ORIGINAL ARTICLE

USER-PACED VERSUS SYSTEM-PACED: EFFECT OF DIFFERENT TYPES OF VIDEO TUTORIAL DESIGN FOR MACHINING OPERATIONS ON LEARNING PERFORMANCE

Muhammad Hafizullah MD SALLEH[1], Ammar ADNAN[1], Radin Zaid RADIN UMAR[2], Siby SAMUEL[3], Norhashimah MOHD SHAFFIAR[1], Mohd Hanafi ANI[1], Malek HAMID[1,*]

[1]Department of Manufacturing and Materials Engineering, Faculty of Engineering, International Islamic University Malaysia, Kuala Lumpur, Malaysia
[2]Faculty of Manufacturing Engineering, Universiti Teknikal Malaysia Melaka, Melaka, Malaysia
[3]Department of System Design Engineering, University of Waterloo, Ontario, N2L 3G1, Canada
[*] Corresponding Author: abdmalek@iium.edu.my

ABSTRACT

Nowadays, the use of video tutorial as a method of teaching and learning has become popular among educators. Video tutorial is more practical and can deliver more information to the users. Nonetheless, the mode of presentation can be hard to process in a short period. User-paced (or self-pacing) application in the multimedia presentation has been shown a positive effect on elaboration learning. Looking at this advantage, a user-paced video tutorial for machining operation is being introduced in the study. To identify the effectiveness of user-paced in video tutorial design, it was compared with the system-paced video tutorial (system determined the duration and pace of the information presented). The objectives of the study are; (i) to evaluate the effect of user-paced and system-paced of machine's video tutorial on learning performance (overall); and (ii) to evaluate the effect of user-paced and system-paced of machine's video tutorial on learning performance (by part of the video tutorial – safety, equipment, machine setup, procedure, and housekeeping). Sixteen participants completed the study where they were pseudo-randomly assigned into two different groups – User-paced or System-paced (eight participants for each group). The User-paced group was stimulated with four video tutorials where they have full control in pacing the tutorials, while the system-paced group was stimulated with four conventional video tutorials where they have no control in pacing the tutorials. After the video tutorials session, all participants were evaluated with quizzes that covered the content of the tutorials (one tutorial at a time), and the maximum score for the quizzes is 50 marks. The findings show that: (i) in overall, User-paced group performed better in the quizzes (88.66% percentage score) rather than the System-paced group (56.60% percentage score), and there is a significant difference in the learning performance for User-paced group (M=44.875, SD=1.959) and System-paced group (M=28.750, SD=3.105) conditions; t (14) = 12.421, p <0.001; and (ii) by category, User-paced group performed better in the quizzes rather than the System-paced group in all categories, and all the differences are significant. These findings show that the use of User-paced in designing video tutorial for machining operations would aid in improving users' learning performances.

Keywords: *User-paced, System-paced, Video Tutorial, Learning Performance*

INTRODUCTION

Recently, the use of video tutorial as a medium for information sharing has increased worldwide. It is considered as the best medium for sharing information, due to its ability to deliver a large amount of information in a short period of time (Ertelt, 2007). The use of video tutorial helps to facilitate teaching and learning among lecturers and students. As the video production and distribution becoming relatively easy and simple, its use for an academic purpose has increased (Jenkins et al., 2011; Fernandez, Simo, & Sallan, 2009). Contrary to human tutor, video tutorial is available on demand to the vast majority of audience via the video sharing channel on the internet (Pongnumkul et al., 2011).

These days, people are using video as a medium to convey message or information to others rather than using paper manual instruction. Many studies have shown the effectiveness of video presentation versus paper manual instructions on conceptual knowledge development (Alexander, 2013; Lloyd & Robertson, 2012; Spannagel et al., 2008; Payne, Chesworth & Hill, 1992). There are many advantages of using video-based tutorial over paper-based tutorial in general. One of the advantages is video presentation provide more superior and effective ways of teaching in terms of practical skills compared to print-based instruction (Donkor, 2010). In addition, He, Swenson, & Lents (2012) stated that video tutorials are an effective way to help students in controlling their learning independently. It provides the user with an easy-to-follow model or real task implementation where the users can mimic the action performed. Besides that, multimedia representations in video tutorial help to stimulate the auditory and visual system simultaneously, known as the modality effect. According to Leahy & Sweller (2011), it occurs when an instructional material that uses dual format (audio and visual) gives a better understanding of a subject matter compared to the visual only.

