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Dynamic Visualization on Student's Performance, Retention and Transfer of Procedural Learning

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***Abstract*—**This study examined the effects of two dynamic visualizations on 60 Malaysian primary school student's performance (time on task), retention and transference. The independent variables in this study were the two dynamic visualizations, the video and the animated instructions. The dependent variables were the gain score of performance, retention and transference. The results showed that the students in the animation group significantly outperformed the students in the video group in retention. There were no significant differences in terms of gain scores in the performance and transference among the animation and the video groups, although the scores were slightly higher in the animation group compared to the video group. The conclusion of this study is that the animation visualization is superior compared to the video in the retention for a procedural task.

***Keywords*—**Dynamic visualization, Procedural Task, Retention, Transference

I. Introduction

TECHNOLOGY and instruction are now so intertwined that it would be difficult to ascertain when technology was seen as an add-on for instruction. The utilization of these technologies is usually to support the process of illustrating an abstract concept or complex procedure to enhance learning. The most common element of these illustrations is the use of visuals either in a static or dynamic form. This paper will be discussing the use and effectiveness of using dynamic visuals to help illustrate a complex procedure. To demonstrate the effectiveness of learning by dynamic visuals, the learner has to be able to replicate the procedures and also be able to transfer this knowledge to another learner.

In general, dynamic visualizations have the potential to support and aid learners in understanding complex domains. However, visualizations are a wide field with a variety of formats and functions. Nowadays, the potential of these computer visualizations are much more exciting, particularly in education and training [1], [2].Therefore, it is easy to present diagrams and images as either animated or video clips [3]. Animation and video are two visualization formats that are commonly used to represent information that involves change over time because of the similarities in relation with time, which plays an important role in learning, facilitating and understanding [4], [5].

Studies regarding animations have concluded that animations have the potential to enable or facilitate the learning processes [7]. According to ([8] animations can reduce the learner's cognitive load by providing external models for a mental representation, hence, helping learners to imagine a process or procedures mentally and enhance a student's capability to imagine motions. While, other studies such as [9] considered video as a powerful medium, which allows students to view actual objects and realistic scenes. It helps them to see sequences in motion, which may enhance their engagement and then improve learning effectiveness.

Using visualizations to represent procedural learning allow us to show processes clearly and explicitly [10], and provide a way for helping the learner to follow a sequence of steps that leads to a final result in procedural contents. For example, folding a paper, or following a recipe, are steps that help learners to reach the final goal [11], therefore, learning such procedural tasks requires understanding of the steps in the procedure, retention of the information and the ability to apply the information in terms of performing the procedure (preferably without the need to refer back to the instructions). These dynamic visualizations will aid a learner's performance and allow them to acquire skills required for carrying out a procedural task. There are two goals of performing a procedural task: first, a simple goal to perform the task only once, without any intention to learn the procedure more than once such as when the new furniture is assembled. The second goal is to learn how to perform the procedure from memory, and be able to apply it across situations such as when children learn to tie their shoelaces and apply it for different shoes or to tie up ribbons on gifts [12].

There are many different types of dynamic visualization based on the degree of realism, such as video (realistic) and animation (schematic). Consequently there is a need to examine the relative effectiveness of different types of dynamic visualizations [3]. As it is not easy to choose the appropriate and effective type of dynamic visualizations to represent such procedural instruction to aid the student's achieve required outcomes, this study explored these issues.

The term animation according to [13], refers to any representation which generates a series of frames, so that each frame appears as an alteration of the previous one, and represents an evolution in time. Thus, an animation can present realistic and schematic visualizations in a rapid succession of pictures such as in a cartoon. We can distinguish the differences between video and animation by how it is

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produced, a video clip is visuals recorded with a video camera or captured by a screen recording software tool, while animations as originally sequenced drawings that, when viewed in quick series, gave the appearance of movement [6]. Consequently, for this study, video is considered as realistic visualization and animation as schematic visualization.

The primary aim of this study was to compare two types of dynamic visualization, the effects of an interactive instructional video and an instructional animation on student's performance, retention, and transference for a procedural task. To examine whether animation or video was more effective on student's performance and retention by learning a procedural task (origami) and to examine the degree students can transfer their understanding to others.

II. Research Questions

This study proposed three questions:

1) Is there a significant difference between animation and video on student's performance on learning of a procedural task?
2) Is there a significant difference between animation and video on student's retention on learning of a procedural task?
3) Is there a significant difference between animation and video on transferring information of a procedural task?

