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The effectiveness of using simulation as an instructional strategy for teaching and learning the scientific research process was explored in this study. A study within a study design utilized a graduate and undergraduate class to investigate the effectiveness of two memory techniques: rote vs. story telling. Participation in an authentic research study indicated that simulation was an effective approach for learning as demonstrated by students' mastery of knowledge of research components.

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Abstract

Learning the Scientific Research Process through Simulation

This study was organized around the body of research supporting the development of conceptual learning through problem solving using active learning experiences. Simulations are particularly useful for active learning, as well as a teaching strategy, as they offer learners opportunities to respond to problems that are analogous to real life, contain properties and sequences of activities that can be transferred to real situations, and allow for feedback that is appropriate for students.

The purpose of this study was to investigate the effectiveness of a memory simulation for teaching scientific research methodology in both graduate and undergraduate classes. A basic scientific research model was used to structure the simulation. The components most centrally illustrated in the simulation included randomization of subjects, types and procedures for data collection, appropriate data analysis, and drawing conclusions based upon findings.

Students (undergraduate=22; graduate = 21) were randomly assigned in each class to an experimental and control group. A pre and post assessment of memory was used to determine whether rote repetition or a story making technique was most effective in recall. A questionnaire was administered and analyzed to describe the participants' attitudes and scientific research knowledge achievement. ANCOVA tested mean differences between pre and post memory techniques (story making vs. rote memory) that were used in the simulation.

Analysis of both quantitative and qualitative data noted favorable attitudes as well as knowledge achievement about scientific research methods for most students. An overall conclusion of this study was that simulation as an instructional strategy for teaching the research process was an effective approach for learning at both graduate and undergraduate levels and was positively regarded by most students. Findings from the "study within the study" were that the memory process of story making was more effective than rote memory recall. In addition, graduate students were more productive than undergraduate in providing ideas for future research. The study also demonstrated that simulation was motivating to most students due to its interactive nature, and positive feedback was reflected in end-of-semester course evaluations.

Learning the Scientific Research Process through Simulation

Simulation is an instructional method that stimulates students' substantive knowledge for solving real-life problems in meaningful ways (Hertel & Millis, 2002). There are different types of simulation-based learning approaches, such as role-playing, games, and computer simulation (Feinstein, Mann, & Corsun, 2002; Hsu, 1989; Lean, Moizer, Towler, & Abbey, 2006). In role-playing, learners act out a role of a character in a particular situation; whereas, in games, students are competitive or cooperative in accomplishing a predetermined goal. Computer simulations replicate specific problems or situations electronically and can be further categorized into modeling, training, and gaming-oriented programs (Lean et al., 2006). Despite the typological differences, these approaches aim to facilitate students' active participation in learning and provide opportunities to practice problemsolving.

Several studies have consistently supported the utility and effectiveness of simulation for teaching and learning in higher education (Auman, 2011; Fuller, 1973; Kaddoura, 2010; Paskins & Pele, 2010; Raymond, 2010). For example, a case study from Auman (2011) indicated that educational psychology students were more engaged in classroom discussion when it was conveyed with role-playing simulation compared to discussions that followed traditional lectures. Graduate students in political science classes also demonstrated more positive attitudes toward learning political concepts after participating in simulation-based interventions either by role-playing (Fuller, 1973) or on-line modeling (Raymond, 2010). Role-play based simulations were also effective for enhancing critical thinking (Kaddoura, 2010) and communication skills and teamwork for students in medical schools (Paskins & Pele, 2010).

Simulation can also play a positive role in motivating students in introductory required courses. Such course requirements in higher education are often problematic when students have no interest in the subject matter, and the content is consistently taught through lecture followed by whole-class discussion (Bernstein, Scheerhorn, & Ritter, 2002). Thus, other innovative instructional approaches are required for more effective participation in learning. As McKeachie, Pintrich, Lin, Smith, and Sharma (1990) concluded, simulation is a discussion-oriented problem solving activity, and it is useful for increasing students' participation in learning. Bernstein et al. (2002) and Dekkers and Donatti (1981) provided robust evidence that simulation was effective for enhancing students' motivation in an introductory class. However, little has been investigated regarding whether simulation is equally effective for motivating students who take the same introductory course but are in different levels of study (e.g., undergraduate versus graduate).

