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Developing Dynamic Visualization Multimedia on Transportation and Excretion System of Organisms Subject

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Abstrac: Visualization is widely defined as means to support instructional process. It is easily adapted by latest technology and results in the improvement of learning achievement. The rapid change of computer technology allows some chances of multimedia learning development. The dynamic visualization multimedia is systematically developed through the following phases; analysis, design, development, implementation, and evaluation. Based on validation by experts and tryout of the product, the dynamic visualization multimedia is feasible to be used in instructional process.
Keywords: Multimedia, Visualization, Science learning

Introduction

Innovation in technology results in a change of instructional process. It brings a great possibility for multimedia in instructional process to develop. Multimedia covers combination of images, texts, and sound through different modality channel (Horz & Schnotz, 2010). In addition, multimedia also enables learners to have real experience through presentation in the form of texts, graphics, images, audios, videos, and combining the images and texts (Gilakjani, 2012).

A theoretical model of multimedia learning developed by Mayer and cognitive load theory developed by Sweller are used as guidance in designing learning with visualization. Cognitive theory of multimedia learning (CTML), as defined by Mayer refers to Dual-Coding theory by Paivio (1986). It assumes that human cognitive process consists of verbal and pictorial subsystem. Nevertheless, every individual uses different representation format to encode and save knowledge.

Based on the model of working memory proposed by Baddeley (1992), Mayer states that there are two subsystems in working memory; auditory system and visual system. The first basic principle of CTML combines those two concepts. Humans use two channels in processing information in the working memory; auditory system through the verbal channel and visual system through pictorial channel. The second principle of CTML states that those two channels have limited capacity in processing received information. The third principle of CTML conveys that humans involve actively in cognitive process to construct their knowledge derived from either new information or their prior knowledge.

According to Sweller (1999, 2005), and Plass, at al., (2010) in CTML, there are three kinds of cognitive load processing demanded during learning; 1) extraneous cognitive processing, 2) essential cognitive processing, and 3) generative cognitive processing. Extraneous processing is a metacognitive process that does not take place in instructional process. There are six principles to decrease extraneous processing; principles of coherence, signaling, redundancy, spatial contiguity, temporal contiguity, and expectation. Essential processing is a cognitive process that is required to mental expression which is mainly caused by inherent complexity of the new information. It is required to understand the complex instruction will exceed learners' cognitive capacity. There are also three principles that can be implemented to manage essential cognitive process; segmenting principle, pre-training principle, and modality principle. Generative processing is a cognitive process which aims to master the presented materials as well as process it more deeply as motivation direct them to the effort to do it.

The high potential of advanced technology to design learning process like in visualization brings huge excitement to instructional designers and education practitioners. Visualization has already been used for a long time in the history as a learning supplement. It also supports a number of previous research that proved visualization is easily adapted to the recent technology and it can improve learning achievement. Thus, visualization is the most essential component in multimedia-based learning.

Visualization is defined as any kinds of non-verbal illustration (graphic, diagram, pictures, or animation) (Hofler, 2010). Visualization in learning is a representation of visual-spatial aimed at supporting the instructional process (Mayer, 2011). Smaldino, at al., (2005:81) state the potential of visualization in learning that "… some students learn more readily through visual imagery, and even those who are verbal learners need visual supports to grasp certain types of concepts". In line with that, Arend (2004:345) proposes the potential of visualization as "A picture is worth of a thousand words when teaching a difficult concept to students".

According to Smaldino, at al., (2005), visualization has some important roles in learning; 1) providing concrete idea references, 2) motivating students by grabbing their attention, maintaining their attention, and building their emotional response, 3) simplifying complex information, 4) helping to organize the topic by illustrating the relationship among elements in form of diagram, and 5) delivering multimodality information to ease students in comprehension.

Visualization is a tool to support instructions (Hoffler, 2010). A dynamic visualization like animation and video contains some series of frame (Ainsworth & VanLabeke, 2004). Lately, they are frequently used to display a certain process. For instance, the animation is used to show the process of light formation (Mayer & Chandler, 2001) and blood circulation (de Koning at al,, 2010). This particular dynamic visualization becomes an interesting part in science learning since it shows how scientific process works (Wichmann & Timpe, 2015). It is different from static visualization since it supports the scientific process on which it can be observed

(Wichmann & Timpe, 2015). In science learning, dynamic visualization is utilized to describe, explain, and predict a scientific process (Barak & Dori, 2011). In the area of education, dynamic visualization is quite promising to be used for beginner, intermediate, and advance level (Barak & Dori, 2011).

Some empirical studies have reported the advantages of the dynamic visualization (Catrambone & Seay, 2002; Hegarty, Kriz, & Cate, 2003; Yang, Andre, & Greenbowe, 2003). A meta-analysis study by Hoffler and Leutner (2007) shows that the dynamic visualization improves learning achievement, especially in procedural knowledge. In line with that, other results of studies show that learning by using the dynamic visualization improves students' mastery (Lewalter, 2003; Yarden & Yarden, 2010; Lin & Dwyer, 2010; Nguyen, Nelson & Wilson, 2012; Wu, Lin, & Hsu, 2013). Hence, dynamic visualization is believed to be effective in helping the students to visualize some processes from concrete to abstract model.

Based on the interview with science teachers, they confessed that they did not optimize the use of multimedia in the learning process. In contrast, the standard process of learning requires the use of Information and Communication Technology including multimedia in the learning process.

