The Effect of Using Visual Information Aids on Learning Performance During Larger Scale Procedural Task

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Abstract

Visual information such as pictures, drawings or dynamic videos is often designed to facilitate learning and instruction. Many studies have explored the effectiveness of presenting procedural learning information through comparing different media and combinations of media; however the mapping of a task and its specific media is still not clear. Therefore, the purpose of this study is to determine the effect of using different kinds of visual information aids on learning a procedural task performance for larger scale equipment. The comparison between the three factors (dynamic, planned, and abstract) of the five learning media indicated the significant effect of different kinds of visual information. The findings show that for this specific learning purpose, the alternative media types for visual information instruction should be utilized. The second and also most important finding in this research is that well-designed and planned pictures were much better than unplanned ones. The third finding is that the abstract drawing is also very important in specific learning situations.

Keywords: Instructional visualization, procedural task, learning performance.

I. INTRODUCTION

Visual information such as pictures, drawings or dynamic videos is often designed to facilitate learning and instruction and has been found to have a positive effect. From the learning and instruction point of view, the effectiveness of the visual information is concerned with cognitive learning and retention. Moreover, the performance criteria of learning materials are mainly focused on comprehension and recall. However, Watson et al. [1] indicate that the performance criteria should be focused on the effect of the actual action than on the retention if the learning materials are applied to a procedural motor task.

Many studies have explored the effectiveness of presenting procedural learning information through comparing different media and their combinations. However the mapping of a task and its specific media is still not clear [2]. Some studies have also mentioned that for some specific purposes, technically simple methods can be very effective when training people to perform simple procedural tasks and that it is not always necessary to use advanced technology for such purposes [3].

Learning procedural task is very important, and there are many examples in daily life such as first aid procedural content, mechanical assembly tasks like car engine assembly, and even the usage of domestic appliances and pieces of furniture. Recent studies on the procedural learning are more focus on the small scale tasks and devices than on larger equipment. However, procedural tasks, in particular, tasks related to larger equipment operation, provide an interesting situation in which to study the effectiveness of instruction, and if it can enhance the actual performance of the human machine system. In this study, the term “learning performance” will be used as in Watson et al. [1], not referring to learning for retention and later recall but instead, learning performance refers to the successful and efficient perception of visual-based instructional information about the equipment operation tasks in order to complete that task accurately. Therefore, the purpose of this study is to determine the effectiveness of using different kinds and properties of visual information aids on the procedural task’s learning performance, especially for larger scale equipment.

A. The Property of Different Kinds of Visual Information

Wileman [4] categorized static visual information into three major ways to present objects, progressing from concrete to abstract, as pictorial symbols (photograph, illustrations or drawings), graphic symbols (pictogram, signs and icons) and verbal symbol (text). And the choice of which of these symbols to use is directly related to the major objective of communication and the specific information that is suitable to the specific situation. For instance, the more abstract symbols, pictograms, are often used in situations where the meaning of a message needs to be comprehended quickly, since well-designed pictograms are intended to convey meanings perceptively [5]. Yamazaki et al. [5] examined the effectiveness of pictograms representing actions in lathe procedures and for steps in manufacturing procedures. The results showed that the pictograms developed for lathe instructions conveyed intended meanings as effectively as common public signs.
Furthermore, being well planned and designed for the visual content and detail is very important. Well-displayed designs are very important for multimedia learning. Michas and Berry [3] demonstrated that enhanced line-drawings which use symbols, such as arrows and highlights, can help to make temporal and spatial relationships within graphical representations clearer and to better convey information about how to get from one step of the procedure to the next.

In the learning and instruction domain, the visual instructions often are distinguished into dynamic and static. Several studies compared the learning effectiveness between dynamic and static instruction. Static information has benefit for the learning efficacy, and its effectiveness can possibly be increased by using certain key pictures that illustrate very specific moments of the process or the procedure to be learned. In the study by Boucheix and Schneider [6], one of their experiments indicated that animated as well as integrated sequential static frames enhanced comprehension in learning dynamic mechanical systems.

