The Effects of Prompts on Paper-based and Mobile Display-based Learning of Technological Knowledge by School Age

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Abstract: In recent years, schools have increasingly made use of computers as tools of education. Both paper- and display-based reading are often incorporated into the same lessons. Especially, mobile computer has become widely used. However, few studies have examined the influence of prompts (boldface, lining, marking, etc.) on students’ ability to learn technological knowledge. This study examined the effect of prompts on the understanding of declarative knowledge of technological materials and procedural knowledge of the subject material for two groups of students, seventh grade and university students, and compared the results statistically. Three experiments were conducted to measure how well students learn when they read text with prompts or are asked to add prompts themselves. The results reveal that, in paper-based learning, prompts positively influence learners’ understanding of the content materials, particularly in the case of seventh grade students. However, in mobile display-based learning, adding prompts by hand requires some mental energy and, therefore, has not so effective on learning.

Key-Words: Prompt, Paper-based Study, Mobile Display-based Study, Declarative knowledge, Procedural knowledge

1 Introduction
Mobile Display-based learning is now used alongside paper-based learning. However, because of differences in the characteristics of each media, differences between the two methods of learning in terms of the efficiency of learning materials are observed. This study analyzes students’ knowledge of textual learning materials. For each of the two methods of learning (i.e., Mobile display-based and paper-based), it examines the differences of learning effects of prompts (boldface, lining, marking, etc.), which are cues to facilitate the recognition of textual learning materials.

Previous studies in this field did not clarify how learners’ understanding of materials is affected by the addition of prompts. In addition, few studies have considered the type of knowledge or learners’ school age. This study compares the influence of prompts on paper- and Mobile display-based learning using the presentation method of the prompts, knowledge type, and age of the learner. The participants in the study were university and seventh grade students. The knowledge type of the learning materials in the experiments is classified as either declarative or procedural.

2 Prompts in Studies
2.1 Roles of prompts
Knowledge can be expressed through various methods, such as the use of text and figures. However, in the present age, it is well known that the expression of knowledge through text is most widely used in the mainstream. Further, as regards learning through text, it is more effective to emphasize the important parts of description contents than to provide a mere description by enumerating continuous letters. For example, important parts of the text can be presented in boldface, and methods such as drawing, color reckoning, and mark reckoning may also be used. These prompts reinforce memory recognition of the relevant knowledge. Prompts can be expressed in one of two ways: passive (when a learner reads text that is shown, for example, in boldface that is added...
beforehand by the writer) and active (when a learner inserts prompts in the process of learning, for example, with a pen) learning methods.

When learners actively add their own prompts, this type of memory promotion works to emphasize the importance of the contents in their understanding of the text that constitutes the learning material. However, inserting prompts represents a trade-off in terms of learning efficiency because the learner must invest more time and labor than if he or she were only reading. Various tools can be used to add prompts to paper-based materials, such as pencils, pens, markers, or highlighters. These are easy to use. However, input tools in display-based learning (e.g., pen tablets or styluses) are not commonly used in schools. Now, mobile computer has become widely used. Mobile computer is said to be good usability, but, are said to be difficult to use since the screen is narrow. Then, mobile computer cannot be said to provide so good usability for adding prompts, as there are several stages of the input stroke (i.e., movement of the pointer, click, and drag). Therefore, ease of use of mobile computer must be validated in the prompt addition experiment on mobile display-based learning, whether mobile computer is considered as an appropriate input tool in education.

Learning efficiency is greatly affected by the type of knowledge being learned. In cognitive psychology and knowledge engineering, teaching material knowledge is divided into declarative knowledge (Declarative knowledge is the type of knowledge that is, by its very nature, expressed in declarative sentences or indicative propositions. knowledge of the existence of things, that describes the relationship by its nature, between things), and procedural knowledge (Procedural knowledge is the knowledge exercised in the performance of some task).³

3 Experiments

3.1 The three experiments

3.1.1 Experiment 1
Experiment 1 measured paper-based learning. Participants read a text that had important parts emphasized in boldface.

3.1.2 Experiment 2
Experiment 2 also measured paper-based learning. Participants were asked to add their own prompts to important parts of the text by underlining or marking them with a pen.

