EFFECTS OF SEGMENTATION OF INSTRUCTIONAL ANIMATION IN FACILITATING LEARNING

Ahmad Zamzuri Mohamad Ali

Faculty of Art, Computing and Creative Industry
Universiti Pendidikan Sultan Idris
35900, Tanjong Malim, Perak, Malaysia
Email: zamzuri@ftmk.upsi.edu.my

Ahmad Rizal Madar

Faculty of Technical Education
Universiti Tun Hussein Onn Malaysia
86400, Parit Raja, Batu Pahat, Johor, Malaysia
Email: rizalm@uthm.edu.my

ABSTRACT

The aim of this study was to investigate the effects of segmented-animation, play-pause-animation and continuous-animation in facilitating learning of low prior knowledge learners. A courseware prototype entitled Transmission Media was developed for the research purpose. The courseware contains nine animations on various topics in Transmission Media. Pre-test and post-test experimental design was employed on three different groups respectively. The data collected were analyzed statistically by using one-way between-groups ANOVA with post-hoc comparisons. Apparently, the result suggests that segmented-animation was significantly more effective than play-pause-animation and continuous-animation in enhancing students' learning performance. The result indicates that segmented-animation was beneficial for students in conducting adequate cognitive processes of the information depicted in the animation. Furthermore, the result shows that allowing students to decide the segmentation in play-pause-animation condition does not necessarily promotes better learning. This was due to low prior knowledge students' inability in deciding the appropriate stop points in animation and/or play-pause-replay button design that might causes split attention effect resulting extraneous cognitive load throughout the learning process.

Key words: *Cognition, continuous-animation, interactivity, mental model, play-pause-animation, segmented-animation*

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1. Introduction

Utilization of animation has been a key component of the instructional courseware design nowadays. New advances in software technology have spurred the development of new means in conveying information in animation form. Defined as a series of rapidly changing computer screen display that represents the illusion of movement (Mayer, 2001; Rieber & Hannafin, 1988), animation plays potential role in supporting the visualization of a dynamic process such as not easily observable in real space and time scales, the real process that is practicaly impossible to realize in a learning situation, or the process that is not inherently visual (Betrancourt, 2005). Animation also plays potential role in reducing the cognitive cost of mental simulation thus saving cognitive resources for learning task especially for novice learners (Betrancourt, 2005). In its best uses, animation presents information in a more interesting, easier to understand and remembered way than static media (Norton & Sprague, 2001; Rieber, 1990). However, even with these advantages and theoretical support, research findings related to the effectiveness of the animation learning remains inconsistent (Lin & Dwyer, 2010; Ayres, Marcus, Chan & Qian, 2009; Ainsworth, 2008; Hegarty, 2004; Lin & Dwyer, 2004 ; Sperling, Seyedmonir, Aleksic & Meadows, 2003). The main reasons of inconsistencies may attributed to design limitations (Tversky, Morrison & Betrancourt, 2002; Liu, Jones & Hemstreet, 1998) and learners' learning characteristics such as prior knowledge, spatial visualization ability, learning style, motivation, age, gender and so on (Spanjers, van Gog & van Merrienboer, 2010; Mayer & Moreno, 2002; Chuang, 1999). There are dozens of models and theories on learning characteristics; however this study only focused on novice or low prior knowledge learners. Prior knowledge has significant impact on learning efficiency (Huk, Steinke & Floto, 2003; Mayer, 2001). High prior knowledge students primarily benefit from animation learning in comparison with low prior knowledge students (Kalyuga, 2008; Lin, Ching, Hsu & Dwyer, 2006). This was due to the availability of relevant cognitive schemas that would influence the construction of event model in their cognitive structure which the low prior knowledge students don't have (Zacks et al., 2007). Therefore, finding design solutions addressing information processing challenges might faced by novice or low prior knowledge students in animation learning seems important. It appears that current approaches to the design and use of animation can be ineffective due to the instructional designers' failure in addressing these challenges posed for learners (Lowe, 2004).

