12-16-2012

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ABSTRACT

Computer training is vital for improving user interaction with a system. Prior research on computer training indicates that behavior modeling is highly effective for computer skill acquisition and can be further improved by incorporating symbolic coding processes. Building upon dual coding theory, our study proposes two new coding strategies, imagery coding and procedural coding, and examines the effects of those alternative coding strategies on computer learning outcomes relative to textual coding in a modeling-based training context. A training program on a popular computer graphic application was offered in a university setting and attended by 190 trainees. The study results show that modeling-based training can be significantly improved by incorporating the proposed new coding approaches but the specific coding strategy should be carefully chosen depending on the target learning outcome.

Keywords

Computer training; Behavior modeling; Dual coding theory; Imagery coding; Procedural coding; Modeling-based training.

INTRODUCTION

Organizations are under constant pressure to effectively utilize information systems (IS) and maximize their potential benefits. Learning and training are important topics for human-computer interaction (HCI) research in IS. Users can productively use a target system only when they have learned how to interact with the system. Empirical findings confirm a significant correlation between computer-related ability and productive use of computing resources (Lee et al., 1995).

In this study, we examine the effects of alternative coding strategies on computer training outcomes in a modeling-based training context. Fueled by the advent of advanced information technology and the need to update one's knowledge to be in line with the rapidly changing environment, universities and corporations worldwide now offer thousands of online courses. The number of video materials has increased due to the rapid acceptance of similar environmental conditions between televisions and online videos. These training materials are typically built upon a modeling-based approach, in which a model demonstrates target behavioral skills, and trainees practice the demonstrated behaviors after observation. As of today, limited attention has been paid to augmenting the effectiveness of these prevalent modeling-based training approaches despite the potential to bring about immediate worker performance improvement.

Observational learning theory posits that humans learn effectively through observing others' behavioral enactment (Bandura, 1977). Consistent with this view, prior studies on computer skill training indicate that behavior modeling, in which trainees observe a model demonstrate computer skills and then reenact the modeled behavior, is a highly effective form of computer skill training (Compeau and Higgins, 1995; Gist et al., 1989; Johnson and Marakas, 2000; Simon et al., 1996). Beyond the computer training domain, behavior modeling has been proven effective in a broad range of behavioral skill training domain, including managerial skill training for which behavior modeling was initially developed.

Although behavior modeling has been demonstrated to be highly effective in managerial skill training and computer skill training areas, most prior behavior modeling research on computer training has overlooked symbolic coding processes, defined as symbolically summarizing key learning points of demonstrated activities and mentally practicing the learned activities (Davis and Yi, 2004). Within the context of computer skill training, Yi and Davis (2001, 2003) demonstrated that behavior modeling technique can be further augmented for better learning outcomes by incorporating symbolic coding. Extending their studies, we examine alternative coding approaches including imagery coding and procedural coding by applying dual coding theory (Paivio, 1971, 1986) to computer training. The objective of the present study is to examine the effects of alternative coding strategies on computer learning outcomes, thereby exploring the potential to further improve the current state of art computer skill training practices.

RESEARCH MODEL

Figure 1 presents our research model, which theorizes that alternative coding strategies will have differential effects on training outcomes and spatial ability will be a moderator of those effects. Kraiger et al. (1993) contend that the most fundamental way of evaluating training is to examine learning outcomes evident from changes in cognitive, skill-based and affective outcomes. The proposed model includes learning outcome variables from all these three categories. We do not specifically hypothesize that the proposed coding strategies to produce differential affective outcomes. Thus, they are represented with dotted lines.

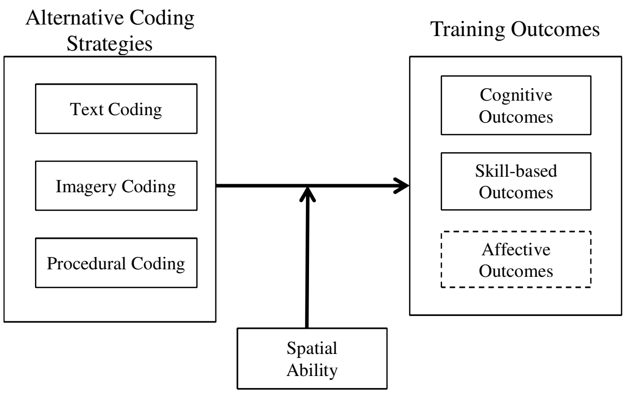

Figure 1. Research Model

Dual coding theory posits that human cognition consists of the simultaneous activity of symbolic representational systems, which are composed of a verbal system and a nonverbal system (Paivio, 1971, 1986). The verbal system deals with linguistic input and output while serving as a symbolic function for nonverbal objects. The nonverbal system is responsible for the analysis of scenes and the generation of mental images. Thus, according to the theory, human experiences are internalized and symbolically represented in multi-modal systems, which represent information differently and operate functionally independently. The two systems may work together in parallel or either system may become active without the other, representing the processed information differently.

