

SELF-GENERATING QUESTIONS AND CONCEPT MAPPING TO IMPROVE
INFORMATION RETENTION IN THE LONG-TERM

by

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ABSTRACT

Self-generating questions as a study strategy has demonstrated benefits for retaining information in the short-term. However, studies investigating its effects in the long term have been quite limited. Furthermore, concept mapping has been shown to facilitate deeper learning by promoting the organization of information. The present study, therefore, incorporated concept mapping and self-generating questions, in an effort to investigate the effects of elaborative and generative forms of learning on retention of information in the long-term. The effects of both self-generating questions and concept mapping on learning were examined. The interaction between the two learning strategies was also investigated. Results were examined immediately following the intervention and after a delay. The results indicated that concept mapping provided greater benefits for retention in the long term when compared to studying the text, generating questions and the interaction (concept mapping and generating questions).

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CHAPTER I: INTRODUCTION

Overview

Within the field of psychology, there has been a push to further expand the understanding of how the human brain processes novel information and how that information is then committed to memory (Brown, Roediger & McDaniel, 2014). The interest in understating the process of learning, has also lead to an interest in understanding the ways in which learning can be maximized in the long term. Over the years, this focus has contributed to the investigation of different learning techniques, beginning with understanding how students in the classroom study and then investigating ways in which study skills can be improved to better promote learning. Some of the more common areas of research include re-reading materials, self-generating questions, answering question, and concept mapping, a learning technique that has more recently risen in interest (e.g. Bugg & McDaniel, 2012; Callender & McDaniel, 2009; Chang, Sung, & Chen, 2002; Weinstein, McDermott, & Roediger, 2010). The following sections will address the above topics in depth and provide an overview of the purpose of the current study.

Basics of Learning

In order to understand the benefits as well as the disadvantages that can stem from different learning techniques, it is imperative to first understand the way in which humans' process and categorize information as they learn. The process of learning begins with encoding (Brown et al., 2014). The authors define encoding as the process by which sensations perceived in the environment are translated in the brain to form mental representations. The process of encoding is followed by the process of consolidation,

whereby the brain elaborates on the mental representation in preparation for storage in long term memory. The authors further elaborate that the brain performs the consolidation process by strengthening the mental representations generated in encoding through deep processing, forming connections between existing information, and providing meaning to the recently processed information. Once the information has been encoded and consolidated from short-term memory into long-term memory, the information is then linked to memory cues, so retrieval can take place.

While encoding and consolidating information are both important to the overall learning process, the ability to then retrieve or recall the information is perhaps the most key element of the learning process (Brown et al., 2014). In order for comprehensive learning to take place, the process of linking information to cues and then retrieving that information must be effortful. Effortful learning takes place in spaced practice intervals, which requires the learner to reconstruct the information from long-term memory. The spaced practicing involved with effortful learning allows for forgetting to take place, which in turn strengthens the cues needed for fast retrieval and learning by requiring the reconstruction of knowledge and thus a deeper learning of the information (Melton, 1963). Perhaps, one of the most beneficial elements of effortful learning is that it requires the learner to expand upon the information presented, a process which increases the effort and thus the comprehension of information (Brown et al., 2014). Two theories of effortful learning are key to furthering the understanding of how retention and thus learning can be maximized, the first is generation and the second is elaboration.

Generation is a learning strategy that requires the learner to solve or answer the problem provided to them in lieu of having the solutions presented to them (Brown et al.,

2014). The extra effort that is required in having to develop the answers allows for a higher order of connection to take place. These stronger connections that are formed, stem from the learner having to search for the solution which strengthens the divides in the learner's memory and thus creates connections that assist in filling these gaps. This differs slightly from elaboration, which focuses more on adding meaning to the new material by connecting that material to information that is already known to the learner. Lehman, Smith & Karpicke (2014) emphasizes that elaboration also encourages the learner to present the novel information in their own words. Essentially, elaboration focuses on taking the concepts that are already known and using that knowledge to draw connections with new material that then allows the learner to create a web of knowledge that strengthens the learners mental models of the material and assists in the increasing long term retention of that material (Lehman et al., 2014).

One of the essential goals of both generation and elaboration, and perhaps a main goal of examining the learning process in general, is to understand and maximize how we process information in the hopes of reducing the loss of information, or forgetting (Brown et al., 2014). This stems from the fact, that in order to fully understand ways in which learning can be maximized, we must also understand why we forget and at what intervals we forget. According to research, most forgetting takes place within 30 days (Murre & Dros, 2015). It is after this period that true comprehension of the given material is reached, with any information retained being considered knowledge. Therefore, since forgetting is a natural element in the learning process, the focus of research shifts to how to maximize comprehension in learners to ensure that information is retained long enough to be converted into true understanding.

The Limited Benefits of Rereading

One of the methods used to enhance comprehension and reduce forgetting is re-reading the information presented. This is one of the most common forms of studying that students engage in, with one survey reporting that out of 170 students, 84% stated that they engage in this form of studying and 55% reporting it as their most frequently used study strategy (Karpicke, Butler, & Roediger, 2009). While this is perhaps one of the most frequently used studying methods, the results that stem from engaging in it are relatively limited. As discussed earlier, one of the key elements of strengthening comprehension is partaking in effortful learning and text elaboration. Lack of learner elaboration in relation to the given information is one of the main argued deficiencies of re-reading as a study strategy. In fact, it has been presented in several theories that students that strictly read the text often fail to build the necessary connections required to construct inferences on the text they are reading (Noordman, Vonk, & Kempff, 1992). Perhaps in the current context this is best explained through the theoretical view of material appropriate difficulty (MAD) (McDaniel & Einstein, 2005).

