Spring 5-2019

The Effect of Computer-Based Simulation on Learning and Self-Efficacy in Speech-Language Pathology Graduate Students

Emilie M. Okopal

THE EFFECT OF COMPUTER-BASED SIMULATION ON LEARNING AND SELF-EFFICACY IN SPEECH-LANGUAGE PATHOLOGY GRADUATE STUDENTS

A Thesis

Submitted to the School of Graduate Studies and Research

in Partial Fulfillment of the

Requirements for the Degree

Master of Science

Emilie M. Okopal

Indiana University of Pennsylvania

May 2019

Indiana University of Pennsylvania
School of Graduate Studies and Research
Department of Communication Disorders, Special Education, and Disability Services

We hereby approve the thesis of

Emilie M. Okopal

Candidate for the degree of Master of Science

12/7/18 — Signature on file
Lori Lombard, Ph.D., CCC-SLP
Professor of Speech-Language Pathology, Advisor

12/7/18 — Signature on file
Lisa Hammett Price, Ph.D., CCC-SLP
Professor of Speech-Language Pathology

12/7/18 — Signature on file
Erin Clark, M.S., CCC-SLP
Assistant Professor of Speech-Language Pathology

ACCEPTED

Signature on file
Randy L. Martin, Ph.D.
Dean
School of Graduate Studies and Research

Title: The Effect of Computer-Based Simulation on Learning and Self-Efficacy in Speech-Language Pathology Graduate Students

Author: Emilie M. Okopal

Thesis Chair: Dr. Lori Lombard

Thesis Committee Members: Dr. Lisa Hammett Price
Mrs. Erin Clark

Computer-based simulation has been utilized in various fields to supplement traditional didactic learning to develop clinical competence skills without compromising patient safety. To date, there is no existing evidence of the effects of computer-based simulation in the field of speech-language pathology. Thus, an analysis of the effects of implementing computer-based simulation in speech-language pathology is needed to explore the potential advantages to developing clinicians that the platform could serve. The current study focused specifically on first-year graduate students in speech-language pathology that were beginning their third semester of a five-semester master's program. Fifteen female participants between the ages of 22 and 29 participated in the study. Each participant was randomized to a simulation group (n=7) or control group (n=8). All participants completed two forms of pre-assessment; a pre-test consisting of six knowledge-based multiple choice questions and *The Self-Efficacy in Patient Centeredness Questionnaire* (Zachariae, O'Connor, Lassesen, Olesen, Kjaer, Thygesen, Morcke, 2015). The simulation group then completed five computer-based simulation case modules in which they were required to read through cases and answer interactive clinical questions based on each case. The control group was given the same five case modules, but in the form of text on paper to emulate traditional didactic learning. After participants completed the six case modules, they were given two forms of post-assessment which were the same six knowledge-based multiple choice questions and *The Self-Efficacy in Patient Centeredness Questionnaire* (Zachariae et al., 2015) as administered at pre-assessment. Results suggest that computer-based simulation has an effect on knowledge and self-efficacy in speech-language pathology graduate students.

ACKNOWLEDGMENTS

I would like to thank the following people for their unwavering support throughout this entire process. This thesis would not have been possible without your guidance, love, and dedication to my life and to my future. I am eternally grateful that you never accepted anything less than excellence from me.

Lori Lombard

Lisa Hammett Price

Erin Clark

The Okopal Family

The Graduate Class of 2019

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

REVIEW OF LITERATURE

Speech-language pathology students enter graduate school to establish skills that will enable them to demonstrate clinical competence upon entering their field of profession. Not only are clinical competence skills required for degree completion in speech-language pathology, but they are critical skills that employers seek when hiring clinicians to serve a specific patient population. To facilitate development of clinical competence skills, simulation technology has been accepted and utilized in various fields of medicine to counterbalance a lack of faculty resources and to expand on the traditional way in which concepts have been taught by instructors. Customarily, students have been taught a curriculum of didactic courses, and then their technical skills were assessed under the supervision of experienced clinicians at the bedside of real patients. However, people in clinical professions have been seeking ways to improve students' skills with patients prior to having them work with real patients to increase patient safety and quality of care (Prat, Charron, Repesse, Coriat, Bailly, L'her, Vieillard-Baron, 2016, Urbankova, 2010).