2. Animation and Cognition

The theoretical framework of this study was grounded on Mayer's Cognitive Theory and Sweller's Cognitive Load Theory. Mayer's Cognitive Theory (Mayer, 2001) explained that information processed in human memory through two channels, namely verbal channel and visual channel and through three cognitive processes. The first cognitive process involves selecting verbal information to be processed in verbal working memory and selecting visual information to be processed in visual working memory. The second cognitive process involves organizing the selected verbal information into verbal mental model and organizing the selected visual information into visual mental model. The final process involves integrating the verbal mental model and visual mental model developed with prior knowledge to be stored in long-term memory. Successive learning occurs when learners are able to attend important aspects of the presented material, mentally organize it into meaningful cognitive structure and integrate it with relevant existing knowledge (Mayer & Moreno, 2003, 2002).

Meanwhile, Sweller's Cognitive Load Theory (Sweller, 2002, 1994) describes learning structures in term of information processing system involving long-term memory which effectively stores all the information gained on more-or-less permanent basis in schema form. Information may only be stored in long-term memory after first being attended to and processed by working memory. Working memory however is extremely limited in both capacity and duration. This limitation under some condition may impede learning especially when learners failed to develop accurate mental model of the visual and verbal information in their working memory. Things may become more crucial for learners with low prior knowledge of the content presented (Muller, Eklund & Sharma, 2006). Cognitive Load Theory assumes that information should be structured to eliminate any avoidable overload on working memory in order to enhance learning outcome (Stiller & Jedlicka, 2010). Cognitive load is mainly divided into three disjoint categories namely extraneous, intrinsic and germane load (Sweller, 2010). Extraneous load is mainly concerned with the instructional procedure or presentation manner, meanwhile intrinsic load is mainly caused by complexity and difficulty of information (Sweller, 2010; Stiller & Jedlicka, 2010). By minimizing extraneous load and intrinsic load, students are more likely to engage in schema acquisition and automation that impose germane load (Stiller & Jadlicka, 2010). Maximizing germane load means fostering schema acquisition which is beneficial for learning (Caspersen & Bennedsen, 2007).

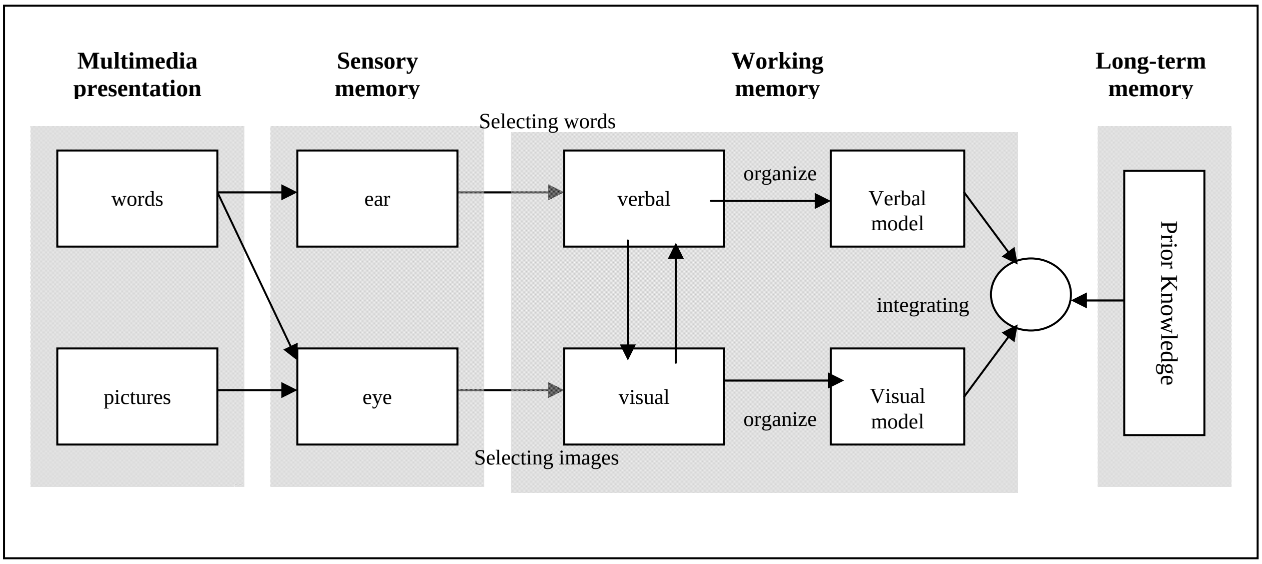

Figure 1: Mayer's model of memory
(Source: Mayer, 2001)

