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Understanding the Effects of Different Study Methods on Retention of Information and Transfer of Learning

Rylan G. Egan

Teaching Consultant, Memorial University, St. John's, Newfoundland

Canada

Correspondence: Rylan G. Egan. Distance Education, Learning and Teaching Support Memorial University of Newfoundland St. John's, NL, Canada A1B 3X8. E-mail: regan@mun.ca

Abstract

Introduction. The following study investigates relationships between spaced practice (re-studying after a delay) and transfer of learning. Specifically, the impact on learners ability to transfer learning after participating in spaced model-building or unstructured sudy of narrated text.

Method. Subjects were randomly assigned either to a model-building or a free study group. All subjects completed a pre-test of topic knowledge. In addition, participants in the model-building group watched a short demonstration of the model-building task. Participants listened to passages and either built a model or studied a transcript of the narration at increasing time lags. Finally, participants wrote a test of memory for detail and an extension test of knowledge transfer.

Results. Knowledge transfer test scores improved for the model-building group as time lag between encoding and restudy increased. No effect was found between time lags in the free study group. No statistically detectable time lag affect was found for the detail test.

Discussion. The following study provides evidence of improved knowledge tranfer resulting from elaborate constructive model-building. When particiapants' study methods were unstructured transfer did not statistically detectably improve as time lags increased between study intervals.

Keywords: Spaced Practice, Transfer of Learning, Elaborate Study, Model-Building

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La incidencia de distintos métodos de estudio en la retención de información y transferencia de aprendizajes

Resumen

Introducción. El presente estudio investiga las relaciones entre la práctica de espacio (re-estudiando después de una pusa) y la transferencia de aprendizaje. En concreto, el impacto en la capacidad de los estudiantes para transferir el aprendizaje después de participar en un espacio de construcción de modelos o no estructurado de texto narrado.

Método. Los sujetos fueron asignados aleatoriamente a un modelo de capacidad o de un grupo de estudios libre. Todos los sujetos completaron una prueba previa de conocimiento tema. Además, los participantes en el grupo de construcción de modelos vieron una demostración breve de la tarea de construcción del modelo. Los participantes realizaron listas de los pasajes y, o bien, construyeron un modelo o estudiaron una transcripción de la narración para aumentar los recuerdos temporales. Por último, los participantes escribieron una prueba de memoria para los detalles y una prueba de la extensión de la transferencia de conocimiento.

Resultados. Los exámenes de conocimiento de transferencia de resultados mejoraron en el grupo de construcción de modelos, con intervalo de tiempo, entre la codificación y reestudio aumentado. No se encontraron diferencias entre los lapsos de tiempo en el grupo de estudio libre. Sin afectar el tiempo de retraso estadísticamente detectable se encontró para la prueba de detalle.

Discusión. El presente estudio proporciona evidencia de tranfer mejor conocimiento resultante de la constructiva elaborada de la construcción de modelos. Cuando los métodos de estudio eran con participantes no estructurados o libres, los resultados de la transferencia no era estadísticamente significativos, pero se detectaron las mejorasr a medida que aumentaron los desfases entre los intervalos de estudio.

Palabras clave: Práctica espaciada, Transferencia del aprendizaje, Estudio elaborado, Construcción de modelos

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Introduction

Activities requiring learners to actively commit mental resources to a task have been shown to facilitate information retention and transfer (Schwartz & Martin, 2004). Spaced practice is one example. Spaced practice refers to presenting equivalent information at delayed intervals. Findings in the literature indicate that increased mental effort due to spaced practice improves retention (Bjork & Allen, 1970; Carpenter & DeLosh, 2006; Cuddy & Jacoby, 1982; Glover, 1989; Kang, McDermott, & Roediger, 2007; Nagy, Herman & Anderson, 1985). In the literature on transfer of prior learning, mental activities requiring participants to self-explore data and invent their own solutions to problems have been shown to improve performance on subsequent tasks (Bransford & Schwartz, 1998; Schwartz & Martin, 2004; Schwartz & Bransford, 1998; Schwartz, Bransford, & Sears, 2007). As transfer problems become more advanced, participants require more mental effort to re-conceptualize problems and solutions. Although both spaced practice and transfer rely on the effects of mental effort, comparisons have not been well documented in the literature.