Several studies show that multimodal representation consisting of both imagery and textual codes is useful (e.g., Brunyé et al., 2006; Diehl and Mills, 1995). According to dual coding theory, meaningful processing of information is more likely to happen when verbal codes and nonverbal codes are used together in converting the stimuli into internal representations. The theory contends that the verbal system and the nonverbal system can activate each other; they can work in parallel and can coordinate their activities. Thus, learning is likely to be maximized when the two systems are engaged. In this study, we test this possibility by combining regular text (verbal) coding with imagery (nonverbal) coding in a modeling-based IT training context and hypothesize that:

Hypothesis 1a: Combining text coding with imagery coding will produce higher cognitive learning outcome than text coding only.

Hypothesis 1b: Combining text coding with imagery coding will produce higher skill-based learning outcome than text coding only.

In general, knowledge is categorized as declarative knowledge, expressed by declarative propositions, and procedural knowledge, expressed by task performance. From an information processing perspective, transforming regular text coding to procedural coding takes an extra effort and potential misrepresentation, as temporal order has to be inferred. Moreover, it would be much more conducive to learning if the transformation occurs at the initial encoding point rather than at the subsequent retrieval or application points. Prior research on computer training has not distinguished procedural coding from regular textual coding. Thus, the relative effects of textual coding versus procedural coding are unknown. In their experiment, Yi and Davis (2001, 2003) asked trainees to summarize the demonstrated computer operations by writing down key points of the demonstration, without specifying the use of procedural codes. Considering that the computer operations covered in a modeling-based training (i.e., input) are mostly in the form of procedural knowledge and that the skill compilation (i.e., output) involves orchestration of the component skills in sequence, it can be more effective to encode the input stimuli in a procedural format, thereby reducing the extra cognitive effort and potential inaccuracy involved with delayed transformational processes. Thus, we hypothesize that:

Hypothesis 2: Combining text coding with procedural coding will produce higher skill-based learning outcome than text coding only.

Dual coding theory acknowledges that individual differences in cognitive abilities can impact the effectiveness of symbolic representation of information (Paivio, 1986). Spatial ability refers to one's ability to form a mental representation of the spatial world and work with this representation. In a computer training context, Sein et al. (1993) found that visualization ability was a strong predictor of end user learning success. More importantly, they also found an interaction effect between a training method and spatial ability. Collectively, the studies on dual coding, and computer skill acquisition suggest that spatial ability can moderate the effect of imagery coding on learning outcomes. We test this possibility by hypothesizing that:

Hypothesis 3a: The effect of imagery coding on cognitive learning outcome is moderated by spatial ability.

Hypothesis 3b: The effect of imagery coding on skill-based learning outcome is moderated by spatial ability.

RESEARCH METHOD

Settings

The training was offered in a lab, which had 30 of the latest computer models, a video projector connected to the instructor's computer, and sound equipment to aid the lecture. The video used in the experiment was a lecture series video on Adobe Photoshop CS4 provided by an online educational service provider. Trainees in the experiment watched three video lecture segments about introducing the toolbox (18 min.), inserting and decorating text in an image (15 min.), and synthesizing image layers (15 min.), through which the same lecturer on the video explained various features of Photoshop showing specific procedures of operations. The video was played using a computer connected to a video projector. Photoshop was installed on every computer so that trainees could access the computer and use the features as demonstrated in the video. Moreover, Microsoft OneNote, a tool for personal note-taking, was also installed on the computers. Depending on their assigned conditions, subjects could conduct coding activities, summarizing the lecture when each video section ended.

Participants

Participants, who voluntarily participated in the experiment, were undergraduate or graduate students in a major university in South Korea. A total number of 190 students participated in the experiment, and each of them received a fixed amount of subject fee (about $15) for participating in the study.