Studies that have examined impact of simulation on academic achievement have shown inconsistent findings. In Chang, Chan, and Siren's study (2013), ESL students who received role-play simulation instruction showed statistically significant improvement in English reading and vocabulary post-tests, whereas control group students did not. Graduate engineering students also demonstrated statistically significant achievement on history tests after experiencing an on-line game simulation program (Davidovitch, Parush, & Shtub, 2008). In contrast, Raymond (2010) claimed that role-play simulation group students in an international relations class had no statistically significant gains in the course exam scores. Krain and Lantis (2006) offered similar findings that simulation group students did not show statistically significant quiz scores compared to their counterparts who experienced traditional lectures. Thus, more empirical studies appear necessary for acquiring comprehensive understanding regarding the effect of simulation on students' academic achievement.

A research synthesis on simulation studies indicated that various debriefing methods (e.g., checklists, think-aloud techniques, written debriefing, and self-assessments) are critical in order to achieve maximum impact on learning when utilizing simulation as an instructional process (Bond et al., 2008). Debriefing is a reflection step that offers students opportunities for looking back at what they have done during the prior simulation activities. Instead of judging what they have done right or not, Rudolph, Simon, Raemer, and Eppich (2008) proposed advocacy-inquiry techniques in debriefing that initiate students' explanations or validations on what instructors observed during the class time. According to Dreifuerst (2012), asking students to review what they have done and articulate their own rationale for doing so enhances the effectiveness of simulations.

Teaching Scientifc Research Methods through Simulation

Critical sub-skills of the scientific research method include: identifying research area; performing a preliminary literature review; specifying a research problem; performing an in-depth, specific literature review; designing the research; developing a detailed research plan; collecting and constructing materials; identifying special subject population needs and recruiting representative subjects; running the experiment; data reduction and coding; analyzing the data; writing a report of the data; and revising the report. Computer simulation has been proposed as an effective method for teaching the steps and processes of scientific research and several studies have pointed to both advantages and disadvantages of this type of simulation.

Cromer (1974) and Harper & Selvin, (1997) reported using computer simulations to teach the scientific method of research as well as survey research methods. In both case studies, researchers concluded that the programs offered multiple opportunities for the students to conduct experimental research by collecting data, establishing research hypotheses, and analyzing the data. The students also reported experiencing meaningful learning through the repetitive practices of conducting the research. Although the case studies implied that computer simulation was a useful instructional method for teaching scientific research methods, several limitations were identified for adopting the method. These included budgets and costs of the hardware and software installations as well as time and effort required by instructors and students to learn and keep the systems updated.

Studies have also shown that other types of simulation are beneficial for college students to experience and learn the scientific research process. For example, Peacock (1981) adapted game simulation in his undergraduate class where students competed in teams to solve a given research problem and to submit a research paper to be selected for publication and a grant award. Based on the class observations, the researcher concluded that using simulation highly facilitated students' motivation and interest in participating in research projects and group discussions. In addition, Schuck (1997) provided an example of role-play type simulation for teaching research methods whereby students took turns as interviewers, research participants, data analysts, and other roles in the research process. Qualitative analysis of the recorded reflections identified advantages of using role-play simulation including: encouraging students to be participants in research; motivating them to create and join in a research community; and facilitating awareness of issues and problems that might be studied in the future.

Although there have been advantages reported in the literature regarding the use of simulation as an instructional strategy for teaching and learning scientific research methods, questionable issues still remain. Several studies focused only on the students' affective responses toward using simulation as a method of learning about research processes (Cromer, 1974; Harper & Selvin, 1973; Peacock, 1981), while relatively little is known about the benefits for improving knowledge of critical elements of the scientific research method. In addition, contextual information for adopting the simulation method has not been carefully considered or reported in previous studies. Participants' characteristics and classroom settings may be important factors affecting attitudes toward using simulation in a scientific research methods class. For example, if the simulation technique is totally new to the participants, they may be motivated not by the instructional properties, but by its novelty. In addition, if the students have previous research experiences, their responses to the simulated research may be different from those who do not. Therefore, further research is needed not only to investigate whether simulation plays positive roles in students' attitudes and knowledge achievement, but also to enlighten how students' characteristics or classroom settings affect learning scientific research methods through simulation.

