THE EFFECTS OF BRAINSCAPE'S CONFIDENCE-BASED REPITION ON TWO ADULTS' PERFORMANCE ON KNOWLEDGE-BASED QUIZZES

by

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A Master's Project
Submitted in Partial Fulfillment
Of the Requirements for the Degree of
Master of Science in Education
Department of Curriculum & Instruction
At the State University of New York at Fredonia
Fredonia, New York

May 2013

CERTIFICATION OF PROJECT WORK

We, the undersigned, certify that this project entitled, ***The Effects of Brainscape's Confidence-Based Repetition on Two Adults' Performance on Knowledge Based Quizzes, by Sarabeth Waterman,*** Candidate for the Degree of Master of Science in Education, Department of Curriculum & Instruction, is acceptable in form and content and demonstrates a satisfactory knowledge of the field covered by this project.

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Abstract

This project was designed to examine the effects of a new instructional approach that combines elements of both inquiry-based and technology-assisted instruction. The iPad App Brainscape, a synchronous web and mobile flashcard program, was used to study individuals' acquisition and retention of important declarative knowledge. While substantial evidence exists to support the empirical foundations of this approach, very little, if any, systematic research has been conducted on its impact on human learning. This project, therefore, examined the effects of the Brainscape program on the acquisition and retention of new knowledge by two male adult volunteers. Both individuals expressed a desire to expand their knowledge in two distinct domains, SAT-related vocabulary and United States trivia. The effects of Brainscape were then compared to a more traditional didactic teaching approach. Results suggested that Brainscape was more effective and that it may be a promising intervention for educators. Implications for future research and practice were provided.

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Introduction

How do people learn and what role(s), if any, do schools and teachers play in this process? If schools and teachers do make a difference in learning, then what is it that they do that makes them more or less effective? Are good teachers born or made? These questions, among many others, have challenged educators, psychologists, and researchers for centuries. In response, many theories and practices were advanced to explain and try to improve the amount and quality of learning that occurs in one's life-time, particularly while in school. These major theories, in turn, provided both *constructivist* and *behavioral* explanations for human learning. Two particularly popular instructional approaches derived from these theories were discovery learning and technology-assisted instruction (Bruner, 1961; Mayer, 2004). Both approaches describe learning as active, process-based, and collaborative in nature. Discovery learning was defined further as an inquiry-based, constructivist theory in which individuals draw on their past experiences and existing knowledge to explore and understand concepts (e.g., Alfieri, Aldrich, Brooks, & Tenenbaum, 2011). According to constructivists, instructional methodologies like discovery learning help students to *internalize* and not simply memorize new knowledge. Technology-assisted instruction, on the other hand, was defined as a method of instruction in which computers and other forms of educational technology (e.g., internet, hypermedia, and e-learning) are used to teach, guide, and assess student performance until a desired level of proficiency is attained (Association for Education Communications and Technology, 1977). In this more behavioral perspective, teachers play a more active role in both structuring individuals' learning experiences and providing relevant feedback (i.e., positive and corrective) regarding their performance. While the theoretical and empirical debates between these two broad explanations continue, new teachers must adopt instructional approaches that meet the escalating needs of an increasingly diverse student population within a context of rapidly expanding curricula and less-than-supportive educational environments (Maheady, 1997).

This project was designed to examine the effects of a new instructional approach that combines elements of both inquiry-based and technology-assisted instruction. Brainscape, a synchronous web and mobile flashcard program, was designed to improve individuals' acquisition and retention of important declarative knowledge (Cohen, n.d.). While substantial evidence exists to support the empirical foundations of this approach, very little, if any, systematic research has been conducted on its impact on human learning. The purpose of this project, therefore, was to examine the effects of the Brainscape program on the acquisition and retention of new knowledge by two male adult volunteers. Both individuals expressed a desire to expand their knowledge in two distinct domains, SAT-related vocabulary and United States trivia. The effects of Brainscape were then compared to a more traditional didactic teaching approach.

Before describing empirical methods, an illustrative review was conducted of two primary literature bases: (a) discovery learning and (b) Brainscape. These knowledge bases were used, in turn, to formulate two specific research questions (a) what effects, if any, will Brainscape's Confidence-Based Repetition (CBR) have on participants' acquisition and retention of declarative knowledge? and (b) how did participants feel about using the Brainscape technology to expand their knowledge bases? More specifically, how did they rate the intervention in terms of (a) importance of goals; (b) acceptability of procedures; and (c) satisfaction with outcomes?

Discovery Learning

Alfieri et al. (2011) defined discovery learning as an inquiry-based, constructivist theory in which individuals draw on their past experiences and existing knowledge to explore and understand concepts (e.g., Alfieri, Aldrich, Brooks, &Tenenbaum, 2011). Jerome Bruner is often credited as the developer of discovery learning in the 1960s, but his ideas were shared by other authors (e.g., John Dewey, Jean Piaget, and Seymour Papert). Bruner (1961) argued that, "Practice in discovering for oneself teaches one to acquire information in a way that makes that information more readily viable in problem solving" (p. 26). Two types of discovery learning, unassisted and enhanced, were described in the professional literature. In unassisted discovery learning, students receive very little instructional assistance (e.g., direction and feedback) from the classroom teacher. Instead, they are expected to "discover" the knowledge and information required to address their questions and concerns. In contrast, enhanced discovery learning provides learners with more direction and feedback regarding what and how well they are learning (Marzano, 2011). Discovery learning can take many forms in the classroom. Teachers may ask students, for example, to design their own experiment, invent their own strategy for solving a problem, or answer a series of guiding questions. A first grade teacher might challenge students to find the sum of two large numbers, provide ample time for them to discover appropriate responses, and then explain their strategies for getting the answers. In an unassisted discovery learning classroom, students are given problems and they must find their own answers.

In contrast, in enhanced discovery learning classrooms students are given some level of teacher assistance as they attempt to discover their answers. Teachers make sure, for example, that students have the necessary knowledge to negotiate the nuances of the content (Marzano, 2011). Enhanced discovery learning usually involves some direct instruction from teachers as well. With this approach, the same math lesson would be presented as a *collaborative effort* among teachers and students. The teacher may present a small "mini-lesson" to show different strategies for making calculations, do several problems as a whole class and then have students generate their own problems and move into unassisted discovery. This particular approach appears to be beneficial for use with younger children who are learning important concepts that will later be linked to higher-order concepts. Memory is also enhanced when learning materials are generated by learners in some way. This is referred to as the generation effect (Slamecka & Graf, 1978). Such outcomes are often used as "evidence" that discovery learning leads to the generation of general principles or explanations of domain-specific patterns (Chi, de Leeuw, Chiu, & LaVancher, 1994). Therefore, the expectation is that discovery-based approaches because of the requirement that learners construct their own understandings and content, should yield improved learning, comprehension, and/or retention (Alfieri et al.,2011). Discovery learning is often cited as a best educational practice.

Alfieri et al (2011) conducted two meta-analyses on a sample of 164 empirical studies to examine the effects of unassisted versus enhanced discovery learning. In the first meta-analysis, they compared unassisted discovery learning to explicit instruction in improving students' academic performance. Using mixed methods (i.e., quantitative and qualitative), the researchers found that unassisted discovery does not benefit learners, whereas feedback, worked examples, scaffolding, and elicited explanations do. In the second meta-analysis, they evaluated the effects of enhanced discovery learning to other forms of instruction and reported that outcomes were favorable for enhanced discovery when compared with other forms of instruction.

In a related study, Balim (2009) used two measures (Academic Achievement Test in Science Perception Scale of Inquiry Learning and Semi-Structured Interview Test) to examine learning retention and the perception of inquiry learning skills (i.e., cognitive and affective) in a discovery-based environment. Using a quasi-experimental design, the researcher examined the performance of 57 seventh grade students (30M and 27F) from a public elementary school in a middle class community in Turkey. He found that students who used a discovery learning approach scored significantly higher than control subjects on both assessments.