According to Duta, Amariei, Bogdan, Popovici, Ionescu, and Nuca (2011), the process of developing competence in clinical skills requires assimilation of large amounts of information and knowledge in combination with problem-solving abilities. Furthermore, Suvinen, Messer, and Franco (1998) stated that the acquisition of clinical skills and the transfer of those skills to the clinical setting with real patients is of paramount importance. Establishing the high-level skillsets related to clinical competence is further challenged when considering some of the trends in healthcare today. For example, the hospital setting is continuously changing, and patients are being admitted with more severe disorders (i.e., higher-acuity patients). Despite disorder severity, the duration of hospitalization has been decreasing which requires that patients receive an increase in care while they are in the hospital. In fact, from the year 1980 to 2000, the average length of inpatient hospital stays decreased from 7.5 days to 4.9 days. Technological advances have introduced another challenge to development of clinical competence. These advances now allow for seriously ill patients who would have received impatient care in the past, to receive care in outpatient settings instead (Stanton, 2004).

One avenue that has been used to help build clinical competence in students-in-training is computerized simulation. Not only does computerized simulation have the potential to support the growth of clinical competence skills, but it also reduces clinician error and increases patient safety.

Simulation in the healthcare field has been recognized as a form of training that significantly improves overall patient safety (Cheng, Kessler, Mackinnon, Chang, Nadkami, Hunt, Duval-Amould, Lin, Cook, Pusic, Hui, Moher, Egger, Auerbach, 2016). Computerized simulation ultimately allows clinicians to practice complex clinical skills that resemble real-life practice without compromising patient care and safety. Given evidence of potential benefits of simulation learning, the frequency of its use in healthcare professions is expected to increase. To date, research has not been conducted on the implementation of computer-based simulation into a learning curriculum with speech-language pathology students. However, current literature does exist on the use of computer-based simulation learning within other healthcare fields.

The following sections contain information regarding the review of literature, including computer-based simulation learning being used in dentistry, psychology, neurosurgery residents and hospital trainees, middle school science, management accounting, psychiatry, and nursing. The evidence found in the literature review serves as evidence for the purpose of the current study.

Description of Computer-Based Simulation

Computer-based simulation is essentially the use of a computer program to emulate real-life scenarios. The core advantage of utilizing computer-based simulation in the healthcare field is that it provides users with the ability to learn and practice realistic skillsets without compromising patient safety. Computer-based simulation can be designed in several platforms including task training, case-based decision modules, virtual reality, and gaming. Task training computer-based simulation allows users to practice skills related to completing a specific task or procedure (LeBlanc et al., Urbankova et al., Gasco et al., Prat et al., Stern et al.). Case-based decision modules permit users to review case studies and make various decisions based on the information that is provided. Users are guided through the case-based simulation experience based on the decisions that they make (Lambert & Meier, Lambert & Lenthall). Virtual reality computer-based simulation allows users to enter a simulated world that imitates an environment that could be seen in the real world (e.g., hospital, nursing home, skilled nursing facility). The virtual reality simulation takes users through a virtual world as clinical decisions are made by the user (Wynder, Jachna et al., Jenson & Forsyth). The gaming platform of computer-based simulation involves users participating in exercises that are game-like in nature to practice particular skills.

Dentistry

The field of dentistry is one of the medical professions that has begun applying computer-based simulation training during didactic coursework for students completing their preclinical learning experience. Of the studies in dentistry, all use a computer-assisted simulator called DentSim. This software program elicits real-time feedback by displaying three-dimensional graphics. Users are held to the highest standard of performance by aiming to achieve the most "ideal" cavity preparation, which is programmed into the DentSim software to provide consistent feedback to guide users through the simulation (Urbankova, 2010). The software also offers users comprehensive patient records including medical history, dental history, x-rays, examination notes, diagnosis, and treatment plans. Once users have competed their simulated experience, their performance is saved to a file that can be reviewed by both instructors and students to identify any errors that were made (LeBlanc, Urbankova, Hadavi, Lichtenthal, 2004).

A simulation training study in dentistry was conducted by LeBlanc et al. (2004). In this study, the researchers compared virtual reality simulator-enhanced training with laboratory-only practice on the development of technical dental skills in a randomized controlled trial. The study utilized 68 students (44 males and 24 females) who were enrolled in the second-year course of preclinical operative dentistry at Columbia's School of Dental and Oral Surgery (SDOS). The students were randomly assigned to either a simulator group (DentSim) or a control group. The simulator group (*n*=20, 12 males and 8 females) received computerized simulator training in addition to 110 hours of traditional laboratory-based training. The control group (*n*=48, 32 males and 16 females) only received the 110 hours of traditional laboratory-based training. Students in both the simulator and control group were permitted to devote any amount of time outside of the study to practice their skills. This additional practice time was not monitored by researchers (LeBlanc et al., 2004).