Memory Strategies

Memory strategies are often referred to as mnemonics, and generally represent ways to connect new knowledge with previously learned knowledge, using words, images, or information of language structures such as phonology and orthography (Levin, 1993; Schmitt, 2000). One of the most popular types of memory strategies in vocabulary learning is a key word technique by which learners first select a familiar word as a key word that is acoustically similar to the new word, and next create images of the key word to link the image to the new word (Atkinson, 1975). Another type of well-known strategy is making associations between new words based on previously learned phonological or semantic categories. Using contextual key is also known as a useful memory strategy for vocabulary learning, which involves learners inferring meaning of the new words from its usages in several sentences or the story context.

Previous studies have consistently shown that these memory strategies were effective for enhancing learners' short-term vocabulary recall (Atay & Ozbulgan, 2007; Sozler, 2012). Both college students and young learners who were trained in using the key word technique remembered more words than did those who used rote-repetition methods (Moore & Surber, 1992; Pressley, Levin, Digdon, Bryant, & Ray, 1983; Avila & Sadoski, 1996; Elhelou, 1994). In addition, Gaskill and Murphy (2004) showed that grouping a list of words in associative categories was an effective method for enhancing middle school students' vocabulary recall and self-efficacy. Using contextual keys was also an effective strategy for college students to remember more words immediately after the instruction (Wang & Thomas, 1995).

Rodriguez and Sadoski (2000) provided interesting findings illustrating that combining the key word technique with the context method was the most effective strategy for middle school English as a foreign language (EFL) learners. Four types of memory strategies were compared in the study; rote-repetition, the key word technique, the context method, and the combination of the key word technique and the context method. The participants were randomly provided a booklet that introduced each type of memory strategy. After receiving instruction of the method in a booklet, the students were provided a 15 words list, one word at a time with two minute intervals between words. During the intervals, the students were asked to use each of the memory strategies about which they had previously received instructed. The students who were in the combination strategy group recalled the most words not only for the immediate post-test, but also for one-week later recall test.

However, there has been little investigation of whether the combination of the two strategies is also the most effective method for college students' learning of vocabulary. Most of the previous studies merely investigated whether one type of memory strategy was better than the other for the age group. For example, Moore and Surber (1992) and Pressley et al. (1983) compared the key word method with rote-repetition, and their finding was the prestigious role of the key word technique. In addition, Wang and Thomas (1995) only compared the context method with the key word method and concluded the former was more effective for college students' vocabulary recall. Furthermore, none of these studies took into consideration whether the combined method would also be the most effective memory strategy among college students whose academic status was different (i.e., undergraduate versus graduate).

The story making strategy for recalling vocabulary is an example of combining two strategies: the key word technique and the context method. Students first read a given list of words and then create their own key word list using acoustic or semantic similarities with the new words. Secondly, the students are asked to think of possible images of the new words by recalling each key word at a time. Third, based on the images connected to the key words, students are encouraged to create and write down their own story by using the list of given words. Fourth, by re-reading their written story, students can redefine the meaning of the target words within the context of sentences or can check the meaningful sequence of words used in their story plot. These steps of the story making technique are not required to be processed in order, but can be simultaneously occurring while the students make semantic relationships between the given words.

Context of the Study

The general purpose of this study was to demonstrate the scientific model for conducting research with undergraduate and graduate students using simulation as an interactive and engaging teaching strategy for learning about essential components and methods of research. For this purpose, the instructor embedded experimental research procedures and methods into instruction in two research methods classes (one graduate and one undergraduate) that he taught at a large university, thereby creating a "study within a study." Students were asked to participate in the experiment as the research subjects. The goal of the sub-study was to determine the impact of the story making strategy on short-term vocabulary recall as part of pedagogy. Both undergraduate and graduate students were separately considered in the classroom study for the purpose of examining whether the simulation effects would be different across students' academic level in higher education. This purpose was also significant for providing robust data on inquiries regarding effective memory strategies for vocabulary learning among students in higher education.