In another science-related study, Lightbody (2011) described a discovery-based approach for teaching an instructional unit on plants to her 8th grade class. She used a pre-assessment to gather information about students' prior knowledge and then weighed the advantages and disadvantages of using heterogeneous or homogeneous groups. She noted that there were pluses and minuses associated with both options. If the intent was to offer choices that allowed some students to extend their investigations in greater depth then students worked in homogeneous groups. In contrast, if the goal was for students to share their knowledge, then heterogeneous arrangements were recommended. Lightbody suggested that investigative activities helped to establish a classroom environment that supported inquiry, differentiated instruction, and promoted mutual trust and respect. An important part of her investigations was hands-on exploration which, in turn, led to biological drawings or journals. She provided two to three days to complete the exploration and suggested that block scheduling might work well in this situation.

Leonard, Boakes and Moore (2009) suggested that the first step in using inquiry-based instruction is to fully define and understand what is involved in using the process. This particular study involved 12 pre-service science teachers (i.e., one white male, four African-American females, and seven white females) who completed inquiry projects during a 9-week practicum. All pre-service teachers were early childhood/ elementary education majors and all but two were traditional college-age students; the other two were 26 and 40 years old. Using a case-study method, the researchers reported on the development of individual teachers over a 2-year time period while they taught earth science classes. They concluded that inquiry-based instruction was a complex teaching practice and that some schools did not support.

In another related study, Saab, Van Joolingen and Van-Hoot-Wolters (2006) examined the effects of collaborative discovery learning instruction on the academic performance of 38 pairs of 10th grade students who had chosen physics as a topic. Students were recruited from three secondary schools in Amsterdam. The study used a pretest–posttest control group design with random assignment to experimental and control groups. Using an instructional method called RIDE (Respect, Intelligent collaboration, Deciding together, and Encouraging) which was based on four collaborative learning principles, the researchers found that these methods produced better understanding of knowledge, improved problem-solving, and better communication skills among experimental subjects. Saab et al suggested that RIDE instruction improved student communication which, in turn, led to a more productive discovery learning process.

Raab, Masters, Maxwell, Arnold, Schlapkohl and Poolton (2009) also examined the effectiveness of discovery learning in sports. Working with 69 undergraduates with no basketball experience (31F & 38M) between the ages of 19–29, the researchers randomly assigned participants to four groups (a) a rule-instructed; (b) perceptual-guided discovery; (c) cognitive guided-discovery; and (b) control. They then trained participants over a four-week period (i.e., four, 120 minute sessions) using the Heidelberg Video Test for Tactical Decisions. Treatment groups differed only in terms of the instructional procedure being used. Unfortunately, the researchers failed to fail any clear differences among the different groups' overall performance.

More recently, Panasan and Nuangchalerm (2010) examined whether the organization of science learning activities was appropriate for learners. They worked with 88, 5th grade students from two classrooms in Thailand. Using cluster random sampling, pupils were divided into two groups initially. Research measures included lesson plans for organization of project-based and inquiry-based learning activities. The researchers conducted pre-tests using achievement tests and measures of analytical thinking and scientific processing skills. Clear interpretations of findings were impeded by the researchers' wording and grammar which did not translate well into English.

Collectively, this illustrative review suggests that discovery learning has produced mixed results when compared to other instructional methods. At least, this appears to be the case for those content areas discussed in this review (i.e., science and sports). Some researchers used pre- and post-tests (Balim 2009; Panasan & Nuangchalerm, 2010; Saab, et al., 2006) while others used standardized measures (e.g., Academic Achievement Test in Science, Perception Scale of Inquiry Learning, and Semi-Structured Interview Tests) (Balim, 2009) and online assessments such as the RIDE program (Saab et al., 2006). Data were also collected using cluster random sampling technique (Panasan & Nuangchalerm, 2010) and two meta-analyses were conducted using qualitative and quantitative data (Alfieri et al., 2011). Lightbody (2011) used a pre-assessment while Leonard et al (2009) used a case-study method and Raab et al (2009) administered post- retention tests and questionnaires. Discovery learning studies also used varied sample sizes ranging from under 30 (Leonard et al., 2009; Lightbody, 2011) to over 50 students (Balim, 2009; Panasan & Nuangchalerm, 2010; Raab et al., 2009; Saab et al., 2006), one study included comprehensive data set from 164 separate empirical investigations (Alfieri et al., 2011), and another examined the researcher's own classroom (Lightbody, 2011). Studies included different subject populations such as adolescents (Balim, 2009; Lightbody, 2011; Panasan & Nuangchalerm, 2010; Saab et al., 2006), as well as college students and pre-service teachers (Leonard et al., 2009; Raab et al., 2009). Importantly, discovery learning studies have been conducted all over the world including Turkey (Balim, 2009), Holland (Saab et al., 2006),Thailand (Panasan & Nuangchalerm, 2010), and the United States (Leonard et al., 2009; Lightbody, 2011). Finally, most discovery learning researchers agreed that effective communication and collaboration skills are essential for success.

Unfortunately, discovery learning may not always be feasible in contemporary classrooms. For one, it is not clear how the use of a discovery learning approach will affect pupil performance on high stakes, standardized exams. If students perform more poorly on such assessments and teacher evaluation is linked to pupil progress, then many educators may be reluctant to use such methods. Preparing discovery learning lessons appear to take more time and require additional instructional materials; two demands that are in short supply in many of our public schools. Second, there does not appear to be data on how discovery learning might impact the performance of students from low socioeconomic status (SES) schools.

Brainscape

A second instructional option for classroom teachers, therefore, may lie in the realm of technology-assisted instruction. The Brainscape Program is a synchronous web and mobile flashcard program designed to improve the retention of declarative knowledge. Brainscape synthesizes the existing theories of *spaced repetition* and *confidence-based* learning to create a new technologically accessible pedagogy called *Confidence-Based Repetition* (CBR). CBR breaks declarative knowledge into its most fundamental building blocks and repeats concepts in carefully determined intervals based on learners' confidence levels. Its pattern for re-assessment is *not* based on a random algorithm or users' past history of correctness. Instead, it relies on users' own judgment of confidence in each piece of information (Cohen, n.d.). Brainscape developers argue that this pedagogical method can facilitate the acquisition of new knowledge and optimize learners' use of study time. Cohen (n.d.) suggested further that the intervention may be, "particularly useful for time-starved individuals preparing for a high-stakes exam or studying a foreign language that they are very interested in learning (rather than being forced to learn" (p.1). Given the recent development of this program, there is very limited applied research on its effectiveness as a pedagogical strategy. This initial investigation will examine what pedagogical effects, if any, CBR has on adults' acquisition and retention of declarative knowledge.

Given that both discovery learning and technology-assisted instruction hold great instructional potential, it was hypothesized that an intervention that incorporated facets of both methods might be effective in improving individual learning. The primary purpose of the proposed study, therefore, was to examine the effects of Brainscape's Confidence-Based Repetition (CBR) on two adults' performance on knowledge-based quizzes administered on the Brainscape Application on the iPad. There is very limited research on its effectiveness as a pedagogical strategy. This initial investigation examined its pedagogical effects on two adults' acquisition and retention of declarative knowledge. In addition, study participants were asked to rate the importance of intervention goals, feasibility and acceptability of instructional procedures, and their satisfaction with important learner outcomes.

Method

Participants and Settings

Participants for this study were two adult males, 28 and 61 years old who were Caucasian, middle-income, and lived in a suburban village in Western New York. Each subject completed the participant consent form (see Appendix A). One subject held a New York State Regents diploma and was a manager at a local Walgreens. The second participant had a master's degree in music education and was a retired teacher. Initially, both individuals approached the investigator and expressed interest in furthering their knowledge in either Scholastic Achievement Test (SAT) vocabulary or trivia regarding the United States. In addition to self-improvement, the latter participant also wanted to enhance his socialization skills by acquiring new knowledge so that he could participate in local trivia nights with friends. The study was conducted in the subjects' private residences in Western New York. Over a period of two weeks, each session was conducted in about 30 minutes. Content was selected based on the participants' personal preferences for initial subject studied and randomized trivia within the subject. The primary investigator provided all materials, directions and scheduled sessions during the study. The investigator simply presented information at each session and completed the procedural checklist (see Appendix B) to ensure that the intervention was being implemented as intended.