Most studies noted that dynamic visual information was superior to the static visual information, especially in specific areas, under specific circumstances. For instance, the results of the meta-analysis conducted by Höffler and Leutner [2] reveal the greater benefits of animations when procedural-motor knowledge rather than problem-solving knowledge or declarative knowledge is being taught. Wong et al. [7] also mentioned that animated instructions are superior to static graphics for cognitively based tasks that involve human movement. On the other hand, a recent study indicated that a combination of instructional animation with static pictures was more efficient in promoting learning than visualizations composed only of videos [8].

From the above literature the property of different kinds of visual information can be discussed from three points of view. Firstly, the most discussed issue is dynamic and static presentation, the second is planning and reorganizing the visual information presentation style, and the third is comparison of the concrete and abstract content.

B. Procedural Task and Learning Performance

Procedural learning involves learning to carry out a series of acts or operations in the proper order. There are different kinds of procedural tasks learning studies as show below. Watson et al. [1] evaluated the effectiveness of dynamic work instructions for a small scale assembly task and the criteria are the building time and the correctness of the assembly task. The study by Michas and Berry [3] showed the advantages of line drawing with text for banding task, when the criteria are banding performance and the answering the question about the task. Wong et al. [7] studied paper-folding tasks, comparing the animated instructions and the static instructions in the learning of human motor skills when the criteria are the total time taken and the number of participants that completed tasks. Ayres et al. [9] also showed that animations are superior to equivalent static representations when learning hand manipulative tasks (knots and puzzle rings) and the criteria are the total number of correct steps and the total time taken. According to the above studies the criteria of the learning effectiveness for procedural tasks could involve four factors: time, correctness, compression and recall.

Because the task of this study is to operate larger equipment, the criteria of performance measurement refer to the usability. Most explanations of what usability mean agree that it consists of three distinct aspects: the effectiveness, efficiency, and satisfaction. Effectiveness is the accuracy and completeness with which users achieve certain goals. Indicators of effectiveness include quality of solution and error rates [10]. In this study, we use error rates as the primary indicator of effectiveness. Efficiency is the relationship between (1) the accuracy and completeness with which users achieve certain goals; and (2) the resources expended in achieving them. Indicators of efficiency include task completion time and learning time. In this study, we use task learning time as the primary indicator of efficiency. The criteria of learning performance are also concerned with the comprehension of the learning material as in other studies.

II. Method

A. Participants and Materials

Thirteen graduate students (4 females and 9 males) volunteered to participate in this study. In this study the procedural task is to use the equipment used in physical fitness testing correctly because use of the equipment with the wrong procedure can influence the result of the testing and the judgment of the physical condition of a subject. There are five tasks to be completed and each task refers to specific equipment: Task A, two minutes stepping for cardiopulmonary endurance testing; Task B, one minute of sit ups for muscle endurance testing; Task C, trunk forward bending while seated for body flexibility testing; Task D, three minutes stepping up and down for cardiopulmonary endurance testing; and Task E, single-leg step with closed eyes for balance testing.

There were five types of visual instructions to be tested as follows. (1) Four videos, short films by a professional physical fitness coach demonstrating how to use the physical fitness testing equipment correctly. (2) Static pictures (snapshot from the videos corresponding to the most important steps of each procedure) reorganized with text, arrows and highlights by the researcher, called planned static picture (P_Pic). Thus, three pictures were taken from the video of task A, five pictures from the video of task B, three pictures from the video of task C and five pictures from the video of task D. (3) A combination of the demonstration videos and the P_Pic (Video + P_Pic) (See appendix) was developed. (4) Drawings which trace out from the P_Pic and which are called planned drawing (P_Draw) (see appendix). (5) Static photographs which were taken by researcher and not reorganized with text, arrows and highlights, designated unplanned static picture (U_Pic).

Furthermore, there are also three factors, including dynamic, planned and abstract, which need to be analyzed
for their effect on the five types of learning media. The dynamic factor includes three levels, Video only, Video + P_Pic and P_Pic. The planned factor of the learning media included two levels, P_Pic and U_Pic. The abstract factor of the learning media also included two levels, P_Pic and P_Draw.

B. Experimental Design and Procedure

The participators were separated into four groups, each group had different experimental combination between learning instructions and tasks show as Table 1.