Research questions addressed the primary and secondary levels of the study:

Primary level: What are the advantages of using a simulation teaching strategy in research methods classes for students in higher education?

Secondary level: What are the differences in recall when using two memory strategies: rote memory vs. story making technique? Are there differences in level of recall for undergraduates vs. graduates? Are there differences in recall by memory strategies for native English speakers vs. English as a second language (ESL) learners?

Method

Participants

The participants in the study were students in the college of education at a large university in the southern part of the United States. Participation was voluntary and with consent from all students. All participants were registered either in an undergraduate or graduate course that the study's primary researcher instructed. The number of participants was 43 in total, including 22 undergraduate students (51.2%) and 21 graduate students (48.8%). There were more female participants (31, 72.1%) than male (12, 27.9%). All of the undergraduate participants were female, whereas graduate students consisted of 12 males and nine females. The majority of the students were native English speakers (32, 74.4%), while 11 participants (25.6%) were English as a second language (ESL) learners. Particularly, most of the undergraduate students were native English speakers except for two students who spoke both English and Spanish. Almost half of the graduate participants were ESL learners (11 students), while seven were English monolinguals, two were speakers of English as L1 and Spanish as L2, and one was English and Taiwanese bilingual.

Data Collection

Pre and posttest measures. Distinct sets of seven vocabulary words (nouns) were used for test materials. The pretest words were *cigar, music, airplane, clock, sun, funnel,* and *painting.* The posttest words were *telephone, senior, fence, customer, mistake, world,* and *storage.* Answer sheets were blank sheets of typing paper on which students recorded their memorized words in sequentially numbered list format.

Questionnaire. A follow-up questionnaire containing six questions was designed to gather information about the participants' perceptions regarding the use of the simulation strategy for teaching research methods and for their assessment of the degree to which it contributed to their knowledge and understanding of research methodology. In addition, students were asked to provide critical comments and suggestions for modifications of the simulation for future investigation.

Procedures

The study was conducted in the same week in the late spring semester in two research methods classes (one undergraduate and one graduate). The class instructor introduced, explained the simulation, and oversaw the data collection procedures. A graduate assistant collected the test forms, scored the tests, and sorted students into groups based upon a predetermined randomizing procedure in both classes.

At the beginning of each of the two participating classes, students were given general information about the study (e.g., the purpose and procedures of the study). They were asked to voluntarily participate in the study and to provide written consent to conform to the described research protocol. Participants were then given a random-numbered answer sheet and instructions to study seven pre-test words for one minute for memory and sequenced recall. The words were projected onto a large screen at the front of the room. At the end of one minute, the projection was removed and students wrote the words in sequence on their answer sheet. A research assistant gathered the answer sheets and scored the tests. All students were instructed to discuss their memory techniques in pairs while the scores (number correct in sequence) were recorded.

The students were then assigned to two groups relative to number of correct scores on the pretest. The groups were formed by rank ordering the students (identified only by their random numbers) from highest to lowest scores and dividing the list at the mid-point of the total number of participating students. The final two groups were determined as follows: the highest and lowest score and the highest and lowest score from the mid-point were assigned to Group 1 and the next highest and next lowest score and mid-point were assigned to Group 2 until all students were assigned. The students were then assembled in their assigned groups within the classroom.

Each group was given a printout describing a type of memory strategy that would be used by the group in the remaining activities to complete the study: the rote-repetition method was given to Group 1; and the story making technique to Group 2. The students were asked to read and self-study the instruction on their printout, and then practice their designated memory strategy with seven new words on the printout (*barking, south, tomatoes, lettuce, bell, coffee, and triangle).* After the individual practice, the groups were encouraged to share and discuss the strategies they used with their peers.