III. Methodology

This research design is a descriptive study which comprises of two treatment conditions, video and animation.

Treament	Post Test Perfomance	Post Test Retention	Post Test Tranference
Animation			
Video			

Two groups of students, for the first group, the origami task was presented in a video clip (Fig. 1), while the second group was exposed to the origami task that presented in an animation sequence (Fig. 2). The learning materials were a 2 minutes instructional video and a 2 minutes instructional animation which showed the pigeon origami construction consisting of 9 steps (Fig. 3).

Fig. 1 Video Clip

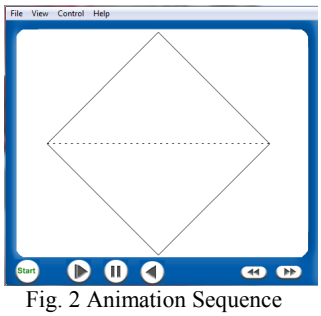

Fig. 2 Animation Sequence

The two methods of learning were interactive, allowing the students to stop the video and the animation, change the speed, and playback and forth. The participants completed three sessions. In the first session, group one (video group) of participant's was chosen randomly from two classes of the 5th level. This group (n=15) used video instruction then completed the origami task.

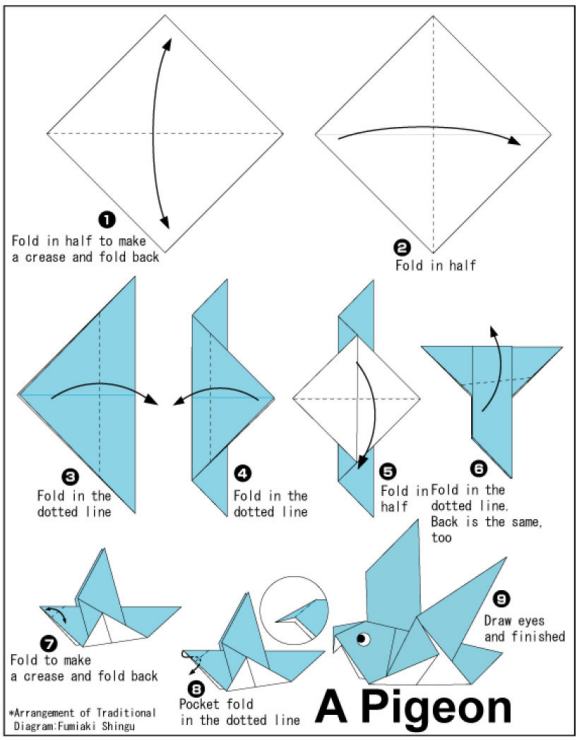

Fig. 3 Nine Step Pigeon Origami Construction

For group two (animation group) the the participants were also chosen randomly from two classes of the 5th level (n=15). This group used animated instruction and then completed the origami tasks. Both groups watched the instructions then performed the task.

In the second session, after a three day period, both groups (animation group and video group) (n=30) tried to repeat the same task individually from their memory. The third and final session, both groups (animation group and video group) (n=30) tried to transfer their knowledge of the same task to another participants group (n=30) by teaching the same origami task to them (in pairs). Time on the task was recorded for each of the three sessions.

Table I and Fig. 3 shows the baseline description of students' observation and performance based of total performance score (Matrix A) on creating an origami pigeon after watching the video and animation.

The mean observation time for the video group was 7.01 minutes and for the animation group was 6.57 minutes. The time for carrying out the folding paper task for the video group was 4.81 minutes and for the animation group was 4.77 minutes. The mean video score of the video group (10.6) was slightly lower than the mean animation score (11.0).

TABLE I
BASELINE DESCRIPTION OF CREATING AN ORIGAMI PIGEON

Video Group			Animation Group		
Group1	Time-taken (Min)	Video score	Group 2	Time-taken (Min)	Animation score
1	6:19	9	1	7:30	10
2	2:30	12	2	5:44	7
3	8:40	11	3	4:11	13
4	8:13	6	4	3:00	15
5	2:40	15	5	2:20	15
6	6:35	9	6	2:20	14
7	4:00	8	7	5:00	9
8	10:05	3	8	6:00	5
9	3:00	9	9	5:00	7
10	3:10	12	10	4:45	10
11	3:27	13	11	3:30	13
12	5:30	10	12	10:00	4
13	2:30	15	13	4:05	15
14	2:33	13	14	4:33	13
15	3:05	14	15	3:12	15