All participants received the traditional laboratory-based curriculum training together. This training consisted of faculty lectures and demonstrations paralleling those of the traditional didactic learning environment. The information was conveyed to all students by the same seven instructors. For those students assigned to the simulator group, supplementary training was given for six to ten hours in three blocks over a span of eight months. In Block 1, which took place from December to April, students in the simulator group were given one to two hours of training with the computerized simulator. In Block 2, taking place from April to May, students received two to three hours of practice with the computerized simulator. In Block 3, spanning from May to July, students participated in simulator training for three to five hours (LeBlanc et al., 2004).

To measure outcomes for the study, student performance was evaluated using practical exams which took place in December, April, May, and July. The practical exams required students to apply their knowledge and perform a variety of dental procedures, such as cavity preparations and restorations. The practical exams included three to six procedures and took approximately five to eight hours each. Two faculty members independently rated students on their performance on a 0-100 scale. The average of both faculty members' ratings determined each student's grade. In the case of this study, the instructors who were rating student performance were blinded to the student's experimental or control group status; however, no reliability data was reported (LeBlanc et al., 2004).

Results of the study showed that all students, both in the simulator and the control group, performed on average with increased accuracy over the course of the academic year. This finding indicated that student's in both groups improved in their ability to prepare cavities. There was no statistical significance between the two groups overall performance during the year (p=.56); however, there was a noted statistically significant difference when comparing the two groups' performance on practical examinations throughout the year. On practical exams completed earlier in the academic year, students in the control group scored higher than those in the simulator group. However, on practical exams completed later in the academic year, particularly on the final practical exam, students in the simulator group showed higher scores than the students in the control group. This comparison reached statistical significance (p=.01) and indicated that the DentSim group improved significantly more than the control group students. The authors concluded that "virtual reality simulation provides an effective training method for the development of operative dentistry skills in students" (LeBlanc et al., p. 381).

The authors were adamant in highlighting their belief that the true benefit to computerized simulation is most valuable when it is offered in addition to the general curriculum. Although the researchers were confident that the integration of computerized simulation was the foundation of those in the simulator group generating higher scores at the end of the academic year, a potential shortcoming of the study was that the amount of time that students spent outside of the study practicing skills on their own time was not monitored. To counter this deficiency, researchers administered an informal survey to students after the study and found that on average, approximately 83 hours were spent practicing outside of class during the academic year (LeBlanc et al., 2004). It can be concluded with confidence that the implementation of DentSim computerized simulation software improved participant performance on practical exams. This conclusion is supported by the finding that the simulator group improved significantly more than the control group by performing with higher accuracy on practical exams completed later in the academic year. The only glaring weakness in this study was that the researchers did not accurately report the amount of time that students spent outside of the study practicing concepts, which could have affected the dependent variables outcomes. However, this is a minor flaw that does not diminish the importance of the research findings.

A second research study conducted by Urbankova (2010) aimed to expand the findings of LeBlanc et al. (2004). Urbankova noted that in LeBlanc's study, computerized dental simulation training was not administered until relatively late in the course curriculum and that the administration time was relatively short. With these potential shortcomings in mind, Urbankova explored how computer-based, simulation training could be useful in the preclinical, operative dentistry curriculum, in addition to determining the optimal timing and duration of training by using a randomized controlled trial. The study's participants consisted of 75, second-year dental students from Columbia University College of Dental Medicine. The participants were randomly assigned to two groups: a simulation group and a control group. The students who were assigned to the simulator group (n=39) received eight hours of training on a computer dental simulator (CDS) in addition to completing the requirements of their regular curriculum course. The control group (n=40) were only trained in the traditional preclinical dental laboratory.

Data was taken during one academic year (September to July) on three exams to observe the participant's progress. Because one aspect of the purpose of the study was to examine when the implementation of computer-based simulation was most advantageous, the simulator group was further divided into a pre-exam and post-exam group. The participants in the pre-exam group (n=26) completed CDS training prior to exam 1 in December. The post-exam group (n=13) completed CDS training prior to exam 2 in March. Scores between raters for any given examination were assessed for reliability. All resulting correlation coefficients were between .69 and .90. This validated that the scoring of exams was completed in a reliable and systematic way.