Over the last century learning researchers have found that spaced practice improves information retention (see review by Dempster, 1988). In a report by Cepeda, Pashler, Vul, Wixted, & Rohrer (2006) of 271 spaced practice experiments, only 4.4% failed to achieve meaningful and statistically significant spacing effects. Information retention due to spaced practice is usually evaluated in comparison to massed practice, which refers to repeated presentation of equivalent information without delay between trials (Cepeda et al.; Dempster, 1989; Janiszewski, Hayden, & Sawyer, 2003). A well supported explanation for the spacing effect is termed elaborate retrieval (Carpenter & DeLosh, 2005 & 2006; Glover, 1989).

Elaborate retrieval refers to the increased mental effort needed to retrieve memories degraded by spaced practice or other interventions. Carpenter and DeLosh provided support for the elaborate retrieval hypothesis. In their study, the number of recall cues was manually controlled to manipulate effort required to retrieve previously studied information. Words were presented with one, two, three, or four letters to cue participants' recall of a targeted word. It was hypothesized that more effort would be required to remember words with fewer cues. The results supported this hypothesis as 42%, 36%, 35%, and 30% of words were recalled after being formatively tested using one, two, three, or four cues, respectively.

In contrast to spaced practice, transfer findings have greater diversity. Transfer has

been viewed alternatively as important (Gagne, 1968), unfounded (Thorndike & Woodsworth, 1901; Detterman & Sternberg, 1993), and ubiquitous (Salomon & Perkins, 1989; for a review see Schwartz, Bransford, & Sears, 2007). With respect to the disunity of these findings, Schwartz et al. suggested that changing the evaluation paradigm could consolidate opinion. Bransford and Schwartz (1999) explored two methods for testing learning transfer. The most common method, termed sequestered problem-solving (SPS), requires that "participants receive a single trial to solve a problem and receive neither feedback nor opportunities to revise" (Schwartz, Bransford, & Sears, 2007, p. 6). A second method, termed preparation for future learning (PFL), evaluates learners' ability to transfer recently learned information into strategies that optimize learning from new instruction.

In many of their studies, Schwartz and colleagues used a technique termed "intervening to prepare for learning" (IPL). Schwartz and Martin's (2004) study is prototypical. In their study, grade 9 students were required to compare test scores using a normal distribution curve. The traditional study group was provided with solutions and given time to practice. The intervention group was required to actively re-conceptualize their understanding by creating and adjusting numerous learner-invented solutions. During exploration no student in the intervention group developed the correct solution. After instruction, both groups took a test requiring an additional step, namely, to standardize scores that were presented on different scales. Half of the participants in each group received a worked example explaining the process of score standardization, the other half were required to solve the problem without assistance. Although both groups performed similarly when worked examples were absent, the intervention group outperformed the instruction group when worked examples were provided. Schwartz and Martin interpreted these results to indicate that intervention participants explored and learned from the test example but instruction participants merely "plugged-and-chugged" their way to a solution. As a result, the intervention group, who arguably were required to use more mental attention and effort during the learning process were better able to expand their understanding and obtain knowledge required to solve the score standardization problem.

The hypothesis that metal engagement facilitates deeper learning is supported by classic cognitive constructivist theory. Rumelhart and Norman (1978) suggested that learning requires information to be encoded in long-term memory as schemas. They hypothesized that schemas are organized by common attributes that are coordinated to form unique meaning.

Rumelhart and Norman (1978) and Rumelhart (1980) proposed three theoretical procedures for grouping meaning within schemas. At the most basic level, new information may be added as a new element of an existing schema. A second, more significant method to coordinate external information into schematic structures involves adjusting current schemas to incorporate new information. Similarly, Piaget (1977) submitted that people adjust schemas in response to cognitive disequilibrium. Equilibrium is out of balance when externally received information does not fit within an individual's schematic paradigm (Piaget, 1977; Wadsworth, 1984). According to Piaget, to re-equilibrate individuals must assimilate (adjust information to fit current schema), accommodate (adjust schema to fit new information), or develop a new schema. In these studies and others it has been suggested that adjusting schematic structure, or accommodation, requires more mental effort and concentration (Pascual -Leone & Irwin, 1994; Piaget, 1977; Rumelhart, 1980; Rumelhart & Norman, 1978; Wadsworth, 1984).