Material appropriate difficulty theory. MAD theory argues that re-reading does not promote the learner to expand upon the information they are reading, but rather that strictly reading limits the processing of information to merely what is presented in the text itself (McDaniel & Einstein, 2005). This theory further proposes that a reader will not engage with a given text, unless it is elicited via an external factor such as a study prompt. Therefore, rereading does not evoke processing on a level conducive to drawing theoretical connections surrounding the text, but rather promotes a mental model construction that is limited to what is strictly provided in the text itself. In essence, MAD

theory presents the idea that reading does not promote the reader to engage in effortful learning, in which comprehensive learning connections are built. The MAD theory was explored in a study conducted by Callender and McDaniel (2009), in which participants were tested on comprehension after reading a passage once in comparison to reading a passage twice. The study tested participants on both multiple-choice questions and on short answer application questions over the course of four separate experiments. The first experiment resulted in a non-significant benefit between reading the passage a second time. Further, a follow up experiment in which counterbalancing, participants read one passage once and one passage twice, yielded results that indicated that rereading was only slightly beneficial on multiple choice questions, but displayed no significant effect on application questions. These results held true across both experiment three and experiment four, in which generally less familiar texts were presented and reading ability and a delay between the re-reading and testing were manipulated, respectfully.

The lack of significant benefit that stems from re-reading coupled with its prevalence as a main study strategy among students has led to the exploration of other, more constructive study strategies that require a higher degree of effortful learning and thus are reported to result in a higher level of comprehension.

Self-Generated Questions

One such study strategy that has been examined as a method for improving comprehension performance is self-generating questions (Bugg & McDaniel, 2012). The idea that self-generating questions can improve recall comprehension is mainly attributed to the generation effect, in which information generating individuals are able to comprehend and recall information more effectively. This perhaps can be attributed to the

fact that generating questions from presented information requires the learner to engage in effortful learning, which as outlined earlier, has been linked to improvements in understanding and recalling conceptual information in the long term.

Within the realm of self-generating questions, an important element of the learning strategy is determining which types of questions are needed to be generated in order for comprehension to be improved. Bugg and McDaniel (2012) examined self-generating and answering questions. They divided the types of questions generated into two distinct categories: (a) detailed questions focusing on facts from the provided text; and (b) conceptual questions focusing on linking concepts across the text. When examined, the results indicated that participants that generated and answered detailed questions did not differ in score level from those that simply reread the text; however, those that generated and answered conceptual questions performed significantly better on the conceptual questions than the other two study strategies. These results indicate that when generating questions, linking concepts across the text can lead to a higher level of comprehension. These results further support the claim that the more effort required in processing information, the more likely comprehension of that information is to increase.

Weinstein et al., (2010) also examined the self-generation effect by exploring the comparison between rereading, answering questions, and generating questions on recall performance in a series of three experiments. These experiments focused on comparing results on tests scores at 2 interval points, 15 minutes post intervention and two days post intervention. Furthermore, this study focused on determining if there was a benefit to strictly answering questions pre-generated by researchers, or if having participants generate their own questions led to higher levels of comprehension. Results indicated that

while both answering questions and generating questions resulted in higher comprehension than rereading, there was no significant difference in scores between those that strictly answered questions and those that strictly generated questions in the 15 minute interval. While those that generated questions did score numerically higher than those that strictly answered questions in the two-day interval, those results were not significant and therefore the conclusion was drawn that there is not a benefit in having students generate their own questions in comparison to having them answer questions created for them. These results appear to contradict to some extent the idea that the higher the effort contributed in the learning process, the more likely information will be comprehended and recalled at a later time. However, this study did not examine the effect that self-generation can have on long term retention, or 30 days post intervention, and listed examining individual differences, such as cognitive ability, as an area for future research.

Concept Mapping

As discussed earlier, elaboration, or learning new material through the use of forming connections with prior knowledge, is one of the main ways in which long term retention of information can be developed (Brown et al., 2014). One study strategy that employs the use of elaboration, is concept mapping. Concept mapping, at its root, is recognized as a manner by which learners can link cognitive structures of past knowledge with novel information in an organized and visual manner (e.g. Akinsanya & Williams, 2004; Novak & Gowin, 1984). In order to fully understand how concept mapping can benefit learners, a brief explanation of what a concept map is, is necessary. A concept map consists of nodes that serve as essential concepts and then lines linking those nodes

that define the relationship among concepts (Fiorella & Mayer, 2015). In recent years, concept mapping has been investigated as a study strategy designed to assist students in not only organizing and visualizing information, but also in improving comprehension.

Chang and colleagues (2002) explored concept mapping by examining the learning across participants that completed partially complete concept maps, corrected incorrect concept maps, and created concept maps. Results indicated that completing concept maps was beneficial for enhancing participant's ability to summarize material; however, it was the map correction condition that provided the most benefit to participant comprehension. Ironically, creating the concept map itself demonstrated the least amount of benefit for the learner. A possible explanation for this result was proposed by Katayama and Robinson, (2000) who noted that creating the map itself can lead to cognitive overload. They further supported this claim, by reasoning that other methods of working with concept maps, such as completing the map or correcting the map, can show a higher benefit in comparison. Fiorella and Meyer, (2016) also provided information that student training on how to develop concept maps is essential in learning how to effectively build spatial representations. There is little evidence however, outlining the impact concept mapping can have when combined with other forms of generative and elaborative study techniques and the majority of information on this subject has not focused on examining concept mapping in the long term. Chang et al., (2002) explored concept mapping by examining the learning across participants that completed partially complete concept maps, corrected incorrect concept maps, and created concept maps. Results indicated that completing concept maps was beneficial for enhancing

participant's ability to summarize material; however, it was the map correction condition that provided the most benefit to participant comprehension.

Purpose of the Current Study

The present study built off the methods presented by Weinstein et al., (2010) with a focus on examining the impact that self-generating questions would have on long term retention. This entailed increasing the 2-day retention interval to 2 to 3 weeks to measure retention across a typical forgetting curve of 30 days. Much of the research in this area has focused on short-term retention intervals; however, the current study expanded upon those intervals substantially to determine whether generative and elaborative study techniques truly benefit comprehensive learning in the long term. Scores were compared to determine the level of forgetting that took place based on assigned condition. The present study also focused on encouraging participants to develop strictly conceptual questions that engaged the participant in linking concepts across the text. This focus on linking concepts was also emphasized by the addition of concept mapping, as a study strategy condition.

The current study employed a 2x2 experimental design. The four conditions that were employed in the present study included: (a) study only, (b) self-generate questions, (c) fill in a concept map, (d) self-generate questions and fill in a concept map. The present study also included the added element of examining participant pre-intervention reading level utilizing participant ACT Scores, to determine if elaborative and generative study strategies had a higher impact on high-performing students when compared to the mean of test scores across participants.