<table>
<thead>
<tr>
<th>Media Type</th>
<th>Group1</th>
<th>Group2</th>
<th>Group3</th>
<th>Group4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Video only</td>
<td>Task A</td>
<td>Task B</td>
<td>Task C</td>
<td>Task D</td>
</tr>
<tr>
<td>Video + P_Pic</td>
<td>Task B</td>
<td>Task C</td>
<td>Task D</td>
<td>Task A</td>
</tr>
<tr>
<td>P_Pic</td>
<td>Task C</td>
<td>Task D</td>
<td>Task A</td>
<td>Task B</td>
</tr>
<tr>
<td>P_Draw</td>
<td>Task D</td>
<td>Task E</td>
<td>Task A</td>
<td>Task B</td>
</tr>
<tr>
<td>U_Pic</td>
<td>Task E</td>
<td>Task E</td>
<td>Task E</td>
<td>Task E</td>
</tr>
</tbody>
</table>

The visual instructions were presented on a computer with a 22-inch LCD monitor set at 1024×768 pixel resolution. The computer was equipped with a keyboard. There were five presentation conditions and the order was video shown alone, video plus P_Pic shown, P_Pic displayed alone, planned static drawing displayed alone and U_Pic displayed alone. All presentation conditions were accompanied by the same spoken commentary. The participants were randomly distributed between these four groups. Next, the participants were seated in front of a computer and viewed the learning material. When they felt confident of the material, they would press the space bar on the keyboard to finish the learning session, and then a paper-based questionnaire composed of three questions was given to participants. After completing the questions the participants were asked to actually do the tasks and the whole process were recorded by video camera. The above procedure was repeated until the five tasks were completed for each group.

In this paper there are three parameters of the learning performance for procedural tasks, the definitions are below:

1. Comprehension score refers to the understanding of visual instructions: three questions were used to test the comprehension of each type of visual aids, and the total score is 3.
2. Learning time refers to efficiency of procedural tasks: the mean time taken to study the learning material until confident.
3. Error rate refers to effectiveness of procedural tasks: the ratio of the total error which occurred to the number of steps in the each task.

Data analyses were conducted using SPSS 16 for Windows. The principal analytic method was the non-parametric method because of the sample size of this study was very small.

III. RESULTS

A. The Result of Learning Performance

The comprehension, learning time, and error rate are the three parameters used in this study to evaluate the learning performance of the visual information instructions for larger scale procedural task. Table 2 shows that there was significant differences in the comprehension score of the five media types, and the difference came from U_Pic which had the poorest results. Otherwise, the other four types of visual instructions had no significant difference and the scores of the comprehension were all higher than 2 of a total score of 3, and the order is planned static drawing, then video plus static pictures, video, and the lowest score was static picture.

<table>
<thead>
<tr>
<th>Media Type</th>
<th>Comprehension Score</th>
<th>Learning Time</th>
<th>Error Rate</th>
<th>X²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Video</td>
<td>2.54±0.51</td>
<td>43.19±17.09</td>
<td>18.78±0.28</td>
<td></td>
</tr>
<tr>
<td>Video+P_Pic</td>
<td>2.73±0.41</td>
<td>47.02±19.61</td>
<td>11.86±0.15</td>
<td></td>
</tr>
<tr>
<td>P_Pic</td>
<td>2.38±0.75</td>
<td>17.72**</td>
<td>20.64±0.27</td>
<td>41.31**</td>
</tr>
<tr>
<td>P_Draw</td>
<td>2.85±0.19</td>
<td>20.64±0.18</td>
<td>20.45±0.17</td>
<td></td>
</tr>
<tr>
<td>U_Pic</td>
<td>1.83±0.69</td>
<td>12.75±4.17</td>
<td>42.31±0.26</td>
<td></td>
</tr>
</tbody>
</table>

(Mean±SD), **P<0.05

The learning time required by the five media types was also significantly different. The video alone and the video plus static pictures took much longer time than the other three types. The other three types of visual instructions had no significant difference and the hierarchy was planned static drawing, then P_Pic, and last, U_Pic. The error rate of the five types of instruction was also significantly different, the difference came from the U_Pic. The type of media with the lowest error rate was the video with P_Pic, which also took the longest time to learn.