Mayer (2005) have defined a modality effect as the idea that if both audio and visual working memory can be used to process the information, the effective cognitive capacity may be increased. Through the study by Moreno & Mayer (1999), they found that participants who received animation and narration have a higher understanding of the subject tested compare to those who received animation and on-screen text. In terms of animation, Tversky, Morrison, & Betrancourt, (2002) suggested that dynamic visualization video were not more effective than the static visualization. He suggested some reasons why animations fail to give more benefits than the static visualization; animation is hard to be perceived and it may be comprehended discretely rather than continuously. Therefore, it is recommended that the animation is played discretely rather than continuously. Thus, the study has suggested that interactivity can help in overcoming the difficulties to digest or capturing the information from the animation.

Interactivity facilities explained about the ability of a user to start, to pause, or replaying the video based on their needs. This is also can be called user-pacing (Sims, 2000; Sims, 1997) in which enable the user to control or pace an instruction that can improve learning (Betrancourt, 2005; Mayer, 2005). On the other hand, a non-interactive multimodal explained about the multimedia presentations; does not allow any adjustments to be made as the system determined the duration and pace of the information presented. This is time-consuming and limits the user in order to process and catch as many as information they can in a limited time (Moreno & Mayer, 2007). This system is also known as system-pacing.

As mentioned above, user-paced video tutorials have been shown to improve learning performance (Betrancourt, 2005; Mayer, 2005). In addition, a study by He, Swenson, & Lents (2012) found that user-paced video tutorial has increases learning difficult concepts of an analytical chemistry course. As the engineering machining operations seems to be a complex task, thus, user-paced video tutorial was introduced in this study to investigate if its effectiveness is held true whenever a piece of complex information (i.e. engineering machining operations) is being delivered to the user. The objectives of the study are; (i) to evaluate the effect of user-paced and system-paced of machine's video tutorial on learning performance (overall); and (ii) to evaluate the effect of user-paced and system-paced of machine's video tutorial on learning performance (by part of the video tutorial – safety precaution, equipment, machine setup, experiment procedure, and housekeeping tasks).

METHODS

Participants

Sixteen Engineering undergraduate students from the International Islamic University Malaysia between 19-20 years of age participated in the study. Only engineering students were considered in the study so that participants would have similar machining operation skills and knowledge. In addition, the chosen participants also have never taken the Workshop Technology courses offered by the faculty - to control the level of familiarity among participants. Ethnic background, first language, and minority status were not considered in the study.

Apparatus and Stimuli

Machines: There are twelve experiments available in the Workshop Technology course which were offered by the Engineering Faculty. These experiments were then categorized into four types – materials remover, joining materials, Programming-based machining, and hand tool processes. One experiment was chosen for each category so that the evaluation in the study cover all different aspect of machining operations. In addition, in each category, the most complex experiment was chosen, on the assumption that by choosing the hardest one, all others will subset under it. Thus, the four machines/workspace chosen and used in the study are: (i) Lathe turning machine (Figure 1) for materials remover operations; (ii) Arc welding machine (Figure 2) for joining materials operations; (iii) CNC milling machine (Figure 3) for programming-based machining operations; and (iv) Bench Work workstation (Figure 4) for hand tool operations.