3.1.3 Experiment 3
Experiment 3 measured display-based learning. Participants were asked to add their own prompts to important parts of the text by highlighting them in boldface using a mobile computer.

3.2 Participants (All participants had previously used a word processor.)

Table 1 Number of Participants by Grade Level

<table>
<thead>
<tr>
<th></th>
<th>Seventh Graders</th>
<th>University Students</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Experimental</td>
<td>Control</td>
</tr>
<tr>
<td>Ex. 1</td>
<td>44</td>
<td>44</td>
</tr>
<tr>
<td>Ex. 2</td>
<td>44</td>
<td>44</td>
</tr>
<tr>
<td>Ex. 3</td>
<td>44</td>
<td>44</td>
</tr>
</tbody>
</table>

* Experimental group has prompts.
** Control group has no prompts.

3.3 Knowledge Type

3.3.1 Declarative Knowledge
The test of declarative knowledge is called Test I in this paper. The test items were selected from technical textbooks.

3.3.2 Procedural Knowledge
The test of procedural knowledge is called Test II in this paper. The test items were selected from Synthetic Personality Inventory (SPI) textbooks. SPI problems are a kind of IQ test.

3.4 Outline of the Experiments
The experiments were carried out using a mobile computer (iPod Touch (4G)) in a quiet laboratory. The tests in paper-based learning were printed in black ink on white A4 paper. The test problems (10 questions) in paper-based learning were edited to fit on one sheet. A 3.5-inch display (163 ppi, anti-glare treatment, 960 × 640 pixel) was used. All participants agreed in advance to participate and to receive an explanation about the purpose of the experiments. All had experience using a mobile phone.

3.5 Specifications (Experimental Group)
1) Explain the experiment purpose
2) Experiment 1 (paper)
3) Two-minute break
4) Experiment 2 (paper)
5) Two-minute break
6) Training on how to make text boldface and use functions such as underlining, letter coloring, and highlighting in the mobile computer (The subjects were informed that they could use any prompt in Experiment 3.)
7) Experiment 3 (display)
8) Impressionistic essay (free description) about the experience of the whole experiment

3.6 Experiment Procedure
1) Explanation of the experiment procedure
2) Test I (declarative knowledge): Showing problems
3) Learning (five minutes)
4) Answer sheet distribution (three minutes) (Experiment 3 did not include this step)
5) Test I (three minutes)
6) Test II (procedural knowledge): Showing problems
7) Test II (two minutes)
8) Questionnaire survey on participants’ impression of the experiments

4 Results and Consideration

4.1 Results of Experiments
The participants’ average test scores are shown in Tables 2 (seventh graders) and 3 (university students). Each test comprised ten questions, and ten is the highest possible score. Tables 2 and 3 show the average scores of the experimental (with prompts) and control (no prompts) groups. The right column gives the “prompt effect,” calculated as the average score of the experimental group divided by that of the control group.

Table 2  Seventh Grader

<table>
<thead>
<tr>
<th>Exp.</th>
<th>Test</th>
<th>Experimental Group</th>
<th>Control Group</th>
<th>Prompt Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exp. 1</td>
<td>Test I</td>
<td>7.63</td>
<td>6.56</td>
<td>116%</td>
</tr>
<tr>
<td></td>
<td>Test II</td>
<td>4.80</td>
<td>3.97</td>
<td>120%</td>
</tr>
<tr>
<td>Exp. 2</td>
<td>Test I</td>
<td>6.24</td>
<td>4.63</td>
<td>135%</td>
</tr>
<tr>
<td></td>
<td>Test II</td>
<td>4.83</td>
<td>3.88</td>
<td>116%</td>
</tr>
</tbody>
</table>

Table 3  University Students

<table>
<thead>
<tr>
<th>Exp.</th>
<th>Test</th>
<th>Experimental Group</th>
<th>Control Group</th>
<th>Prompt Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exp. 1</td>
<td>Test I</td>
<td>8.59</td>
<td>8.28</td>
<td>103%</td>
</tr>
<tr>
<td></td>
<td>Test II</td>
<td>5.23</td>
<td>5.14</td>
<td>101%</td>
</tr>
<tr>
<td>Exp. 2</td>
<td>Test I</td>
<td>7.12</td>
<td>5.85</td>
<td>121%</td>
</tr>
<tr>
<td></td>
<td>Test II</td>
<td>4.87</td>
<td>4.28</td>
<td>113%</td>
</tr>
<tr>
<td>Exp. 3</td>
<td>Test I</td>
<td>6.02</td>
<td>7.32</td>
<td>82%</td>
</tr>
<tr>
<td></td>
<td>Test II</td>
<td>4.12</td>
<td>5.05</td>
<td>82%</td>
</tr>
</tbody>
</table>

