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Improving Learning Outcome with Segmentation and Cueing

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Abstract : The computer animations certainly help in deeply understanding the complex concepts. Moreover, computer animations are broadly used for nearly all subject disciplines. Some past studies highlighted that comprehension can be improved by deploying effective design principles within the computer animations. Thus, this study is aimed at finding the effectiveness of design principles particularly when segmentation and cueing design principles are served together within computer animations. A quantitative experimental study was designed and conducted. A total of 56 students willingly participated in the study which were then randomly divided into two groups of 28 students each. Both groups got different treatments and after the post-test the independent t-test was applied on the quantitative data and it was observed that modern animations made with segmentation and cueing design principles were more effective as compared to conventional animations. The mean post-test score of group-1 (M=7.6429, SD=0.95) who was treated with modern animations was comparatively much higher than the group-2 (M=5.5000, SD=1.13). The limitation of the present study is that it did not consider the individual growth of students. In fact, cumulative group scores were measured. The implication of the present study is that it can certainly support the educational institutions in designing effective animations which in turn can improve the learning outcome.

Keywords : Computer Animations, Effective Design Principles, Segmentation and Cueing

1. Introduction

It is said that computer animations can improve comprehension (Berney & Bétrancourt, 2016; R. K. Kaushal & Panda, 2019; R. Kaushal, Panda, & Kumar, 2020; Lee & Wong, 2014; Nguyen, Nelson, & Wilson, 2012; Stebner, Kühl, Höffler, Wirth, & Ayres, 2017) but design principles are also essential in animation based learning environment (Biard, Cojean, & Jamet, 2018; Paas, Renkl, & Sweller, 2003; Schneider, Beege, Nebel, & Rey, 2018; Schnotz & Kürschner, 2007; Xie, Wang, Zhou, & Wu, 2016). For a long time, the researchers have been trying to find out effective design principles and their effectiveness through the experimental studies. The past literature primarily emphasized on segmentation, dual modality, cueing and prediction prompts (Biard et al., 2018; Arslan-Ari, 2018; Schneider et al., 2018; Amadieu, Mariné, & Laimay, 2011; Schmidt-Weigand, Kohnert, & Glowalla, 2010a, 2010b). Most of the design principles were made keeping cognitive load theory in mind. These design principles help to reduce intrinsic and extraneous cognitive load and increases germane load marginally.

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The intrinsic load appears when learners face excess load on their mind due to the subject complexity. The learners feel extraneous load on their mind when they struggle in finding necessary information due to poorly designed computer animations (Paas et al., 2003). Both intrinsic and extraneous load must be reduced for better comprehension. The germane load is necessary for comprehension and it must be increased marginally (Pollock, Chandler, & Sweller, 2002; Van Merriënboer, Kirschner, & Kester, 2003; De Koning, Tabbers, Rikers, & Paas, 2011; McEldoon, Durkin, & Rittle-Johnson, 2013).

Majority of the past studies performed the experiments to compare the impact of segmented versus non-segmented and cueing versus non-cueing animations on the learning outcome. These experiments were conducted in order to find the effectiveness of a specific design principle. The present study made an attempt to find the effectiveness of computer animations when presented with multiple design principles together. The present study investigated the effect of segmentation and cueing together on the learning outcome.

2. Related Work

The past literature emphasized heavily on offering computer animations when made in accordance to effective design principles. The most cited design principles were cueing and segmentation. The principle of cueing is also known as signaling (Arslan-Ari, 2018; Khacharem, 2017).

Diverting participant's attention to key regions within animations is known as cueing. This is usually accomplished by highlighting key areas with colored dotted lines or by pointing arrows. The empirical studies in the past has proved cueing approach effective(Amadieu, Mariné, & Laimay, 2011; Arslan-Ari, 2018; Khacharem, 2017; Lin, Atkinson, Savenye, & Nelson, 2016; Schneider et al., 2018; Xie et al., 2016) .

Xie, Wang, Zhou, & Wu, 2016 conducted a meta-analysis and found that cueing improved retention and transfer of knowledge. This study reported 0.53 and 0.36 as the mean effect size of impact of cueing on retention and transfer of knowledge respectively. Likewise, Schneider, Beege, Nebel, & Rey, 2018 proved the effectiveness of cueing approach through extensive meta-analysis. A total of 117 effect sizes out of 139 reported positive effect of cueing on transfer of knowledge. This study reported 0.53 and 0.33 as the mean effect size of impact of cueing on retention and transfer of knowledge respectively.

The segmentation principle emphasizes on splitting a complex concept into sub-concepts wherever viable and recommend to make a separate animation for each of them. This strategy assists the participants to manage the complexity of the concept and thus reduces intrinsic load which in turn improves comprehension (Ali & Madar, 2010; Biard et al., 2018). Many researchers in the past have proved the effectiveness of segmentation principle by well designed experimental studies (Fong, 2013; Hasler, Kersten, & Sweller, 2007; Spanjers, Wouters, Van Gog, & Van Merrienboer, 2011) . Rey et al., 2019 reported 0.32 and 0.36 as overall effect size of impact of segmentation on retention and transfer of knowledge respectively.

The related work clearly demonstrated the effectiveness of segmentation and cueing. As a result, this study fused both of these design principles together within the animations.

3. Objective

The aim of this study is to investigate does conventional animations without any design principles are equally good as compared to computer animations designed according to segmentation and cueing principles together?

4. Methodology

This section describes about the demography of participants involved in the study, material used and the procedure followed. This study utilized quantitative methods to achieve the objective. Due to the nature of data-set, t-test and eta-square were computed.

