propositional network forming some reciprocal relationship (medium).
Propositional network pattern which is forming some reciprocal relationship of information
component already connecting the correct concept, in accordance with when identifying constructed
information component. One of example from propositional network pattern that show some
reciprocal relationship described to figure 4.

Figure 3. Propositional network pattern is linear form with the correct concept (a) and incorrect
concept (b)
Figure 4. Propositional network pattern that show some reciprocal relationship (medium)

The reciprocal relationship happened because information component number that is obtained more information. More information that is owned by student, then the causal relationship that is made is increase [11]. This is caused of the student beginning knowledge is related with information processing speed in working memory so causal network can be formed [13]. Based on table 2, most of it (77,8%) identifying all of the important information component expected (light as object, cornea, aqueous humor, pupil, iris, lens, vitreous humor, retina, fovea, photoreceptors that is consists of stem cells, cone cells, bipolar cells, interneuron, ganglion cells, inverted shadow from object, optical nerve, brain, objects real picture) and also writing the information component that is not too necessary in seeing process mechanism (ciliary muscles, artery and vena and also ligament). Meanwhile about 22.2% of respondent are writing some important information component, but less than complete.

Table 2. Ability to processing student information on the 2nd pattern (reciprocal relationship with medium level)

| No | Information Identification | Respondent Percentage |
|----|----------------------------|-----------------------|
| 1  | Writing almost all of the information components on diagram | 77,8% |
| 2  | Less complete in writing information component on diagram | 22,2% |

| No | Information Integration | Respondent Percentage |
|----|-------------------------|-----------------------|
| 1  | Less complete in describing information component but the concept is already correct | 94,7% |
| 2  | Describing information component completely and the concept is correct | 5,3% |

| No | Information Relevance Analysis | Respondent Percentage |
|----|--------------------------------|-----------------------|
| 1  | Connecting most of information component properly and correctly | 100% |

3.1.3. 3rd Pattern: Propositional network forming more reciprocal relationship (complex). On the pattern that was constructed with connecting information component in a complex way aligned with
the respondent’s way when identifying almost all of the information component on the diagram. The reciprocal relationship complexity is happened because the information component that is obtained relevance with the purpose of diagram that is wanted to be delivered. Student who can choose and interpret the diagram so they can connect information component correctly. This is also related with information processing speed and student’s beginning knowledge [13], [3]. Important information component that is identified almost all (light as object, cornea, aqueous humor, pupil, iris, lens, vitreous humor, retina, fovea, photoreceptors that is consists of stem cells, cone cells, bipolar cells, interneuron, ganglion cells, inverted shadow from object, optical nerve, brain, objects real picture) but also writing information component that is not too important in seeing process mechanism (ciliary muscles, artery and vena and also ligament). Beside, information component that is identified and described also completely and correctly concept. This is proven with reciprocal relationship that can consists of many information component and also the concept is correct. Propositional network pattern with complex relationship that is constructed by student can be an example to figure 5.

![Figure 5: Propositional network pattern that shows complex reciprocal relationship](image)

3.2. Factors that influence student’s propositional network representation

Various internal or external factor that influence student to build propositional network representation when are faced to a convention picture may need to know. On the questionnaire, consists of 15 statement and can be grouped to be two parts about student’s problem in understanding the diagram and constructing propositional network. According to questionnaire’s answer analysis, most of student agree that teacher have used a diagram to explain material in studying activity. The explanation of material using a diagram from teacher more preferable by most of student and also easy to understand compared with verbally explanation. Beside via teacher’s explanation, student are also prosecuted to be able to find and explain the diagram in front of the class as one of biology assignment in groups. Student are given a freedom to use a diagram from various source like text book or another relevance source like internet. Most of the student feel that diagram on the text book is very complex and hard to understood. When explaining the diagram, most of student feeling easy to explain the diagram that is used because student have many information from diagram so it can help them understand the material that have been studied. But if it compared with verbally explanation, student prefer to explain the diagram through verbally explanation compared with using diagram.
4. Conclusion
Student’s propositional network representation when interpreting convention diagram reveal three causal network pattern which are linear, some reciprocal relationship and complex reciprocal relationship. The pattern variation is influenced by the different of information processing that is happened in student’s working memory. Linear pattern is more dominating when student connecting the concept between information component that consists in convention diagram and guided by prior knowledge that is obtained by student in studying process moment. The revealed propositional network representation quality in this research cannot guarantee that using a diagram can push the cognitive load. The implication that is could reported to biology learning process is the need of other strategy that can strengthen the student beginning knowledge first.

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