Hypothesis 1. There would be a positive effect of self-generating questions on learning and retention scores, such that scores would be higher for participants that generate questions.

Hypothesis 2. There would be positive effect of concept mapping on learning and retention scores, such that scores would be higher for participants that fill in concept maps.

Hypothesis 3. Self-generating questions and concept mapping would have a positive interaction, such that the effect is stronger when a concept map is used and weaker when a concept map is not used.

Hypothesis 4. Self-generating questions, concept mapping and reading ability would have a positive interaction, such that participants that have a high reading ability and engage in both tasks would have higher retention scores than those that have a low reading ability.

CHAPTER II: METHODOLOGY

Participants

The pool of participants consisted of undergraduate students enrolled in general psychology classes at a large southeastern university during the Fall of 2017. Participants elected to participate in the study as an extra credit opportunity in their classes. The experiment consisted of two phases, both of which took place in a classroom setting. The first phase required participants to first read a passage and then engage in a designated study task followed by a recall tests. The second phase was a final test that took place 2 to 3 weeks post intervention. Participants were divided into four conditions (study, self-generate questions, fill in concept map, self-generate questions and fill in concept map) prior to beginning phase one.

Materials and Measures

Participants completed a practice reading task that consisted of a passage adapted from Wikipedia pages on the Taj Mahal (Appendix A). They then completed the experimental reading task that consisted of a passage adapted from Wikipedia pages on Salvador Dali (Appendix B). The passages consisted of approximately 575 words. Both the practice passage and the experimental packet contained further materials based on condition such as a lined sheet for generating questions (Appendix C) or a fill in the blank concept map (Appendix D & Appendix E). The retention tests consisted of 16 questions from the Salvador Dali passage in a multiple-choice format and question order varied from test 1 to test 2. Scoring was determined by adding one point for each correct answer and adding zero points for each incorrect answer, for a maximum score of 16 and a minimum score of 0. The score of the initial retention test (test 1) compared to the score

of the final retention test (test 2) 2 to 3 weeks later served as a measure of the knowledge retention. Test 1 (Appendix F) and its accompanying rubric (Appendix G) as well as Test 2 (Appendix H) and its scoring rubric (Appendix I) were adapted from McDermott and Roediger (2010). An instruction sheet was also developed and used when proctoring the study (Appendix J). Learning ability was measured with the ACT reading subject test scores obtained from the school by the faculty advisor on this study.

Procedure

Before data collection began, approval for the study was given by the Institutional Review Board at Middle Tennessee State University (Appendix K). Approximately 3 to 4 weeks before the experiment, students in psychology classes were informed by their instructors of the extra credit opportunity of participating in this study. A sign-up sheet for the study with time slots was given to students to sign up for the experiment. An approved consent sheet was signed by all students prior to the beginning of the experiment.

The procedures for this experiment are adapted from Weinstein et al., (2010) and the experiment took place in a classroom setting. In phase one of this study participants were randomly divided into the four conditions and all participants were provided with detailed instructions on the processes and the nature of the study (Appendix J). These instructions directed participants to read their provided passage and perform a designated study task. Following the completion of reading the passage and performing the task dependent upon their condition, all participants completed a comprehension test (test 1) of the assigned passage and were reminded to return in two to three weeks to complete the final test (test 2) as part of phase two of this study.

Phase one. Participants in the study only condition (Condition 1) were instructed to read a passage and then study that passage before participating in the comprehension test and returning 2 to 3 weeks later to participate in the final test.

Participants in the generate questions condition (Condition 2) were instructed to read each passage and generate eight questions for that passage before participating in the comprehension test and returning 2 to 3 weeks later to participate in the final test.

Participants in the concept mapping condition (Condition 3) were instructed to read a passage and fill in a partially completed concept map for that passage before participating in the comprehension test and returning 2 to 3 weeks later to participate in the final test.

Participants in the concept mapping plus generate questions condition (Condition 4) were instructed to read a passage, generate questions for that passage and fill in a concept map for that passage before participating in the comprehension test and returning 2 to 3 weeks later to participate in the final test.

The experiment began by having the participant read and sign a consent form, it was during this time that participants were also given instructions on the logistics of the study. After this was completed, participants engaged in a practice phase, which allowed them to familiarize themselves with the format of the passage, generating questions, and concept mapping.

During the practice phase of the experiment, participants were given a practice scenario based on the condition they had been assigned. The packet provided contained the practice passage and the materials necessary to complete the given task. Participants

were instructed to read and work at their own pace. After the practice phase was completed, participants returned the packet to the researcher and the experiment began.

Participants were then given their passage and accompanying materials based on condition. If participants were assigned to the study condition, participants were instructed to study the passage by re-reading and were provided with scratch paper to study in any manner of their choosing. For the self-generate condition, participants were given a lined sheet of paper and asked to generate eight questions. If the participants were instructed to fill in a concept map, participants were given a partially completed concept map that they were instructed to fill in. Participants were not given a time restraint for the conditions; however, time taken was documented.

Phase two. The final test was administered approximately 2 to 3 weeks post completion of the intervention. The post intervention comprehension test (test 2) consisted of sixteen questions that were randomized from the first test. The test was administered by the researcher during the beginning or end of class time during the allotted time for the participating classes. Participants were asked to sign a consent form prior to taking the final test. Following the completion of the final test, participants were debriefed on the study, including its conditions.

CHAPTER III: RESULTS

Preliminary Analyses

The total sample size was 78 participants; however, four participants did not return for part 2 of the study and their information was therefore not used in the analyses. This led to a sample size of 74 participants with $n = 20$ in condition one, $n = 18$ in condition two, $n = 19$ in condition three, and $n = 17$ in condition four. ACT Reading scores were obtained by the faculty advisor for this study through the university database. ACT scores were unavailable for some students, so scores were collected for 47 of the 74 participants. After data collection, the researcher scored the two comprehension tests using the rubrics found in Appendix G and Appendix I. Participants' scores were entered in Microsoft Excel and then imported into SPSS, where all data analyses were conducted. A two-tailed alpha level of .05 was used for all analyses.

Table 1 shows the descriptive statistics for the two comprehension tests. Each test had the same 16 items and answer choices, but in a different form. The minimum and maximum amount of points a respondent could have received were 0 and 16 points, respectively. Participants received 1 point for every correct answer and were given 0 points for every incorrect answer. See Appendix F and Appendix H for the comprehension tests.