Dependent Variables

There were three primary dependent variables (a) amount of learning gain from pre- and post-tests of declarative knowledge (see Appendix C); (b) percentage of mastery during individual sessions; and (c) consumer satisfaction ratings of the Confidence-Based Response Brainscape application (see Appendix D). Knowledge-based, pre- and post-assessments contained a minimum of 50 items to which subjects made verbal responses. The investigator scored individual responses as correct or incorrect and separate scores were derived for each subject's pre- and post-test performance. Learning gain scores were then calculated using the formula post-test minus pre-test divided by amount of possible gain times 100% (Hake, 1997). This particular outcome described the amount of participant learning gain as a function of the amount of gain possible given pre-test performance. Subsequent learning gain scores will be compared statistically using simple tests. All quiz items were selected based on subjects' initial skill and interest levels and content taken from Brainscape flashcards.

The second dependent measure was subjects' scores on quizzes completed at the end of each baseline and intervention session. Participants completed simple, 10-item, factual quizzes based on content taught during specific work sessions. The Brainscape application calculated mastery percentages at the end of each session. These data were then plotted on simple line graphs for each subject and analyzed visually using data inspection rules established by What Works Clearinghouse (WWC) (Kratochwill, Hitchcock, Horner, Levin, Odom, Rindskopf, & Shadish, 2010). To ensure that data were collected reliably, the investigator also independently calculated participant scores during 25% of all experimental sessions. Independent scorings were then compared on an *item-by-item* basis. If an item was scored the *same way* (i.e., both correct or both incorrect) by Brainscape and the investigator then it was marked as an agreement (A). If items were scored *differently* (e.g., one correct and one incorrect) then they were marked as disagreements (D). Inter-scorer reliability was then calculated as the number of agreements divided by the number of agreements plus disagreements times 100%. It is anticipated that data will be collected with at least a mean of 90% agreement.

The third dependent variable was participants' mean ratings of (a) the importance of the intervention *goals*; (b) acceptability of intervention *procedures*; and (c) their satisfaction with intervention *outcomes*. Immediately after the study was completed, both adults completed a 12-item, Likert-type consumer satisfaction survey *independently* and *anonymously* (see Appendix B). Students rated each item from 1 to 7 on the basis of how they felt about the CBR Brainscape App intervention. Pupil responses were then be aggregated and presented as mean ratings for each item (i.e., scores approaching 7.0 reflected more positive evaluations). It was predicted that subjects would enjoy the CBR intervention.

Independent Variables

The primary intervention was the Brainscape App Program. Brainscape is a synchronous web and mobile flashcard program designed to improve the retention of declarative knowledge. Brainscape synthesizes the existing theories of *spaced repetition* and *confidence-based* learning to create a new technologically accessible pedagogy called *Confidence-Based Repetition* (CBR). CBR breaks declarative knowledge into its most fundamental building blocks and repeats concepts in carefully determined intervals based on learners' confidence levels. Its pattern for re-assessment is *not* based on a random algorithm or users' past history of correctness. Instead, it relies on users' own judgment of confidence in each piece of information (Cohen, n.d.). Brainscape developers argued that this pedagogical method can facilitate the acquisition of new knowledge and optimize learners' use of study time. Cohen (n.d.) suggested further that the intervention may be, "particularly useful for time-starved individuals preparing for a high-stakes exam or studying a foreign language that they are very interested in learning (rather than being forced to learn" (p.1). Given the recent development of this program, there is very limited applied research on its effectiveness as a pedagogical strategy. This initial investigation examined what pedagogical effects, if any, CBR had on adults' acquisition and retention of declarative knowledge.

One appealing aspect of the Brainscape program is that it offers a diverse array of subject matter. One participant (M=61 years old) for example, was interested in improving his acquisition and retention of important SAT-related vocabulary to expand his vocabulary and to enhance his SAT tutoring for high school students. The second adult (M=29 years old), in contrast, focused on expanding his understanding of United States landmarks and landforms to (a) expand his knowledge in this area of interest; and (b) enhance his socialization skills by allowing him to participate more readily and successfully in local trivial night activities. To impact participant learning, Brainscape flashes questions or words to participants on a computer screen (e.g., name the capital of Hungary). Rather than providing multiple-choice response options, the program asks users to *mentally retrieve* the target sentence and then manually reveal the correct answer by virtually flipping the flashcards (e.g., Budapest). Users then rate their response confidence by answering the question — "How well did you know this on a 1-5 scale" (i.e., 1 = not confident at all; to 5 = very confident in answer). The users' response is referred to as their *Judgment of Learning* (JOL) and it is used to determine *how long* until concepts are reviewed again. Typically, high confidence responses are reviewed progressively less often while less familiar concepts are repeated more frequently (Cohen, n.d.).

One appealing aspect of the Brainscape CBR app is its relative simplicity and ease of implementation. The specific steps involved in using CBR can be seen in the fidelity of implementation checklist (see Appendix C). Brainscape allows participants to sign into the program and select a subject on which they would like to learn more. They are then presented with a series of flashcards that were developed for that particular topic. Participants read and make mental notes of each question (e.g., Name the capital of Hungary) and the "flip" the card to reveal the correct response (e.g., Budapest). Participants are then required to rate their level of confidence in answering by responding to the question “”How well did you know this?” using a 5-point, Likert-type scale (1 = not confident to 5 = very confident). Participants’ responses to this question are referred to as their *Judgment of Learning* (JOL) and this information is used to determine *how long* until concepts are reviewed again. Typically, high confidence responses are reviewed progressively less often while less familiar concepts are repeated more frequently (Cohen, n.d.).

Brainscape also provides a variety of data visualization tools that allow participants to monitor their progress. For example, a *mastery bar* shows a weighted average of all confidence ratings (e.g., 0 to 100%). Second, an individual bar graph also depicts the relative number of cards in each confidence category (i.e., 0 to 5). Finally, a “library” screen permits participants to see the average mastery scores for all decks or “packages” (i.e., collection of decks) across the entire account. This latter snapshot provides participants with individualized guidance for which subjects or topics might be studied further.

Experimental Design and Procedures

An A–B data-based case study design was used to examine the effects of CBR on the two adults’ learning gains on declarative knowledge quizzes. This particular design is *not* capable of establishing a cause-and-effect relationship, but it can contrast the impact of two pedagogical approaches on subject performance (Kennedy, 2005). The effects of Confidence-Based Repetition (CBR) were compared to baseline data on two adults’ weekly declarative knowledge quiz scores. During a typical baseline session, the two adults played a matching game. Each correct match was followed by a brief discussion directly relating to the corresponding matched cards. Initial baseline data served two primary functions: (a) to determine if there was a need for intervention and (b) to predict future adult performance if existing instructional conditions were maintained; for example, if both subjects' failed to retain important information under typical conditions (e.g., retention less than 70%), then this signaled a need for intervention. The intervention package was then implemented and pupil performance was compared across baseline and intervention phases to assess the impact on target subjects. A typical CBR session worked as follows. First, the investigator gave a pre-test to each subject and recorded the data (i.e., response accuracy and degree of confidence). The subjects turned on the iPads. They then tapped the Brainscape App that was purchased by the investigator at no cost to the subjects. They signed in under the primary investigator's account and chose the subject they wanted to work on. They then began reviewing relevant flashcards and rating their Judgment of Learning after each response. At the end of the flashcard deck, they were given a *mastery percentage*. After each session, this percentage was recorded by the investigator. This process was repeated every other day for a minimum of six sessions. At the end of two-weeks, subjects were given post-tests. The investigator used the fidelity checklist to make sure that she followed prescribed procedures throughout the study.

