Pattern of student mental representation when faced media animation video of plant transport and its relation with mental effort

N Juliyanti¹, A Rahmat²* and R Riandi²

¹Program Studi Pendidikan Biologi, Sekolah Pasca Sarjana, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi No.229, Bandung 40154, Indonesia.
²Departemen Pendidikan Biologi, Fakultas Matematika dan Ilmu Pengetahuan Alam, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi No.229, Bandung 40154, Indonesia

*adirahmat@upi.edu

Abstract. Media animation video is one of visualization media that can describe the movement and transformation in a process as process of transport in plant. This study aimed to analyze the pattern of student mental representation when faced with media animation video and its relation to student mental effort. This research is a descriptive research conducted on 33 students of 4th semester who are studying the course of Plant Physiology at one of the University in Bandung, Indonesia. The measurement of mental representation is done by using worksheet CNET-Protocol while the measurement of mental effort is done by using questionnaire subjective rating scale. The analysis shows that there are 3 patterns of mental representation formed by the students when faced media animation video that is one-way linear pattern, simple branched pattern and branched more than two pattern. The analysis of correlation between mental representation and student mental effort show no significant correlation of both. This results describe that pattern of students mental representation formed on the media animation video shows a variety patterns. But in its formation, mental representation is not influenced by the mental effort done by the students but purely from working memory.

1. Introduction
Plant physiology is a course which discuss about process and function that occur in plant. One of subjects/material in plant physiology is process of plant transportation. In this subject, it consists of concepts of abstract [1]. It needs to occur representative learning with the help of learning media/instructional media. Media is aids in learning activity process of learning and teaching that can evaluate teaching material [2]. Visual media will help students to use their cognitive capacity to depict abstract visualization concept [3]. Appropriate visual media which is to depict a process by creating transformation is animation video media [4].

Media usage requires student in relying representation ability from what they see to form the new information. Mental representation is internal representation that related to knowledge representation in cognitive scheme [5]. Good representation happens when someone is able to understand and rewrite all the information on their mind into a cognitive scheme. The quality formation depends on mental representation that is generated during the process of learning [6]. Formation of mental representation
is based on the relation between information elements and it is formed only in certain time and condition [7]. The more relation networks that are formed, there are many complex knowledge that are owned by individual. It is because working memory of each individual is different [8]. Formation of mental student representation in this research is based on archetype of Causal network [9]. Previous research reveals that representation of mental student is affected by the ability to receive and process information in working memory [10]. This research wants to prove that whether mental effort can become another factor in the formation of someone’s mental representation since the activity of working memory is in line with mental effort, and both of them are the component of cognitive load [11]. Mental effort is a concept to help in determining how hard the person tries in processing information [12].

The aim of the research is to analyze mental representation pattern of student when they are faced in performance of animation video media in biology learning activity. In addition, it is to analyze the relation between student’s mental representation and mental effort that are done by students in obtaining information. To find out mental representation pattern of mental from student, lecturers use learning media called animation video media as media that supports in activity process in teaching and learning. In this case, animation video media is used because it is considered appropriate as the effort to control cognitive load in facing abstract biology material and depicting a process of plant transport. This research can be used as consideration to help teacher in planning the learning by using appropriate learning media and knowing the ability of student in obtaining information through used learning media. Other than that, to give information related to one of cognitive load components which is mental effort. By doing measurement of mental effort, student can determine learning efficiency by comparing learning appropriate strategy to help students in obtaining information. Therefore, this research is conducted to find out how deep mental effort in affecting the students in forming mental representation.

2. Method
This research used descriptive method, it aimed to give information of pattern mental representation of student that was formed when faced to animation video media and the relation with mental effort. This research was done to 33 college students in 4th semester who were taking plant physiology in one of universities in Bandung, Indonesia. Mental representation of students’ was representation result when faced in animation video media process of water movement in root. In the video, animation depicted a process of movement and formation with elements of information. The measurement of students’ mental representation was measured by using worksheet of CNET-Protocol developed by Arentz [7], there were criteria which were measured in worksheet such as (1) completeness and the order of the information elements, (2) the reasoning on order of the information element and (3) the relation between elements of information. Whereas the measurement of mental effort was done by using questioner of subjective rating scale with the scale of 1-9, category of responses consisted of score 1 if the respond was very helpful and score 9 if the respond was not helpful [12]. The questions consisted of learning strategy, media usage and discussion activity in learning activity. Analysis of mental representation pattern was formed based on pattern of causal network [9]. Obtained score was to find out students’ mental effort that was based that the lower score, it was less mental effort that is done by students [12]. Then for knowing analysis relation between mental effort and mental representation that were formed by students, it is done examination statistically which was doing correlation test. Pattern of mental representation was based of causal network using topological order developed by Ito [9] as can be see in table 1.
Table 1. Pattern of mental representation based on causal network.