Taking into account of the aforementioned explanation, this study aims at describing the systematic process of the dynamic visualization multimedia development on transportation and excretion system of organisms subjects. The development of innovative teaching media is undertaken due to the needs to improve the quality of the learning. The dynamic visualization multimedia can be one of innovative technology product to be used in science learning.

Method

Research Design

This study employs a research and development study. It focuses on developing and validating products that are used in education (Borg & Gall, 2003). It is not aimed at testing or proposing a theory, on the other hand, it develops the existing products to be effectively used at school.

ADDIE model is employed in this study. It stands for analysis, design, development, implementation, and evaluation (Branch, 2009). ADDIE model is a system-oriented model which aims at producing a broad scope of learning system, e.g. system design of a workshop or school curriculum.

The steps of this model are explained as follow; a) analysis, in this step the researcher defines what students will learn, including identifying instructional problems, need analysis, and analyzing the environment. Therefore, the media created will be based on the profile of the students, the gap identification, and the needs analysis, b) design, this step includes forming contents, making structure of the program, making storyboard, designing interface meeting, preparing systematic presentation of the topic, illustration, and visualization, c) development, it is the process of realizing the design. The researcher creates and assembles the contents that are created in the design phase. If it requires software in the form of multimedia learning in the design phase, it means that the multimedia must be developed, d) implementation, the process of implementing learning system that was being developed. All of the software are set and installed and it is run according to its roles and function, e) evaluation, this step runs to check whether the learning system is well applied or not. This process could be administered in the previous four phases. When the evaluation step is administered in each of previous phase, it is called formative evaluation since the purpose is to check the clarity, applicability, as well as revise the system.

Participant dan Data Collection Tools

The subjects of this study consist of three students for individual tryout, ten students for small group tryout, and 26 students for field tryout. Data are derived from the evaluation of material experts and media experts, and questionnaire regarding students' opinion toward the dynamic visualization multimedia. Instruments for data collection are in the form of evaluation sheets for material experts and media experts. The questionnaires are given to individual tryout, small group tryout, and field tryout. The data are further analyzed descriptively by changing the format of the data in the evaluation sheet into score interval with Likert scale in the Table 1.

Table 1. Dynamic visualization multimedia category

Score	Category
M > $\overline{X_i}$ +1,80 SD	Very good
$\overline{X_i}$ + 0,60 SD < M ≤ $\overline{X_i}$ + 1,80 SD	Good
$\overline{X_i}$ - 0,60 SD < M ≤ $\overline{X_i}$ + 0,60 SD	Adequate
$\overline{X_i}$ -1,80 SD < M ≤ $\overline{X_i}$ - 0,60 SD	Not Good
M≤ $\overline{X_i}$ -1,80 SD	Bad

Results and Discussion

The dynamic visualization multimedia is developed based on the needs analysis. The data are collected from literature review and the field study. The results show that the use of the dynamic visualization multimedia had positive impact toward the process of learning as well as learning achievement (Hoffler & Leutner, 2007). This study also reveals that the students are not really engaged in the instructional process as teachers did not maximize the use of the dynamic visualization multimedia in the teaching process.

The phases of the development of dynamic visualization multimedia product includes: 1) making flowchart, 2) making storyboard, and 3) gathering additional materials. In development phase, the dynamic visualization multimedia is created by using Adobe Flash and program test to ensure the results fit the expectation.

After the product is implemented, it is followed by *evaluation* phase. In this phase, the product is validated by the material experts and the media experts. Then, it is continued by first phase of product revision, individual tryout and followed by second phase of product revision, small group tryout and followed by third phase of product revision, and field tryout which is further followed by final product revision.

The validation from material expert and media expert is further explained in the Table 2.

Table 2. Dynamic visualization multimedia quality validation result by content experts and media experts

Aspect	Score Average	Category
Content aspect	3.75	Good
Media aspect	4.33	Very good

Based on Table 2, the dynamic visualization multimedia has proven as good material quality with average score 3.75. It also shows that the dynamic visualization multimedia has good media quality with average score 4.33. Overall, the quality of this learning media was good.

The result in learning media tryout can be seen in Table 3.

Table 3. The quality of dynamic visualization multimedia try out

Try Out Phase	Average Score	Category
Individual	4.15	Very Good
Small Group	4.01	Very Good
Field	4.12	Very Good

Based on the individual, small group, and field tryout, it can be seen that the students gave very good responses toward dynamic visualization multimedia. Hence, dynamic visualization multimedia product can be a proper media to be used in learning process.

Conclusion

Visualization is the key component in multimedia-based learning. Dynamic visualization becomes interesting part in science learning since it shows how scientific process works. Accordingly, the dynamic visualization multimedia in this study has five phases; in the analysis phase the researcher analyzed the gap between the expected result and students' prior knowledge and skill. Next, the design phase resulted in flowchart and storyboard, the development phase resulted in dynamic visualization media prototype, the implementation phase resulted in the tryout of the product, and the evaluation phase resulted in the report about the implementation and evaluation. Results and the recommendation regarding the use the dynamic visualization multimedia are also added.

According to the result of the study, some recommendations in relation to the use and further development are proposed. First, dynamic visualization multimedia generally can be used as instructional media on transportation and excretion of organisms subject. Second, as for those students who are equipped with computer, this media is helpful to help them learn independently. Third, the improvement of the product quality can be done from the content and topic perspectives.

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