TABLE II
PERFORMANCE TIME AND RETENTION SCORE

Video Group			Animation Group		
Group1	Time-taken (Min)	Video score	Group2	Time-taken (Min)	Animation score
1	4:15	11	1	7:03	13
2	3:00	6	2	1:10	14
3	2:12	9	3	2:05	13
4	2:00	12	4	3:00	14
5	6:00	5	5	6:00	10
6	8:30	6	6	4:45	10
7	7:01	7	7	9:00	9
8	5:10	12	8	3:46	12
9	2:56	11	9	6:01	10
10	3:21	12	10	4:00	9
11	4:44	9	11	2:50	13
12	1:45	14	12	2:30	13
13	2:22	14	13	2:50	15
14	4:11	8	14	4:10	14
15	4:03	10	15	2:50	14

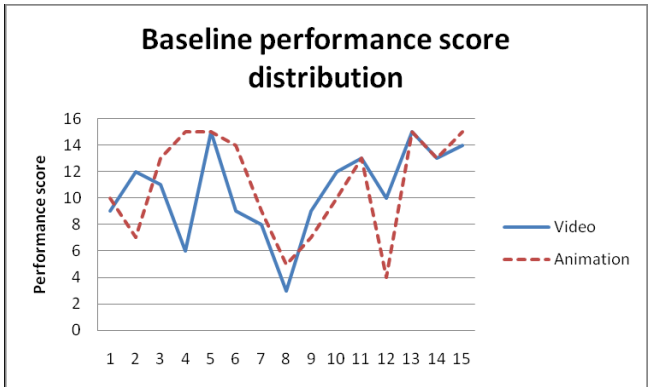

Fig. 3 Baseline Performance Score Line Graph

Matrix A

Post-test Rubric: Origami Task (performance)

Student's Name					
Demonstration Tasks by	▫Animation ▫ Video				
Time	Observation:		Taken:		
criteria	3	2	1	0	Score
Followed the steps	The student has followed all the steps, the origami have been as the example.	The student has followed most of the steps however, the shape of the origami have not been completed exactly as the example.	The student has followed some of the steps, the shape of the origami have not been as the example.	The student has not understood the concepts of the origami. The student did not follow steps.	
Completed All Steps	Origami is Completely constructed.	Much effort was made; origami is mostly constructed	Little effort was made; origami is partially completed.	No effort was made; origami is not constructed	
Neatness of Folds	Folds are neatly creased and even.	Folds are mostly neat and even.	Folds are somewhat sloppy and not quite even.	Folds are sloppy and uneven.	
Errors	The student do all of the steps without errors.	The student do all of the steps with 2 error	The student do all of the steps with 4 error	The student do all of the steps with 6 error	
Time	The student create origami in (2-4) min	The student create origami in (4:01- 6) min	The student create origami in (6:01-8) min	The student create origami in (8:01 - 107) min	
Comments					
Total Score					

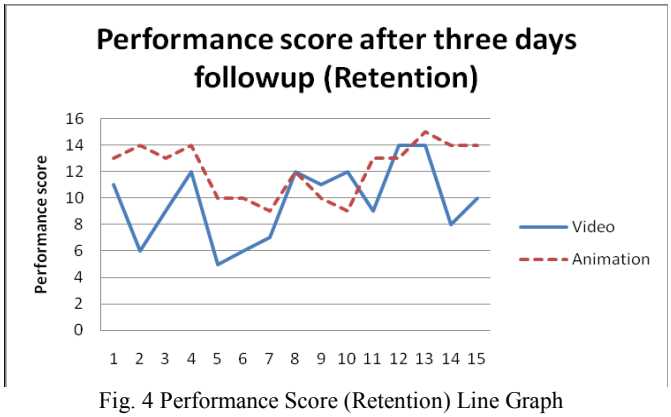

Fig. 4 Performance Score (Retention) Line Graph

The performance time and score (retention score) was based on Matrix B after three days of the baseline exposure for both types of dynamic visualization as illustrated in Table II. The mean time-taken after a three days elapse time was slightly higher in the animation group (4.01 minutes) than the video group (3.98 minutes). The total mean performance score after three days was also higher among the animation group (12.20) than the video group (9.73).