Based on Mayer's and Sweller's theories, animation presentation that enables students to extract necessary information from it in order to develop accurate mental model of the information presented is important for successive learning (Lowe, 1999). Continuous flow of changing information in animation may cause cognitive overload and hinders accurate mental model development (Betrancourt & Rebetez, 2007). This is due to inability of learners to process new information while simultaneously trying to remember and integrate important past information, thus creating extraneous load as working memory resources are focused on dealing with demands of the presentation, rather than focused on learning (Ayres, Marcus, Chan & Qian, 2009). However, it appears to be another view claiming that animation triggers passive information processing and may leads to overconfidence (Rozenblit & Keil, 2002). Study by Awan and Stevens (2006) revealed that confidence level of understanding in the animation condition was high in comparison with static media. They pointed out that higher confidence indicates lower mental effort that leads to the perception that animation is easy to process. This situation can keep learners from doing relevant cognitive processes on their own (Schnotz & Rasch, 2005), which may influence the effectiveness of animation learning (van Oostendrop, Beijersbergen & Solaimani, 2008). Therefore, need of studies in finding design solutions addressing these issues are important.

3. Segmented-Animation

Due to the speed and visual complexity of animation, learners may confused and overwhelmed throughout animation viewing as they were unable to properly process all incoming information before it disappears (Ayres, Marcus, Chan & Qian, 2009; van Oostendrop, Beijersbergen & Solaimani, 2008; Lowe, 2004; Wier & Heeps, 2003; Lowe, 1999). Therefore, designs that do not provide appropriate time for learners to focus their attention on the information being presented may be among the reason for failure of animation in assisting learning (Torres & Dwyer, 1991). Without appropriate time allocation, learners may fail to develop new or adapt to existing schemas effectively (Garhart & Hannafin, 1986). Whereas, the more time learners spend interacting with the instructional material, the better they will be able to register the information in the long term memory structure (Slater & Dwyer, 1996).

Segmented-animation with features that allow learners to control the segment viewing rather than passively view the whole animation continuously can be a design solution addressing this drawback (Plass, Homer & Hayward, 2009; Moreno, 2007; Mayer & Moreno, 2003; Mayer & Chandler, 2001). In segmented-animation design, the whole animation will be chunked into meaningful segments, including pause or time break after each segment and learner-control features to move from segment to segment. Thus, pause or time break between segments and learner-control features will allow learners to rehearse in order to extract necessary information from one segment before moving to the following segment. In addition, during the pauses learners can analyze the visual spatial structure of the content on the screen, something that can be difficult to do when a display continuously changes (Lowe, 2004).

Research findings indicates that segmented-animation with learner-control features will allow appropriate exposure duration on animation that helps learners in interpreting and understanding the animation better (Aminordin, Ng & Fong, 2004; Fong, 2001). Comparison studies on segmented-animation and continuous-animation also revealed that segmented-animation appears to be more beneficial in enhancing students learning performance (Hasler, Kersten & Sweller, 2007; Moreno, 2007; Mayer & Chandler, 2001). However, in these studies segmentation was decided by the instructional author. Question arises; does the same result would be obtained if students were allowed to decide the segmentation? Interactivity with dynamic media has been proposed as a way to encourage students to engage in activities contributing to learning (Wouters, Tabbers & Paas, 2007). In addition, allowing higher degree of interactivity (such as traditional functions of VCR) should be considered in instructional design with assumption that students have the capabilities in managing their cognitive resources for each part of animation (Betrancourt, 2005). Therefore, allowing interactivity in the form of segmenting the animation at own pace may encourage students to focus on sub events or sub steps depicted in an animation that may promote effective animation learning (Spanjers, van Gog & van Merrienboer, 2010). A study by Hasler, Kersten and Sweller (n.d.) revealed that learner-paced animation group showed higher learning performance with relatively lower cognitive load compared to continuous-animation group despite the fact that the stop-play button was used very rarely by students. They suggested that mere presence of the stop-play button along the instructions in its use increased germane cognitive load, thus leading to enhanced learning performance. However, in their study animation was supported with concurrent narration. Question arises again; does the same result will be obtained if the animation was without narration? Since the stop-play button was used very rarely, there might be a possibility that the meaningful narration was the element that supports students learning as pointed out in Mayer's multimedia design principles (Mayer, 2001). In addition, the intonation of the narration might have guided the students in deciding the meaningful stop points in the animation. Taking these arguments into consideration, this research was focused on studying the effects of interactivity level in segmenting the animation with concentration on animation with text instead animation with narration as study by Hasler, Kersten and Sweller (n.d.).