Results of this randomized controlled trial showed that for the first two examinations, participants in the CDS group (pre-exam and post-exam) performed significantly better than participants in the control group. However, on the third examination that was administered at the end of the academic year, the CDS group performed better than the control group, but the comparison did not reach statistical significance. When outcomes were reviewed regarding when the CDS training was implemented during the academic year, pre-exam CDS group scores were higher on exam 1 when compared to those of the post-exam and control groups. Furthermore, on exam 2, the post-exam CDS group scored higher than the control group, but similarly to the pre-exam group. Finally, the results of performance on exam 3 showed that the pre-exam and post-exam CDS groups scored slightly higher than the control group, but not in a statistically significant manner.

In discussing the results of the study, researchers generally concluded that the implementation of CDS into a preclinical, operative dentistry curriculum did indeed improve student performance. Despite examination results not always being statistically significant in the simulation group versus the control group, the students in the CDS group did achieve higher scores than the control group for the entire academic year. With regard to when simulation training should be implemented in the curriculum, the authors concluded that there was not sufficient evidence to suggest that early and intense implementation was advantageous.

The study also revealed an interesting point regarding metacognitive skills. Urbankova (2010) described metacognition in the learning environment as "…a level of thinking that involves active control over the procedure performance, including planning the way to approach a task, monitoring comprehension, and evaluating progress towards the task completion." (p. 407). Metacognition was then tied to computer-based simulation by noting a qualitative observation that was made by professionals in preclinical dental training at Columbia University College of Dental Medicine. This observation was that as students began developing more knowledge due to experiences, their learning and performance became more automatic, therefore requiring less feedback. In referencing this noted observation, the author suggested the possibility that computer-based, simulation training could be additionally valuable to students because of its ability to provide "frequent feedback" and "play a meaningful role in student training" (Urbankova, 2010, p. 407).

The author further supported computer-based simulation learning by emphasizing three characteristics of the CDS program that were specified as beneficial for students. These characteristics included the CDS program providing "twenty-four-hour availability with step-by-step guidance and evaluation, standardized educational experiences that can be used repeatedly with fidelity and reproducibility, and an individualized learning process that allows students to focus on areas that will enhance their level of competence most efficiently." (Urbankova, 2010, p. 407).

Although the study largely supported utilizing CDS, the author reported one major shortcoming: researchers were unsure of the amount of time that students may have spent outside of the study practicing their skills. Particularly in the control group, if participants were aware that their classmates were receiving additional education, they may have spent extra time outside of the curriculum practicing their skills, given the typically-competitive nature of professional students. From the opposite perspective, students receiving CDS could have dedicated additional time out of the study to practice skills related to the curriculum that they were being taught traditionally. Unfortunately, the researchers did not collect data on the amount of time that students were studying outside of class and simulation experiences.

Both the LeBlanc et al. (2004) and Urbankova (2010) research studies supported the utilization of computerized simulation in the training of preclinical dentistry students. Urbankova (2010) explicitly stated that "…virtual reality simulators should not be viewed as a substitute for human instruction, however, they do provide an additional layer of instructional quality and content to the preclinical educational experience" (p. 408). The studies included in this section were both of high-quality research design and report statistical significance, blinding, randomization of participants, and respectable measures of reliability and validity. Mutually, the studies mention that computerized simulation should not be employed in isolation, but rather, amid traditional learning curriculum in the classroom. An overarching shortcoming consistent between both studies is the glaring limitation that the degree to which students were practicing outside of the studies was not thoroughly documented. Although this flaw may not have skewed the results in a significant way, it should not be ignored in reviewing the outcomes found by both studies.

Psychology

Psychology is another discipline within the field of healthcare that has scrutinized computerized simulation for teaching purposes. Of the minimal research that exists, the findings of studies probing the effects of computerized simulation training in psychology present several caveats related to simulation training itself, in addition to limitations in evidence regarding research design. Lambert and Meier (1992) conducted a quasi-experimental research study to discern the utility of three computer simulations for training and evaluation purposes. The researchers compared psychology students from a large southwestern university (Site 1) and a large northeastern university (Site 2) to determine the participants' perceptions of computerized simulation learning and to evaluate any differences in group performance.

