STUDY OF THE ROLE OF MULTIPLE REPRESENTATIONS IN BUILDING MENTAL MODELS AND SELF-EFFICACY OF BIOLOGICAL STUDENTS

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Abstract: The concept of biological studies is divided into four levels of representation, namely macroscopic, microscopic, molecular, and symbolic levels. The interconnection of these four levels makes a major contribution to the development of students' mental models in building the meaning and conceptual understanding of biological materials. Mental models are ideas in the minds of students that are used to develop, explain, and predict a phenomenon. The formation of mental models is influenced by the experiences they have, their confidence or self-efficacy, and the problems they face. Multiple representations are believed to influence the formation of mental models and students' self-efficacy. For this reason, an in-depth study of the role of multiple representations in building mental models and students' self-efficacy is needed. This research is qualitative research with descriptive analysis techniques and a literature review (library research). The analysis is carried out by reviewing articles that are relevant to the study being discussed. In the search for articles, four keywords were used, namely: multiple representation learning, biology learning, mental models, and self-efficacy. The articles used in this study were 25 international articles obtained from Google Scholar and ERIC. From the results of the study, it was found that learning multiple representations is very effective in building mental models and self-efficacy in biology students. From the results of this study, it is recommended for lecturers and teachers to use multiple representations learning in the learning process to build mental models and self-efficacy in students.

Keywords: Role; Multiple Representations; Build; Mental Models and self-efficacy

INTRODUCTION

The concept of biological material is divided into four levels of representation, namely macroscopic, microscopic, molecular, and symbolic. First, at the macroscopic level, the concept of biology involves biological structures that can be visualised with our five senses, such as plants, animals, and other real phenomena. The second level is microscopic, namely biological structures in the form of real phenomena but cannot be visualised by the naked eye, requiring tools to be able to see them, for example cells and microorganisms. All three molecular levels involve DNA, hormones, enzymes, or proteins, which are identified using analytical tools such as electrophoresis, chromatography, or centrifugation. Finally, the symbolic level is composed of biological structures that are classed in the form of symbols, such as phylogenetic trees, inheritance patterns or genotypes, metabolic pathways, and chemical equations (Tsui & Treagust, 2013).

The learning that occurs today is more about teaching point participants at the macroscopic and symbolic level (Tasker &Daldon, 2006). Meanwhile, the microscopic and molecular levels of representation are studied separately from the other two levels of representation. The integration of microscopic and macroscopic or molecular and macroscopic or symbolic phenomena is left to the students themselves to understand them through pictures and diagrams in the book, without the guidance and direction of the teacher/lecturer (Farida, 2010). Most students tend to only memorise representations of microscopic, molecular, and symbolic phenomena that are abstract verbally (in the form of words). As a result, they are not able to imagine how the structures and processes that occur in the concept of biological studies.

If students can understand the role of each of the four levels of biological phenomena, they will be able to transfer knowledge through interconnections from one level to another, which means students can acquire the conceptual

knowledge needed to solve problems. Conceptual knowledge is an essential part that must be possessed by students when studying science concepts that must be stored in long-term memory and easily accessed again to solve problems. In order for the knowledge gained by students to enter into long-term memory, students must be encouraged to use their mental models in connecting the four levels of biological phenomena. According to Tsui&Treagust (2013), these four levels of phenomena are interconnected and make a major contribution to the development of students' mental models in building meaning and conceptual understanding of biological material.

Mental models are ideas in the minds of students that they use to develop, explain and predict a phenomenon (Jansoon*et al.*, 2009; Wang, 2007). The formation of mental models is influenced by the experience and previous knowledge of students, their attitudes and beliefs or self-efficacy, as well as the problems they face. When students are faced with a problem and asked to find a solution to the problem, the student will make a mental model in his mind about how to solve the problem. Mental models can be built through the process of observing, interpreting, imagining and understanding a phenomenon or scientific discourse (Chittleborough, 2004; Jansoon*et al.*, 2009). Mental models will increasingly develop as more information is obtained and remembered (McClary & Talanquer, 2011).

One of the factors that influence the formation of mental models is self-efficacy. Self-efficacy is a person's confidence in solving the problems he faces. Self-efficacy is needed by students so that they can solve problems faced in the learning process, such as completing tasks given by the teacher. Students who have high self-efficacy will be more daring to express opinions, dare to argue, and have high motivation to learn (Schunk & Hanson, 1985). For this reason, learning strategies are needed that can build mental models and self-efficacy in students. The learning strategy in question is a multiple-representation learning model.