Procedures

The participants read the online advertisement notice and responded to a simple questionnaire about their prior experience in using the target software (i.e., Photoshop) and other graphic tools if they chose to participate in the experiment. Then, they were randomly assigned to one of the experimental groups.

At the beginning of the experiment, a trainer welcomed participants and introduced the experiment, following the prepared scripts, which were written to eliminate inconsistencies between the class sessions. After the introduction, the trainer handed out the pretest questionnaires. Finishing the pretest, trainees watched the three video lecture segments. At the end of each video segment, trainees conducted skill compilation practice for five minutes and the assigned coding for three minutes, except for the no-coding condition in which trainees conducted only skill compilation practice for five minutes. After finishing the three segments, trainees in the coding conditions reviewed their notes for five minutes for cognitive rehearsal, following Yi and Davis (2001). Then, each trainee took the declarative knowledge (cognitive outcome) test (5 min.) and task performance (skill-based outcome) test (7 min.). Finally, trainees filled out a posttest questionnaire, and then were debriefed.

Treatment Conditions

A 2 X 2 (image coding, procedural coding) factorial between-subjects design, supplemented with a control group, was used to manipulate the text, procedural and imagery coding, yielding the following five experimental conditions.

No-Coding (NC) Group

Trainees in this group performed only procedural practice and did not take any notes or do any coding activities after each video segment.

Text Coding Only (TCO) Group

At the end of each video segment, trainees in this condition summarized the contents of the lecture by taking notes using normal text coding so they could review the overall notes before the posttest.

Text and Imagery coding (TIC) Group

Trainees in TIC group performed both regular textual coding and imagery coding at the end of each video segment. For textual coding combined with imagery coding, trainees were asked to capture a Photoshop screen (using PrtScr key), paste it on an OneNote document, and perform textual summary coding on top of the captured screen connecting the text.

Procedural Text Coding Only (PCO) Group

Similar to the TCO group, trainees were told to summarize the contents of the lectures by taking notes, but in the form of procedural sequence where appropriate.

Procedural Text and Imagery Coding (PIC) Group

Trainees in this condition were told to use a screen capture from Photoshop for imagery coding and take notes in the form of procedural sequence.

Measures

Pretest

The pretest included the measures of demographics, prior motivation to learn, prior experience with Photoshop program, prior usage skill about graphic software, pre-training self-efficacy, and spatial ability.

Posttest: Cognitive Learning Outcome

The cognitive learning outcome was measured using a declarative knowledge test, which consisted of 10 multiple-choice questions designed to test trainees' comprehension of concepts about the target software. The questions were 10 points each, thus the potential total score ranging from 0 to 100.

Posttest: Skill-Based Learning Outcome

Trainees' task performance on Photoshop skills was measured using a large, integrative question that consisted of six equally related subtasks: cut the target image from a photo, copy this segment into a background photo, insert shadow into the target image, insert text, decorate the text, and save the edited image. Points were graded whether each task was completed correctly. Ten dimensions to evaluate the task performance were constructed. Each dimension was worth 10 points, thus the potential total score ranging from 0 to 100.

Posttest: Affective Learning Outcome

To examine affective outcomes, attitudinal factors (i.e. perceived ease of use, perceived usefulness, behavioral intention, satisfaction, enjoyment) were measured by using existing instruments.

RESULTS

The answers to the task performance test were scored by two independent graders who had substantial experience in using Photoshop for more than five years. The Pearson correlation between the two graders was high (ρ=.90). The average of the scores from the two graders was used as the final skill compilation test score.

	N	Declarative Knowledge	Task Performance
NC	37(35)	69.19(15.16)	67.79(22.38)
TCO	34(32)	68.53(15.79)	68.59(20.72)
TIC	37(36)	73.78(14.21)	71.67(22.24)
PCO	40(38)	70.24(15.22)	78.82(19.82)
PIC	42(36)	77.75(16.41)	77.70(19.10)
Total	190	72.00(15.61)	73.09(21.13)

Note: For N, the first number indicates the number of subjects who took the declarative knowledge test and the second number (shown in parentheses) indicates the number of subjects who took the task performance tests. The difference is due to the subjects who lost their work while taking the test.