If instructional activities such as classroom lectures are not structured to facilitate active mental effort and concentration, students may be more inclined to assimilate misinformation to current schemas (Schwartz, Bransford, & Sears, 2007). In contrast, participants in Schwartz and Martin's studies were constantly experiencing disequilibria when their novice solutions to statistics problems were not successful. Since the learners were novices, they were likely to require considerable concentration to alter or re-conceptualize their understanding. In the current study multiple concentrated schematic adjustments, resulting from disequilibrium, are expected to create a more malleable understanding that is less resistant to change. Specifically, this study attempts to isolate the roles that elaborate retrieval and active re-conceptualization (elaborate re-conceptualization) play in learning transfer.

The current study will be conducted using SPS testing. SPS was chosen to evaluate the benefits of elaborate re-conceptualization on direct transfer. However, unlike most SPS experiments, but consistent with experiments by Schwartz and colleagues, participants' engaged in activities requiring elaborate re-conceptualization. Also, as in Schwartz and Bransford's (1998, 2004) studies, participants in this experiment were required to: (a) compare their invented solutions to common sense; (b) attempt to find solutions that generalize to different contexts; and, (c) describe the creative process used to invent solutions.

To evaluate effects of elaborate re-conceptualization on transfer, two study tasks termed model-building and free study were tested. Using spaced practice, the model–building task gave participants opportunity to elaborately re-conceptualize information and subse-

quently apply it to a new context. In contrast, the free study task did not scaffold the re-conceptualization process and participants were required to self-direct their study strategies. Except for the study variable, the experimental method was identical for both groups.

Objetives and hipothesys

To better understand the effects of elaborate retrieval on transfer, time intervals between study tasks and the presentation of narrated passages were incrementally lengthened. The interval lengths were approximately the same for both groups. Using this technique, the effect of interval length on learning transfer could be compared both across learning tasks and spaced intervals. Two tests referred to as terms and knowledge extension were given at the end of the experiment. The intent of the terms test was to evaluate participants' rote memory of definitional terms. In contrast, the knowledge extension test evaluated participants' ability to transfer knowledge amassed during the experiment to a complex "real world" situation. This research had two key goals. The first was to investigate the impact of elaborate retrieval on learning transfer. The second was to evaluate which study task would be most affected by spaced practice.

Method

Participants

Thirty subjects were recruited; 15 participated in the model-building group and 15 in the free study group. Subjects were adult learners between 23 and 40 years old. All participants had completed high school and at least part of a university or college program. A broad age group range was chosen to extend previous studies focused on high school or freshmen/junior college students. Recruitment was conducted primarily in the staff and faculty population at a mid-sized college in Eastern Canada.

Materials

Narrated Passages. Three orally presented information passages, focusing on constructivist learning theories, were used in this study. Passages were pre-recorded and presented as part of the flash based program designed for this experiment. Passages covered theories of abstraction, schema development, and spaced practice. Each passage contained four key concepts that were the target of assessment for both the knowledge extension and terms tests. Participants listened to passages of 210-330 words that were read by the re-

searcher at an average of 135 words per minute, for an average total reading time of 1min 45secs. Context specific examples were used to explain important concepts during narration. Visual presentation was limited to a black screen, a large white "toolbox", and the four previously mentioned terms (presented in white boxes) that synchronously floated into the toolbox from the bottom of the screen as they were mentioned in the passage.

Model-Building. Participants used text boxes, concepts, brackets, and arrows to build a mind map or model of the 4 key concepts in each passage. Participants used the concepts in conjunction with prior knowledge, to illustrate how the concepts could be applied to a personal experience (see Figure 1).

