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Submission date: 10-Sep-2022 08:28PM (UTC+0700)
Submission ID: 1896492752
File name: of_Prospective_Biology_Teachers_in_the_Wimba_Learning_Model.pdf (214.93K)
Word count: 3902
Character count: 21244

International Journal of Innovation, Creativity and Change. www.ijicc.net
Volume 9, Issue 1, 2019

The Role of Media in the Learning Outcomes of Cognitive Learning and Logical Reasoning of Prospective Biology Teachers in the Wimba Learning Model

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Spatial ability has received less attention in learning, whereas it is well known that spatial ability makes it easier for students to understand science. This research aims to determine the role of 3D media on cognitive learning outcomes and reasoning for prospective biology teacher candidates by using the Wimba learning model. The Wimba learning model is a visuospatial-based learning model for enhancing spatial abilities. Research on the role of traditional media playdough (PD) and modern media with 3Ds Max software on learning outcomes and logical reasoning has been observed. The research was conducted by using a descriptive quantitative method and applying it to different learning outcomes on treatment with PD and 3Ds Max media. This was undertaken with two classes of Biology students during semester four, amounting to 56 students who took the course of plant anatomy. The first class was evaluated with PD media, while the second class was evaluated with 3Ds Max media. The results of the research based on PD showed improved learning outcomes with low categories, while logical reasoning can develop proportional variables and enhanced control variables. The results of the research based on 3Ds Max showed an improvement of learning outcomes with the medium category, and that logical reasoning can develop better on correlational and combinatorial variables and is able to improve student intellectual development. It was concluded that 3Ds Max media plays a better role in cognitive learning outcomes and reasoning.

Key words: *Learning, Education, Spatial Ability, 3D Media*

Introduction

Preparing teacher candidates for Generation Z and Generation Alpha, it is not enough to use verbalism (Chun et al., 1969). We recommend that learning for prospective teachers includes developing active learning models that are more creative and innovative. Currently, science learning generally still uses verbalism, including Biology. Biology is difficult to understand when the delivery of matter uses verbal means, especially biological material related to the structure and function, such as the anatomy of plants. Students will find it difficult to imagine the relationship between the structure and function of plants. Dale (1969) states that in learning we must know that what is absorbed is 10 per cent of what is read, 20 per cent of what is heard, 30 per cent of the views, 50 per cent of the seen and heard, 70 per cent of what is said, and 90 per cent from what is done and said.

In general, when studying the structure and function in plant anatomy, we ignore the imagination of three dimensions (3D). Though, the image of objects that exist in our brain are in 3D (Tabrani, 2009). Therefore, one's 3D imagination needs to be realised by using the media, so that we know one's perception of the 3D shape of the object. Visuospatial (VS) is a combination of the words visual and spatial and is the basic capability that humans possess; the ability as one to acquire knowledge (Holyoak & Morrison, 2005). The ability of visuospatial representation is one's ability to understand and understand concepts through visual representation related to spatial learning and performing tasks (Barkowsky et al., 2006). Representation is the ability to describe or simulate several ideas, concepts or objects (Gilbert, 2005). Visuospatial representation in this research is an activity of analysing a 2D form, the result is then designed in 3D with picture and then made into a concrete shape, as the result of creation. Visuospatial representation activities can improve spatial intelligence (Lazear, 2004). Spatial intelligence is necessary for everyday life, such as predicting a space, studying maps, driving a vehicle on the road and being able to help solve problems.

Microscopic representation, by means of visuospatial representation, is a process of building imagination and mental processes that can also increase logical reasoning. There are many examples and evidence that imaginary representation is also used in the process of reasoning (Nersessian, 2008). This is also expressed by leading scientists and technologists who report that visual and spatial components are supported very strongly in their thinking. Ramadas (2009) states that spatial imagination and visualisation are essential for creativity and discovery (Ramadas, 2009). Furthermore, it was also reported in various publications over the past 20 years, that there is a connection between spatial ability and success in science and maths (Sorby, 2009). Results show that spatial ability training (3D) can improve learning outcomes in the engineering faculty, especially in female students (Sorby, 2009). It is also stated that learning through visual and spatial means can improve problem-solving ability in science learning (Ramadas, 2009).