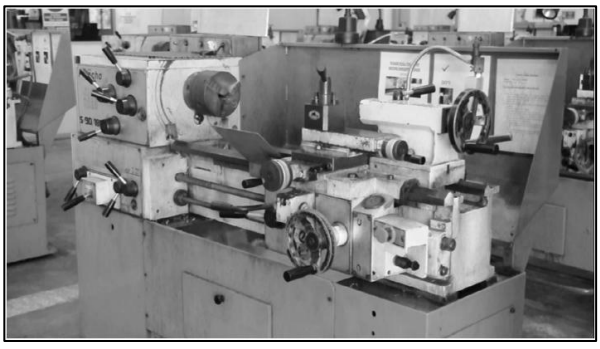

Fig. 1 Lathe turning machine

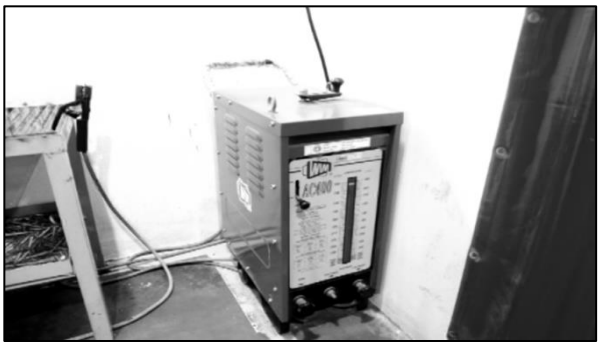

Fig. 2 Arc welding machine

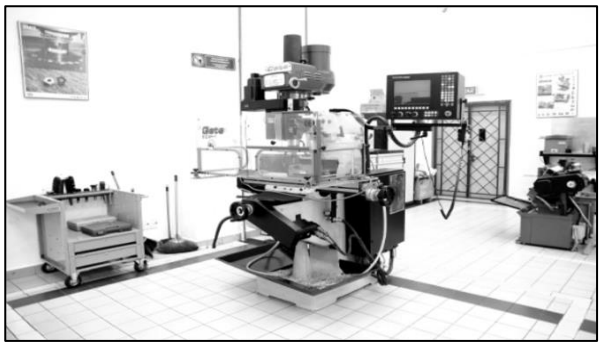

Fig. 3 CNC milling machine

Fig. 4 Bench work Workstation

Video Tutorials (system-paced): Four video tutorials were developed – one for each machining operations mentioned above. Each video tutorial consists of five sections: (i) safety precautions; (ii) equipment; (iii) machine setup; (iv) experiment procedure; and (v) housekeeping procedure. For system-based design, the video is playing continuously, where the user would have no control to choose to which part of the video they would like to watch. However, a user can use the cursor to scroll the video. Sony Vegas Pro software was used to combine parts of the videos into one complete video. After that, the voice of instruction in the video was inserted in the video. Finally, the caption for the video was placed. Then, the completed video – with the voice of instruction and captions – was rendered. The length of each video is approximately about 7 minutes. Content of the videos was verified by the relevant personnel – course coordinator and technician. In addition, the language used in the audio and caption were verified by English lecturer.

Video Tutorials (user-paced): The same videos developed for system-paced were used to develop the video tutorials for user-paced. For user-paced design, each video was cut into its respective sections – safety precautions, equipment, machine setup, experiment procedure, and housekeeping procedure. Microsoft PowerPoint software was used to develop the user-paced video tutorial (Figure 5). Each video starts with the safety precaution part. Users were not given a choice to skip this part of a video so that the safety precaution would be watched before they proceed into other parts of the video. After finished the safety part of the video, user can opt to which part of the video (i.e. equipment, machine setup, experiment procedure, or housekeeping) that they would like to watch by clicking on the appropriate button. In addition, for each part, users also can opt to which subpart that they would like to watch. For instance, in the experiment procedure part for Lathe machine, they can opt to watch the measuring, facing, rough turning, finishing, and drilling by clicking on the appropriate button (Figure 6). This interactivity option relaxes the users to jump from one sub-part to another, and from one part to another. In other words, enable the users to control the flow of the video.

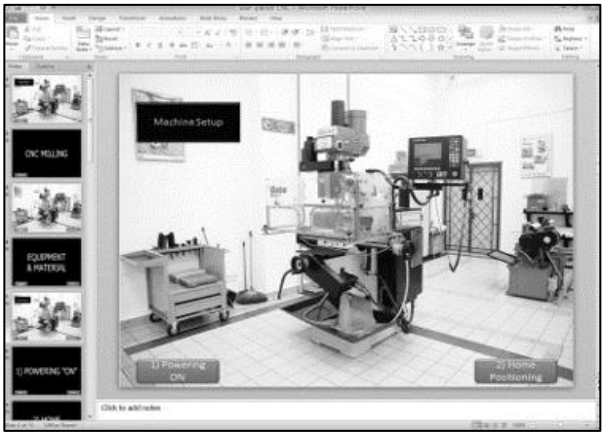

Fig. 5 Microsoft PowerPoint software was used to develop the user-paced video tutorial

