Students Mental Representation of Biology Diagrams/Pictures Conventions Based on Formation of Causal Network

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Abstract. Diagrams/pictures conventions is one form of visual media that often used to assist students in understanding the biological concepts. The effectiveness of use diagrams/pictures in biology learning at school level has also been mostly reported. This study examines the ability of high school students in reading diagrams/pictures biological convention which is described by Mental Representation based on formation of causal networks. The study involved 30 students 11th grade MIA senior high school Banten Indonesia who are studying the excretory system. MR data obtained by Instrument worksheet, developed based on CNET-protocol, in which there are diagrams/drawings of nephron structure and urinary mechanism. Three patterns formed MR, namely Markov chain, feedback control with a single measurement, and repeated feedback control with multiple measurement. The third pattern is the most dominating pattern, differences in the pattern of MR reveal the difference in how and from which point the students begin to uncover important information contained in the diagram to establish a causal networks. Further analysis shows that a difference in the pattern of MR relate to how complex the students process the information contained in the diagrams/pictures.

1. Introduction

Representations can be a mental representation (MR), which varies depending on the abstractions, for example, is a representation may be similarities, photos, portraits, descriptions, symbols, picture/diagram, art, etc. [1]. The level of mental representation that is formed is obtained from the relevance of the detailed information of the Causal network [2]. Intelligence development of learners must be a concern in the learning process, it is useful for learners to be able to think well. In each of the learning process, the ultimate goal is to establish a pattern of thinking, because thinking activities involving high mental activity [3]. Difficulties students in understanding abstract concepts of biology is because the human mind was not able to give the best response to representations that are abstract [4]. One form of information presentation visual media through diagrams/pictures, ie in the form of diagrams/pictures conventions, diagrams/pictures conventions using color, arrows, and notation describing the structure and relationships between functions or processes to represent any of the information contained in the picture, it will describe the non-structural features, such as picture/diagram of a process or behavior [5]. Picture has a role in understanding science concepts including learning system concepts in biology, the ability to represent, understand and read the picture becomes very important in education, especially learning activities [6].
Previous research by revealed, when students read images of convention representations, MR of students shows different patterns, the formation of a mental representation and the student's ability to interpret the component information in the picture, is an important aspect in order to fully understand the picture [7] however in this study the pattern of representation refers to the pattern developed by Ito. Data obtained by the causal network is the result of a process of observation and analysis, a model of causal network will be shaped like the mechanism of the system [8]. To represent a variety of visual media would require a model of representation, CNET Protocol involves activities of working memory to create a cognitive schema in active form, cognitive schema contains information that is interconnected, and its formation is very dependent on working memory involved in receiving and processing information [9]. Processing information in working memory is fundamental to represent the mental, so that the information obtained necessarily refer to the process of acquiring information, information integration, coding of information to be stored in the form of a scheme, and coding the information to be represented back [2]. Working memory will vary between each individual, so that each individual will produce a mental representation that is different in reading a variety of instructional media [10]. Therefore the mental representation forms is determining the formation of cognitive schemas and comprehension levels of students during the learning [11].

The main objective of this study was to analyze the pattern of students' mental representations with topological order of causal network when reading picture representation convention on the concept of the excretory system. Knowing the pattern of student mental representation when reading diagrams/pictures, teachers can select and define diagrams/pictures that can be used appropriately as a media of learning biology, so it will affect the control of the cognitive load that may arise against material abstract that exist in learning biology. This study is one that can serve as a bridge to help teachers in planning and seeing the students' ability in shaping knowledge through learning media as a whole by promoting the cognitive processes to achieve affective and psychomotor better. By knowing the pattern of mental representation of students in reading conventions diagrams/pictures, the teacher can knows that conventions diagram/picture can help students in the form of their knowledge, and may assist teachers in selecting appropriate learning media in accordance with the material being studied. Also helpful for students in developing their ability to read and fully understand the diagrams/pictures.

2. Research Method
This research uses descriptive method, aims to give an overview of how different patterns of mental representations of the students when reading the picture as measured by the establishment of a network of causal instruments worksheet-based CNET-protocol. Worksheet contains a number of conventions diagrams/pictures, statements and/or questions, done after students get the teaching materials. Formation of students mental representation is the result from the representation of the information elements contained in Figure 1. The results of the analysis is qualitative data in the form described by variations of the formation pattern of causal networks. The pattern formations of causal networks analyzed with topological order that can show the different pattern with a level of causal network [12].

Participants are 30 students of class XI MIA, determined by convenience sampling. Research conducted at one of senior high school at Banten area. Implemented in the first semester of the academic year 2016/2017, exactly in the March-April 2017.

3. Result and Discussion
The findings showed a tendency RM pattern formed on the picture representation convention. The picture presented is a picture on the Relationship of Structure Formation Process nephron and urine (Figure 1).
Patterns formed mental representations adapted to the basic pattern of the development of Ito [12]. Research findings showed a variation of the pattern of causal networks formed by students, for more details, here is a breakdown of the data on the MR students to the conventions picture. Representation of mental of Figure 1 is formed by determining the variable part of the information elements and sort the elements of the information correctly, and can build a causal network relationships among elements information. The findings showed three variations of patterns formed, the pattern of the first refers to the pattern of Markov Chain, second pattern refers to the pattern of feedback control with a single measurement, and third pattern refers to the pattern repeated feedback control with multiple measurement. Percentage of pattern formation tendency of students' mental representations can be seen in Figure 2.