Table 1
Descriptive statistics for comprehension tests

	<i>N</i>	Minimum	Maximum	μ	<i>SD</i>
Test 1	74	7	16	14.00	2.09
Test 2	74	5	16	11.01	2.64

To determine reliabilities for the two comprehension tests, answer choices were coded as 1 for correct and 2 for incorrect. This method of coding was selected as all questions consisted of four answer choices of which there was only one correct answer and three incorrect answers. The reliability coefficients for each of the 2 tests is summarized in Table 2 below.

Table 2
Cronbach's alpha for each comprehension test

	Number of items	Coefficient α
Test 1	16	0.66
Test 2	16	0.55

Primary Analyses

Hypothesis 1 stated that there would be a positive effect of self-generating questions on learning and retention scores for the comprehension tests, such that scores would be higher for those that self-generated questions. Hypothesis 2 stated that concept mapping would have a positive effect on learning and retention scores, such that scores would be higher for participants that developed concept maps. Further, Hypothesis 3 stated that learning and retention scores would be higher when there was an interaction between self-generating questions and concept mapping. As such, this hypothesis suggested that adding concept mapping to self-generating questions would lead to a higher score on the comprehension test in the long term than when a concept map was not

developed. For these hypotheses, One-Way ANOVAs were conducted with the independent variable being the conditions and the dependent variable being learning. Learning was looked at in both the short term (test 1) and the long term (test 2).

Because the sample sizes in each condition were unequal, the SPSS mixed procedure was used to conduct Sidak pairwise comparison analyses to see if there was a significant difference in test 2 scores based on whether participants generated questions, concept mapped, or both generated questions and concept mapped. Results indicated that there was a significant difference between participants that concept mapped and participants that did not concept map, $F(1, 64.75) = 5.94, p = .018$, with those that concept mapped having a higher retention score on test 2. There was no significant difference between those that did not generate questions and those that did generate questions, $F(1, 64.75) = 0.11, p = .74$. There was also not a significant difference between those that generated questions and concept mapped and those that did not, $F(1, 64.75) = 0.68, p = .41$. Therefore, Hypothesis 2 was supported and Hypotheses 1 and 3 were not supported. See table 3 for descriptive statistics on these analyses.

A One-Way ANOVA investigating the effect of study condition on learning in the short term was also investigated. The results indicated that there were significant differences between groups, $F(3, 70) = 7.65, p < .001$. Post hoc comparisons using Games-Howell were conducted and revealed that test 1 scores were significantly higher when a participant concept mapped in comparison to solely studying the content $F(3, 70) = 7.65, p = .007$. Results also indicated that there was a significant difference when a participant concept mapped instead of generated questions, $F(3, 70) = 7.65, p = .005$. Finally, results indicated that there were significant differences found when a participant

generated questions and concept mapped over studying, $F(3, 70) = 7.65, p = .08$ and over generating questions, $F(3, 70) = 7.65, p = .08$. There was no significant difference in test one scores between participants that concept mapped and generated questions and those that just concept mapped, $F(3, 70) = 7.65, p = .59$. See table 3 for descriptive statistics on these analyses.

Table 3
Descriptive statistics for test score by condition

Condition	Test	<i>n</i>	<i>M</i>	95% <i>CI</i>	
				Lower Bound	Upper Bound
Control	Test 1	20	13.45	12.51	14.39
	Test 2	20	10.15	8.88	11.42
Generating Questions	Test 1	18	12.61	11.26	13.97
	Test 2	18	10.44	8.97	11.91
Mapping	Test 1	19	15.21	14.80	15.62
	Test 2	19	12.11	11.12	13.09
Generating Questions*Mapping	Test 1	17	14.76	14.15	15.38
	Test 2	17	11.41	13.52	14.48

Hypothesis 4 stated that self-generating questions, concept mapping, and reading ability would have a positive interaction, such that participants that had a high reading ability and engage in both tasks would have higher retention scores than those that had a higher reading ability and did not engage in both tasks. In order to investigate this hypothesis a One-Way ANCOVA was performed with concept mapping serving as a

fixed factor and ACT reading scores serving as the covariate. The relationship between ACT reading scores and test 2 performance was explored using polynomial regression prior to its inclusion in the ANCOVA analysis. Both the linear test, $t(44) = 1.26, p = .25$, and the quadratic test were not significant, $t(44) = -1.72, p = .25$. Due to this non-significance, no further analyses were required. Therefore, Hypothesis 4 was not supported.

CHAPTER IV: DISCUSSION

Summary of Findings

The purpose of the current study was to explore whether engaging in generative forms of learning, generating questions, increased the retention of information in the long term. Concept mapping was added to the process to see if elaborative forms of learning enhanced the generative learning. Hypotheses 1, 3, and 4 were not supported. There was no main effect for generating questions on learning and the interaction between generating questions and concept mapping was not significant. Concept mapping did, however, have a main effect on learning and retention scores in the long term, supporting Hypothesis 2.

There are several possible reasons for the lack of significance for Hypothesis 1, 3 and 4. To begin with, this was a small sample size that could have led to significance not being detected and it is possible that a study with greater power could have achieved statistically significant results. Also, there was no motivation for participants to perform well on the retention test as their performance on the test did not have an impact on the participants' grades or other personal outcomes. The fact that participants that generated questions were allowed to use the materials to generate questions without direction could have implications on the quality of questions generated. It is possible that students generated more fact or detailed based questions which were found to have non-significant results instead of developing conceptual questions which demonstrated significant results in a previous study (Bugg & McDaniel, 2012).

The significance of Hypothesis 2 can have great implications, especially given the small sample size and low power. This suggests there is a learning advantage when

individuals develop concept maps, as consistent with past research. It is important to note that interestingly while concept mapping was significant on its own, concept mapping with generating questions was not significant. It is also interesting that generating questions while significant in the short-term (test 1) was not significant in the long-term (test 2). The significance being limited exclusively to concept mapping in the long term when all forms of elaborative learning were significant in the short term indicates that concept mapping is impacting long-term retention in a manner that generating questions is not. The reason for why concept mapping was significant and generating questions was not, even when concept mapping was used in conjunction with generating questions, cannot, however, be determined.