The posttest word list was then presented on the screen, and each group participant was asked to utilize their group's assigned memory strategy for one minute to recall and reconstruct the list in sequence on provided answer sheets. The posttest answer sheet was gathered and the research assistant scored the results. The differences of pretest and posttest scores between Group 1 and Group 2 were statistically analyzed to examine the effects of the story-making technique vs. rote memory for vocabulary recall. The students' academic status (undergraduate vs. graduate) and language background (native English speaking vs. ESL) were also included in the data analysis to test whether these differences would affect the participants' vocabulary recall.

Debriefing in the form of oral discussion was conducted to determine and judge the students' reactions to the simulated components of scientific research. In this stage, the participants were encouraged to review the simulated research procedures and identify components of the activity that defined scientific research. Structured debriefing questions were also addressed one at a time to facilitate the students' knowledge gains:

1. What happened to you in the simulation?
2. How is this simulation related to a scientific study?
3. What are the main components of a scientific study?
4. How would/could you change this simulation?
5. Do you have other comments? Explain?

The discussions were audio recorded and analyzed for key concepts regarding each question by the graduate assistant. Finally, a follow-up questionnaire was given to the students to freely write down how they evaluated the simulated research class, to identify what they learned through the activities, and how they would improve or change the study.

Data Analysis

Both quantitative and qualitative data analyses were used in the study. The participants' vocabulary recall scores were quantitatively analyzed with analysis of covariance (ANCOVA) procedures to determine differences between rote memory and a story making strategy for vocabulary learning. The participants' open-ended questionnaire answers were qualitatively analyzed to describe benefits of and reactions to using simulation as an instructional strategy for learning in a scientific research methods class.

Results

Vocabulary Recall

Pre-test. The participants' pre-test scores of vocabulary recall were examined and compared based on their academic status (class), language backgrounds (language), and experimental conditions (group; see Table 1). The undergraduate participants recalled slightly more vocabulary (M = 6.82, SD = 0.50) than that did graduate students (M = 6.57, SD = 0.81). Native English speaking students scored a little higher (M = 6.75, SD = 0.67) than ESL learners (M = 6.55, SD = 0.69). The mean scores of Group 1 (M = 6.71) and Group 2 (M = 6.68) were very similar, and the standard deviations of the means showed a small difference (SD = 0.72 for Group 1 and SD = 0.65 for Group 2). Independent sample t-test showed that these differences were not statistically significant (all ps > .05).

Post-test. Similar patterns of the pre-test results were found in the post-test (see Table 1). The post-test scores were higher in the undergraduate class (M = 6.82, SD= 0.50) than the graduate (M=6.52, SD= 0.60), and the native English speaking students' results were higher (M=6.69, SD= 0.59) than ESL learners' (M=6.64, SD= 0.51). Both Group 1 and Group 2 showed very similar post-test scores: (M = 6.67, SD = 0.58 for Group1 and M = 6.68, SD= 0.57 for Group 2). These differences showed no statistical significance in the independent sample t-test results (all ps > .05).

Pre-test vs. post-test. To evaluate the effects of the story making strategy on vocabulary recall, three way ANCOVA (2×2×2) was utilized. Each way in the ANCOVA analysis was a grouping variable constructed by two levels: class (undergraduate vs. graduate); language (native English speaking [L1] vs. ESL learners [L2]); and group (rote memory [Group 1] vs. story making [Group2]), respectively. Pre-test scores were included as a covariate to control for individual differences before the experiment. The design of the ANCOVA analysis was factorial, but the two-way interaction (language×class) and the three-way interaction effects (language×class×group) were not analyzed because the degrees of freedom (df) equaled 0. Thus, three main effects (class, language, and group) and two two-way interaction effects (class×group, language×group) were included in the final analysis (see Table 2).