Figure 1. The relationship nephron structure and process of the formation of urine [13]

Figure 2. Percentage of pattern formation of students mental representations

This study found three variations of the pattern of mental representations found. The first pattern consists of respondents that can form a pattern like a work flow or process involving the whole or some of the elements in the picture information related to the structure and process. The second pattern consist of respondents can form different patterns flows between the elements of the process and structure information but still in one relationship, which involves an element of information and the overall process or some elements of the structure information. The third pattern consist of respondents can form different patterns flows same as the second pattern between structural elements and process information but still in one relationship, but it involves more than one element of the overall process and the information or some element of structure information. Of the three kinds of patterns such representations, third representation patterns are patterns that are expected for the representation of Figure 1. Charta shown in Figure 2 can be seen that the pattern of the third most dominating with a percentage of 47%, higher than pattern 1 by 43% and pattern 2 by 10%.
Three patterns variations of representation formed based on completeness and sequence of information elements, and relationships between information elements. In the picture of the relationship nephron structure and process of formation of urine contains several elements of information that is divided into two, that is information element of structure and process. Elements of structure information that is glomerulus, Bowman’s capsule, proximal tube, loop of henle, distal tubule, collecting duct. As for the information elements associated with that process, that is filtration, reabsorption, and augmentation. The pattern of this representation if it is linked with the picture relationship nephron structure and process of the formation of urine, then the two parts separate information elements, element structure and process information, but the second part of the information elements to be interconnected to perform activities of the excretory system. The pattern of mental representations are obtained by an worksheet instrument, can be seen in figure 3.

**Figure 3.** The Formation pattern of students' mental representation, a and b are pattern 1; c and d are pattern 2; e and f are patterns 3

In figure 3 shows some examples of the variation formation pattern of MR, the pattern proves that the MR pattern formation is formed based on the completeness of the information elements and the order of the information elements and relationships between information elements. On the a and b (Figure 3) visible difference from the amount of information and the order of elements of different information and the relationship between process elements and different structures, and both are shaped like flows of process mechanism, on the part of a contained element structure information and processes into one, while part b only structural information elements are formed flows. On the c and d
(Figure 3) shows the pattern of MR which has one separate elements into an element called element attached, seen from the difference networking causal formed between the two have differences of completeness of information, sequences, and the relationships among elements of information, part c visible presence of the element bound ie glomerulus/Bowman’s capsule subsequently forming a flow, and on d seen meandering but seen only form a flow with reabsorption as elements bound, while the filtration should be elements of other dependent seen getting into the same flow. In part e and f seen students are able to distinguish between information elements and processes but interconnected between one and the other becomes a mechanism that looks more complex. The third variation of patterns formed describe that each pattern MR on different students, starting from which students form their networks to form a causal networks that showed comprehension and complexity thinking of students.

Patterns of representation will relate to the establishment of causal networks, the study showed differences in causal networks are different for each student. Third pattern (RepeatedFeedback Control With Multiple Measurement) shows a more complex representation compared with other patterns. Variety of patterns formation will vary depending on the students not only depend on the completeness of the information elements in the picture, but also the students' understanding of the picture reading and the knowledge they had before. More information students have correlated with the greater network of causal formed, the establishment of causal networks is determined by processing information (information processing) in working memory, because the MR formation is influenced by the activity of working memory [2]. Thus the amount of information does not necessarily prove that the students can and understand the intent of the picture which, prior knowledge related to the speed of processing information in working memory [10]. Thus the formation of MR depending on processing information in working memory that influenced by prior knowledge of students, students' understanding of the picture, and the complexity of the information in the picture. The amount of information that students will understand correlated with students prior knowledge and form a unity, so that the working memory will form a representation of the picture derived from the prior knowledge and the amount of information that students understand.

Proven with varied formation patterns of representation, it indicates that not all students are able to understand the information on the picture with a high degree of complexity. The difference from the pattern formed representations show the complexity of the picture represents the students in the form of causal networks. The information that has a high level of complexity that can limit the cognitive process and reduce the level of comprehension of students [14]. When given a picture with a high complexity early take on the role as a knowledge base for understanding the picture, understanding the picture portrayed through the representation of the pattern formed by the students. Prior knowledge lack of proper knowledge about a concept or information held by students, can lead to decreased ability students to interpret the information element in a diagram/picture [15]. Forming a good mental representations needed a good prior knowledge, understanding of the picture to identify each element of the information properly, so that it will form a good representation of the picture, although the level of complexity of the picture is high. So that different patterns of mental representations that reveal how and where the information element representation of picture which begins to form a causal network. The ability of student when reading conventions diagram/picture describe the performance of working memory each student represents the diagram/picture becoming a pattern of causal network. Causal network reveal

4. Conclusion
Difference from the Formation patterns of MR show the complexity of the picture represents the students in the form of causal networks. The formation of a MR is influenced by three factors, that is the prior knowledge of students, students understanding of the picture, and the complexity of the pictures presented. Mental representations needed a good prior knowledge, understanding of the picture to identify each element of the information properly. MR reveal how and where the information element representation of picture which begins to form a causal network. The ability of student when reading conventions diagram/picture describe the performance of working memory each student represents the diagram/picture becoming a pattern of causal network. Causal network reveal
complexity of thinking each student, than shows different mental representation of students towards the diagram/picture.

By knowing the pattern of mental representation of students when reading conventions diagrams/pictures, the teacher can knows that conventions diagram/picture can help students understand concepts of relationship between structure and process of the body, and may assist teachers in selecting appropriate learning media that convenient with the concepts, also helpful for students in developing their ability to read diagrams/pictures to understand the concepts better.

This research is still far from perfect, lacking in some things like the lack of measurement of the prior knowledge of students, so it will be correlated with the pattern of representation is formed, and therefore in further research needs to be some things in order to strengthen and support research into better.

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