The results showed that the three learning performance criteria of the five learning media had significant differences. And the effects of these media are shown below.

B. The Effect of Different Kinds of Visual Information

The comparison between the three factors (dynamic, planned, and abstract) showed their effect of the visual information in the learning media.

The dynamic factor of the learning media included three levels, Video only, Video + P_Pic and P_Pic. Fig. 1 shows that only the learning time had a significant difference. The error rate had no significant difference but the results were opposite to the learning time. These results revealed that if learning by dynamic media, the learning time will be much longer than with static media, but the comprehension and error rate would show a positive effect, but there were no significant difference overall.
The Y-axis was used logarithmic transformation

Fig. 1. The effect of the dynamic factor on learning performance

The planned factor of the learning media included two levels, P_Pic and U_Pic. Fig. 2 shows that all three learning performance ratings were significantly different (α=0.1). The P_Pic was much better than U_Pic regarding comprehension and error rate, but the P_Pic still required a longer time for learning the task.

The abstract factor of the learning media also included two levels, P_Pic and P_Draw. Fig. 3 shows that only the comprehension score was significantly different (α=0.1) and the P_Draw was better than the P_Pic.

IV. DISCUSSION

The purpose of this study is to determine the effectiveness of using different kinds of visual information aids for the teaching of larger scale procedural tasks. The results of this study showed that different types of learning media had a significant effect on learning performance. The results also revealed that large scale tasks are similar to small scale tasks, although no previous study has studied larger scale equipment. This finding is in line with previous studies, but the effect of the comparison of different media and their combinations are still not clear. Therefore, the discussion mainly focuses on the effect in relation to the three factors. The first factor is dynamic; in this study, the instructional video had no significant better effect than P_Pic, the finding is consistent with the study by Watson et al. [1] which showed that there was no significant difference between animation and static diagrams for small scale assembly tasks. Otherwise, these results revealed that if learned by dynamic media, the learning time would much longer than if static media is used, and although the comprehension and error rate showed a pattern of positive effect, there were no significant difference. On the contrary, learning by P_Pic would take much less time and the comprehension and error rate would be significantly different. Therefore, as Michas and Berry’s study [3], in some specific purposes, technically simple instructional methods can be very effective when training people to perform simple procedural tasks and that it is not always necessary to use advanced technology for such purposes. If the emphasis on learning efficiency, the P_Pic is better. However, if the learning purpose is on the learning correctly, the dynamical video is better. Besides, the Video + P_Pic showed the pattern of having better comprehension and fewer errors.

From the planned factor point of view, there was significant difference between P_Pic and U_Pic. The result may be explained by considering the design. Well designed and P_Pic had more clues for learners to follow. Therefore, the comprehension and error rate would have a positive effect. The learning time of the P_Pic was also longer than U_Pic, because there were more information elements that needed to be learned. This is also in agreement with a study by Michas and Berry [3] which showed that the use of symbols, such as arrows and highlights, can help to make temporal and spatial relationships within graphical representations clearer and to better convey information about how to get from one step of the procedure to the next. This also supports the view that the content and quality of pictures influences their effectiveness [5]. The findings have implication for instruction and system designers when they plan instructions and training systems.

The third factor of learning media effect is the abstract factor. The comprehension score of the P_Draw was better than the P_Pic. One explanation for this is that sometimes the concrete pictures such as photograph are very realistic and good for representing the object, but sometimes it contains too many information and confuses learner, especially in the time-sensitive situations like reading road signs.
V. CONCLUSION

A limitation of this study is that the sample size is quite small. Although the sample in the study was small, the following recommendations could serve as some general principles for researcher who would like to design the multimedia instruction in learning procedural task. First, for a specific learning purpose, the alternative media type of visual information instruction should be considered. Second, and also most important in this research, is that the well-designed and P_Pic was much better than the U_Pic. Third is that the abstract drawing is also very important in specific learning situations. Finally, there was no consideration of the effect between the five tasks. Future study should concern the effect of the tasks.

APPENDIX

An example of video with static pictures.

An example of drawings

REFERENCES