In supporting the development of 3D creations, PD media is a concrete media and 3Ds Max is a virtual media. Copolo (1995) shows no positive effects from concrete models compared to virtual computer models, when used by students in the middle class (Copolo & Hounshell, 1995). In their study, concrete models were shown to improve student achievement in content assessment when used together with learning concrete models and virtual models. Kirsh (1994) suggests that the physical manipulation of concrete models is a complementary activity to display a student's mental process (Kirsh & Maglio, 1994). Interventions that include concrete models can help students better learn how to represent images into three-dimensional and mental practices simulating the spatial transformation of molecular structures to enhance their representational competence.

Jones (2011) states that there is a relationship between visuospatial ability with logical thinking ability (Jones et al., 2011). The ability of reasoning or logical thinking can be measured using the Test of Logical Thinking (TOLT) (Valanides, 1996). There is a significant correlation found between the magnification rating (zoom) and the TOLT. This suggests that there may be underlying developmental characteristics to be able to effectively visualise enlarged objects at different scales. The correlations found in this study were between spatial visualisation, logical thinking, and concepts of objects on different scales. The study also suggested that scales may be underlying and possibly overlapping cognitive abilities that individuals use in reasoning about environments on different scales (Jones et al., 2011).

Lu (2008) conducted a 3D representation of the embryonic development of nematode Caenorhabditis elegant, and the results showed that 3D representation is useful for students to understand key concepts in embryology (Lu, 2008). Suprapto (2012) shows that the 3D learning model (Wimba model) on plant tissue material using PD media in an inductive approach can better improve logical thinking ability, while in the deductive approach, it can achieve a better cognitive knowledge result (Suprapto, 2012).

The purpose of this study was to determine the differences in the role of 3D media. Namely, conventional and modern media on cognitive learning outcomes and reasoning with the Wimba learning model.

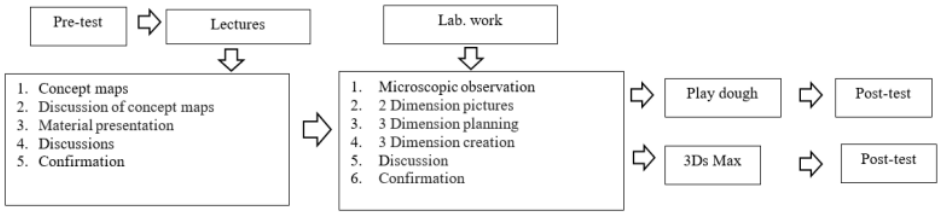
Experimental Method

Participants of this research were Biology teacher candidates from one of the universities in a small town in the East Priangan region of West Java, Indonesia. The students who study at the university come from rural, suburban, and urban areas. This research method was a quasi-experiment. The population in this study were the fourth semester students who took the

course of plant anatomy in Biology Education; amounting to as many as three classes of 56 students. Samples were taken purposively in two classes.

The Wimba learning model (based on visuospatial) was divided into the activities that were in the lecture in class and the lab in a laboratory. Activities in the laboratory begin with microscopic representations by observing plant tissue preparations for transverse, longitudinal and tangential incisions. Then students draw in 2D from observations. These 2D images were designed into 3D images, then concreted with 3D Media. 3D media used in this research was PD and 3Ds Max. Media PD represents conventional media, while 3Ds Max software represents modern media. Because of the limitations of computers that meet the 3Ds Max specifications, this research was carried out in groups. Students were divided into five groups. Each group consisted of five students. The lectures were conducted in class by creating concept maps, presentations and discussions after the lectures where practical (Figure 1).

Figure 1. Learning process



The concept map assigned was made before the lecture and presented and discussed at the beginning of the lecture. The subject matter covered included ground tissue, dermal tissue, stem, and leaves.

After the concept map discussion, the material was then presented by the group assigned to the presentation. Then the discussion ended with confirmation and an assessment of concept maps based on concept map scoring criteria (Novak & Gowin, 1984).

The learning result data was obtained through pre-test and post-test of plant tissue material. N-gain was calculated based on the work of Meltzer (2002). While the assessment of reasoning through the TOLT (Test of Logical Thinking) was based on Valanides (1996). The data processing of the learning result was completed using t-test with SPSS 23 for Windows.