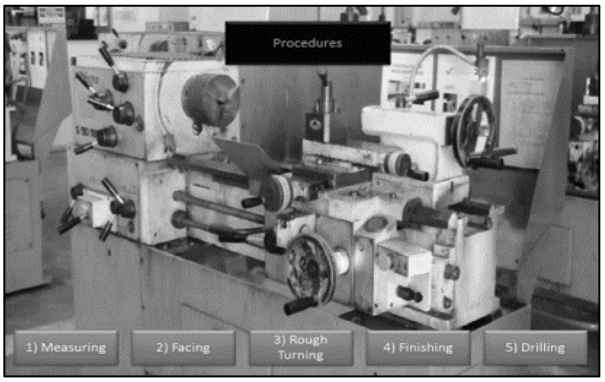

Fig. 6 Sub-parts under the experiment procedure for Lathe Machine

Quizzes: One set of quiz was developed for each machining operations – Lathe turning operations, Arc welding operations, CNC milling operation, and Work Bench operations. Each quiz consists of five sections – safety precaution, equipment, machine setup, experiment procedure, and housekeeping procedure. In the safety precaution part, participants were asked to name three safety precautions for a particular operation. In the equipment part, participants were asked to name three equipment used in a particular operation. In the machine setup part, participants were asked to fill in the blank of a sentence that covering the information in setup

a machine. In the experiment procedure part, participants were given the steps of the experiment procedure and were asked to arrange them in the correct order. Lastly, in the housekeeping procedure part, participants were asked to address one or two of housekeeping tasks in order to return the workstation into its initial condition. The total marks for each section (combine all four machines) are: (i) safety precaution – 13 marks; (ii) equipment – 12 marks; (iii) machine setup – 8 marks; (iv) experiment procedure – 10 marks; and (v) housekeeping procedure – 7 marks. Thus, the total marks each participant can obtain is 50 marks.

Laptop & Head Phone: The same laptop (Acer Aspire) was used throughout the experiment in order to maintain the same quality of the video tutorials. In addition, headphone (Beats by Dr Dre) was used during the video tutorials session to maintain the sound quality of the videos as well as to minimize the environmental noise that may occur.

Administrative Form: Participant form and payment voucher were designed and used in the experiment. The participant form was used to record the demographic data of participants – age, gender, and nationality – as well as the data collected in the experiment. Payment voucher was used to record the compensation made to the participants.

Design of the Study

The experiment was only conducted on weekdays (Monday to Friday). The weekend was excluded to avoid any potential factoring effect on the participant performance (i.e. the lifestyle of the participants would be different. Thus, a different performance may be shown). In addition, the experiment was only conducted between 2:00 p.m. to 5:00 p.m. to ensure that the level of comprehension was similar among the participants.

Video tutorials stimuli counterbalancing: Each participant was stimulated with four videos tutorials. Thus, in order to minimize the ordering effect of the stimuli on user performance, it was counterbalanced using the Latin Square method. In explanation, each participant had received a different arrangement of the video tutorials so that, for example, the Lathe turning operation will not always be the first operation that the participant will simulate with. For instance (refer to Table 1), participant A watched video tutorial for Lathe turning operation, follow by arc welding operation, Bench Work operation, and end with the CNC milling operation, while participant B watched the CNC milling operation first, followed by the Lathe turning operation, Arc welding operation, and end with Bench work operation.

Table 1 Arrangement of the video tutorials that were stimulated to the participants

Group	Pax	Lathe	Weld	CNC	Bench
System-paced group	A	1	2	4	3
	B	2	3	1	4
	C	3	4	2	1
	D	4	1	3	2
	E	1	2	4	3
	F	2	3	1	4
	G	3	4	2	1
	H	4	1	3	2
User-paced group	A	1	2	4	3
	B	2	3	1	4
	C	3	4	2	1
	D	4	1	3	2
	E	1	2	4	3
	F	2	3	1	4
	G	3	4	2	1
	H	4	1	3	2

Procedures

Introduction Session: Participants were asked to fill in the demographic information on the participant form. Then, participants were pseudo-randomly assigned into either System-paced or User-paced group. After that, the details of the experiment were briefed to the participant without prejudice the objective of the experiment. They were told that they need to watch four video tutorials of machining operations on a laptop (video tutoring session) and answer a quiz at the end of each video tutorial.