The result of the ANCOVA analysis showed that two interaction effects were statistically significant, while all the main effects were not. First, the interaction between class and group was statistically significant (F [1, 42] = 4.41, p = .04 < .05, η^2 = .11). The Group 1 (rote) students (M = 6.87, SD = 0.15) scored higher than Group 2 (story) (M = 6.72, SD= 0.15) in the undergraduate class, whereas Group 2 (M = 6.74, SD = 0.17) scored higher than Group 1 (M = 6.60, SD = 0.18) in the graduate class. Second, there was also statistically significant difference of interaction between language and group (F [1, 42] = 5.87, p = .02 < .05, η^2 = .14). The native English speakers in Group 2 (story) (M

= 6.83, *SD* = 0.17) scored higher than Group 1 (*M* = 6.53, *SD*= 0.12). On the contrary, ESL learners scored higher in Group 1 (rote memory) (*M* = 7.00, *SD* = 0.29) than did Group 2 (*M* = 6.54, *SD* = 0.18) (see Table 2 for the ANCOVA results; Table 3 for the mean differences). Based on these results, two implications can be generated: first, the story making strategy was more effective for graduate students' vocabulary recall than undergraduates; and second, the story strategy facilitated native English speakers' vocabulary recall, while rote memory was more effective for ESL learners.

Student Perceptions of Learning through Simulation

Two major themes were generated based on qualitative data gathered in response to the questionnaire. One theme related to participants' experience and attitudes toward learning scientific research methods through a simulation teaching strategy. The second theme reflected students' attitudes toward the methods and design of the experiment, including suggestions for how to improve the simulation as a strategy for learning research methods. In addition, students commented about the experiment's overall contribution to their knowledge base and made suggestions for how to improve the simulation as a strategy for learning research methods.

Perceived attitudes.

Positive engagement. Using simulation facilitated the participants' engagement and motivation for learning scientific research methods. One student noted that the simulation was good for preserving her attention. Another commented: "It was more relaxed and open for error than other experiments that I have participated in. It was also short so people were able to maintain focus." Another student mentioned that simulated research was interesting, so she devoted herself in the experiment. “I enjoyed this study. Even though it wasn't graded, I really tried to do my best to memorize all the words.” This findng was consistent with previous studies indicating that the simulation instructional strategy holds good potential for increasing students’ positive engagement in learning (Auman, 2011; Bernstein et al., 2002; Dekkers & Donatti, 1981; Fuller, 1973; McKeachie et al., 1990; Raymond, 2010).

Favorable vs. Stressed. Two different reactions were found with regard to the participants’ perceptions of the simulated research. Some students expressed high favor on using simulation as an instructional technique for teaching scientific research methods. These participants described their impressions as *interesting*, *enjoyable*, *simple, efficient*, *fun,* and *educational*. One reason for this positive response was that the simulated research met the participants’ personal interests and curiosities.

> “It was interesting because it allowed me to realize which memorization I preferred to use and how capable I am of memorizing.”
>
> “It was interesting to be involved in the study because I have never been in one before.”

Other comments indicated the simulated research was meaningful for the participants because they expected to be conducting similar studies in the future.

> “Fun! I will try to consider it in the future too and give clear instructions to my subjects.”
>
> “This study can be tailored for upper- or intermediate level students and even elementary students of ESL. One of the big issues of ELLs is that they cannot

remember the vocabulary they have learned for a long period of time. Therefore, it (story making) is a good instructional strategy."

Some students indicated that they felt *stressful, nervous,* and *challenged* while participating in the simulated research. They reported having little interest in the experimental condition of the simulation and noted that they felt some pressure that they were being tested on their cognitive ability.

"I really didn't have a preference on this study. I didn't like being told which way to memorize the words though."

"I felt like I was being tested and I wanted to succeed even though it was anonymous."

Progressive changes in attitude. One interesting observation from some student comments was that the participants' attitudes toward the simulated research were gradually changed throughout the processes. One student indicated that her negative feeling about participating in the simulated research was changed when she had a clearer picture of the experiment.

"At first, it was stressful because I didn't know what to expect but after the first set of words it was fine."

Attitude changes have also been noted in other simulation studies (Auman, 2011; Loui, 2009; Schuck, 1997). For example, in Auman's study, some of the students felt nervous and uncertain at first when using a simulation game in their psychology class. However, as was true in the present study, their attitudes were modified with satisfaction after experiencing the new instructional method.

Knowledge achievement.

Acknowledged elements of scientific research methods. Participants indicated that the simulated research guided them to better understanding of several critical elements for conducting scientific research. A large number of students pointed out that *controlling variables* was key for scientific research. Particularly, they identified two critical control variables for the success of the experiment in the simulated study: time length for practicing memory techniques and number of given words.