Result and discussion

Results

Concept map

The lectures are conducted in several stages: presentation of concept maps, discussions, material presentations, and confirmations. Concept maps are created by students as tasks that must be done before the lecture, then presented at the lecture. After being presented in class, they are then discussed. The results of the concept map assessment made by the students can be seen in Table 1. The results of the average value of the concept maps showed PD was the better media group on the concept of plant tissues. Whereas, on the concept of the plant organs, it showed a better result in the 3Ds Max group. The student group of PD showed no improvement in making concept maps on the concept of growing tissue and the concept of plant organs, while students of the 3Ds Max group showed an improvement.

Table 1. The average value of concept map plant tissues and organs.

Media	Plant Tissue	Plant Organ
PD	68.9	65.73
3Ds Max	64.84	67.39

When assessing the results mentioned above, it shows that the use of 3Ds Max media can motivate students to create better concept maps. To find out whether there is a significant difference between PD and 3Ds Max on the concept map score, a hypothesis test with an independent t-test was performed. The resulting analysis of the independent sample test for learning results was 1.950 with a t-table value of 0.680. This means that there is a difference in the concept map scores on the material sub-concept of plant tissue in the classroom, identified from the learning process using PD and 3Ds Max. From the table of analysis results of the sub-concept of organ systems, independent sample tests obtained t-count of learning results of -1.739 and a t-table value of 0.680. This means that there is a difference in the concept map scores on the sub-concept of the organ system in the classroom, identified from the learning process using PD and 3Ds Max.

Improved Learning Outcomes

The increased learning outcomes of tissue material were measured by computing N-Gain. The result shows that the N-Gain value of learning using PD media is 2.5, and the N-Gain value of learning using 3Ds Max media is 2. From the N-Gain score produced, it shows that there is an improvement of learning result, but still in a low category. While on the organ material — that is the concept of root, stem, and leaves — students who use PD seem to show an improvement in the low category (N-Gain = 1.7). The results of learning with PD media still seems low. However, the learning outcomes that utilise 3Ds Max seem to increase, i.e.

4.8, included in the moderate category (Meltzer, 2002). The use of PD media does not seem to improve learning outcomes well. Furthermore, students who use 3Ds Max media look more serious in carrying out their duties. 3Ds Max media is quite interesting, in that it can motivate students to learn better.

To determine whether there is a significant difference in the use of PD or 3Ds Max to the learning result, the hypothesis test with the independent t-test was used. From the table of analysis results, the independent sample t-tests obtained a value t-count learning result of 0.982 and table value of 0.680. This means that there are differences in the learning outcomes in the study of plant tissue materials using PD and 3Ds Max.

Logical reasoning

Logical reasoning measurements were carried out using the TOLT (Test of Logical Thinking), consisting of five types of reasoning: proportional, variable control, probability, correlational and combinatorial. Wimba's learning, using 3Ds Max media, tends to better increase the probability, correlation and combinatorial, while the PD media tends to better increase proportionally, and control the variables (Table 2).

Table 2. TOLT scores and students ' intellectual development when pre-test and post-test.

Media	Playdough (PD)		3Ds Max	
Intellectual development	pre-test	post-test	pre-test	post-test
Concrete	56	20	56	16
Transitional	40	48	24	40
Formal operational	4	32	20	44

Discussion

This Wimba model is a visuospatial-based learning model with a constructivism approach. Students build their own knowledge through concept map tasks. Concept maps are created by students before lectures and are intended to help students to understand the concept being studied. Before creating a concept map, a student must first understand each concept to be mapped. Concepts that have been understood by students relate to connecting words to form proportion and meaningful sentences. Creating concept maps is a mental activity that can improve memory in students. This makes it easier for students to understand the concept before the lab is implemented. The results of the concept maps created by students did not vary greatly between groups using PD and 3Ds Max media, hence student learning outcomes also appear to be influenced by the concept map. The concept map results highlighted that student groups using 3Ds Max media tend to be better and impact on better learning outcomes.

3D image design (3D representation) based on 2D images of transverse, longitudinal and tangential incisions is also a complicated activity. Designing 3D images from 2D images is a visual-spatial activity that requires the ability to accurately understand three dimensional (3D) objects from two dimensions (2D), 'spatial orientation', and the ability to imagine what representations will look like from different perspectives (Barnea, 2000).