Experimental Session: Participants that were assigned into the System-paced group were stimulated with system-paced video tutorials, while the participants that were assigned into the User-paced group were stimulated with user-paced video tutorials. Each participant was given ten minutes to watch the first video tutorial based on the designed counterbalanced arrangement of the stimuli. Immediately after they finished the first video tutorial, they were given five minutes to answer the quiz for that particular video. The process was repeated until they finished all four video tutorials.

Thanking Session: Participants were thanked for their participation in the study and was compensated MRY 15 for completing the study.

Variables and Hypotheses

Dependent Variable 1: Percentage of scores on the quiz (overall). The total mark for the quiz was 50 marks. Hypothesis 1: User-paced group will score a higher percentage score rather than the System-paced group. This is because the user-paced video tutorials allow users to control or pace an instruction/information that can improve learning (Betrancourt, 2005; Mayer, 2005). In addition, a study by He, Swenson, & Lents (2012) found that user-paced video tutorial

has increases learning difficult concepts of an analytical chemistry course.

Dependent Variable 2: Percentage of scores on the quiz (by part of the video – safety precautions, equipment, machine setup, experiment procedure, and housekeeping tasks). The total marks of the quiz for the safety precautions, equipment, machine setup, experiment procedure, and housekeeping tasks are 13, 12, 8, 10, and 7 respectively. Hypothesis 2: User-paced group will score a higher percentage score rather than the System-paced group in all categories. This is because the user-paced video tutorials allow users to control or pace an instruction/information that can improve learning (Betrancourt, 2005; Mayer, 2005). In addition, a study by He, Swenson, & Lents (2012) found that user-paced video tutorial has increases learning difficult concepts of an analytical chemistry course.

RESULTS

Effect of user-paced and system-paced of machine's video tutorial on learning performance (overall).

Figure 7 illustrates the effect of user-paced and system-paced video tutorial of machining operations on users' learning performance. In overall, comparing the percentage of the total score of the quizzes, the percentage score of User-paced group (88.66%) is higher than the System-paced group (56.60%). The data was then further analyzed using the SPSS software (version 23). Utilized the independent t-test model, it reveals that that there was a significant different in the scores for User-paced group (M=44.875, SD=1.959) and System-paced group (M=28.750, SD=3.105) conditions; t (14) = 12.421, p <0.001. This result suggests that different type of pace of the video tutorial for machining operations does have an effect on learning performance. Specifically, when user-paced video tutorials were used, the learning performance of the machine's video tutorial increased.

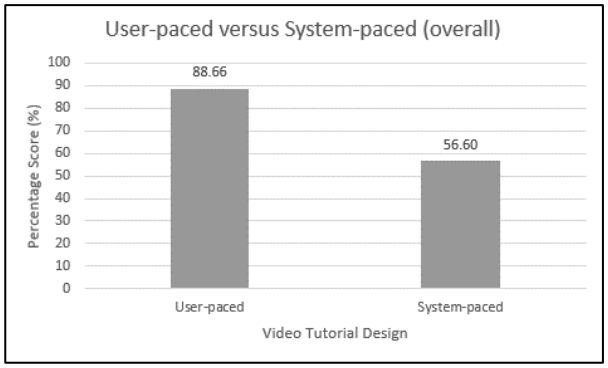

Fig. 7 Effect of User-paced and System-paced video tutorial on users' leaning performance (overall)

Effect of user-paced and system-paced of machine's video tutorial on learning performance (safety precaution).

Figure 8 illustrates the effect of user-paced and system-paced video tutorial of machining operations on users' learning performance (for safety precaution part of the video). In overall, comparing the percentage of the total score of the quizzes, the percentage score of User-paced group (99.04%) is higher than the System-paced group (76.92%). The data was then further analyzed using the SPSS software (version 23). Utilized the independent t-test model, it reveals that that there was a significant different in the scores for User-paced group (M=12.88, SD=0.35) and System-paced group (M=10.00, SD=0.76) conditions; t (14) = 9.744, p <0.001. This result suggests that different type of pace of the video tutorial for machining operations (on safety precaution part) does have an effect on learning performance. Specifically, when user-paced video tutorials were used, the learning performance of the safety precaution part of the video tutorial increased.