Lambert and Meier (1992) exposed participants to the Clinical Diagnosis and Treatment Decision-Making (CTDM) computerized, simulation software. CTDM ultimately renders realistic situations in which users are required to practice diagnostic and clinical skills in order to sufficiently treat simulated clients. CDTM software presents general information about a client, and then permits the user to take an active role in the decision-making process by selecting options from various menus that provide users with information to establish a clinical diagnosis and to create a treatment plan.

The Lambert and Meier (1992) study contained 35 students from Site 1 and 32 students from Site 2. The participants selected for the study were taken from three groups: undergraduate students (Site 1, *n*=13, Site 2, *n*=10), first-year graduate students (Site 1, *n*= 13, Site 2, *n*= 8), and third- and fourth-year graduate students (Site 1, *n*=11, Site 2, *n*=14). The undergraduate students were only drawn from junior and senior classes. The mentioned difference between first-year graduate students and third- and fourth-year graduate students was that the first-year graduate students were still considered to be "novice", while the third- and fourth-year graduate students were labeled "experienced" (Lambert & Meier, 1992).

Participants in the study completed three, computerized case simulations that were designed to analyze diagnostic, assessment, and treatment information in order to make decisions. The simulation software introduced cases of patients presenting with chronic headache, bulimia, and cocaine abuse that would be typical of the kinds of patients seen in various mental health facilities. Ultimately, during the simulation experience, participants were expected to conduct interviews and examine the results, administer physiological, cognitive, behavioral, and motoric assessments, review assessments that may have already been completed, request consultations and referrals, conduct treatments, and administer follow-up assessments after treatment had been given. The authors obtained data for the participants' simulated performance and perceptions of the simulated experience by averaging results over the three administrations of the computerized case simulations (Lambert & Meier, 1992).

In addition to assessing participants' performance on the aforementioned conditions, the authors also used a Simulation Perceptions Form (SPF) to gather information about how participants felt about the computer-simulated learning experience. The SPF contained five items that were strategically developed to attain information from participants concerning whether their knowledge was tested in an effective way that was harmonious with what they had been taught, how closely the simulations mirrored the real-life clinical decision-making process, how useful the simulations were to the learning process, how the simulations compared to other learning tools (i.e., textbooks), and how useful simulation would be prior to practicum experiences (Lambert & Meier, 1992).

The participants were independently scheduled to complete the three computerized case simulations. On average, the simulation took students approximately thirty to forty minutes to complete. Once the participants completed the simulations, they were then asked to rate their experience using the SPF form. (Lambert & Meier, 1992).

Results of the study showed that there were statistically significant differences between Site 1 and Site 2 in the number of psychological tests administered, reviewed criteria, options selected, and critical decisions made. The students from Site 1 consistently administered more psychological tests and reviewed criteria more often but made less option selections and critical decisions than those students from Site 2. The researchers also saw statistically significant group differences in the number of interviews that were examined, clinical interviews conducted, psychological and cognitive tests administered, and follow-up assessment administered after treatment had been given. When comparing the differences, however, researchers were unable to establish a pattern of the complex results to come to conclusive findings (Lambert & Meier, 1992).

Due to the inconsistent group findings, the researchers opted to alter the analyses of the results by calculating general, clinical behaviors of students during the computerized simulation experiences. Three composite scores, SCORE1, SCORE2, and SCORE3, were generated to satisfy the reestablished method of analysis. SCORE1 reviewed how students gathered information prior to treating the simulated patients (i.e., review of intake interviews, conducting clinical interviews, administration of assessments, review of existing criteria, requesting consultations or referrals). SCORE2 combined all scores from SCORE1, except for reviewing intake interviews, conducting clinical interviews, reviewing existing criteria, and requesting consultations or referrals. SCORE3 produced data concerning the amount of information gathered and critical decision-making activities that were completed by students before executing treatment with simulated patients (Lambert & Meier, 1992).

Univariate analysis of the composite scores revealed a significant site by group interaction for variables under each SCORE. Students from Site 1 utilized more information from existing resources than undergraduate or third- and fourth-year graduate students. Also, students from Site 2 utilized information from existing resources as their experience with the computerized simulation increased. The authors concluded that the inconsistences in data resulted from the site differences of the experimental groups and were therefore, present prior to obtaining the composite scores (Lambert & Meier, 1992).