Results

Data on participants' performance can be seen in Figure 1. As shown both individuals scored less than 70% correct on their pretest suggesting a need for intervention. Participant A, who was working on improving his SAT vocabulary scores, began with a mastery score of 61%, while Participant B's percentage correct for U.S. landmarks was just 48%. Participants' scores on the pre-tests were also quite low and suggested the need for intervention. As seen in Figure 2, Participant A had a pre-test score of 52% while Participant B earned 38% correct. The effect of Brainscape training on Participant A's mastery scores at the end of each session can be seen in Figure 3. As depicted, Participant A data showed an accelerating trend in mastery scores across each session. Initially, the largest gain was seen between the second and third session and there was clear growth across most, if not all, sessions. Over the course of the study, Participant A increased his mastery scores for SAT vocabulary to 94% or the equivalent of a 38% improvement over initial baseline performance. Similar data were found for Participant B. As shown in Figure 4, Participant B began with a relatively mastery score of 39%. The largest improvements in his performance were seen over the first three sessions. By the end of the investigation, Participant B had raised his mastery scores to 91%, an increase of about 53% over initial baseline performance.

Figure 5 depicts both participants performance on cumulative post-tests administered at the end of the investigation. As shown, Participants A and B both scored at least 90% correct on their respective mastery tests. Visual comparisons of participants' pre- versus post-test scores can be seen in Figure 6. Again, it is quite clear that Brainscape produced noticeable improvements in participants understanding of SAT vocabulary and U. S. landmarks. Both post - test scores were similar to the scores of the last intervention session. Finally, results from the consumer satisfaction survey are displayed in Figure 7. As shown, both participants agreed that Brainscape was an effective method for knowledge acquisition and memorization. However, they differed somewhat in their opinions of the importance of material learned. For example, Participant B rated the importance of his topic lower than the other participant. Both individuals, however, rated most if not all procedural components as highly acceptable. They liked, for example, using the apps, seeing their mastery scores and the pacing at which materials were presented. They differed a bit with regard to verbal versus multiple -choice responses with Participant B providing a lower acceptability rating. Finally, both participants were satisfied with the outcomes from using Brainscape. They felt that it had improved their understanding of selected topics and was relatively easy and fun to use. Both participants agreed that Brainscape could not be harmful to others.

Discussion

The present findings showed that Brainscape had a positive effect on two adult volunteers' knowledge acquisition. Research on discovery learning and Brainscape provided the basis for this emergent technology and this investigation documented its effects on two individuals' performance. Students can use discovery learning in education if teachers are organized and well-prepared to carry out discovery based learning in the classroom with its requisite technology. The results from this exploratory study showed the potential for using Brainscape and related technologies for improving learner outcomes. To the best of the investigator's knowledge these are the first data sets that examined individual performance over time using the Brainscape technology.

Accurate personal assessment is essential to success while using Brainscape. It is not clear, however, that learners will have opportunities to collaborative while using Brainscape. Several studies have shown that collaboration without instruction or support, however, may not lead automatically to effective knowledge construction (Saab, Van Joolingen, & Van-Hoot-Wolters, 2006). It might be interesting, therefore, to examine the effects of Brainscape technology with and without peer collaboration. It is also a bit unclear what impact if any Brainscape would have with students with communication, speech or other special needs.

Some teachers may engage the students in longer discovery learning sessions. The technology – assisted discovery learning approach can be an exciting way for children to take responsibility for their own learning. Some believe that beginning teachers, in particular, may have more difficulties using discovery learning approaches (e.g., Marzano, 2011; Mayer, 2004).

However, many beginning teachers can apply this method effectively because they were taught to do so in their preparation programs. The only liability for beginning teachers is their limited experiential background in the classroom. They may have other problems, specifically behavior and time management, that may hinder their participation in learning. That aside many novice teachers are eager to apply methods they learned in education classes. Learning something through doing (i.e., discovery learning), on their own and understanding the logic behind it allows students to think for themselves, and these are provided by discovery learning. We must bridge the gap between novice and experienced teachers. The generations were very different and teacher education was also different. To work together new practices and technologies must be embedded in our teacher preparation programs. As Hatch (2005) explained, "[Educators] make local theories that they can apply in a number of related contexts and that other teachers can learn from and build upon" (p. 2). Providing educators with the time, space, and a group of similarly motivated colleagues substantially enhances these enriching and empowering connections between theory and practice (King et al., 2010).

Conclusion

Unfortunately, in today's educational system, technology-assisted discovery learning is not always feasible. Lower income districts and students from low socioeconomic status environments may not have the resources to purchase the necessary technology. Students are expected to solve more examples to achieve higher ratings on mandated assessments and their teachers struggle to keep up with these growing requirements. Educators want students to think, speak, and engage yet the curriculum often wants them to finish a subject on time. Students should be provided with opportunities to appreciate and understand various forms of instructional strategies. Brainscape provides a technology-based tool for students that may enhance their performance in the classroom and on exams.

Obviously, much more research must be done on the Brainscape technology. Similar caution should be used in interpreting the present findings. There are some inherent limitations to the present study that must be considered when making interpretation. First, there were only two participants in this investigation and both were adults who volunteered. As such, generalizations to other age groups, subject areas, and non-voluntary status are not warranted. Second, the investigator also served as the primary data collector. As such, one cannot rule out the possibility of experimenter bias. Future research, therefore, should include independent researchers and data collection systems. Third, the present study did not use an experimental research design. As such, it is not appropriate to conclude that Brainscape and not some other extraneous variable was “really” responsible for participants’ improvements in knowledge acquisition. The present data simply provide an initial descriptive picture of participant performance on Brainscape. Future research using quasi-experimental and experimental designs are strongly recommended (Kennedy, 2005). Finally, the setting and the nature of the learning tasks differed quite dramatically from school settings. Therefore, caution must be exercised when making generalizations to classroom-based conditions. Aside from participant ages and the fact that the study was conducted in their homes, most children have few opportunities to select their own learning topics; a variable that may be of great importance to classroom-based instruction.

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Figure 1 shows the two participants' percentage correct scores on the initial baseline assessments.