Limitations and Future Directions

While yielding important insights, the present study has a number of limitations. Due to the nature of a two-part study, attrition was a factor. The sample size for this study was also quite small due to time requirements that limited the number of participants that could complete the study. Due to time restraints participants were measured at 2 and 3 weeks post intervention, which placed the retention interval at less than the 30-day forgetting curve (Murre & Dros, 2015). While this was still a longer retention interval than previous studies, future studies should investigate if the results of this study are maintained at 30 days.

While significance was found, it is also important to note that the reliabilities of the two comprehension tests were low for psychological standards. The low reliabilities could be attributed to inadequate measures of retention; however, it should be highlighted that the reliability for test 2 (.55) was much lower than that of test 1 (.66) which was

close to meeting accepted psychological standards. The low reliabilities could also be attributed to difficulty in the questions. For example, in test 2, 56% of participants missed the question “What was the profession of Salvador Dalí’s acquaintance Paul Laszlo?” The correct answer was that he was “architect”; however, since a political leader was also mentioned in the passage this was a common incorrect answer. Another commonly missed question was “What political philosophy did Salvador Dalí embrace?”; 54% of participants did not select the correct answer, which was “both a and b”. All other questions did have a more normal distribution of incorrect and correct answers.

As discussed earlier, participants were not provided with training on how to best develop conceptual questions, which has been shown to improve long term retention (Bugg & McDaniel, 2012). Since the concept maps were fill in the blank, they provided participants with a base that directed participants to draw connections on a conceptual level. Future studies should examine if providing participants with conceptual type questions as examples would yield similar results to concept mapping. Further, future studies should focus on concept mapping and generating questions utilizing more complex texts. The text that was provided in this study was short and being biographical in nature was more fact based. As generating questions and concept mapping have been shown to have more significant results with conceptual information, it would be interesting to see if effects would be stronger for information that is more challenging and disorganized in nature.

Finally, now that research has found that concept mapping is effective for retaining information over a long period of time, research should further investigate the interaction between concept mapping and generating questions. Specifically, the reason

as to why generating questions was significant in retaining information in the short-term (test 1), but not in the long term (test 2). Additionally, research into the reasons as to why there was no significance on long term retention when concept mapping and generating questions were both utilized by participants provides further avenues for research.

Conclusion

Though not fully understood, concept mapping has displayed its usefulness in increasing the retention of information in the long term. This research provided greater insights into the difference in retention that can stem from both generative and elaborative forms of learning, with main effects for concept mapping being significant. The significance of concept mapping in comparison to generating questions has opened the door to further research in the differences between the two forms of learning. It is important to note however, that the limitations of the present study may have prevented the benefits of generating questions from appearing. As most concept mapping research has focused on science texts, the use of a biographical text has furthered the research of concept mapping into other subjects; however, future concept mapping research should expand into other educational areas and settings including job training. Though more research is required, further developments could have great implications for understanding how to maximize elaborative forms of learning.

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APPENDICES

APPENDIX A: PRACTICE PASSAGE

TAJ MAHAL

The Taj Mahal is a monument located in Agra, India, that was constructed in the twenty-two years between 1631-1653 by a workforce of twenty-two thousand. It is one of the finest examples of the Mughal architectural style. The Emperor Shah Jahan used his vast wealth to commission the construction of the Taj Mahal as a mausoleum for his favorite wife, Mumtaz Mahal, who died during childbirth. The total cost of the Taj Mahal's construction was about fifty million rupees, which would translate to more than five-hundred million dollars. While the white domed marble mausoleum is the most familiar part of the monument, the Taj Mahal is actually an integrated complex of structures that includes elements of Persian architecture. The monument has achieved special importance in Indian culture because of the romance of its inspiration.

Part of this romantic inspiration is that the Taj Mahal was built to be perfectly symmetrical throughout the entire set of structures. From the number of bushes and trees planted to the width of the sidewalks and ponds, everything seems to be a mirror image. Since four is a holy number in Islam, everything was planned in quadrants to ensure symmetry, such as the number of flowerbeds (sixteen) and flowers planted within them (four-hundred). Another example is the tomb of Mumtaz Mahal, a symmetrical building with an "iwan", an arch-shaped doorway, topped by a large dome. The base of the tomb is a cube with the coffin of the empress was placed in the exact center. Interestingly, Shah Jehan's son introduced a flaw into the design when he later made the choice to place his father's tomb next to his mother, squeezing his coffin in beside hers.

By the late 19th century parts of the Taj Mahal had fallen badly into disrepair after decades of poor maintenance. In addition, during the early British Colonial era, the monument was damaged by looting, such as people chiseling out precious stones and lapis lazuli from its walls. Around 1900, British viceroy Lord Curzon ordered a massive restoration project, marking the beginning of a new period in which the Taj Mahal has been better maintained. More recently, the white marble domes of the Taj Mahal have been discolored by acid rain caused by emissions from the nearby Mathura oil refinery and automobiles. After the monument was designated a UNESCO World Heritage Site in 1983, a major movement began in Agra to limit the air pollution close to the monument, including restricting the number of motor vehicles. Today the Taj Mahal continues to be a major tourist destination, attracting people from all over the world.

APPENDIX B: TEST PASSAGE

SALVADOR DALI

Salvador Felipe Jacinto Dalí, known popularly as Salvador Dalí, was a Spanish artist. One of the most important painters of the 20th century, he created some of the most widely recognized images that came out of the Surrealist movement in the visual arts. His best-known work, *The Persistence of Memory*, was completed in 1931, while he was living in the Montparnasse quarter of Paris. In this famous piece, Dalí introduced the image of the soft, melting pocket watch in an attempt to debunk the assumption that time is rigid or deterministic. Dalí wanted to express pure psychic automatism, the real functioning of thought in the absence of all control exercised by reason. His paintings are easily identified by their striking, bizarre, and dreamlike images.