Designing 3D images based on 2D images of microscopic observations is a creative process, that requires the power of imagination and good drawing skills. Some students are able to imagine well and can explain well (abstract imagery) but they are also not able to make 3D images well (preview), while some students can describe the 3D representation well (concrete image). The use of concrete media with PD media and 3Ds Max media helps students to represent their 3D imagination by using the media, then the results of the process of microscopic images. Although 3D results have not shown perfect detail, using 3Ds Max media can improve learning outcomes (N-gain) in the medium category.

The visual spatial imagination process for 3D model construction using Wimba's learning model not only improves learning outcomes, but also increases logical reasoning and intellectual development. According to Barnea (2000), the ability of spatial construction is important from all models of human capability (Lohman, 1993). In 3D modelling, objects built can change in virtual 3D space, which can trigger students to start predicting activity results. This rotation involves understanding the proportions of space, spatial orientation, and visualisation (Lohman, 1993). The results of Safhalter et al. (2016) show that 3D training has a positive effect on spatial reasoning. The results of this study indicate that the study of the Wimba model on the subject of plant anatomy can increase reasoning. Wimba's learning using 3Ds Max media tends to increase the probability, correlation and combinatorial better, while the PD media tends to increase proportionally, and control the variables better.

The perpetual reasoning is the reasoning associated with creating and interpreting data in tables and graphs, as well as interpreting images. The results showed that at the time of the pre-test result of the TOLT, the study of Wimba using PD and 3Ds Max dominated proportional reasoning. After Wimba learning, the reasoning of the variable, probability, correlational and combinatorial reasoning seems to increase in both media. Variable control is the reasoning ability to recognise and control variables. Control variables are important for controlling important variables in planning, implementing and interpreting things. Probability reasoning occurs when a person interprets data from research, observation or experiments. Probability reasoning is fully controlled by students at the level of formal operations. The correlational reasoning is the reasoning used to determine the strength of the interrelationships between variables. The correlational reasoning is important to hypothesise relationships among variables. The combinatorial reasoning is the ability to consider all

possible alternatives in certain situations. When solving a problem in the formal phase, it can use all possible combinations of the problem (Yelminez et al., 2005).

Piaget defines the logical thinking ability observed in concrete and abstract operations (Labinowicz, 1980). Students in concrete operations can use the ability to think logically in solving concrete problems. At the stage of abstract operation, the student reaches an adult level in terms of logical thinking. In fact, for prospective teachers who have grown up at the time of the pre-test, 56 per cent of students are still in the concrete stages, both on PD media and 3Ds Max media. Subsequently, 40 per cent are in the transitional phase and 4 per cent are in the formal operational stage of PD media, and 24 per cent are in the transitional stage and 20 per cent are in formal operation of the 3Ds Max media. After learning with the Wimba model, this model can improve the intellectual development of students, which is able to reduce the concrete stage to 20 per cent, can increase the transitional stage to 48 per cent, and achieve 32 per cent in the formal operational stage in PD media. The Wimba model, with 3Ds Max media, is capable of reducing concrete stages by up to 16 per cent, and increasing the transitional stage by 40 per cent, and the formal operational stage by 44 per cent. The Wimba model, with 3Ds Max media, can improve students' intellectual ability well. The mental process that occurs in students using the Wimba model with 3Ds Max can improve greater intellectual development. The 3Ds Max virtual media is very interesting, as it can be played and reversed and has a dancing colour. This is what stimulates the brain to be creative. Thus, 3Ds Max media can better improve intellectual development.

Conclusion

Both media — PD and 3Ds Max media — can be used for the Wimba learning model, even though modern 3Ds Max media tends to provide better learning outcomes and logical reasoning in prospective biology teachers. Logical reasoning with 3Ds Max media tends to be better on indicators of probability, correlational and combinatorial reasoning, whereas PD media can increase proportional reasoning and control variables.

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Acknowledgment

We gratefully thank to the Indonesian Ministry of Research, Technology and Higher Education, and Institute of Research and Community Service (LPPM) of Universitas Siliwangi, because this research was financially supported by a research grant (competitive national grant).

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