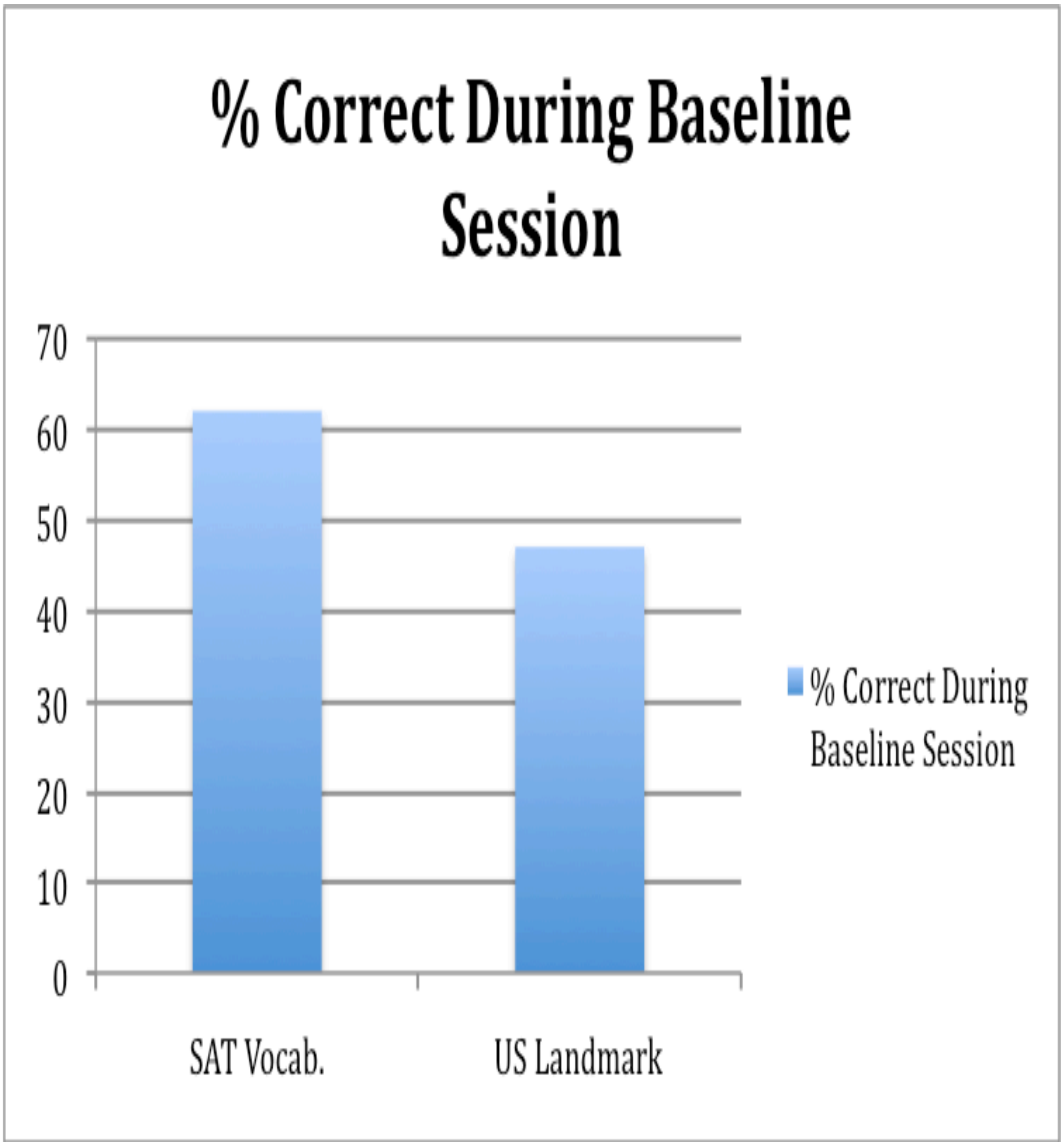

Figure 2 shows the two participants' percentage correct scores on the pre-test assessments.

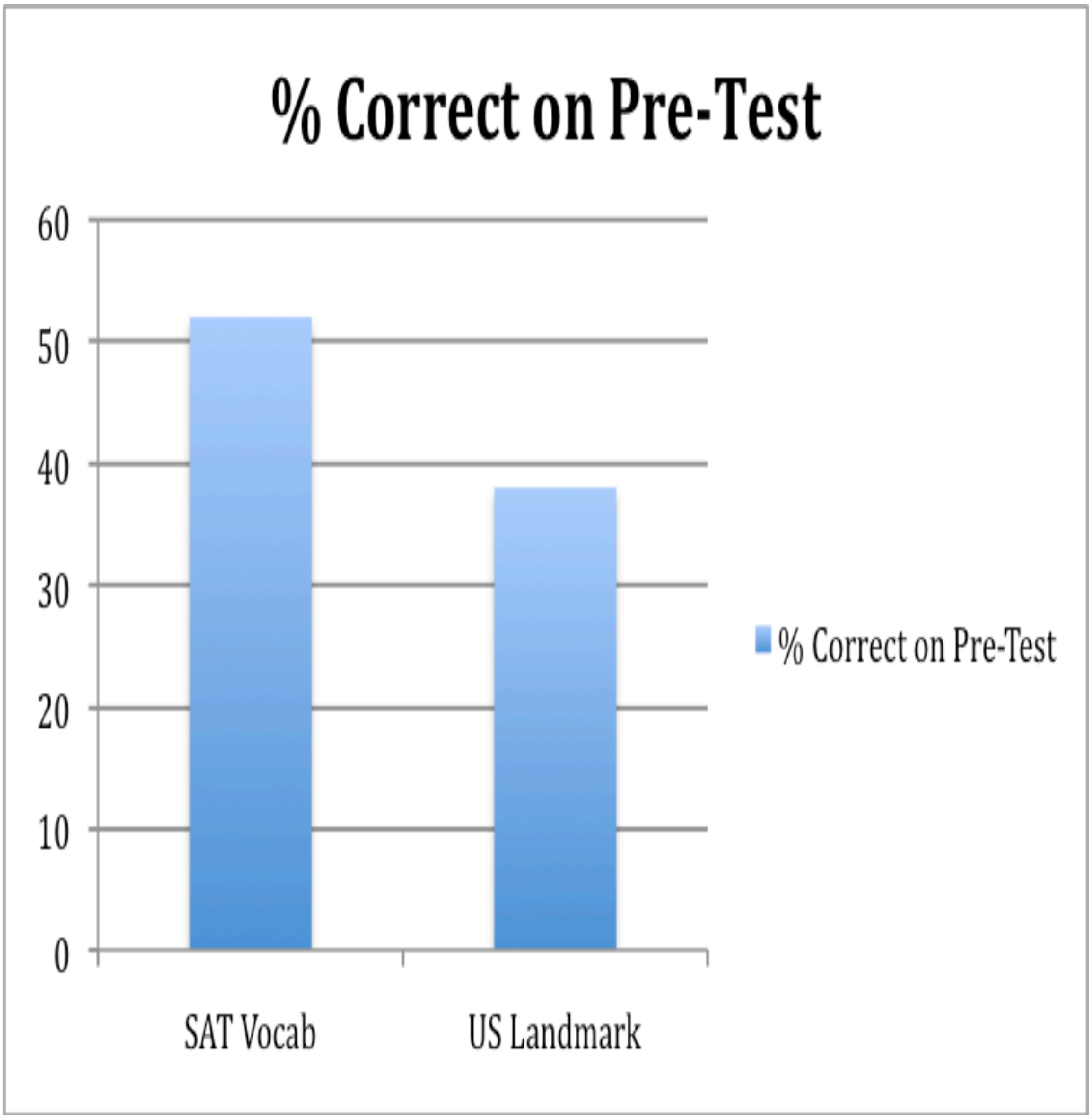

Figure 3 shows the percentage correct for Participant A during intervention sessions.