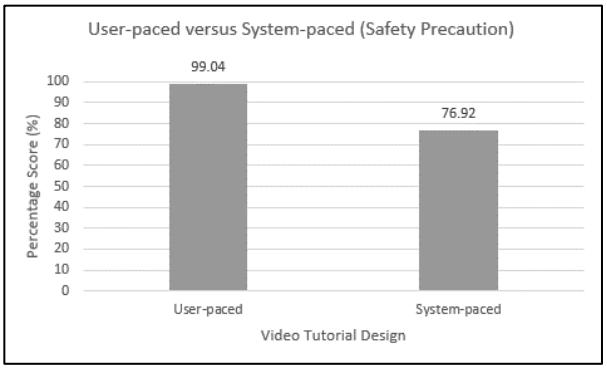

Fig. 8 Effect of User-paced and System-paced video tutorial on users' leaning performance (Safety Precautions)

Effect of user-paced and system-paced of machine's video tutorial on learning performance (equipment).

Figure 9 illustrates the effect of user-paced and system-paced video tutorial of machining operations on users' learning performance (for equipment part of the video). In overall, comparing the percentage of the total score of the quizzes, the percentage score of User-paced group (88.54%) is higher than the System-paced group (47.92%). The data was then further analyzed using the SPSS software (version 23). Utilized the independent t-test model, it reveals that that there was a significant different in the scores for User-paced group (M=10.63, SD=0.52) and System-paced group (M=5.75, SD=1.17) conditions; t (14) = 10.817, p <0.001. This result suggests that different type of pace of the video tutorial for machining operations (on equipment part) does have an effect on learning performance. Specifically, when user-paced video tutorials were used, the learning

performance of the equipment part of the video tutorial increased.

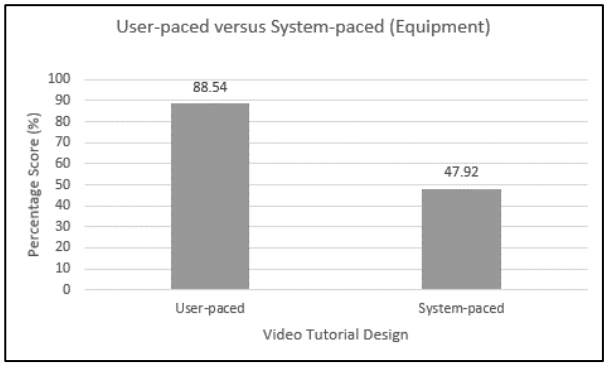

Fig. 9 Effect of User-paced and System-paced video tutorial on users' learning performance (Equipment)

Effect of user-paced and system-paced of machine's video tutorial on learning performance (machine setup).

Figure 10 illustrates the effect of user-paced and system-paced video tutorial of machining operations on users' learning performance (for machine setup part of the video). In overall, comparing the percentage of the total score of the quizzes, the percentage score of User-paced group (75.00%) is higher than the System-paced group (39.06%). The data was then further analyzed using the SPSS software (version 23). Utilized the independent t-test model, it reveals that that there was a significant different in the scores for User-paced group (M=6.00, SD=1.51) and System-paced group (M=3.13, SD=0.84) conditions; t (14) = 4.709, p <0.001. This result suggests that different type of pace of the video tutorial for machining operations (on machine setup part) does have an effect on learning performance. Specifically, when user-paced video tutorials were used, the learning performance of the machine setup part of the video tutorial increased.

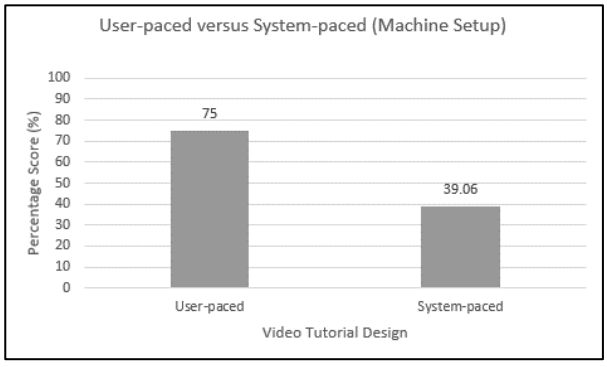

Fig. 10 Effect of User-paced and System-paced video tutorial on users' learning performance (Machine Setup)

Effect of user-paced and system-paced of machine's video tutorial on learning performance (experiment procedure).