4.2 Consideration

4.2.1 Effects of boldface on paper-based learning
Analysis of variance (ANOVA) of the Test I results for the two groups (experimental and control groups) of seventh grade students in Experiment 1 (see Table 2) revealed a significant difference between the groups (P level 0.007), with the experimental group showing higher performance (P level 0.025). A significant difference between the groups was also found in the Test II results. Therefore, the findings indicate boldface as a prompt in paper-based learning is effective for seventh grade students.

ANOVA of the Test I results for the two groups of university students in Experiment 1 (see Table 3) did not reveal a significant difference (P level 0.35), although the experimental group had a somewhat higher performance (103%). Similarly, no significant difference was found between the
experimental and control groups of university students in Test II (P level 0.82); thus, the prompt effect is 101%. Therefore, for university students, use of boldface as a prompt in paper-based learning is not particularly effective, although it appears to have a slight positive influence. Based on these findings, there is a clear case for presenting important information in boldface to seventh grade students. For university students, however, the presence of this prompt makes no statistical difference. This may be because university students, because of higher cognitive ability, are better able to distinguish important information in a text.

4.2.2 Effects of inserting prompts on paper-based learning
ANOVA of the Test I results for the two groups of seventh grade students in Experiment 2 (see Table 2) showed a significant difference between the groups (P level 0.0001), with the experimental group showing a higher performance. A significant difference was also found in the Test II results (P level 0.01). Therefore, it can be said that adding prompts has a positive effect on seventh grade students’ paper-based learning.

ANOVA of the Test I results for the two groups of university students in Experiment 2 (see Table 3) revealed a significant difference between the groups (P level 0.04). A significant difference was also found in the Test II results (P level 3.01E-08). Therefore, adding prompts has a positive effect on university students’ paper-based learning as well.

These findings indicate that inserting their own prompts is an effective approach to paper-based learning for seventh grade and university students. In particular, for the seventh grade students, the learning result of the experimental group was 35% higher than that of control group. Thus, prompts are effective in aiding paper-based learning.

4.2.3 Effects of inserting prompts on display-based learning
ANOVA of the Test I results for the two groups of seventh grade students in Experiment 3 (see Table 2) showed a significant difference between the groups (P level 0.04), with the experimental group showing a lower performance. A significant difference was also found in the Test II results, and the experimental group again had a lower performance (P level 0.03). Thus, adding prompts had a negative effect on display-based learning for the university students.

The findings indicate that when both seventh grade and university students are asked to add their own prompts in mobile display-based learning, their learning is negatively affected. The reason for this must be analyzed.

Figures 1 to 3 (Experiments 1 to 3, respectively) show the results of the impression questionnaire for learners in the experimental group. Participants rated their level of agreement with each item on a 7-point scale (I strongly agree, I agree, I somewhat agree, Neutral, I slightly disagree, I disagree, I strongly disagree) (+3 ~ 0 ~ -3). The question items are shown as ~ in each figure. Note that Question ⑤ in Figure 1 (Experiment 1, which did not require participants to add prompts) differs from its counterpart in Figures 2 and 3.

Comparison of Figures 1 to 3 shows that there are significant differences in these Questions. (Question in Figure 1 cannot be compared.)

Figure 1 Questionnaire Results of Experiment 1

<table>
<thead>
<tr>
<th>Level</th>
<th>Contents is difficult</th>
<th>Easy to memorize</th>
<th>Easy to read</th>
<th>Able to concentrate</th>
<th>Easy to read prompts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seventh</td>
<td>1.2</td>
<td>-1.5</td>
<td>2.1</td>
<td>1.2</td>
<td>2.1</td>
</tr>
<tr>
<td>Univ.</td>
<td>1</td>
<td>-1.2</td>
<td>1.2</td>
<td>0.6</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Figure 2 Questionnaire Results of Experiment 2
According to Figure 2, many participants agreed that prompts were easy to add to the text. However, in Figure 3, the same question has a negative index. In other words, most seventh grader and university students reported that it is difficult to add prompts by hand.