Table 1. Means (Standard Deviations) of Study Variables by Experimental Group

Table 1 lists the means and standard deviations of the learning outcomes by the experimental conditions. In the declarative knowledge test, the three treatment groups (TIC, PCO, and PIC) obtained higher scores than the NC group and the TCO group. In particular, the two imagery coding groups (TIC, and PIC) achieved noticeably higher scores than the NC group and the TCO group, the two groups with no imagery coding and no procedural coding. In the task performance test, two procedural text groups (PCO and PIC) achieved the highest scores while those two groups (NC and TCO) with no imagery coding and no procedural coding obtained the lowest scores.

ANOVA tests were performed in order to assess the effects of alternative coding strategies on training outcomes, as shown in Table 2. In support of H1a, imagery coding had a significant effect on declarative knowledge ($F = 7.29$, $p < 0.01$), indicating that combining text coding with imagery coding produces better cognitive learning outcome. In contrast to H1b, imagery coding did not have a significant effect on task performance ($F = 1.34$, ns). In support of H2, procedural coding had a significant effect on task performance, indicating that combining text coding with procedural coding produces better skill-based learning outcome. The results of ANCOVA conducted to isolate potential noises due to individual differences in both prior experience on Photoshop software and pre-training computer self-efficacy replicated the findings of the ANOVA tests.

	Declarative Knowledge	Task Performance
Imagery coding	F=7.29, p<0.01	F=0.13, p=0.71
Procedural coding	F=1.34, p=0.25	F=6.64, p<0.02
Imagery*Procedural	F=0.32, p=0.57	F=0.51, p=0.48

Table 2. Results of ANOVA tests on Declarative Knowledge, and Task Performance

The results of the ANOVA and ANCOVA tests conducted to test the hypothesized moderation effects of spatial ability for the relationships between imagery coding and learning outcomes show that spatial ability is not a significant moderator of the effect imagery coding has on cognitive learning outcome (H3a) and not a significant moderator of the effect imagery coding has on skill-based learning outcome (H3b). However, it should be noted that the moderation effect was close to the significance of $p < 0.05$ for declarative knowledge.

DISCUSSION

The purpose of the present research was to understand the effects of alternative coding strategies on computer learning outcomes. The current study findings show that the two coding strategies are superior to no coding or regular textual coding. Regular textual coding has been used to improve the extant training practices, particularly in conjunction with behavior modeling. Yi and Davis (2001, 2003) found that incorporating symbolic coding and cognitive rehearsal could improve the existing behavioral modeling technique. The current study extends those previous studies by going further and examining alternative symbolic coding strategies, tapping the potential to further improve the best practices of modeling-based computer training.

The findings of the study show that using regular text coding for symbolic coding activities is not enough. The study results show that combining it with imagery coding, procedural coding, or both produce better learning outcomes. For the acquisition of declarative knowledge, it was found that imagery coding makes a significant difference. Trainees in the experimental conditions that included imagery coding showed significantly higher achievement than trainees in those conditions that did not include imagery coding ($MD = 6.46$, $p < 0.01$). For the acquisition of task performance skills, it was found that procedural coding makes a significant difference. Trainees in the experimental conditions that included procedural coding showed significantly higher achievement than trainees in those conditions that did not include procedural coding (MD = 8.85, $p < 0.01$). Those two treatment effects did not significantly vary across spatial ability, showing that the observed significant treatment effects were true regardless of individual spatial ability. The combined results indicate that imagery coding should be used if the comprehension of the training material is the primary focus of the training program, and that procedural coding should be used if the compilation of the demonstrated skills is the primary focus of the training program. Combining those two coding strategies together was the best condition for cognitive learning outcome, but the second best condition for skill-based learning outcome. Overall, the findings indicate that there are tradeoffs – relative strengths associated with each coding strategy. However, the results consistently show that those two coding approaches are better choices, no matter whether they are combined or not, than no-coding or text-coding only.

In conclusion, this research shows that modeling-based training can be further improved by incorporating imagery coding and procedural text coding approaches. Dual coding theory provides a sound rationale of why combining text coding with imagery coding can be more effective in recording obtained information in memory. However, dual coding theory does not clearly discuss different types of transformations between alternative representation schemes and their potential problems. To conclude, this research is one of the first studies of how observational learning with regard to computer applications can be improved through alternative coding strategies. Our study findings show that the existing behavior modeling technique can be significantly improved by incorporating the proposed new coding strategies.

ACKNOWLEDGMENTS

This work was supported by the Korean Government IT R&D program of MKE/KEIT. [Project No. 10035166, Development of Intelligent Tutoring System for Nursing Creative HR]

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