| Pattern | Sample Pattern | Topological order causal network |
|---------|----------------|---------------------------------|
| 1       | ![Pattern 1](image1.png) | **Markov chain**, Shows that the main information element is similar with other information element, are not separated into two elements which is interconnected, so it looks like groove. |
| 2       | ![Pattern 2](image2.png) | **Feedback control with a single measurement**, Shows the existence of one information element relationship of causal network formed, but there is no reciprocal relationship of main information elements. |
| 3       | ![Pattern 3](image3.png) | **Repeated feedback control with multiple measurement**, Shows the existence of some reciprocal relationship on causal network formed but not all elements of information. |

3. Result and discussion

Pattern of mental representation which was formed when they were faced to animation video of structure and process of water movement in root. Pattern of mental representation showed several variations that depicted casual network that were formed from information elements that had been represented. There were three variations of mental representation pattern which were formed by students that is pattern 1, one-way linear pattern, simple branched pattern and branched more than two pattern. If it referred in formation of Causal network [9], the finding was the same as pattern 1 which was Markov chain, pattern 2 was feedback control with a single measurement and pattern 3 was repeated feedback control with a single measurement. Tendency percentage of formation of mental representation can be seen in figure 1.

![Figure 1](image4.png)

**Figure 1.** Percentage of students’ mental representation pattern formation.

Figure 1 shows that three patterns of mental representation that was formed had tendency of percentage with the biggest percentage which was formation of pattern 3 with percentage of 46% and pattern 1 and 2 had balance percentage of 27%. It showed that students had been able to form representation by forming several relations between element of information that were more complex in pattern 3. Working memory each individual is variate, so that each individual would generate different mental representation in understanding learning media [8]. Formation of mental representation pattern also showed several variation of different pattern while being faced to animation video media of structure and process of...
water movement in root. If it is showed from presentation tendency, 46% of students had understood material of plant transport in process concept of water movement in root. It is because the formation of mental representation determined the formation of cognitive scheme and understanding level of student during learning activity [6].

Three variations of mental representation pattern were formed based on completeness and order of information elements, the reasoning on order of the information element and the relation between information elements. In performance of animation video media about structure and process of water movement in root consisted from several information elements that could be represented, in root structure (hair root, cell wall, cell membrane, plasmodesmata, epidermis, cortex, endodermis, perisikel, xilem) or movement process of waterway (diffusion, apoplas, transmembrane, simplas). Mental representation pattern by students and the depiction can be seen in this figure 2, figure 3 and figure 4.

![Figure 2](image1.png)

**Figure 2.** The example of mental representation Pattern 1 that was formed by students.

Figure 2 shows mental representation pattern 1 that was formed by students was based on representation ability toward performance of animation video media. Pattern 1 was one-way linear pattern, and if it was seen of pattern causal network, it was in Markov chain pattern, in which this pattern was seen the relation but it was in one way which was not separated between structure and process. All information element was as the main component. In this pattern, students had been able to find out the relation between information element information. Pattern formation had been seen such as process flow, it was started from information element of water molecule that move to hair root. However, the nest order, students found it hard to make appropriate relation path by choosing plasma membrane and plasmodesmata but it was saved in less appropriate order and it was not completed the element order of information about the way of water movement which were transmembrane and simplas. However the order that was depicted in pattern after endodermis had been right to root xilem.

![Figure 3](image2.png)

**Figure 3.** The example of mental representation pattern 2 that was formed by the students.
Figure 3 showed the example of pattern 2 which was formed by students. This pattern was called simple branched pattern, and if it was seen in pattern of causal network like pattern of feedback control with single measurement. In the pattern, there is relation between elements of structure information but it was not completed with element of process information. However, students had understood several concepts of structure that were through by process path of water movement in root such as cell wall, plasma membrane and plasmodesmata. In addition, there was other relation that was equal between element information endodermis with element information pita caspary which is parallel then the next order was continued by perisikel and xilem roots.

![Figure 3](image3.png)

**Figure 3.** The example of pattern 2 which was formed by students.

Figure 4 showed example of pattern 3 that was formed by students. This pattern was called branched more than two pattern, and if it was seen in pattern causal network such as pattern of repeated feedback control with multiple. It was seen in the pattern that information element between stucture and proces of water movement path in root had completed and related to each other with appropriate size. In pattern that was formed had been depicted clearly between root stucture of cell wall with path of apoplas process, plasma membrane with transmembrane process and plasmodesmata with simplas process. In addition, the order of endodermis information element and pita caspary were related to each other. In path of simplas also had the relation with other stucture such as perisikel and root xilem.