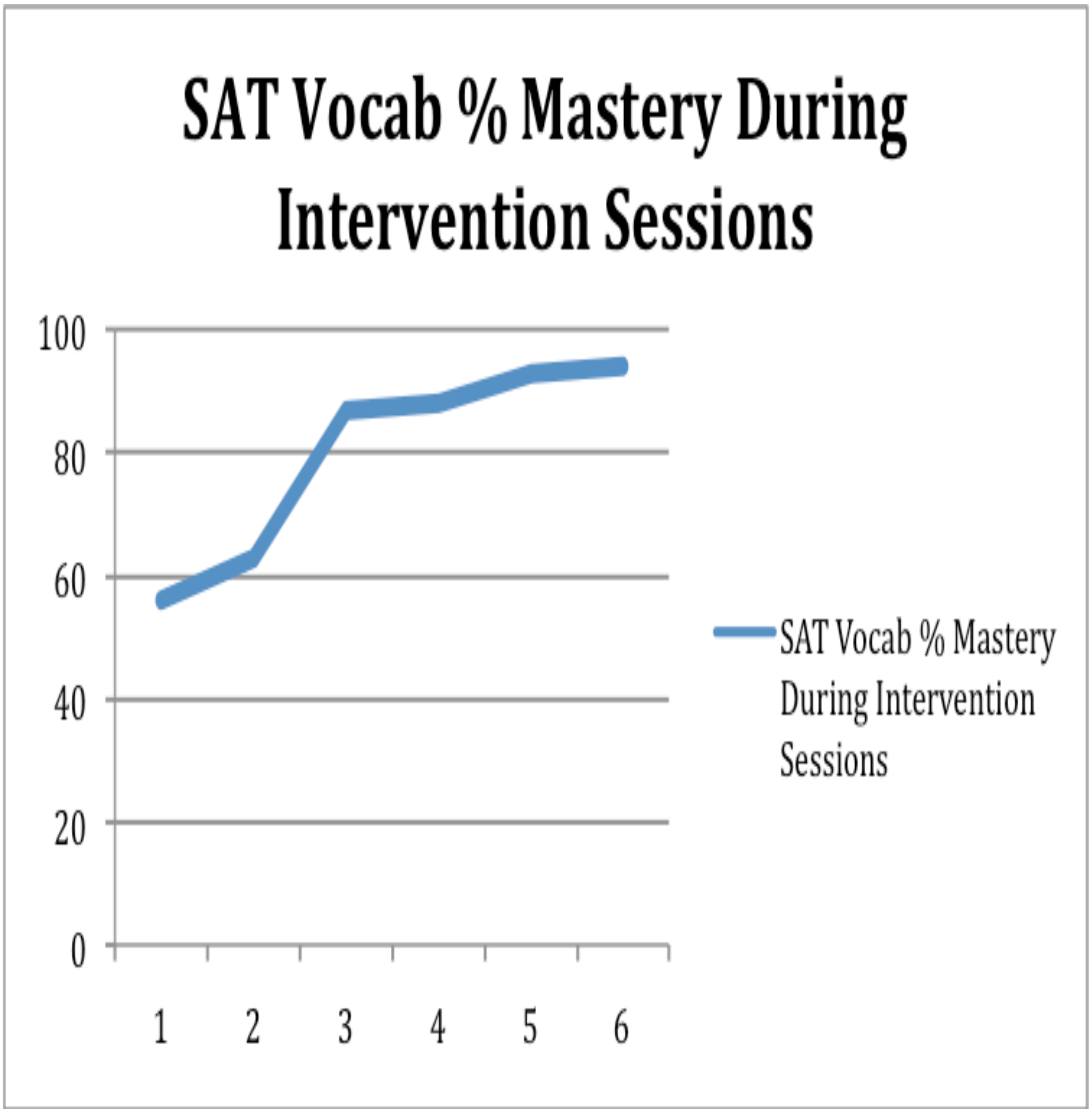

Figure 4 shows the percentage correct for Participant B during intervention sessions.

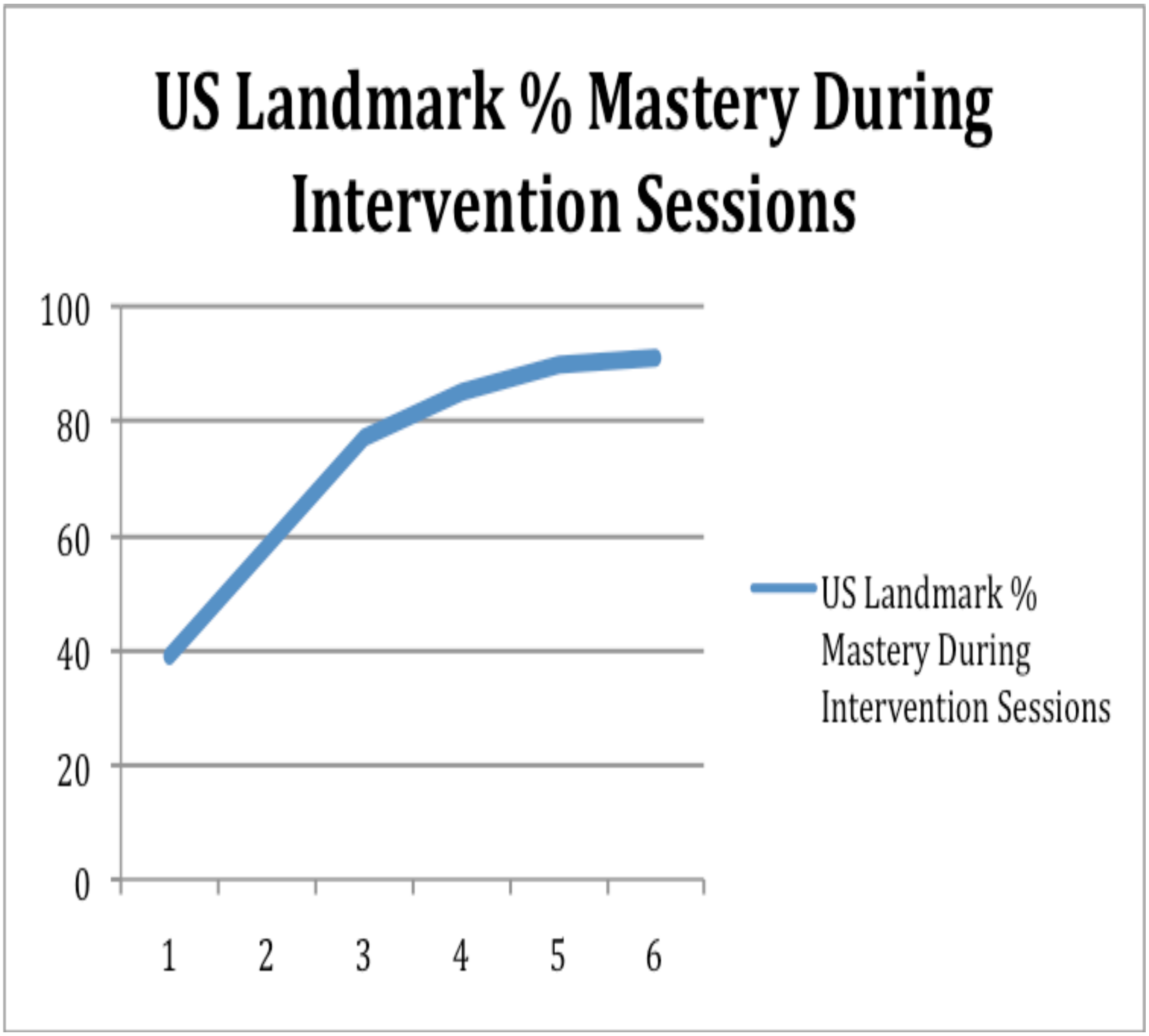

Figure 5 shows the percentage correct for both participants on the cumulative post-test.