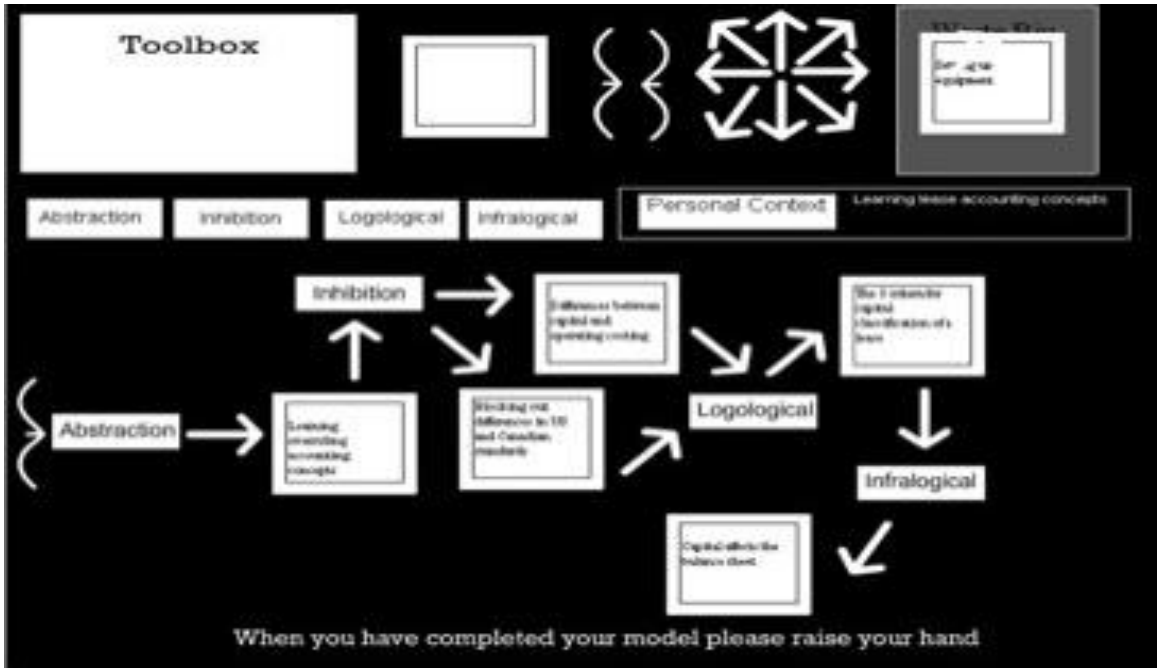

Figure 1. **User interface for model-building group**

Participants completed the model-building exercise using a software program developed for this experiment. Using a rollover technique (i.e., curser was rolled over a specified definition box) definitions for target concepts were provided. Prior to model construction, participants were required to indicate a context from their own experience to which narrated information may apply. It was explicitly required, and consistently adhered to, that participants chose topics not associated with the examples provided during narration. This ensured that model-building, after a spaced interval, required participants to elaborately re-conceptualize information. The intent was for participants to explain with text and objects

how the contents of the narrated passage could be applied within their personal experience. Prior to the first model-building exercise, a five-minute tutorial was provided to explain and demonstrate the task.

The model-building format was chosen because it is similar to concept mapping techniques that were successfully used as elaborative learning techniques in the transfer literature (Biswas, Leelawong, Schwartz, & Vye, 2005). Also, a meta analysis by Nesbit and Adesope (2006) concluded that "[i]n comparison with activities such as reading text passages, attending lectures, and participating in class discussions, concept mapping activities are more effective for attaining knowledge retention and transfer (p. 434).

Free Study. The free study experimental task required participants to study the narrated script in a manner they believed would be most effective. Participants were reminded before each study session that they would be tested on materials. Participants were asked to study scripts until the information was thoroughly committed to memory. Half of the participants were randomly assigned to the model-building group and half to the free study group. Both experimental groups completed a pre-study test consisting of the constructivist theories presented during narration. In addition, participants in the model-building group watched a short demonstration of the model-building task. Next, all participants were instructed to listen carefully to the narrated passage as concepts would be tested. Both experimental groups received the same narrated passages and key concepts. The only difference between the two groups was the required study task. To ensure increasing time intervals between narrated passages and study trials, passage presentation (PP) and study trials (ST) were conducted in the following order; a) PP1; b) ST1; c) PP2; d) PP3; e) ST2; f) 5 minute break; and g) ST3. After all passage presentations and study intervals were completed participants took the terms test and completed the knowledge extension test.

Statistical Measures

Pretest. A 5-item multiple-choice pretest was given to assess prior knowledge of the cognitive theories of abstraction, schematic development, and spaced practice used in this study. Questions were directly related to information provided in the study. No time limit was imposed for any tasks.

Terms Test. Questions on the terms multiple-choice test required participants to match definitions to concepts identified during narration. The terms test contained 12 questions,

four from each passage. Using a recognition-recall test was expected to be the most appropriate means of measuring rote memory.

Knowledge Extension Test. The knowledge extension test presented learners with a convergence problem adapted from Gick and Holyoak (1983). Through the eyes of the main character two analogical stories are presented to the reader. Participants were asked to explain how the character derived meaning from the analogous stories to respond to his current circumstance. Answers were blind coded and participants were awarded 2 points for examples of conceptual transfer between the passage and problem contexts. An additional point was given if correct conceptual terms were used with the implementation of the concept. No point was given for a term if it was used incorrectly or without any direct reference to its use. The intent of this marking structure was to identify instances where information had been transferred to a new context, and to control for definitional reiteration as a result of rote memorization. Participants were given a limit of 250 words to control for answer length and resultant score inflation.