"The groupings and time limit were both critical components."

"Specific numbers of words are critical."

Several students also mentioned *treatment condition* as an important element. The homogeneity of experimental and control groups, researchers' clear directions, and using reasonable instruments were also specifically pointed out.

"Good to have pre-test to have equal group. It may avoid bias in terms of researcher's hypothesis."

"The way the directions were given is critical."

"The power point font size and written instructions are important components."

In addition, several students identified *research topic*, *participants' characteristics*, and *data analyses* as important components of scientific studies:

"Memory techniques."

"The tested subjects."

"Comparing the performance of students in 2 groups."

Critical reflections with future study application. Students were critical in their reflections on the simulated study and actively provided their own ideas for future directions of the study. A higher level of critical reflection was more apparent among graduate students than undergraduates. In particular, their suggestions for modifications of the simulation and further study of the topic were more abundant, unique, and creative.

Several students proposed more *challenging tasks with variations*. They reflected that length of time (1 minute) for practicing the memory technique was too long, and the number of words was too small in the simulated study. Various ideas for improving these problems were suggested: using content words in specific subject areas, adding colors and shapes to the words, and providing different forms of words.

> "On the second round, you could either have more words or have the same amount of words but with less time."
>
> "I would modify by asking mathematical (technical) words to research my major."
>
> "I would personally add color or maybe shapes to the study."
>
> "Use a mix of verbs, nouns, adjectives."

Other suggested modifications were related to the research design. Some students suggested that the simulated study should be based on *randomized sampling* to meet the homogeneity of experimental and control groups.

> "Grouping method in this study may make sure the apple-to-apple comparison between groups. Due to the high within group variance, the mean score for each group may poorly represent the group performance."

Other students suggested an extension of the study experiment for *testing long-term effect*, or comparing effects of other memory techniques.

> "I think the next phase of this research may be long term vs. short term technique or vice versa."

"I think using more techniques would be interesting. Just to see if one technique is better or easier for the majority than another method."

In addition, several students provided ideas for improving the treatment condition. They suggested a different manner of introducing target words and memory techniques for the experiment.

"Showing words one at a time instead of all together."

"Maybe show the participants a video about memorization technique."

Discussion

The study provided several unique implications for using simulation as an instructional tool for teaching scientific research methods. First, simulation facilitated students' active engagement in learning. Particularly, students showed more positive attitudes when the simulated research topic met their personal or academic interests. Second, after experiencing the simulation, students not only acknowledged better understanding of key elements of the scientific research method, but also were able to suggest and extend innovative ideas for modifying the simulated research in future studies. Third, for vocabulary recall, the story making strategy showed statistically significant effects for graduate students than for undergraduates and for native English speaking students than for ESL learners. In addition, this information stimulated new and unique paths for investigation of learning and teaching in follow-up discussion.

Advantages of using simulation for teaching scientific research methods were somewhat different according to the students' academic level. For undergraduates, the research simulation was a useful example for identifying key elements of scientific research. For graduate students, it was a meaningful chance to develop critical points of view and to generate creative modifications of the given study. One explanation for this difference may be the participants' previous research experience. All of the graduate students in this study were doctoral students, and likely had participated in one or more research projects where they had gained knowledge of basic elements of scientific research methods while they were in bachelors' or masters' degree work. Thus, instead of focusing on understanding the components of research, the graduate students were more likely to extend prior knowledge and evaluate whether the given study was conducted well or how the study could be modified for future investigation.

Regarding vocabulary learning, the story making strategy, which was proposed in the present study as an alternative to rote memorization, was more effective for graduates than undergraduates and for native English speakers than ESL learners. The story making strategy required constructing meaningful connections between given words. It is possible that students may need more advanced cognitive and linguistic abilities to create a story based on a random list of words. They may also need to consider what happened in the story (plot), where or when it occurred (context), and who is in the story (characters). They may also require more time to check sentence structures, word order, verb tenses, and conjunctional word usages in their story. Finally, the story making strategy may have been a more powerful memory strategy among graduate students than undergraduates due to their advanced academic levels; and stronger for native English speakers whose English proficiency was better than ESL learners.