This research showed that each individual had pattern that variate toward formed representation. In forming pattern of mental representation, there were many factors that could affect such as complexity of information element, complexity media level, obtained information and initial knowledge of each individual [13]. Other than that, material of plant transport was one of material that had been learned before by students so that it became one of factors in determining the successful of students in understanding concept of water movement in root. The more revealing the meaning with association, picture and story that had been experienced, then the bigger someone to remember something [12]. The role of teacher also had contribution to support one of students’ effort in forming good representation. The most affected factor in formation of mental representation was initial knowledge of students and understanding in working memory activity [7].

Other research findings were the measurement of students’ mental effort from questioner showed that students tent to be able to follow learning strategy easily. It was proved with average score obtained by students of 26.41. It showed that mental effort of students were categorized low. Then for average score of mental representation of students had score of 62.58. To find out the effect of students’ mental representation formation by mental effort, it was done examination statically by using correlation test. The correlation test between formation of mental representation with mental effort is \( r = -0.219; p < 0.220 \). The result in r value indicates that there is a negative correlation. The value of p shows no significant between those two variables. Students’ mental effort was obtained from how deep students
could follow learning strategy done by lecturer. To remember simple factual information was considered that having little mental, it was different with inferential learning that needed more mental effort [10]. In addition, one of factors that could affect the low of mental effort was the usage of animation video in concept of water movement in root in plant transport material. Studying by using media needed little more mental effort in learning whereas studying from reading books was considered needed more mental effort because it increased the learning deeper [12].

This research showed that the formation of mental representation pattern was not affected by mental effort and mental effort of students was in low category. Mental effort would be high if individual did hard effort in processing information actively in the material [12]. So that mental effort done by individual, even though the effort was high, it would not give big effect if the representation was low. The ability of students’ representation would affect if the ability to rake and manage information in working memory were good. So that students could form a complex representation pattern according to study experience and information they had. Thus, pattern of mental representation formation was affected by activity of working memory [10].

4. Conclusion
Formation of mental representation pattern of students is vary depending on complexity of students’ understanding in representing information in performance of animation video media. To form mental representation, it needs good prior knowledge, understanding toward information element in video must be right and the ability in searching the relation between related information elements. It is affected toward individual’s working memory. If cognitive load is low, the ability of mental representation would be good and if cognitive load is high, it will affect toward formation of individual mental representation. However, correlation result toward cognitive load is mental effort that shows negative correlation toward representation ability of students. Formation of mental representation pattern of individual is pure from activity of working memory and it is not from mental effort that they have done.

Acknowledgments
The author would you like to thank the parents who have given support for this research and Lecturer of plant physiology on university of pasundan who have allowed and help in conducting this research.

References
[1] Vitharana 2015 Students Misconceptions about Plant Transport European Journal Of Science and Mathematics Education 3 pp 275-288
[2] Arsyad A 2014 Media Pembelajaran (Depok: Raja Grafindo Persada)
[3] Vavra K L, Janjic-Watrich V, Loerke K, Phillips L M, Norris S P, and Macnab J 2011 Visualization in Science Education ASEJ 40
[4] Sastrawan 2014 Pengaruh Model Pembelajaran PBL Berbantuan Media Visual Animasi Terhadap Hasil Belajar IPA. e-Journal Mimbar PGSD Universitas Pendidikan Ganesha
[5] Paivio A 1990 Mental Representation: A Dual Coding Approach [ninth edition] (New York: Oxford University Press, Inc)
[6] Arentze T, Dellaert B G C and Timmermans H J P 2008 Modeling and Measuring Individuals’ Mental Representations of Complex Spatio-Temporal Decision Problems Environment and Behavior 40 pp 843-869
[7] Gathercole S and Alloway T 2009 Memori Kerja dan Proses Belajar [Working Memory and Learning] (Jakarta: PT.INDEKS)
[8] Ito S 2016 Bayesian Networks and Causal Networks, Infromation Thermodynamics on Causal Networks and its Application to Biochemical Signal Transduction, Springer Theses (Springer Science+Business Media Singapore)
[9] Rahmat 2016 Studi Beban Kognitif Siswa SMA dalam Pembelajaran Biologi: Representasi Mental Ketika Dihadapkan Pada Diagram Isomorfisme-Spasial
[10] Kirschener P A, and Kirschener F 2011 Mental Efficiency: Mental Effort (2182-2184)
[11] Plass J L, Moreno R and Brunken R 2010 *Cognitive Load Theory* (Cambridge: Cambridge University Press)

[12] Sampurno A W, Rahmat A, and Diana S 2017 Students Mental Representation of Biology Diagram /Pictures Conventions Based on Formation of Causal Network *Journal of Physics: IOP Publishing*

[13] Sweller J 2005 *Implication of Cognitive Load Theory for Multimedia Learning: Mayer R E The Cambridge handbook of multimedia learning* (New York: Cambridge University Press)