Multiple representations are a way for someone to represent the same concept in various forms of representation. Multiple representations can also be used as instruments that provide facilities and support for meaningful learning or deep learning (Prain & Waldrip, 2006). Multiple representations are believed to influence the formation of mental models and students' self-efficacy. For this reason, an in-depth study of the role of multiple representations in building mental models and students' self-efficacy is needed.

MATERIAL AND METHOD

This research is qualitative research with a descriptive analysis technique in the form of library research. The analysis is carried out by reviewing articles that are relevant to the study being discussed. In searching for articles, researchers used four keywords, namely: multiple representation learning, biology learning, mental models, and self-efficacy. The articles used in this study were 25 international articles obtained from Google Scholar and ERIC. The articles obtained are then analysed and reviewed so as to form a complete discussion in this study.

RESULT AND DISCUSSION

Multiple representation learning

The concept of multiple representations arises because of the student's need to explore and complete a variety of tasks that involve large amounts of abstract information. The information obtained must be able to be visualised and manipulated so as to form new scientific information that is easy to understand. The concept of multiple representations arises against the background of differences in learning styles, different levels of understanding, differences in the environment, and so on. The diversity of these differences requires educators to innovate to create learning that is able to facilitate the diversity of these differences. In this case, the National Center on Universal Design Learning (UDL) has designed teaching and learning materials and activities that enable the achievement of learning objectives by all students with different backgrounds and abilities to see, hear, speak, move, read, and write. understanding language, paying attention to organizing, being actively involved, and remembering (CAST, 2011). The CAST (2011) formulation concerns important aspects of universal design for learning, which has three principles, namely:

1. Multiple mean of representation, meaning that learning is presented in various ways. Such as providing various forms of representation

2. Multiple means of action and expression, meaning that the learning provided allows students to express themselves and act in various ways.
3. Multiple means of engagement, meaning learning that allows all students to be involved in various forms of learning activities.

Learning with multiple representations provides opportunities for students to develop their understanding of biological material concepts, solve problems, and create conceptual relationships. Learning with multiple representations is able to bridge the process of understanding students' concepts (Wiyarsi*et al.,* 2018). There are three main functions of multiple representations that are used to build students' conceptual understanding. The first function uses representations to obtain additional information or support existing and complementary cognitive processes. Second, representation can be used to limit possible interpretations, and third, it can be used to encourage students to build deeper understanding (Ainswort, 2008).

Mental Model

A mental model is an individual's depiction, personal idea, or internal representation of a phenomenon, collection of ideas, or concepts. Mental models can be described as ideas that represent a picture of the construction of understanding and visualisation of the imagination that is in the minds of students in explaining a concept or phenomenon. Mental models can also be interpreted as the way students conceptualise concepts by giving them the opportunity to explain them in their own words (Kilic, 2019). Mental models are built from perceptions, imaginations, and students' understanding of a concept of the material being studied (Harrison &Treagust, 2000).

Mental models as incomplete dynamic representations will continue to grow and develop as information increases. Mental models are generative because they can direct students to new information and can then be used to predict and explain the new information obtained. Therefore, educators, both teachers and lecturers, need to know the initial level of students' mental models before the learning process begins in order to create more effective and meaningful learning (Hamdiyati*et al.,* 2017). According to Sunyono (2015c), in the thinking process, a person needs to build a good mental model. If someone has difficulty in building mental models, it will cause difficulties in developing thinking skills, so they will not be able to solve problems properly. Mental models are used to generate simpler concepts, provide support for simulation and visualization, and provide explanations for scientific phenomena (Albaiti*et al.*, 2016).

Self-efficacy

Self-efficacy is a person's belief in his ability to organise and carry out a series of actions needed to complete a certain task (Bandura, 1997). Self-efficacy can also be interpreted as a person's belief in estimating his ability to carry out certain tasks or actions needed to achieve the desired results (Nuzulia, 2010). Bandura (1997) in his book entitled "Self-Efficacy: The Exercise of Control," describes how self-efficacy will affect one's actions, effort, persistence, flexibility in differences, and the realisation of one's goals, so that self-efficacy related to one's abilities often determines one's abilities results before the action occurs.

Furthermore, Bandura (1997) states that self-efficacy is central in the construction of a person's social cognitive theory, such as 1) the influence on decision making and the influence on the actions that a person will take; 2) how much effort he puts into an activity; how long he lasts when he gets into trouble; and how flexible he is in dealing with situations that are less favourable for him. The greater a person's self-efficacy, the greater the effort, persistence, and flexibility; 3) affects the mindset and emotional reactions.