Before he became a renowned artist, Dalí grew up in the town of Figueres in the Catalonia region of Spain with parents who were strict disciplinarians, but also very unconventional. As a result, his childhood was rather unusual and marked by unique events that would shape his personality. For example, Dalí's parents treated him as though he was the reincarnation of his older brother, also named Salvador, who had died of meningitis prior to the artist's birth. As he grew into adulthood, Dalí developed an affinity for doing unusual things to draw attention to himself. He grew a giant, pencil-thin moustache, which became iconic of him, and often wore flamboyant outfits, including a purple cape and cane. An artist of great imagination, Dalí's behavior sometimes irked those who loved his art as much as it annoyed his critics, since his eccentric manner sometimes drew more public attention than his artwork

During the middle period of career, the politics of Salvador Dalí played a significant role in his emergence as a successful artist. In his youth, Dalí embraced for a time both anarchism and communism, but eventually became a supporter of Francisco Franco's fascist regime. Some of Dalí's public statements supported the repression enacted under Franco's reign and praised Franco for signing death warrants for political prisoners. Still, it is impossible to determine whether his tributes to Franco were sincere or whimsical. Indeed, some of Dalí's private actions signal that his views were somewhat different. He continued praise of Federico García Lorca even in the years when Lorca's works were banned and he was a friendly acquaintance of famed architect and designer Paul Laszlo, who was ethnically Jewish.

Late in his career, Dalí did not confine himself to painting but experimented with many unusual or novel media and processes. In 1960, Dalí began work on the Dalí Theatre and Museum in his hometown of Figueres, a project that would not be completed until 1974. He also spent much of his time with his wife and muse, Gala, whom he had married in 1934, before her sudden death in 1982. The final years of Dalí's life were marked by two possible suicide attempts, first in 1983 when he deliberately dehydrated himself and then in 1984 when a fire broke out in his bedroom under unclear circumstances. After these events, Dalí was rescued by a group of his friends who saw to it that he was comfortable living in his Theater-Museum for his final years. He died of heart failure at Figueres on January 23, 1989 at the age of 84.

APPENDIX C: GENERATE QUESTIONS SHEET

Using the lines below, please generate eight test questions using the provided passage.