Table III described the difference between two types of dynamic visualization means the interactive video and the Interactive animation on students' performance, retention of the knowledge and transference information among fifth year school students. The mean score of performance was slightly higher among the animation group (11.00) than the video group (10.60) the mean score of retention also higher among the animation group (12.2) than the video group (9.73). The mean score for transferring the knowledge was also higher among the animation group (11.27) when compared to the video group of student (11).

Matrix B

Post-test Rubric: Origami Task (Retention and Transference)

Student's Name	
Group	▫Animation ▫ Video
Demonstration Tasks by	▫Retention ▫ Pair learning
Time	Taken:

criteria	3	2	1	0	Score
Followed the steps	The student has followed all the steps, the origami have been as the example.	The student has followed most of the steps however, the shape of the origami have not been completed exactly as the example.	The student has followed some of the steps, the shape of the origami have not been as the example.	The student has not understood the concepts of the origami. The student did not follow steps.	
Completed All Steps	Origami is Completely constructed.	Much effort was made; origami is mostly constructed	Little effort was made; origami is partially completed.	No effort was made; origami is not constructed	
Neatness of Folds	Folds are neatly creased and even.	Folds are mostly neat and even.	Folds are somewhat sloppy and not quite even.	Folds are sloppy and uneven.	
Errors	The student do all of the steps without errors.	The student do all of the steps with 2 error	The student do all of the steps with 4 error	The student do all of the steps with 6 error	
Time	The student create origami in (2-4) min	The student create origami in (4:01- 6) min	The student create origami in (6:01-8) min	The student create origami in (8:01 - 107) min	
Comments					
Total Score					

TABLE III
TIME TAKEN FOR TRANSFERENCE SCORE

Video Group			**Animation Group**		
Group1	Time-taken (Min)	Video score	Group2	Time-taken (Min)	Animation score
1	5:00	8	1	6:30	6
2	4:00	14	2	2:20	12
3	3:30	14	3	1:52	12
4	3:00	10	4	1:28	13
5	3:08	12	5	2:01	12
6	3:15	15	6	3:20	15
7	4:00	11	7	5:30	12
8	2:11	9	8	2:45	13
9	4:05	14	9	4:39	10
10	4:05	9	10	6:10	11
11	6:40	11	11	3:50	10
12	5:09	8	12	3:00	13
13	6:02	7	13	3:40	13
14	3:00	13	14	4:00	9
15	4:01	10	15	4:30	8

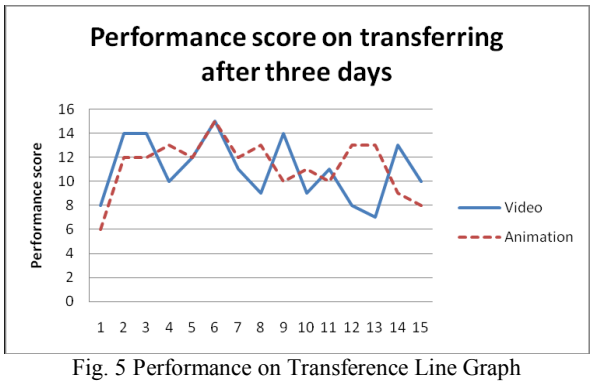

Fig. 5 Performance on Transference Line Graph

IV. DISCUSSION AND CONCLUSION

The key issue of this study was not to determine whether animation or video is more beneficial to learning but rather when and why they may be effective, and whether the different degrees of realism between the two dynamic visualizations will have different effects on learning. Between the two types of dynamic visualization it was observed that the viewing time to review either the video clip or animation was inversely related, when the student take a longer period to review the origami steps, they took less time to actually complete the task. Although, at a first glance, students who observed the use of video clips seemed to perform and retain the information better, upon closer examination, the statistical results was shown to favor the animation group as slightly better than video group for procedural learning.

The results showed that visualization in the form of animations has a great potential to improve student learning, especially when the goal is to follow steps or procedures to reach the final goal. However, in order to use animation effectively, it is useful to understand under which conditions and as to which type of learning it should be applied. The learning outcomes may be improved by the use of animation for sequential processes, as especially for procedural learning such as creating paper origami folding. A learner's cognitive load may be reduced by removing irrelevant details of the background which may be found in the videos with a higher degree of realism and included more details [14].

Finally, decisions can be made based on the goals of the procedural learning, if the objective of the instruction is for learners to memorize information, animation visualization may be useful. On the other hand, students may benefit more from video (realistic visualization) if the conceptual understanding is the objective of the instruction.

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