4. Method

4.1. Research Objective

Based on the literature overview above, the main objective of this research was to study the effectiveness of segmented-animation, play-pause-animation and continuous-animation on learning achievement of students with low prior knowledge. In detailed, the hypothesis or prediction derived from the literature overview done is play-pause-animation is significantly more beneficial in assisting learning of low prior knowledge students in comparison with segmented-animation and continuous-animation.

4.2. Teaching Material

A courseware prototype entitled Transmission Media with three different animation presentation strategies was developed. The courseware contains nine animations on various topics in Transmission Media. All modes display the same animations. Animation was embedded in the courseware's interface (figure 2). Rational of interface design and content presentation strategy in reducing cognitive load can be referred in Ahmad Zamzuri (2007, 2008). The proper content presentation design and strategy to reduce any intrinsic load and interface design to reduce any extraneous load is important to avoid factors that may interfere with schema acquisition of students throughout the study (Sweller, van Merrienboer & Paas, 1998).

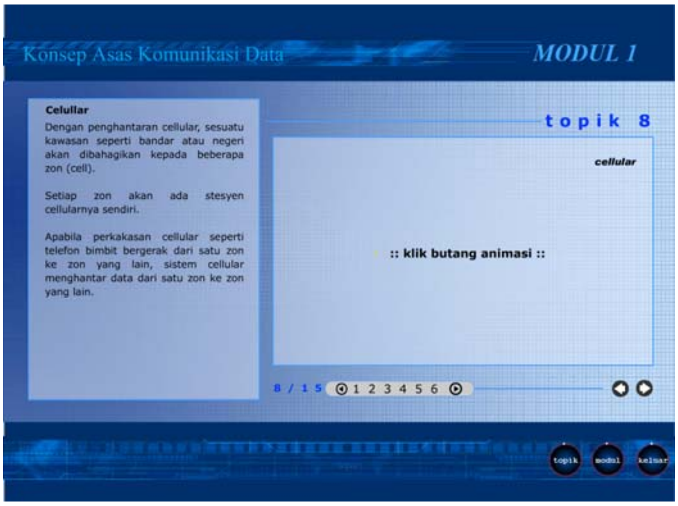

Figure 2: Courseware interface

The first animation mode is segmented-animation (figure 3), which consist animations that were chunked into segments and the user can display the segments in sequence by using the next and previous control buttons. It appears to be no clear guidelines or design principles in determining the best segment's length. However, two options available based on researchers practice were (1) the length are based on theories with regard cognitive functioning (2) the length are based on content experts view in order to determine the meaningful segments (Spanjers, van Gog & van Merrienboer, 2010). This study imposed both options. The animation was chunked into meaningful segments based on expert's view. The segments were kept short which is necessary and helpful for novice learners, since all the information is new for them (Spanjers, van Gog & van Merrienboer, 2010).

Figure 3: Segmented-animation mode

The second animation mode is continuous-animation (figure 4), which consist same animations but will be displayed continuously when the user clicked the start button.

Figure 4: Continuous-animation mode

The third animation mode is play-pause-animation (figure 5), which consist same animations with play, pause and replay buttons that allows users to segment the animation at their own pace.