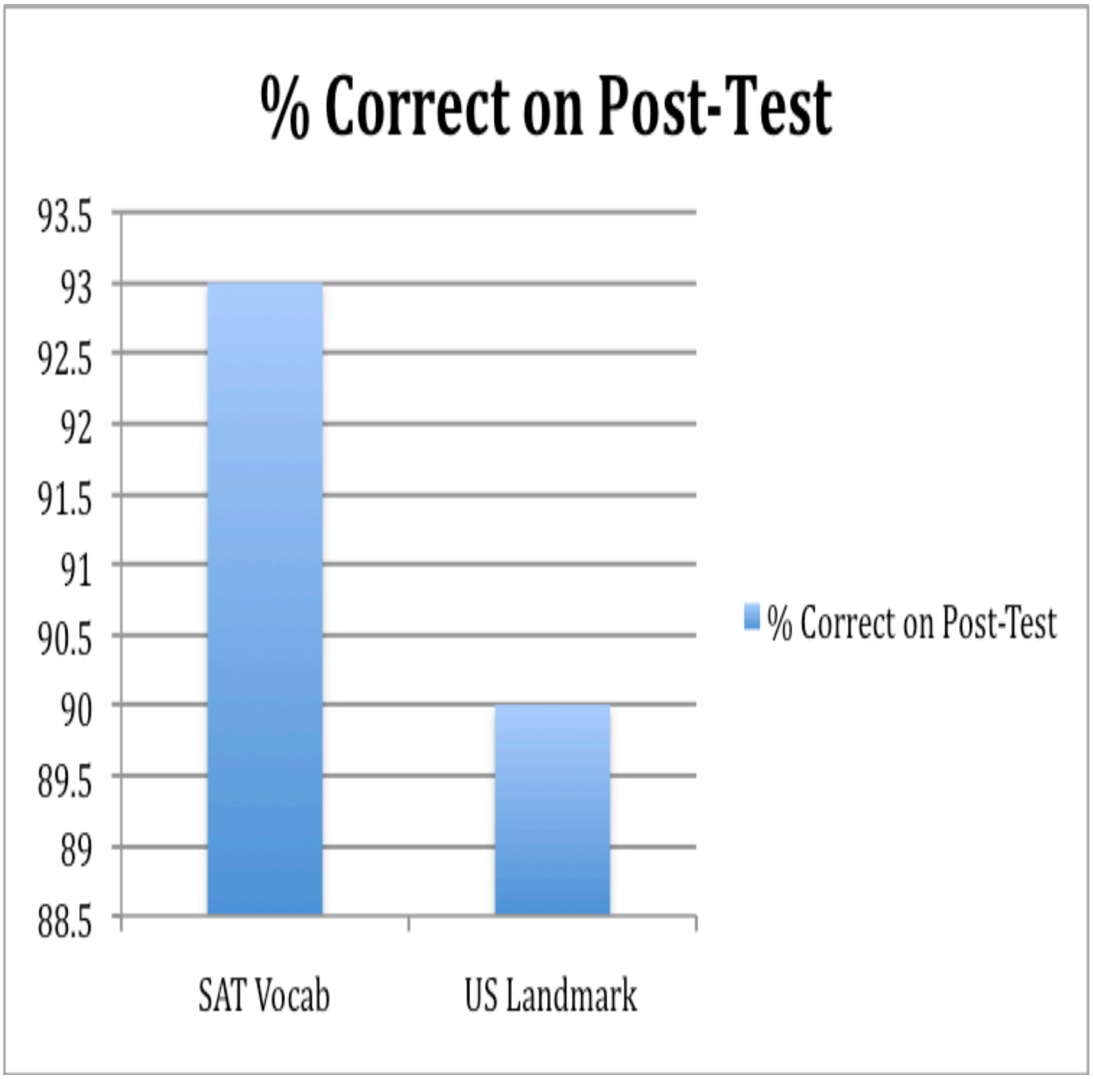

Figure 6 shows the pre-and post-test scores for both participants.

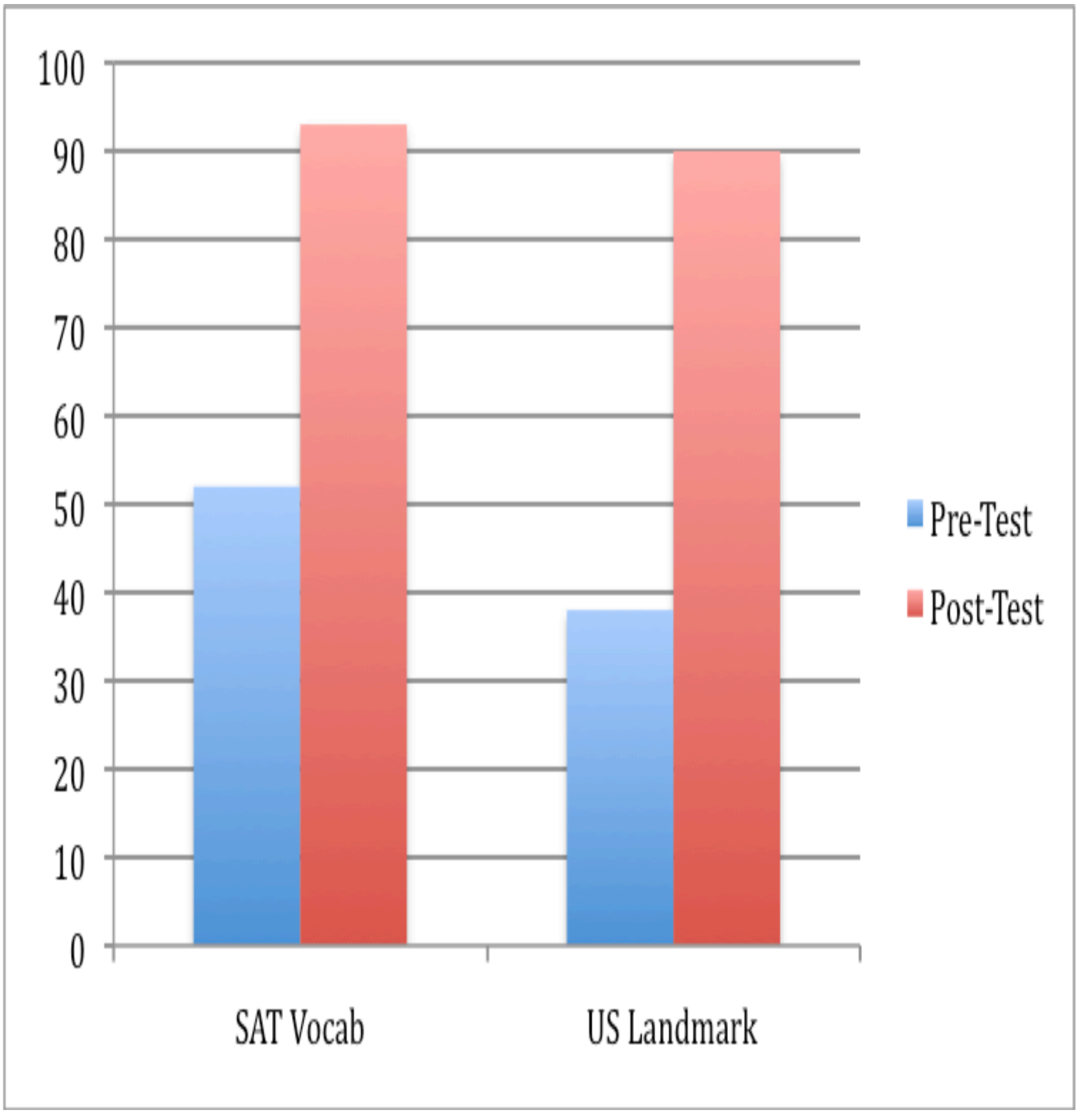

Figure 7 shows participants' social validity ratings for the Brainscape intervention