Figure 11 illustrates the effect of user-paced and system-paced video tutorial of machining operations on users' learning performance (for the experiment procedure part of the video). In overall, comparing the percentage of the total score of the quizzes, the percentage score of User-paced group (82.50%) is higher than the System-paced group (51.25%). The data was then further analyzed using the SPSS software (version 23). Utilized the independent t-test model, it reveals that there was a significant difference in the scores for User-paced group (M=8.25, SD=1.17) and System-paced group (M=5.13, SD=0.84) conditions; t (14) = 6.168, p <0.001. This result suggests that different type of pace of the video tutorial for machining operations (on experiment procedure part) does have an effect on learning performance. Specifically, when user-paced video tutorials were used, the learning performance of the experiment procedure part of the video tutorial increased.

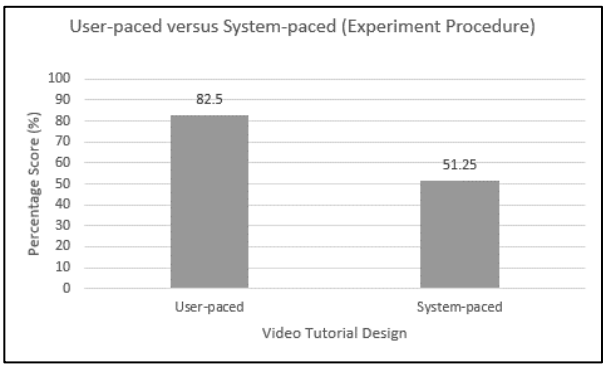

Fig. 11 Effect of User-paced and System-paced video tutorial on users' learning performance (Experiment Procedure)

Effect of user-paced and system-paced of machine's video tutorial on learning performance (housekeeping tasks).

Figure 12 illustrates the effect of user-paced and system-paced video tutorial of machining operations on users' learning performance (for housekeeping tasks part of the video). In overall, comparing the percentage of the total score of the quizzes, the percentage score of User-paced group (98.21%) is higher than the System-paced group (67.86%). The data was then further analyzed using the SPSS software (version 23). Utilized the independent t-test model, it reveals that there was a significant different in the scores for User-paced group (M=6.88, SD=0.35) and System-paced group (M=4.75, SD=1.17) conditions; t (14) = 4.937, p <0.001. This result suggests that different type of pace of the video tutorial for machining operations (on housekeeping tasks part) does have an effect on learning performance. Specifically, when user-paced video tutorials were used, the learning performance of the housekeeping tasks part of the video tutorial increased.

These results suggest that, for all the five criteria compared, a different type of pace in the video tutoring does have an effect on learning performance of the machine's video

tutorial. Specifically, the results suggest that when user-paced was used in the video tutorial, the learning performance of participants increased.

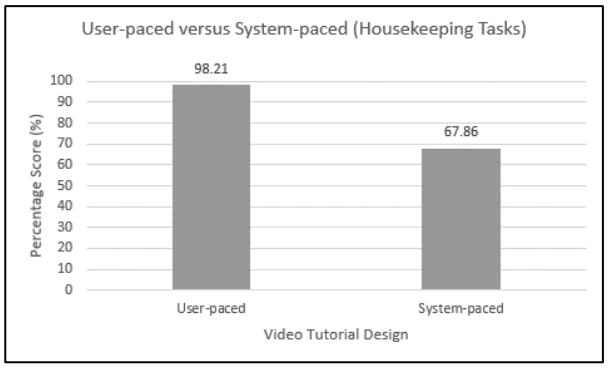

Fig. 12 Effect of User-paced and System-paced video tutorial on users' learning performance (Experiment Procedure)