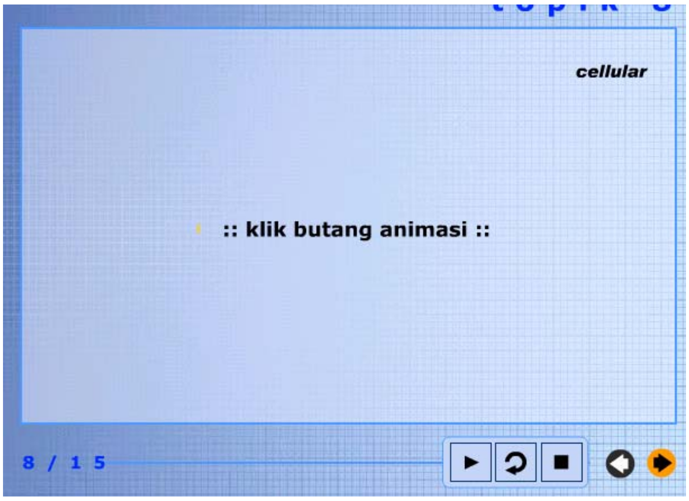

Figure 5: Play-pause-animation mode

4.3. Procedure

This experimental study investigates the effects of three different animation presentation modes on learning achievement of students with low prior knowledge. The independent variables were the segmented-animation, continuous-animation and play-stop-animation meanwhile the dependent variable refers to the post-test. The research sample were 101 polytechnic students from three intact classes, age ranged from 19 to 21, enrolled in Diploma in Information Technology course.

The study was conducted separately for all the groups in controlled lab environment. Pre-test was conducted before the commencement of study. Immediately then, students were required to explore the courseware. 30 seconds were allocated for them to explore the courseware on self-paced learning condition. Each student was allocated one personal computer. Post-test was conducted immediately after the exploring session.

4.5. Test Instrument

Pre-test and Post-test were employed on these groups that viewed the three different animation presentation modes respectively. Pre-test and Post-test were fill in the blank and essay test which was constructed based on Bloom's Taxonomy. The test only focused on measuring three low cognitive ability of Bloom's Taxonomy namely knowledge, comprehension and application. The test was examined by three different instructors and the average marks were considered as the final marks. High prior knowledge students were identified through the pre-test results. The high prior knowledge students, which were obviously low, were removed from the research sample. One-way between-groups ANOVA with post-hoc comparisons was employed to analyze the data collected statistically.

5. Results

Consistency of prior knowledge was examined from the pre-test results. From the one-way ANOVA test, Levene's test for homogeneity of variances was not significant (p>0.05) and therefore the population variances for each group were approximately equal. The output shows that there was no significant difference in the pre-test achievement of students in segmented-animation, play-pause-animation and continuous-animation modes $F(2,98)=2.38$, $p>0.05$. This result further assured that there was no pre-existing difference in prior knowledge by group. Total mean scores of prior knowledge were also obviously low (M=5.72, SD=4.35), which was necessary for the study.

To examine whether there was any significant difference in the learning performance of students in the segmented-animation, play-pause-animation and continuous-animation modes, one-way between-groups ANOVA with post-hoc comparisons was employed on the post-test results. Levene's test for homogeneity of variances was not significant ($p>0.05$) and therefore the population variances for each group were approximately equal. The output shows that there was significant difference in the post-test achievement of students in segmented-animation, play-pause-animation and continuous-animation modes $F(2,98)=7.22$, $p<0.05$. Results from the post-hoc Tukey HSD test in table 1 shows that there was significant difference between segmented-animation versus continuous-animation ($p<0.05$) and segmented-animation versus play-pause animation ($p<0.05$). Meanwhile it appears to be no significant difference between continuous-animation versus play-pause-animation ($p>0.05$).

Table 1: Summary of post-hoc Tukey HSD comparison between group test

Comparison groups	Mean Difference	Std. Error	Sig.
segmented-animation versus continuous-animation	12.93	3.67	0.00
segmented-animation versus play-pause animation	10.93	3.59	0.01
continuous-animation versus play-pause-animation	2.00	3.56	0.84

Mean scores in table 2 indicates that students in the segmented-animation mode obtained better mean scores (M=69.00, SD=14.61) than students in continuous-animation (M=56.07, SD=14.42) and play-pause-animation (M=58.08, SD=15.25) modes. Meanwhile students in continuous-animation (M=56.07, SD=14.42) and play-pause-animation (M=58.08, SD=15.25) modes obtained almost similar mean scores. Therefore the hypothesis derived that play-pause-animation is more beneficial than segmented-animation and continuous-animation was rejected.