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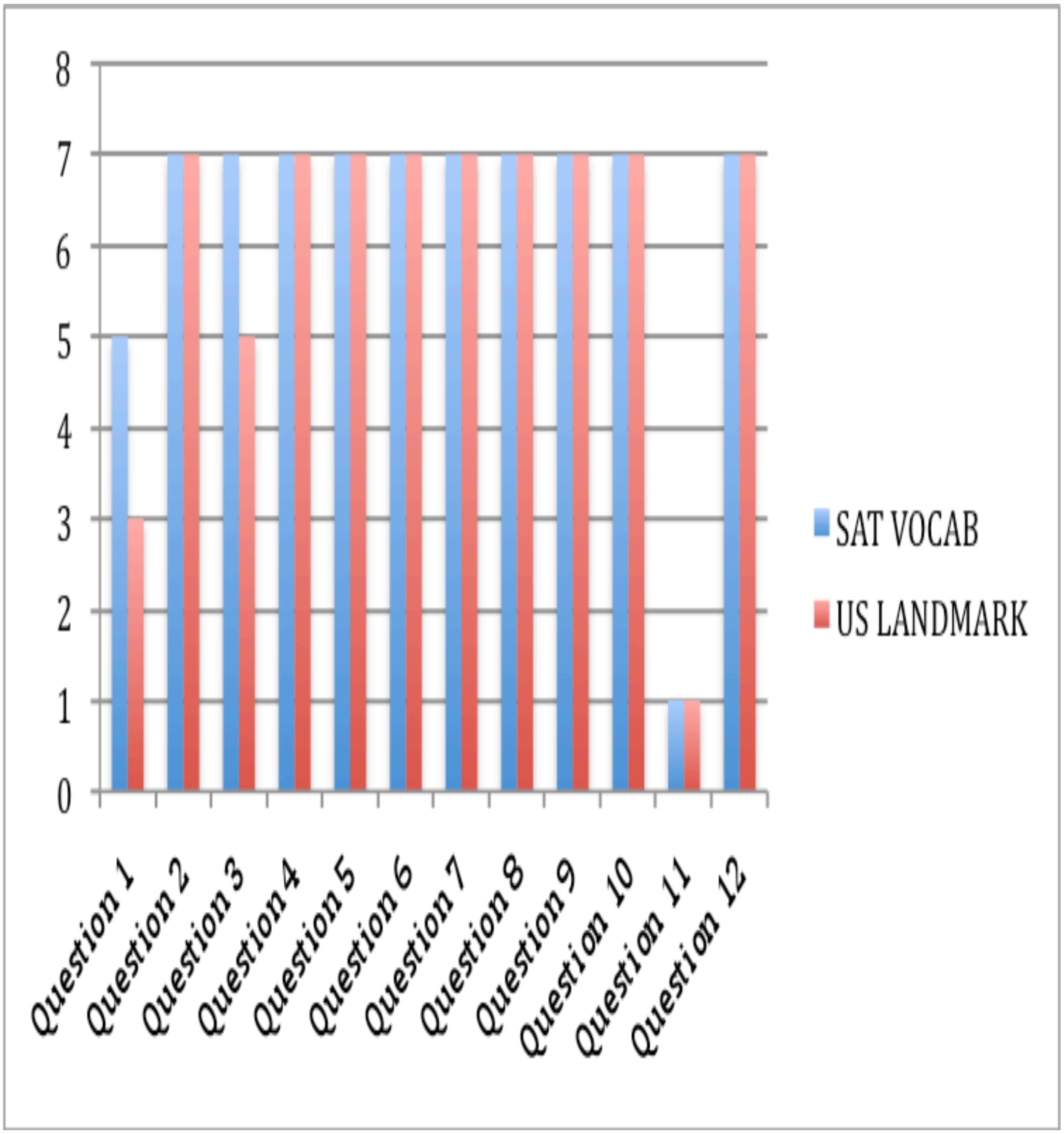

Appendix A

Participant Consent Form

Project Title: ***The Effects of Confidence-Based Repetition (CBR) on vocabulary and U.S. Landmark knowledge in two adult males.***

Principal Investigator: Sarabeth Waterman

Mrs. Waterman would like to conduct a research study this year as part of her research through SUNY Fredonia. She would like to study the effects of Confidence-Based Repetition with the Brainscape App on knowledge acquisition. She would like to use your pre- and post-test scores as well as mastery percentages for this study.

Purpose: To improve subjects' test scores and mastery percentages through the use of the Brainscape iPad App.

Description of the Study: The investigator will give a pre-test to each subject and record the data. The subjects will turn on the iPad. They will then tap the Brainscape App that has already been purchased by the primary investigator at no cost to the subjects. They will sign in under the primary investigator account and choose the subject they will be focusing on. They will then begin the flashcards rating their Judgment of Learning after each response given. At the end of the deck, they will be given a mastery percentage. After each session, the investigator will record this percentage. This process will repeat every other day for 6 sessions. At the end of the two-week study, each subject will be given a post-test. The investigator will use the fidelity checklist to make sure that she is following prescribed procedures throughout the study. The study will last for approximately 2 weeks.

Risks: There will be no risks if you choose to participate in this study. Information, such as your name, will be confidential. Your scores used for the study will not have your name attached to them.

Benefits: A direct benefit you may experience would be an increase in subject knowledge.

Voluntary Participation: It is entirely up to you whether or not to take part in this research study. You are free not to participate or to withdraw from this study at any time, for whatever reason, without any penalties. If you decide you want to withdraw from the study, please tell primary investigator, Mrs. Waterman.

Contact Persons: If you have any questions about this research you may contact Mrs. Waterman by phone (716) 912-8888, or by email, watermansarabeth@gmail.com

Maggie Bryan-Peterson, Director, Grants Administration/Research Services Office

Phone: 673-3528; e-mail: petersmb@fredonia.edu

Lawrence Maheady, Professor, Curriculum and Instruction

Phone: 673-3440; e-mail: Lawrence.Maheady@fredonia.edu

I want to be part of the research on the effects of Confidence-Based Repetition with the Brainscape App on knowledge acquisition. I will allow Mrs. Waterman to use my data on pre and post tests and mastery percentages for her research project.

____________________________ ______________________________

Subject Name Subject signature

____

Date

Appendix B

CBR Procedural Checklist

Subject: ______________________ **Date:** __________________

Observer: __________________

Time Session Begins: ______________________ **Time Session Ends:** _________________

***General Directions*:** Check **Yes** next to each item that was present during your session. Check **No** if a particular activity was not present during your session.

		Yes	**No**
1.	Subject turned on iPad	____	____
2.	Subject tapped Brainscape App to open	____	____
3.	Subject signed in under the appropriate username and password.	____	____
4.	Subject chose the appropriate area of study.	____	____
5.	Subject completed 25 flashcards and rated Judgment of learning after each card.	____	____
6.	Investigator records percentage mastery on data sheet after each session.	____	____
	Sub-Total	____ / 6 =	____ %

Anecdotal Comments:____

____

____

Appendix C

Pre- and Post- Test Sample

The following examples will be included on 50-item pre- and post-tests on the two designated topics. Responses will be verbal to be consistent with flashcard style.

SAT Vocabulary	**U.S. Landmark & Landform**
-TUMERITY	-What is Old Faithful and where is it located?
-DEPREDATE	-Where is Niagara Falls located?
-GENUFLECT	-Which state is the home of the famous Carlsband
WEND	Cavern?

Appendix D

Consumer Satisfaction Survey

***Directions*:**

Please read each item aloud to your students and ask them to **circle the number** that best represents their feelings about that particular item. Emphasize the importance of completing the rating ***individually and privately***. Thanks!

1. How important is it for you to do well in ***the subject you chose***?

1_________2_________3_________4_________5_________6_________7_________
not at all somewhat important very important

II. Acceptability of Instructional Procedures

2. How much did you like ***using the iPad app, Brainscape*** to use during this study?

1_________2_________3_________4_________5_________6_________7_________
not at all some a lot

3. How much did you like ***answering the questions verbally rather than multiple choice*** during the study?

1_________2_________3_________4_________5_________6_________7_________
not at all some a lot

4. How much did you like ***rating your judgment of learning*** after each question?

1_________2_________3_________4_________5_________6_________7_________
not at all some a lot

5. How much did you like ***seeing your mastery percentage progress*** after each deck?

1_________2_________3_________4_________5_________6_________7_________
not at all some a lot

6. How much did you like ***the pace*** at which the flashcards were shown?

1_________2_________3_________4_________5_________6_________7_________
not at all some a lot

III. Satisfaction with Strategy Outcomes

7. How satisfied are you with your overall performance in this study?

1_________2_________3_________4_________5_________6_________7_________
not at all somewhat satisfied very satisfied

8. How satisfied are you with ***your*** performance when using Brainscape?

1_________2_________3_________4_________5_________6_________7_________
not at all somewhat satisfied very satisfied

9. How much did Brainscape help ***you*** to learn the subject better?

1_________2_________3_________4_________5_________6_________7_________
not at all some a lot

10. Does Brainscape seem like something that should be done in classrooms?

1_________2_________3_________4_________5_________6_________7_________
not at all maybe definitely should

11. Could Brainscape be harmful to other students?

1_________2_________3_________4_________5_________6_________7_________
not at all maybe definitely could

12. Overall, what did you think of Brainscape

1_________2_________3_________4_________5_________6_________7_________
didn't like at all liked somewhat liked it a lot