High school students’ proposition network representation and its relationship with thinking level in learning human nervous system using Modeling Based Learning (MbL)

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Abstract. The purposes of this research were to identify the students ability to form a proposition network representation and to analyze the relationship of that thinking level with the students ability to form a representation of proposition network on human nerve system concept. This is a descriptive research with 30 science class students of grade XI from one private school in Bandung as the subject research, who learned human nervous system concept, using modeling based learning (MbL). The data collection was taken by rubric instrument and thinking level test. The result of this research show that the ability of high school students’ to develop a representation of proposition network on general is in the fair category. The correlation result shows no significant relationship between thinking level and the students’ ability to form a proposition network on learning of neuron structure and function (r= 0,075; p=0,692) with low complexity of content. The significant relationship between thinking level and the ability to form proposition representation is obtained during the study of central nervous and peripheral nervous system (r= 0,506; p= 0,004) with higher concept complexity. It means the higher students’ thinking level, the better their abilities to form a proposition network.

1. Introduction

True learning brings someone to improve his thinking ability and get new knowledge so that learning is not about mastering the concept but it is about the mastering and skill of a more specific knowledge learned which come from the result of thinking process [1]. Thinking process is a very important factor to develop mastery of knowledge so students can get meaningful knowledge as the result of their learning process. In connection with that, Marzano & Kendall, developed this knowledge mastery domain into three domains, which are cognitive system, metacognitive system, and self-system, and also divided this knowledge mastery into six thinking level system, which are: retrieval, comprehension, analysis, knowledge utilization, metacognitive system, and self system. To improve thinking level for each knowledge domain, a certain learning approach is needed so that during the learning process, students are able to integrate the three knowledge domains [2].

Studying Biology as a part of science learning are supposedly able to stimulate and improve students’ thinking and reasoning abilities. But in reality, students experience difficulties in understanding the concepts in biology which are abstract, complex, and connected to one another. This
generally causes misconceptions among students [3]. Learning of physiological processes of human body at school is one of the concepts which is considered the most difficult one by the students. Their main difficulty is on understanding the abstract physiological concepts. Human nervous system is one of the abstract concepts considered really difficult to learn. Concept characteristic is complex because it links one element to another which is also connected to a complex chemical mechanism and that makes the students be in their formal stage of thinking. Causal mechanism, which becomes one of the principles used on human nervous system concept, causes difficulty in understanding the concept [4]. The lack of innovation in learning strategy, the learning process which focuses only on the theory, and uses only text books as the learning source give more difficulties to students in understanding this human nervous system concept [5].

To overcome the difficulties in understanding those abstract concepts, some researches for biology education have suggested some teaching strategies using pictures, simulation using computers, and props model as parts of representations which can be used by teachers [6]. Modeling based learning (MbL) is a learning approach where the students themselves build their own scientific phenomenal models, and this approach is considered to give a positive contribution learning science by researchers [7]. Researchers also said that models come from MbL products are scaffoldings to support the learning process, curriculum concepts, additional tools in supporting the learning process of science, and is a representation from realities used by someone as a media to understand more about the phenomenon learned [8]. The models made by the students whether they are in the forms of 2 or 3 dimensional models, are the forms of actualization to represent knowledge in their own ways. Through modeling and the models made, students are able to present the abstract concepts to be more real. When the students are able to represent the models correctly, then their understandings about the concepts and phenomenons of science are improved [9].

The MbL application in learning science is able to improve the cognitive, social-concept, epistemological and metacognitive aspects, and is able to build spatial. Besides, MbL is also a media which plays a very important role in building student’s scientific knowledge and thinking ability [10]. MbL is an effective way to reach a good understanding for scientific concepts, in operational and also structural terms from knowledge domain, and to develop reasoning skill [11]. Furthermore, according to [12], studying modeling and developing modeling skill applied in modelling based learning play a big part in scientific literacy, which are: (1) Modeling reduces learning burden for students; (2) Modeling is admitted as the main component in scientific behavior, validation and technology; (3) Modeling can increase thinking and communication skills; (4) Modeling develops personal values and makes students more aware to their society and surroundings.

Learning biology also uses lots of diagrams and visual representation forms. Nevertheless, connecting one part to another in diagrams needs texts to clarify the relationship patterns [13]. The texts used to clarify the relationship patterns are known as propositional representation developed by cognitive psychological experts to learn a meaningfulness, as someone only remembers the most meaningful thing from an object. Proposition as a representation concept has a role in information processing model (describing any kind of information) which is often interpreted as relating to images. The empirical component which saves information based on experience can be explained in the form of proposition network. The forming of this proposition network can be shown through proposition network patterns. These patterns will measure students’ ability in representing concepts into a whole and meaningful unity [14]. Based on the principles of the constructivism approach, the use of mind maps can facilitate meaningful learning [15]. Diagrams in the forms of mind mapping completed with proposition to show associative relationship among informations in it, enable students to create visual images in improving learning. Furthermore, it can be used to measure metacognitive ability which allows them to make connections and find conceptual relationship so the thinking scheme, unity and unanimity of knowledge are formed [16].

The description of the above background is the basis of the research. Therefore, be conducted research aimed to identify high school students’ ability to develop proposition network representation
and to analyze the relationship of thinking level with students’ ability to form proposition network in learning human nervous system using modeling-based learning (MbL).

2. Methods

2.1. Research method
This is a descriptive research, with 30 science students of grade XI from a private Senior High school in Bandung who are learning human nervous system as the research subjects. The learning process was done with the MbL approach for 4 meetings. The first meeting, students learned a concept about neuron’s structures and functions from the handbook they usually use in biology class, and then were asked to make 3D model designs in the form of images, and then individually asked to make their 3D designs in the forms of images into real 3D models as their home assignment and would be submitted a week after. The second meeting was held after a week, the students submitted the 3D models they had made and at that time were asked to make proposition network representation about neuron’s structure and functions. On the third meeting, the students were asked to learn about central nervous system (CNS) and peripheral nervous system (PNS) from the handbook they usually use, after that they were asked to make the 3D model designs in images and then individually asked to turn their 3D model designs into real 3D models as a home assignment and would be submitted a week after. The fourth meeting was held a week after, the students submitted the 3D models they had made at home and at that time were asked to make the proposition network representation about CNS and PNS.

2.2. Data collection
The proposition network representation’s datas were taken twice at the second and fourth meeting, while the thinking level measurement’s datas were taken after the learning processes were finished. The students’ thinking level was measured based on their abilities to do tests made and developed based on the new Marzano & Kendall’s taxonomy indicators to measure students thinking level related to human nervous system concept. The result datas from representation of proposition network is assessed using instrument rubric which is developed and adapted based on the information processing standards [17].

2.3. Data analysis
The score results from proposition network representation are then categorized into five categories: very poor (0-19), poor (20-39), fair (40-59), good (60-79), and very good (80-100) [18]. The data analysis for the thinking level was held by categorizing the result tests into six thinking levels (L1-L6) based on each level’s minimum standard mastery. If a student is able to get the minimum score 70 for a certain level, then he is said to have reached the intended thinking level. The relationship between thinking level and the student’s ability to form proposition network representation is analyzed using Pearson Product Moment correlation tests on SPSS 23.0 program for windows.

3. Result and Discussion

3.1. Proposition Network Representation
The percentage categories of the students’ achievements in forming these proposition networks are shown in Figure 1.
Figure 1. The skill of forming proposition network (A=for neuron’s structures and functions; B= for CNS and PNS)

Data on Figure 1, shows the number of students were able to achieve Fair, Good, and Very Good categories on forming the proposition network for CNS and PNS concept less than the number of students were able to achieve Fair and Good categories on forming the proposition network for neuron’s structures and functions.

The average score achieved by the students for the neuron’s structures and functions proposition network is 47.62 and is included to be in Fair category and the results of the average score for the second proposition about CNS and PNS are 43.86 and is included to be in Fair category. The students’ ability in forming proposition network looks a bit different for the two concepts. The concepts’ complexity seems to be the factor which differs the results achieved from the two proposition network diagrams [19]. The neuron’s structures and functions concept has a lower complexity so it has a fewer information elements and proposition compared to the CNS and PNS concept, it is also less difficult and easier to understand and easier to make the proposition network for this concept so the result achieved is better than the proposition networks for CNS and PNS which has a higher complexity. Even though there are some students who are capable to reach the Very Good category in forming CNS and PNS proposition networks, generally, the average score is decreasing and the total percentage for students who achieved Fair, Good and Very Good categories are also decreasing.

3.2. The relationship between thinking level and the ability of forming proposition network representation

The results for the students who have not reached the minimum standard mastery level and those who have are related to the students’ ability in representing the neuron’s proposition network are shown by Figure 2.
Figure 2. Thinking level’s standard mastery and the average score of proposition network for neuron’s structures and functions. (Note: A= students who have not achieved the standard mastery learning, B= students who have achieved the standard mastery learning).

The picture above shows that along with the increased thinking level, it seems that the average score for proposition networks made by the students who can not pass the standard mastery is lower than those who pass the standard mastery for their thinking level. After the Pearson Product Moment correlation test has been held, correlation coefficient value 0.075 is obtained with significance value 0.692. It means, there is no correlation between student’s thinking level and their ability in forming proposition network representation for neuron’s structures and functions. These statistical analysis results show that there is no relationship between thinking level and student’s ability in representing neuron’s structures and functions concept in the form of proposition network, it means either students with higher or lower thinking level tend to have the same abilities in forming their proposition networks.

The result received for the students’ skill in representing proposition network for central nervous system (CNS) and peripheral nervous system (PNS) is shown in Figure 3.

Figure 3. Thinking level’s standard mastery and the average score of proposition network for CNS and PNS (Note: A= students who have not achieved the standard mastery learning, B= students who have achieved the standard mastery learning).

Based on the result achieved from the analysis of the students’ skill on forming the proposition network for CNS and PNS concept as provided in Figure 3, it is seen that the students who complete all thinking level tend to have higher average scores for their proposition networks than those who cannot complete their thinking levels. An exception happens for level 2, a higher result for the average score on proposition network is reached by the students who do not pass the standard mastery for that.
The result of proposition networks for CNS and PNS also shows a tendency of increasing results in line with the students’ thinking levels. This is reinforced by Pearson correlation analysis using the SPSS 23.0 program for Windows. A correlation of 0.506 is obtained between thinking level and student’s ability to form CNS and PNS proposition network with significance level 0.004. The correlation coefficient result of 0.506 shows a quite strong relationship level with significance level 0.004 also shows a significant result [20], so it means that student’s thinking level significantly has a quite strong relationship with the ability in forming proposition network for CNS and PNS.

The students who can complete higher thinking levels have the ability to represent this concept better than those students who can only complete lower thinking levels. The concept’s complexity seems to also influence the students’ ability to form this proposition network representation. The neuron’s structures and functions concept is simpler compared to CNS and PNS concept. For a simpler concept, thinking level does not affect the student’s ability to represent the concept, as for the more complex one, it needs a better and more complex thinking process so that the thinking level achievement would affect the student’s proposition network result. This proves that there is a significant relationship between student’s thinking level and their ability to form proposition network for a more complex concept, such as this CNS and PNS concept.

The student’s thinking-level achievement is also related to their reasoning skill and emotion. Thinking level does not only refer to thinking processes but also psychological processes that influence learning behavior [21]. Students who are able to complete or reach the stage of thinking level for metacognitive system (L5) and self-system thinking (L6) are not only able to think from the cognitive aspect but also able to manage themselves, they have self-control and are able to set their goals and learning strategies, moreover, students who are able to reach L6 have an awareness to be involved in learning process and the assignments given. Students who have reached L5 and L6 have a strong confidence so that they have wills, eagerness, self-awareness, struggling power and always try to look for sources to support their assignments in studying so their motivation in learning is also high [22]. This is probably the important factor so students who are in thinking level L5 and L6 are able to learn from their mistakes and are motivated to have self-improvements so that the results they get on making the second proposition network about CNS and PNS are a lot better than students in a lower thinking levels (L1-L4) even though the learning concept has a higher complexity.

Besides the previous factors mentioned above, the learning approach using modeling based learning which has been done by the teacher is also one of the factors that causes a higher thinking level student (L5 and L6) to undergo improvements in forming their proposition network. According to experts, learning activity using MbL approach where the students themselves make their own visual representation is believed by the experts as a good media to improve scientific knowledge, thinking knowledge, give contribution for cognitive, metacognitive, social concept and epistemological aspects in learning science [23,24]. MbL can hone student’s skill to represent something abstract to be real in their own way so that the student’s understanding of scientific phenomena will increase [25,26]. For students with higher thinking levels, (L5 and L6) learning and practicing to represent their knowledge in their own way so that the student’s understanding of scientific phenomena will increase [25,26]. For students with lower thinking levels do not have (L1-L4).

The research from [27], shows that modeling is closely related to the exercise conducted and the facts seen by students in everyday events. Students in their daily life can understand the brain and spinal cord more easily because they can see images, human torso model, or even the real objects even though they are not human brain or spinal cord, so even though CNS and PNS concept has a high complexity but it is contextually felt more by students if compare with neuron’s structure and function. Meanwhile, neuron is an object which cannot directly be seen, abstract and hard to imagine the process carried out by neuron, so the context cannot be felt by students in everyday life even though the complexity is low. The difficulty in this neuron’ modeling becomes one of the factors of students’ lack of understanding in building proposition networks, either for low or high thinking level students.
However, a further research for this matter needs to be conducted to confirm whether the problem is as mentioned above.

4. Conclusion

Based on the research has been done, the students’ ability to form a proposition network representation of human nervous system was in the fair category. In conclusion, MbL can facilitate a significant relationship between thinking level and the ability to form proposition networks if the concept taught has a higher complexity compared to the lower complexity concept.

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