Results

On average, the model-building and free study test scores were below 50%. In total, 5 participants scored higher than 50% on the pre-study test; four participants were in the free study group and one was in the model-building group. No statistically detectable differences on pre-test scores were observed ($F < 1$). Terms test and knowledge extension test scores were reliable [Cronbach $\alpha = .72$ and .87].

To test for between passages terms test score differences, a repeated measures ANOVA was conducted on both the model-building and free study groups between passages 1-3. Results from the model-building scores showed statistically detectable differences between passages [$F(1, 14) = 9.33$, $p = .00$]. A test of simple measures using a Bonferroni correction indicated that there was a significant difference between passages 1-3 ($p < .05$). A repeated measures ANOVA, conducted on free study scores, also showed statistically detectable differences between passages [$F(1, 14) = 6.65$, p , $< .01$]. A simple measures test however showed no significant differences between individual passages.

A second repeated measures ANOVA was conducted on knowledge extension scores for the model-building and free study groups. A statistically detectable difference was found between model-building scores [$F(1, 14) = 9.41$, $p = .00$]. Simple measures tests indicated a

statistically detectable difference between passages 1-3, and 2-3. In contrast to the model-building scores, a statistically detectable difference was not found on knowledge extension scores for the free study group [$F(1, 14) = 1.33$, $p < .27$].

Lastly, *t*-tests were conducted between model-building and free study term test scores for passages 1 ($t(28) = 0.00$, $p = 1$), 2 ($t(28) = 0.61$, $p > .3$), and 3 ($t(28) = 0.59$, $p > .3$). No statistically detectible differences were found between model-building and free study groups on terms test scores. An identical test was also conducted on model-building and free study knowledge extension scores for passages 1 ($t(28) = 0.74$, $p > 3$), 2 ($t(28) = 0.34$, $p > .5$), and 3 ($t(28) = 0.51$, $p > .3$).

Discussion

Schwartz and colleagues advocate for using elaborative exploration and invention based study techniques to improve future learning. However, no clear cognitive explanation has been provided to explain the effectiveness of this phenomenon. In the current study support is provided for the theory of elaborate re-conceptualization. Both free study and model-building groups in this study received identical instruction. Both were given approximately equal time to study newly presented information. Identical experimental designs meant that approximately equal time was provided between narrated passage presentations, study, and testing. As a result, participants were required to use increasingly elaborate retrieval while re-conceptualizing passage concepts in the model-building group. Results indicated that free study participants showed no improvement in the knowledge extension test of transfer. In contrast, participants in the model-building group, who were required to elaborately re-conceptualize passage information, showed a statistically detectable positive trend across passages 1 and 3, and 2 and 3. However, it should be noted that no detectable difference was found between the free study and model-building groups.

The results of the terms test indicate that spaced practice had a positive effect on memory for the model-building group. This finding is consistent with findings in the spaced practice literature. Of greater interest is the lack of spaced practice effect for free study participants on the knowledge extension test. These results suggest that, unless an activity is structured properly, transfer can mitigate spaced practice effects. In contrast, when participants' elaborately re-conceptualized information, increased spacing intervals improve transfer. Specifically, participants were able to evaluate and interact more effectively with new

information (analogical stories). This is consistent with findings by Schwartz and colleagues. However, in contrast with previous findings, in this study solutions were provided to, and not invented by, the learner. This indicates that invented "learner derived" solutions may be less important than elaborate re-conceptualization.

Using the IPL paradigm, this study takes a step toward viewing spaced re-conceptualization as a partial explanation for findings by Schwartz and colleagues. Results indicate that model-building improved learning transfer when spaced intervals, and more specifically, elaborate retrieval afforded re-conceptualizing information. Interestingly, even when participants did not receive additional instruction (e.g., the worked example in the study by Schwartz & Martin) they were still able to transfer information in an SPS testing format. Further research is needed to replicate these results with different learning tasks. Moreover, to parallel studies by Schwartz and Martin, efforts should be made to investigate the effect of elaborate retrieval in a classroom setting. Testing elaborate re-conceptualization in a PFL format will also be necessary to expand the scope of these findings. Lastly, future studies should examine the impact of intra-individual cognition factors, such as motivation, self-regulatory skill, and verbal ability on elaborate re-conceptualization and learning transfer.

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