Relationship of Multiple Learning Representations, Mental Models and Self-efficacy

In the learning process, the construction of mental models is very important, because mental models are the essence of meaningful learning. To understand and reason a system works, an individual needs to develop a mental model in his mind of a phenomenon or problem he sees or feels. In order to understand the phenomenon or problem, the individual will build a network of related concepts and understand the functional relationships of a number of different aspects and levels of the system.

In the learning process, an educator must be able to facilitate the development of mental models of students. Carrying out learning with multiple representations is one way to grow students' mental models. In this learning process, students can explore knowledge related to the material being studied and present it in various forms of representation models. Based on the results of research by Sunyono*et al.* (2015a) and Sunyono*et al.* (2015b), it is found that learning with multiple representations is very effective in growing students' mental models.

Based on various research results, the use of multiple representations in learning can help students form their mental models. Learning with multiple representations can build students' procedural and conceptual knowledge if in the learning process interesting visualisations are carried out for concepts at the microscopic (sub) level and there are procedures for transforming from macroscopic to symbolic levels and or vice versa (Davidowitz, *et al.,* 2010; Jaber &Baujaude, 2012; Tasker & Dalton, 2006).

Multiple representations of learning Besides being effective in building students' mental models, multiple representation learning is also very influential on students' self-efficacy. In the multiple representations learning process, students are trained to ask questions and argue in response to questions and opinions from their friends. Learning with multiple representations can support the development of self-efficacy from the beginning of learning to the end of learning. In the learning process, students are guided to make questions, trained to explore the material, express opinions, represent the results of discussions, respond to questions, and conclude the material (Safitri*et al.*, 2021).

When students are faced with problems in learning, such as doing assignments, they will explore various references to solve the problem. That's when the mental model of students is formed. The concepts they get from various references form information networks in the students' brains, which in turn form new information. Students who have high self-efficacy will be diligent and active in conveying ideas in problem solving and will be able to communicate properly and correctly the resolution of the problem (Jatisunda, 2017; Citra *et al.,* 2020). With self-efficacy, students can determine the actions or steps taken in completing the task so that the desired goals and results are achieved properly (Aurah, 2013).

Students are required to be actively involved in the learning process at each stage of multiple representation learning. From the explanation above, it can be seen that the mental model also affects the self-efficacy of students, or vice versa, self-efficacy affects the formation of the mental model of students. The relationship between multiple representation learning, mental models, and self-efficacy can be seen in Figure 1.1 below.

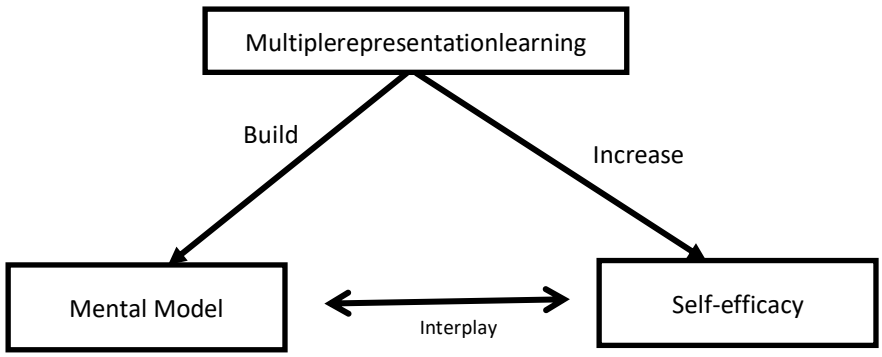

Figure 1.1The relationship between multiple representation learning and the formation of mental models and self-efficacy

Learning with multiple representations is very effective in forming students' mental models and can increase students' self-efficacy in learning. Each stage carried out in the learning process greatly influences the formation of mental models and students' self-efficacy. In addition, the development of mental models also affects the self-efficacy of students. The more developed the mental model of students, the higher their self-efficacy. As stated by Ramalingam *et al.*, (2004), developing a strong mental model will increase students' self-efficacy.

CONCLUSION

Multiple representation learning is one of the most effective ways of learning in building mental models and students' self-efficacy. Multiple representation learning can support the development of self-efficacy from the beginning of learning to the end of learning. Each stage carried out in the learning process is very influential on the formation of mental models and self-efficacy of students. Mental models affect students' self-efficacy or vice versa, self-efficacy affects the formation of students' mental models. Given the importance of the role of multiple representation learning, it is recommended that lecturers and teachers use multiple representations learning in the learning process to build mental models and students' self-efficacy.

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