A summary of the contents of the free impressionistic essay is shown in Figure 4.

Figure 4 Summary of Participants’ Opinions on the Experiments

Figure 4 presents participants’ various opinions on the mental workload of adding prompts on the mobile computer display in Experiment 3. The seventh grader and university students reported similar opinions. The results reveal that participants regard using fingers to add prompts as not being as convenient as using a pen. It seems that the movements of controlling the button, clicking, and dragging interfered with participants’ ability to concentrate on learning. Thus, asking students to add their own prompts by fingers on mobile computer for a long time is not recommended as a learning tool. They say the work busy, troublesome, need two much time.

4.2.4 Comparison of change rates in score by prompting between seventh grade and university students

The results in Tables 2 and 3 show the average score of the control group of university students, that is 4.99, and that of seventh graders, 5.99. Approximately 20% of university students scored higher than 4.99. This finding represents the difference in average ability to answer the test problems between the seventh grade and university students.

Because of the different kinds of problems used in the experiments, it is necessary to statistically compare each result for each experiment. In addition, the results of Experiments 1 and 2, which show that prompts had a positive effect, must be analyzed separately from those of Experiment 3, which show that prompts had a negative effect.

Regarding the prompt effect in Experiment 1, the score increase due to use of boldface was 16% in Test I and 20% in Test II for the seventh grade students, and 3% in Test I and 1% in Test II for the university students. Thus, the ANOVA revealed that boldface prompts have a significantly higher effect on seventh grade students than on university students. In other words, boldfaced presentation of text has only a small effect on university students but significantly promotes memory of the materials for seventh grade students.

Regarding the prompt effect in Experiment 2, the score increase due to participants adding their own prompts was 35% in Test I and 16% in Test II for the seventh grade students, and 21% in Test I and 13% in Test II for the university students. Therefore, the ANOVA showed there is no significant difference in prompt effect between seventh grade and university students when they are asked to insert the prompts themselves on paper. In other words, adding prompts has a significant and approximately equal memory promotion effect on university and seventh grade students.

Regarding the prompt effect in Experiment 3, the score increase due to participants adding their own prompts was -18% in Test I and -8% in Test II for the seventh grade students, and -18% in Test I and -18% in Test II for the university students. Therefore, ANOVA showed there is no significant difference in effect between seventh grade and university students when they are asked to insert the prompts themselves on mobile computer display. In other words, adding prompts on mobile computer display in display-based learning has the opposite effect on memory promotion for both university students and seventh grade students. This finding can be explained through the physical awkwardness of inputting prompts.

4.2.5 Comparison by knowledge type
This analysis included only the results of Experiments 1 and 2, not those of Experiment 3.

As Table 2 shows, the prompt effect of Test I (declarative knowledge) for the seventh grade students is 116%, and that of Test II (procedural knowledge) is 120%. Table 3 shows the prompt effect of Test I on university students is 103%, and that of Test II is 121%. These findings indicate that prompts have a greater effect on declarative knowledge than on procedural knowledge for both seventh grade and university students. The effect of prompts on learning is greater for seventh grade students than for university students in regard to declarative knowledge, but there is no significant difference for procedural knowledge. These findings indicate that asking students to add prompts to texts is an effective instruction method, especially when the lesson pertains to declarative knowledge.

5 Conclusions

1) Boldfaced presentation of text has a significant effect on learning for both seventh grade and university students.
2) Adding prompts has a significant effect on paper-based learning for both seventh grade and university students, and particularly the former.
3) Adding prompts has a negative effect on display-based learning for both seventh grade and university students, as adding prompts such as moving the pointer, clicking, and dragging take away from the ability to concentrate on learning, and is troublesome, and make learners tiring.
4) Adding prompts has a greater effect on the learning of declarative knowledge as opposed to procedural knowledge for both seventh grade and university students.
5) Adding prompts is a more effective learning method of declarative knowledge for seventh graders than for university students.

References: