3D animation modelling using After Effect in biogeochemical cycle study to develop cognitive activities

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Abstract. The biogeochemical cycle is material that uses diagrams and is difficult to understand. Cognitive activity has a contribution in building understanding when studying a diagram. The purpose of this study was to obtain information about 3D animation modelling using after effect in biogeochemical cycle to develop cognitive activities. This research is a descriptive study. The model in this study is the biogeochemical cycle animation model using adobe after effect. Cognitive activity is measured before and during the study using a modelling example. All verbal data that appears is recorded and analysed according to think-aloud protocols (TAPs) which will then be translated and categorized into types of cognitive activity. The results of this study indicate that before using the modelling example the activity of activating the initial knowledge (K11) included in the high category. There was a development when study using modelling examples, namely elaboration (K41) most appeared with a high category. This study can be concluded that the 3D animation modelling using after effect can develop high-level cognitive activities, namely inference accurately (K31) and elaboration accurately (K41) in the biogeochemical cycle.

1. Introduction

In Biology, one of the diagrams is used in biogeochemical cycle material. Biogeochemical cycle material includes the water, carbon, nitrogen, sulphur, and phosphorus cycles. Respondents find it difficult to study the biogeochemical cycle. This is explained by the fact that the biogeochemical cycle is a difficult material. The material is said to be difficult because, during the study, the respondent cannot directly observe the processes that occur both in the water cycle, nitrogen, carbon, sulphur, and phosphorus [1]. Also, it was found that the average achievement of respondents' abilities in completing the diagramming process was classified into the very low category [2]. Many respondent fail to understand diagrams accurately. For example, respondents fail to read labels or titles, misunderstand colour codes or follow arrows in the wrong direction. Respondent remember fewer steps in the process when they have seen diagrams with arrows instead of arrows with text [3]. In information processing theory, cognitive processes of visual perception and visual processing are thought to influence the study [4]. However, most do not assume that understanding information from complex diagrams requires a lot of cognitive activity and initial knowledge that starts from oneself. Cognitive activity and prior knowledge are involved in visual thinking [5].
Cognitive activity is a variety of cognitive activities that involve mental activities that occur in working memory when someone is doing the thought process. Cognitive activity consists of activating accurate initial knowledge (K11), activating initial knowledge inaccurately (K12), hypothesis (K2), referring knowledge accurately (K31), inferring inaccurate knowledge (K32), elaborating accurately (K41), and elaborate inaccurately (K42) [6]. Cognitive activity has a major contribution in building respondent understanding when studying a diagram. According to cognitive theory, visual perception is very selective so that the reader can focus only on some elements in the diagram [7]. Success in understanding diagrams requires a set or sequence of many cognitive activities [8]. Based on the complexity of the information contained in the biogeochemical cycle and cognitive activity, a study approach is needed that can develop respondents' cognitive activities. One approach that can be applied is modelling.

Modelling examples can provide opportunities for respondents to observe an adult, peer, or animation agent as a model when doing assignments. Models can take place face to face, video, or animation [9].

Animation are display elements whose properties change over time [10]. Three types of animation: changes of form, changes of position, and changes of the elements [11]. One software that can be used to create animations in Adobe After Effects. Adobe after effect is software digital motion graphics, visual, effects, and compositing application develop by adobe system. A study with modelling examples can improve the ability of the respondent to process and describe the information presented and evaluate it [12]. Study by using modelling examples can be effective for doing complex tasks with unstructured domains [13], for example in the study of the biogeochemical cycle. In his research, the stages in the study with modelling examples are preceded by activating initial knowledge [14]. Activating initial knowledge is one type of cognitive activity. Respondents with high prior knowledge can reduce the burden of analysing examples of misinformation [15]. Based on the description of the importance of developing the cognitive activities of respondents when understanding biogeochemical cycle diagrams, therefore this research reveals the development of the cognitive activity of respondents using modelling examples in study biogeochemical cycles.

2. Methods
This research is a descriptive study that aims to get a description of the development of cognitive activities of respondent in the biogeochemical cycle using modelling examples. The subjects of this study consisted of 30 respondents in the study of the biogeochemical cycle (water, nitrogen, and carbon cycles). 3D animation modelling made using adobe after effect. The stages of making a model use adobe after effect: the first is to arrange the composition needed to make a biogeochemical cycle, make the components contained in a cycle, and create a 3D display. The model that has been made is then tested and applied to respondents.

Cognitive activity is obtained before and when study using modelling examples. Before using modelling, examples respondents learn about the water cycle and the nitrogen cycle, and when modelling examples respondents learn about the carbon cycle. In this study respondents are given an example of a water cycle video, then respondents explain and ask questions about the components and stages of the process involved in the water cycle. After that, respondents are given examples of the nitrogen cycle, and respondent work on worksheets. Then, the respondent explain about the nitrogen cycle, and ask questions. There are three stages in the study using modelling examples, namely exploration, making models, and communicating models. All verbal data that appears is recorded and analysed according to think-aloud protocols (TAPs) which will then be translated and categorized into types of cognitive activity. Think-aloud protocols (TAPs) are used to identify cognitive activity in working memory [16]. In this study, verbal data were obtained using audio recording and video recording. Data recorded through TAPs are only in the form of cognitive activity data that appears in verbal form spoken by respondents. In this study, calculated the frequency and percentage of cognitive activity that appears during the study.
3. Result and discussion

The results of this study indicate the development of respondents' cognitive activities from before study using modelling examples and when using modelling examples (Figure 1). A study before using the modelling example is more likely to elicit activities that activate the initial knowledge accurately (K11) (51.43%). This shows that more respondent use their initial knowledge when studying the water cycle and the nitrogen cycle. The initial knowledge of respondents influences eye movements, respondents with low initial knowledge are more interested in striking colours, while respondents with high initial knowledge are more interested in relevant content concerning the theme of the material [17].