Limitations and Future Directions

The research components demonstrated through this simulation did not cover the entire process of scientific research. Particularly, the simulation was focused on selected methodological aspects of conducting real time experiments rather than additional processes required in scholarly and scientific studies, such as reviewing literature to generate research questions, analyzing data, and interpreting results. Accordingly, for future study, the advantages of using simulation need to be investigated by including the entire process of conducting scientific research.

Another limitation of this "study within a study" was the lack of showing genuine intervention effects. Although post-test results showed statistically significant differences between the two memory strategies, it cannot be concluded that the one-time trial would recommend story making as a more effective strategy for vocabulary recall than rote-memory. Additional intervention studies need to be conducted to make the simulated study's findings more plausible.

Conclusions and Instructional Implications

This simulation strategy provided a common experience for students to inquire and learn more about scientific research while also demonstrating that simulation can be an efficient instructional strategy for enhancing students' knowledge of research processes and methods. In addition, responses to the instruction, as noted by the instructor, students, and end-of-semester class evaluations, were positive and indicated increased student involvement in learning.

Two important points should be carefully considered before adopting simulation as an instructional method for teaching and learning scientific research processes. First, the instructor needs to assess students' prior knowledge of and experience with the scientific research process. In addition, students should have a clear concept of what their participation in the simulation will contribute to their knowledge base of how to conduct scientific research. If the majority of students already have knowledge of essential components of research methods, the instructor may need to put more emphasis on generating topics that are of current interest to students, and then simulating processes that would be appropriate for conducting a study of one or more selected topics. This can be challenging for the instructor, however, if the emphasis shifts to the research topic rather than to the research process as intended in the simulation.

Another extension of simulation as an instructional strategy might provide students in research methods classes an opportunity to use the simulation process on their own research designs, individually or in groups, so that others in the class could provide feedback and experience multiple processes for conducting research. In addition, results generated from simulated studies can also provide motivation for students' further investigations in future, authentic studies.

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Table 1.

Summary of Pre- and Post-test Results

			Pre-test		Post-test	
		N	*M*	*SD*	*M*	*SD*
Class	Under	22	6.82	0.50	6.82	0.50
	Grad	21	6.57	0.81	6.52	0.60
Language	L1	32	6.75	0.67	6.69	0.59
	L2	11	6.55	0.69	6.64	0.51
Group	G1	21	6.71	0.72	6.67	0.58
	G2	22	6.68	0.65	6.68	0.57

Note. N = number of participants; Under = undergraduate students; Grad = graduate students; L1 = native English speaking students; L2 = ESL learners; G1 = Group 1 (rote-memory strategy group); and G2 = Group 2 (the story making strategy group).

Table 2.

Summary of Testing Main- and Interaction-effects in ANCOVA

Source	*SOS*	*df*	*MS*	*F*	*P*	η^2
Pre-test	0.77	1	0.77	3.01	.09	.08
Class	0.31	1	0.31	1.20	.28	.03
Language	0.18	1	0.18	0.71	.41	.02
Group	0.08	1	0.08	0.30	.59	.01
Class×Group	1.12	1	1.12	4.41	.04	.11
Language×Group	1.50	1	1.50	5.87	.02	.14
Within	9.18	36	0.26			
Total	12.84	42				

Note. Class×Group = two way interaction effect of class and group; and Language×Group = two way interaction effect of language and group.

Table 3.

Means (M) and Standard Deviations (SD) of the Interaction Effects.

			M	*SD*
Class×Group				
	Under	G1	6.87	0.15
		G2	6.72	0.15
	Grad	G1	6.60	0.18
		G2	6.74	0.17
Language×Group				
	L1	G1	6.53	0.12
		G2	6.83	0.17
	L2	G1	7.00	0.29
		G2	6.50	0.18

Note. Under = undergraduate students; Grad = graduate students; L1 = native English speaking students; L2 = ESL learners; G1 = Group 1 (rote-memory strategy group); and G2 = Group 2 (the story making strategy group).