DISCUSSION

Based on the finding in Figure 7 above, the overall mean score of learning performance of User-paced group (M=44.875) is better than the System-paced group (M=28.750). This finding is parallel with finding by Stiller et al., (2009) in which learner-paced instructions gives a better effect on users' learning performance compared to the system-paced instruction. User-paced video tutorial allows the participants to control the pace of video instruction, thus allowing the participants to process the information according to their own processing time. Based on Betrancourt (2005), by allowing the learners' to control the pace of the animation, it helps the learners to learn more effectively in the computer-based environment. In addition, user-paced video helps to minimize the information gain and focusing on understanding and processing the information before proceeding to the next part, hence, improve learners' understanding. According to Stiller et al., (2009), by focusing on one part of an information at a time, it helps to reduce the mental effort while learning. Too much of information been exposed at a time can cause cognitive overload to the learner.

On the other hand, for System-paced group, the learning performance is worst compared to the User-paced group because the learner were not allowed to control the pace of the video presentation. By using system-paced, it forces the leaners to their limits by putting a high extraneous load on working memory through a continuous and speedy presentation of information (Moreno & Mayer, 2007). Learners need to adjust and follow the pace of the video, making it difficult to process the information. They need to extract the relevant information in a limited time, at the same moment maintaining the working memory until the information is organized before proceed to the next part of the video. The main idea behind the cognitive load theory is that more efficient use of human working memory is needed when there is a risk of overload (Sweller, 2005).

Based on the criteria (different part of the video for machining operations – safety precaution, equipment, machine setup, experiment procedure, and housekeeping tasks) - there were significantly different in all the aspects. In this experiment, participants are required to label some pictures that were shown in the video tutorial. For instance, participants are required to label the equipment that is used in each particular machining operations (Lathe turning, Arc welding, CNC milling, and hand tools process). From the results, it is proven that participants using the user-paced video tutorial have higher score compared to the ones that are using system-paced video tutorial. As stated by Stiller (2011) and Mayer & Chandler (2001), user-paced instruction gives a higher score on the task of labelling picture and structural knowledge.

Besides that, participants that are using user-paced video tutorials also score high percentage score in transferring structural knowledge. In the experiment, participants need to list down the safety precautions and also arranging the correct procedure of particular machining operations which test on their structural knowledge transfer. From the finding, it is proven that participants performed better on structural knowledge transfer when using user-paced video tutorial compared to the system-paced video tutorial.

The reason why participants using the system-paced video tutorials cannot obtain a high score is because of the overload in the working memory. These participants have difficulties in processing the information from the video tutorials thus, making it hard for them to label the picture correctly and also to transfer their structural knowledge regarding the experiment. Therefore, it is better to use the user-paced video tutorial or any media instruction that enable a user to pace the flow of information as it gives a better understanding and has positive effects in the learning performance.

CONCLUSION

As a conclusion, the current study found that the used of user-paced in video tutorial of machining operations increases learning performance when compared to system-paced. In overall, there was a significant difference in the learning performance between the User-paced group (M=44.875, SD=1.959) and System-paced group (M=28.750, SD=3.105) conditions; $t(14) = 12.421$, $p < 0.001$. For the five criteria (safety precaution, equipment, machine setup, experiment

procedure and housekeeping tasks), all these criteria show significant different. Specifically, for safety precautions: User-paced group (M=12.875, SD=0.354) and System-paced group (M=10.000, SD=0.756) conditions; t (14) = 9.744, p <0.001; for equipment: User-paced group (M=10.625, SD=0.518) and System-paced group (M=5.750, SD=1.165) conditions; t (14) = 10.817, p <0.001; for machine setup: User-paced group (M=6.000 SD=1.512) and System-paced group (M=3.125, SD=0.835) conditions; t (14) = 4.709, p <0.001, for experiment procedure: User-paced group (M=8.250, SD=1.165) and System-paced group (M=5.125, SD=0.835) conditions; t (14) = 6.168, p <0.001; for housekeeping tasks: User-paced group (M=6.875, SD=0.354) and System-paced group (M=4.750, SD=1.165) conditions; t (14) = 4.937, p <0.001.

Contribution: The results from this study provide additional information regarding the machine's video tutorial in general, and more particularly, the use of a suitable type of pace in the video tutorial. The finding shows that the used of user-paced in the video tutorial for machining operations increase the learning performance. Moreover, the finding from this study also could lead to other similar research studies in deeper approaches.

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