![Figure 1. Example 3D animation modelling carbon cycle using adobe after effect.](image)

Table 1.Examples of verbal data from respondent before using modelling examples.

| Cognitive activity                              | Examples of respondent verbal data                                      | f  |
|------------------------------------------------|------------------------------------------------------------------------|----|
| Prior knowledge activation accurate (K11)     | Humans are one of the living things that play a role in the nitrogen cycle. I know that the water cycle involves the process of evaporation. | 18 |
| Prior knowledge activation inaccurate (K12)   | Transpiration is the process of cloud formation.                       | 1  |
| Hypothesis (K2)                                | In my opinion, the rain will fall on all the plains, not only in the highlands. | 7  |
| Inference accurate (K31)                       | Animals and humans get nitrogen from plants in the form of protein.    | 5  |
| Inference inaccurate (K32)                     | The biogeochemical cycle is the cycle of biology, geography, and chemistry. | 2  |
| Knowledge elaboration accurate (K41)           | The processes involved in the nitrogen cycle are fixation, ammonification, nitrification, and denitrification which are aided by the role of bacteria. | 2  |
| Knowledge Elaboration inaccurate (K42)         |                                                                         | 0  |
| ∑                                               |                                                                         | 35 |

Table 1. Shows that 35 cognitive activities occur before study using a modelling example. Inaccurate knowledge elaboration (K42) activity did not emerge and only 2 inaccurate knowledge elaboration activities occurred.
activities were conducted in this study. This shows that although the initial knowledge possessed by respondents is high, but the initial knowledge cannot yet be used to support the knowledge acquired during the study. Besides K11, hypothetical activity (K2) appears as much as 20% (Figure 2). Based on his initial knowledge, respondents hypothesize about the processes that occur in the water and nitrogen cycle (Table 1). The frequency of cognitive activity that arises is different from when study using modelling examples (Table 2).

Table 2. Examples of respondent verbal data when study using modelling examples.

| Cognitive activity                           | Examples of respondent verbal data                                                                 | f    |
|---------------------------------------------|-----------------------------------------------------------------------------------------------------|------|
| Prior knowledge activation accurate (K11)   | One activity that can release carbon is volcano eruption.                                           | 16   |
|                                             | I know that plants play an important role in the process of photosynthesis.                          |      |
| Prior knowledge activation inaccurate (K12) | In my opinion, if there are no plants, carbon will accumulate in the atmosphere.                    | 4    |
|                                             | Phytoplankton is the biggest producer of oxygen and carbon sink compared to plants.                  |      |
| Hypothesis (K2)                             | If sea animals need a long time to die, then a small source of petroleum will be produced.          | 6    |
| Inference accurate (K31)                    | Humans do respiration by breathing oxygen and emitting carbon dioxide.                              | 29   |
|                                             | There is a role for decomposers to decompose living things that have died which will then release carbon. |      |
| Inference inaccurate (K32)                  | Human activities that produce the greatest carbon are industrial activities.                         | 4    |
| Knowledge elaboration accurate (K41)        | Carbon in the atmosphere is used by plants for photosynthesis which produces inorganic carbon in the form of glucose, and glucose will be stored in the form of starch. | 58   |
| Knowledge elaboration inaccurate (K42)      | The carbon source obtained by animals comes from the fusion of the sun's exploding core, and the form of its compounds in the form of simple compounds. | 7    |

Table 2. Shows that the most cognitive activity that appears is knowledge elaboration accurate (K41). These results are higher than before using the modelling example (Figure 2). This means that respondent have been able to draw conclusions reinforced with prior knowledge. All cognitive activities occur, including K42 activities that do not appear in the study before using modelling examples. The frequency of occurrence of cognitive activity in the study using modelling examples is higher that is 124 times compared to before using modelling examples which are only 35 times.
A study with modelling examples can improve the ability of the respondent to process and describe the information presented and evaluate it [12]. Initially, K11 was the most prevalent (51.43%) and had the least occurrence for higher cognitive activity (K41 5.71%) (Figure 2). However, K41 developed when study to use modelling examples which is 46.77%. In addition to K41 there is also K31 with a percentage of 23.39% which was previously only 14.29%. This shows that respondents can infer (draw conclusions based on the material being studied) and elaborate (draw conclusions reinforced with prior knowledge) accurately. This is consistent with Cromley's research that studying diagrams with many explanations on their own can encourage respondents to conclude [6].

4. Conclusion
Based on the results of the study, it can be concluded that cognitive activity in the study of the biogeochemical cycle can be developed using modelling examples. A study using modelling examples can develop high-level cognitive activities, namely inference (K31) and elaborate accurately (K41). Elaboration (K41) was the highest activity when study using modelling examples.

Acknowledgments
The author would like to thanks the school where the research was conducted and lecturer Biology Education in Universitas Pendidikan Indonesia, Department Biology Education who have helped guide the research process.

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