1. _____

2. _____

3. _____

4. _____

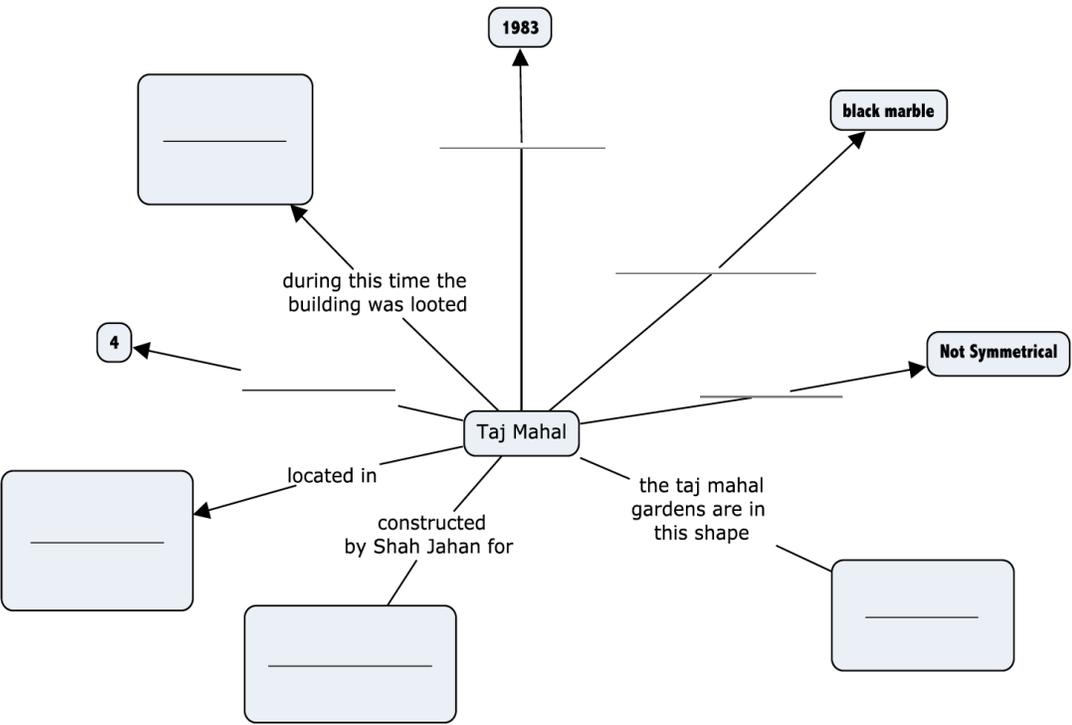
5. _____

6. _____

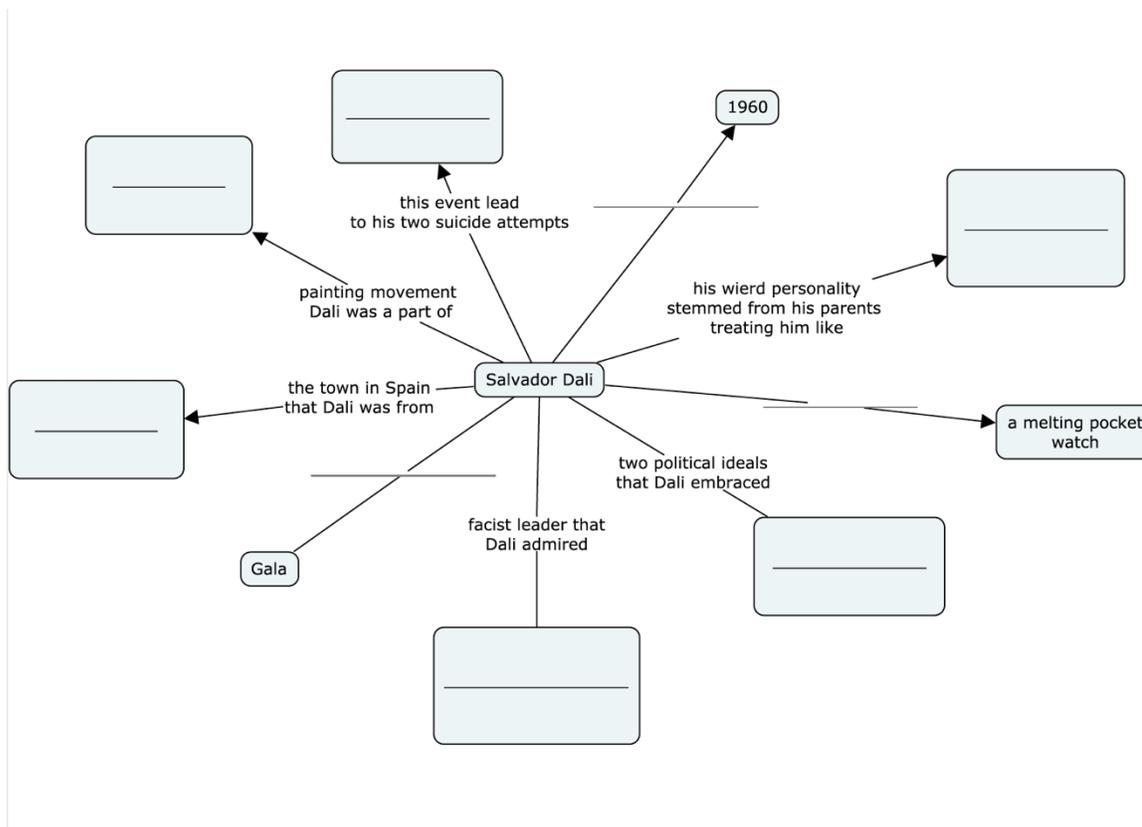
7. _____

8. _____

APPENDIX D: INCOMPLETE PRACTICE CONCEPT MAP



APPENDIX E: INCOMPLETE TEST CONCEPT MAP



APPENDIX F: TEST 1

Please answer the following questions to the best of your ability.

1. What painting movement was Dalí a part of?
 - a. Impressionism
 - b. Expressionism
 - c. Romanticism
 - d. Surrealism

2. What is the name of Salvador Dalí's best known work?
 - a. *The Elephants*
 - b. *The Burning Giraffe*
 - c. *The Persistence of Memory*
 - d. *The Son of Man*

3. Salvador Dalí's brother passed away due to what illness?
 - a. Meningitis
 - b. Pneumonia
 - c. Tuberculosis
 - d. His brother died from an accident

4. Salvador Dalí died in 1989 in what Spanish town?
 - a. Barcelona
 - b. Madrid
 - c. Figueres
 - d. Malaga

5. What was the profession of Salvador Dalí's acquaintance Paul Laszlo?
 - a. political leader
 - b. author
 - c. architect
 - d. photographer

6. Francisco Franco was a leader in Spain under what form of political regime?
 - a. Communism
 - b. Socialism
 - c. Anarchism
 - d. Fascism

7. What was the name of Dalí's wife?
 - a. Maria
 - b. Gala
 - c. Anna
 - d. Isabella

8. Why did Salvador Dalí's paint a melting pocket watch?
 - a. There is no meaning behind the pocket watch melting
 - b. To symbolize how time slips away
 - c. To debunk the assumption that time is rigid or deterministic
 - d. To portray a dream like state

9. Salvador Dalí's images were a part of what artistic movement?
 - a. Expressionism
 - b. Impressionism
 - c. Surrealism
 - d. Romanticism

10. What city in Spain was Salvador Dalí from?
 - a. Barcelona
 - b. Madrid
 - c. Figueres
 - d. Seville

11. Which Spanish political leader did Salvador Dalí openly support?
 - a. Francisco Franco
 - b. Federico García Lorca
 - c. Paul Laszlo
 - d. Mariano Rajoy

12. What was Salvador Dalí's main muse?
- a. His wife
 - b. His parents
 - c. His friends
 - d. All of the above
13. Salvador Dalí's painting *The Persistence of Memory* is an image of what?
- a. His wife
 - b. A bird
 - c. A purple cane
 - d. A pocket watch
14. In what way were Salvador Dalí's parents unconventional?
- a. they made him wear flamboyant clothes
 - b. they treated him like his dead brother
 - c. he was forced to draw a moustache on his face
 - d. both a and c
15. What political philosophy did Salvador Dalí embrace?
- a. Anarchism
 - b. Communism
 - c. Socialism
 - d. Both a and b
16. How many times did Salvador Dalí attempt to commit suicide?
- a. Two
 - b. One
 - c. Three
 - d. He never attempted suicide

APPENDIX G: TEST 1 SCORING RUBRIC

Question 1 correct answer: A

Question 2 correct answer: C

Question 3 correct answer: A

Question 4 correct answers: C

Question 5 correct answers: C

Question 6 correct answer: D

Question 7 correct answer: C

Question 8 correct answer: A

Question 9 correct answer: B

Question 10 correct answer: C

Question 11 correct answer: C

Question 12 correct answer: A

Question 13 correct answer: D

Question 14 correct answer: B

Question 15 correct answer: D

Question 16 correct answer: A

Scoring: 1 point per correct answer chosen and 0 points for every incorrect answer
chosen

Number of possible points: 16

APPENDIX H: TEST 2

Please answer the following questions to the best of your ability.

1. What is the name of Salvador Dalí's best known work?
 - a. *The Elephants*
 - b. *The Burning Giraffe*
 - c. *The Persistence of Memory*
 - d. *The Son of Man*

2. Which Spanish political leader did Salvador Dalí openly support?
 - a. Francisco Franco
 - b. Federico García Lorca
 - c. Paul Laszlo
 - d. Mariano Rajoy

3. Salvador Dalí died in 1989 in what Spanish town?
 - a. Barcelona
 - b. Madrid
 - c. Figueres
 - d. Malaga

4. What was Salvador Dalí's main muse?
 - a. His wife
 - b. His parents
 - c. His friends
 - d. All of the above

5. What painting movement was Dalí a part of?
 - a. Impressionism
 - b. Expressionism
 - c. Romanticism
 - d. Surrealism

6. Francisco Franco was a leader in Spain under what form of political regime?
 - a. Communism
 - b. Socialism
 - c. Anarchism
 - d. Fascism

7. What was the name of Dalí's wife?
 - a. Maria
 - b. Gala
 - c. Anna
 - d. Isabella

8. Why did Salvador Dalí's paint a melting pocket watch?
 - a. There is no meaning behind the pocket watch melting
 - b. To symbolize how time slips away
 - c. To debunk the assumption that time is rigid or deterministic
 - d. To portray a dream like state