A. Participant

All participants were of CSE (Computer Science Engineering) fourth semester. A total of 56 students willingly participated in the study. All participants were of age group 19 to 21 and majority of the students were male.

B. Material

The computer animations were made in ADOBE FLASH. The principle of cueing was incorporated

with red-dotted lines. The play and pause features were also incorporated within animations to give participants control over the pacing. To implement the principle of segmentation the concept was sub-divided into sub-concepts wherever possible and a separate animation of every sub-concept was made. The ADOBE FLASH was also used to incorporate computer voice to explain the concepts. A flash player plugin compatible with google chrome was used within labs to play these animations.

C. Procedure

All 56 participants were first randomly divided into two groups of 28 students each. Two computer labs of university were utilized to treat both the groups differently. The group 1 was taught with computer animations incorporated with segmentation and cueing principle whereas group 2 was taught with conventional animations made without any design principles. The complete strategy is explained in the Table 1.

Table 1: Strategy and Rationale

Group	N	Animation Type	Design principle	Rationale for Experimental Design
Group 1	28	Modern	Segmentation and Cueing	Post-Test marks analysis will reveal the effectiveness of segmentation/cueing.
Group 2	28	Traditional	No design principles adopted	

Red dotted lines were used to highlight the key areas to gain the user attention and the timings of highlighting key areas were synchronized with auditory explanation of the concept. This is one of the recommended approaches to implement the principle of cueing (Boucheix & Guignard, 2005;Fischer, Lowe, & Schwan, 2008).

The concepts of BST (Binary Search Tree) were sub-divided into smaller sub-concepts and a separate animation was made for each of them. The BST deletion operation is very complex in nature and teaching it through a single animation could overwhelm the participants.

Thus, the present study divided this concept into three sub-concepts i.e. deletion of a node from BST having no children, deletion of a node having one child and deletion of a node having both children. Thereafter, a separate small animation of each of these sub-concepts were made and presented to participants. Moreover, participants were given the control over pacing through play and pause buttons. This way segmentation was implemented.

The concepts of BST were introduced within the study. The participants were not aware of these concepts as it was not part of their ongoing semester curriculum. A post-test having 10 multiple choice questions was conducted at the end to measure the impact of incorporated design principles on the learning outcome. The post-test scores of both the groups were analysed using the independent t-test.

5. Results

The post-test scores were analysed using IBM SPSS 23. Independent t-test was used to measure the post test scores of both the groups. The group statistics are depicted in the Table 2.

The independent t-test results are depicted in the Table 3. The t-test result shows the equal variance between the groups (F=.807, Sig = .373) and thus t-test value (t=7.643) in the first row was utilized for the further analysis. Likewise, a two-tailed significance value (Sig=.000) in the first row was used to find the significance.

Table 2: Post-test group statistics

	group	N	Mean	Std. Dev.	Std. Error Mean
performance	group1	28	7.64	0.951	.17976
	group2	28	5.50	1.138	.21517

As two tailed significance value was < .05 which suggested that the performance score of both the groups were notably different. As a result, the present study compared mean scores of both the groups and found that group-1 benefited more with computer animations made according to the design principles.

The effect size was also calculated using the eta-square equation. The eta square equation considers t-test value and sample size to compute the magnitude.

$$\text{Eta Squared} = \frac{t^2}{t^2+(N1+N2-2)} \qquad (1)$$

The calculated eta squared (0.519) found that the impact of the treatment was really large and effective.

Table 3: Independent t-test results

		t-test for Equality of Means					
	Variance Assumed	F	Sig.	t	df	Sig. (2-tailed)	Mean Diff.
performance	Equal	.807	.373	7.643	54	.000	2.14286
	Not Equal			7.643	52.34	.000	2.14286

As far as the outcome based education is concerned, the strategy of integrating multiple design principles namely segmentation and cueing within computer animations is recommended after detailed analysis using t-test and eta-squared computation. This effect can be seen in the Table 1 and Table 2

6. Discussion

This study was aimed at finding the effectiveness of design principles when served together within the computer animations. This study used segmentation and cueing principle together within computer animations to improve the comprehension. This study named such animations as modern animations. Improving learning outcome is vital for the success of every student . Whereas, the computer animations designed without any design principles were treated as conventional animations. The challenge for both the groups were to understand the underlying concepts of binary search trees (BST). The most challenging part was to make modern style computer animations as it was very critical to correctly decide which portion of an animation needs to be highlighted with red dotted lines and at what time. The decision to make multiple segments and making their corresponding animations was also very crucial. As a result, the authors of this study have devoted lot of time and efforts particularly while making animations. Due to the experimental design, the participants were randomly divided into two groups of 28 students each. Both the groups got different animated treatment. To achieve the research objective, the effect of modern and conventional animations on the learning outcome was compared using the independent t-test on post-test exam data. The results were significantly in the favor of design principles like cueing and segmentation.

7. Conclusion

The study exhibit that the mean performance score of the group who studied with modern animations was comparatively higher (M=7.6429, SD=0.95119). Thus, the study showed that conventional animations are not equally effective and must be incorporated with effective design principles. The segmentation and cueing principle incorporated within the animations played a vital role. The principle of segmentation helped in reducing the intrinsic cognitive load and principle of cueing reduced the extraneous cognitive load. A positive effect of reduced cognitive load can be seen in the performance scores of group1.

The limitation of the present study is that it did not consider the individual growth of students. In fact, cumulative group scores were measured. The implication of the present study is that it can certainly support the educational institutions in designing effective animations which in turn can improve the learning outcome.

In future, there is need to find more such design principles and there is need to discover techniques/methods to embed those principles into computer animations.

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