Table 2: Summary of post-test results

Groups	N	Mean	Std. Deviation
segmented-animation	32	69.00	14.61
play-pause animation	36	58.08	15.25
continuous-animation	33	56.07	14.42

6. Discussion

As pointed out earlier, animation has strong research and theoretical support towards effective learning. However, the characteristics of animation that changes over time might impose cognitive overload throughout the learning process. This situation might impede learning especially for students with low prior knowledge. Therefore segmentation was proposed as a potential solution to facilitate students' cognition in animation learning (Moreno, 2007; Mayer & Moreno, 2003; Mayer & Chandler, 2001). This research finding was inline with the segmentation proposal. Overall, the research finding revealed that students in the segmented-animation mode performed better mean scores than students in other modes which were consistent with many other studies on segmentation (Hasler, Kersten & Sweller, 2007; Moreno, 2007; Mayer & Chandler, 2001). This finding further strengthen the assumption that animation that was chunked into meaningful segments and including pause or time break between segments will allow appropriate time for students to extract necessary information in order to develop more accurate mental model of the process depicted in the animation. With accurate mental model, formation of meaningful schemas to be registered in long-term memory is possible even for students with low prior knowledge. In addition, during the pauses learners can analyze the visual spatial structure of the animation at certain meaningful points which could be impossible if the animation continuously changes. Apparently, pauses play the role of static display at certain meaningful points in animation. Therefore, this situation might overcome the passive cognitive processing phenomena that leads to overconfidence and negative animation learning outcomes as pointed out by Awan and Stevens (2006).

The result of this research seems not in favour with the prediction derived on play-pause-animation. Furthermore, the result revealed that there was no significant difference on the learning outcome of students in play-pause-animation mode and continuous-animation mode. This indicates that allowing students to decide the segmentation of animation was not necessarily beneficial for low prior knowledge students. From the observation done during the study, it was noticed that the play-pause button was used very rarely by the students. This might due to low prior knowledge students' inability in deciding the meaningful stop points in the animation throughout the learning process. The second possibility was the play-pause button design strategy. From the observation, it was found that students having difficulty in using the interactive buttons effectively. Moving from one button to another and focusing on the message depicted in the animation concurrently causes split attention effect that might increased the extraneous cognitive load which was not good for effective learning (Stiller & Jedlicka, 2010). This finding seems not consistent with Hasler, Kersten and Sweller (n.d.), even though stop-play button was used very rarely in their study as well. However as pointed out earlier, there was a possibility that students in stop-play animation mode outperformed students in continuous-animation mode due to the support of concurrent meaningful narration and the narration's intonation that assisted students in deciding the meaningful stop points. Comparison study on the effects of play-pause animation with narration and with text should entail to investigate this assumption. The second potential future study should be on play-pause button design strategies. Play-pause-animation might still have positive effect on learning if proper button design solution can be found, especially in minimizing extraneous cognitive load effects throughout the learning process. Among the potential button design strategies are mouse over buttons instead of mouse click buttons, one button with play and pause functions alternately instead of two separate buttons for play and pause, etcetera.

7. Conclusion

Development of computer animation is relatively time-consuming and costly. Therefore, to ensure maximum effectiveness of animation the instructional designer should ground their design based on current research findings and theories. They should not base their design on their own preferences that may or may not work well. Thus, this research finding suggests that segmented-animation presentation has advantage in promoting better animation learning, especially for students with low prior knowledge. Segmented-animation actually plays the role of both dynamic and static display. During the segment viewing, animation assists the learners in construction of an adequate mental model in the working memory. Thus, this supports the formation of more meaningful schemas to be registered in long term memory. Meanwhile, static display during the pauses promotes learners to do relevant cognitive processes on their own by integrating with previous developed schemas. Therefore, combination of passive and active cognition promoted by segmented-animation might play potential role for successive learning.

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