9. Salvador Dalí's images were a part of what artistic movement?
 - a. Expressionism
 - b. Impressionism
 - c. Surrealism
 - d. Romanticism

10. What city in Spain was Salvador Dalí from?
 - a. Barcelona
 - b. Madrid
 - c. Figueres
 - d. Seville

11. Salvador Dalí's brother passed away due to what illness?
 - a. Meningitis
 - b. Pneumonia
 - c. Tuberculosis
 - d. His brother died from an accident

12. What political philosophy did Salvador Dalí embrace?
- Anarchism
 - Communism
 - Socialism
 - Both a and b
13. In what way were Salvador Dalí's parents unconventional?
- the made him wear flamboyant clothes
 - they treated him like his dead brother
 - he was forced to draw a moustache on this face
 - both a and c
14. How many times did Salvador Dalí attempt to commit suicide?
- Two
 - One
 - Three
 - He never attempted suicide
15. Salvador Dalí's painting *The Persistence of Memory* is an image of what?
- His wife
 - A bird
 - A purple cane
 - A pocket watch
16. What was the profession of Salvador Dalí's acquaintance Paul Laszlo?
- political leader
 - author
 - architect
 - photographer

APPENDIX I: TEST 2 SCORING RUBRIC

Question 1 correct answer: C

Question 2 correct answer: A

Question 3 correct answer: C

Question 4 correct answers: A

Question 5 correct answers: D

Question 6 correct answer: D

Question 7 correct answer: B

Question 8 correct answer: C

Question 9 correct answer: C

Question 10 correct answer: C

Question 11 correct answer: A

Question 12 correct answer: D

Question 13 correct answer: B

Question 14 correct answer: A

Question 15 correct answer: D

Question 16 correct answer: C

Scoring: 1 point per correct answer chosen and 0 points for every incorrect answer
chosen

Number of possible points: 16

APPENDIX J: INSTRUCTIONS

Instruction Script Before Practice:

Thank you for signing up to participate. Today you will be participating in part one of a two-part study. After completing the task today, you will be asked to participate in a final 15-minute test in two-three weeks.

Today, you will begin by participating in a practice phase. I will shortly be passing out a practice packet. This will include a short passage and instructions on engaging in a learning technique before completing a short quiz. When you have completed this task, you will return the packet to me. Once the practice packets have been turned in, the experiment will begin.

Pass out the practice packets

When practice passages are turned in

Instruction Script After Practice:

Now you will begin the experiment. I will shortly be passing out a passage. You will follow the instructions provided in your packet. After reading the passage you will be asked to engage in a designated learning technique. When you have finished studying, you will return the packet to me. You will then receive a final test. Once the test has been completed, you will return the test to me and you are free to leave. There is no time limit, so please work at your own pace.

Are there any questions before we begin?

Pass out the numbered packets to each participant.

When each student returns their packet, provide each student with a test. After the participant turns in the test, they are free to leave and remind them to sign up for phase 2 of the study.

Appendix K: IRB APPROVAL

IRB
INSTITUTIONAL REVIEW BOARD
 Office of Research Compliance,
 010A Sam Ingram Building,
 2269 Middle Tennessee Blvd
 Murfreesboro, TN 37129



IRBN001 - EXPEDITED PROTOCOL APPROVAL NOTICE

Wednesday, October 11, 2017

Principal Investigator **Sydney Cooper** (Student)
 Faculty Advisor Michael Hein
 Co-Investigators NONE
 Investigator Email(s) *slc7t@mtmail.mtsu.edu; michael.hein@mtsu.edu*
 Department Psychology

Protocol Title ***Self-generating questions and concept mapping to improve information retention in the long-term***
 Protocol ID **18-2055**

Dear Investigator(s),

The above identified research proposal has been reviewed by the MTSU Institutional Review Board (IRB) through the **EXPEDITED** mechanism under 45 CFR 46.110 and 21 CFR 56.110 within the category (7) *Research on individual or group characteristics or behavior*. A summary of the IRB action and other particulars in regard to this protocol application is tabulated as shown below:

IRB Action	APPROVED for one year from the date of this notification
Date of expiration	10/30/2018
Participant Size	100 (ONE HUNDRED)
Participant Pool	Undergraduate students from a general adult (18 or older) population
Exceptions	Permitted to collect identifiable information from the participants
Restrictions	1. Mandatory signed informed consent. 2. Identifiable information must be destroyed after data processing.
Comments	Lindsey Murry permitted to assist with data analysis.

This protocol can be continued for up to THREE years (**10/31/2020**) by obtaining a continuation approval prior to **10/30/2018**. Refer to the following schedule to plan your annual project reports and be aware that you may not receive a separate reminder to complete your continuing reviews. Failure in obtaining an approval for continuation will automatically result in cancellation of this protocol. Moreover, the completion of this study **MUST** be notified to the Office of Compliance by filing a final report in order to close-out the protocol.

Continuing Review Schedule:

Reporting Period	Requisition Deadline	IRB Comments
First year report	9/30/2018	TO BE COMPLETED
Second year report	9/30/2019	TO BE COMPLETED
Final report	9/30/2020	TO BE COMPLETED

Post-approval Protocol Amendments:

Date	Amendment(s)	IRB Comments
NONE	NONE	NONE

The investigator(s) indicated in this notification should read and abide by all of the post-approval conditions imposed with this approval. [Refer to the post-approval guidelines posted in the MTSU IRB's website](#). Any unanticipated harms to participants or adverse events must be reported to the Office of Compliance at (615) 494-8918 within 48 hours of the incident. Amendments to this protocol must be approved by the IRB. Inclusion of new researchers must also be approved by the Office of Compliance before they begin to work on the project.

All of the research-related records, which include signed consent forms, investigator information and other documents related to the study, must be retained by the PI or the faculty advisor (if the PI is a student) at the secure location mentioned in the protocol application. The data storage must be maintained for at least three (3) years after study completion. Subsequently, the researcher may destroy the data in a manner that maintains confidentiality and anonymity. IRB reserves the right to modify, change or cancel the terms of this letter without prior notice. Be advised that IRB also reserves the right to inspect or audit your records if needed.

Sincerely,

Institutional Review Board
Middle Tennessee State University

Quick Links:

[Click here](#) for a detailed list of the post-approval responsibilities.
More information on expedited procedures can be found [here](#).