Student perceptions of the computerized simulation experience using the SPF form indicated that students generally accepted the program as an effective means of learning. The authors caution readers on this positive perception, however. The researchers present the possibility that due to the game-like nature of the computerized simulations, it is not possible to say whether or not those who use computerized simulation would value the utility of the program over the long haul. Further, researchers support this possibility by stating that because the subjects in the study were naïve to the computerized simulations, there is a chance that there was a subconscious "novelty or entertainment effect" (Lambert & Meier, 1992, p. 81) felt by participants that could rather quickly fade. From this possibility, researchers conclude that computerized simulation may be beneficial to use as an evaluation tool for general problem-solving skills, but not for practicing more precise, clinical approaches (Lambert & Meier, 1992).

The results of this research experiment can be mostly trusted with confidence. The study is a quasi-experimental research design that reports thorough analyses of results for between group differences. However, the study does have some uncontrolled threats because of the lack of a control group. Also, caution should be used when interpreting the results of the SPF because it is a self-report measure and may be affected by bias or by participants' attempts to respond in a way that they believe would be viewed positively (Lambert & Meier, 1992).

A second research study of similar design to that of Lambert and Meier's study was conducted by Lambert and Lenthall in 1998. In this study, three computerized simulation case studies were used that nearly identically emulated the analyzed skills and decision-making processes in the Lambert and Meier study. The three simulated case studies were named *Mr. Howard*, *Mr. Kopf*, and *Ms. Barnes*, and demonstrated symptoms associated with agoraphobia, chronic headache, and bulimia. The three simulated case studies were used with undergraduate students in an Abnormal Psychology and Counseling Theories course. The students were permitted to assume a therapist's role for the simulated clients in assessing, diagnosing, and treating the symptoms of their assigned client.

The computerized simulations for Mr. Howard and Mr. Kopf were utilized by students in an Abnormal Psychology class during the fall semester of 1986 (n=27). Seven students completed the Mr. Howard simulation, while twenty completed the Mr. Kopf simulation. The computer simulation case study for Ms. Barnes was utilized by students in a Counseling Theories class in the spring semester of 1987 (n=16). Before the start of the study, all participants were given an orientation on how to use the computerized simulation program and an instruction sheet to guide participants through the simulation start-up process. Participants were asked to sign up for a designed 30-minute block of time outside of class to complete the computerized simulation experience. Additionally, students were told that "…the simulation was a course requirement, yet their performance would not be graded" (Lambert & Lenthall, 1998, p. 134). In addition, participants were conveyed the message that they should "…view the simulation experience as a learning experience to facilitate understanding the course material" (Lambert & Lenthall, 1998, p. 134). Following the computerized simulation, each student was also required to write a one-page paper reflecting on their experience. The researchers then reviewed participant papers to identify patterns across all reflections (Lambert & Lenthall, 1998).

Participants' reactions based on the reflection papers generally offered information that the computerized, simulation experience was positive and should continue to be utilized for learning. A common finding in several participants' papers was that their anxiety of learning the material was reduced by using the computerized simulation, rather than didactic learning in the classroom environment. Students additionally mentioned that the computerized simulations acted as a "motivator" (p.134) in their learning experience, particularly because of a felt "novelty effect" (p.134), due to the change of pace that the computerized, simulated learning experience offered. Many students also mentioned one undesirable aspect of the computerized, simulation experience – a limitation to their knowledge. The participants that described about a negative experience said that the computerized simulation emphasized areas of psychology that they were not yet proficient in, which therefore led to some feelings of frustration when working through the simulation (Lambert & Lenthall, 1998).

The authors of this study concluded that despite the negative report from the participants, the positive results yielded from the study ensures the significant potential to implementing computerized simulation into learning curriculum. Further, the authors hypothesize that an "instructional package" (Lambert & Lenthall, 1998, p.134) approach, in which computerized, simulation programs are designed within traditional course materials as supplemental teaching aids, would be the most effective means of implementation. With this approach, the authors are confident that students would receive both a theoretical and applied materials style that would foster a prosperous learning experience (Lambert & Lenthall, 1998).

Based on the findings of both Lambert and Lenthall (1998) and Lambert and Meier (1992) in the field of psychology, computer-based simulation learning was positively perceived. Like the research studies conducted in dentistry, the psychology studies also found computer-based, simulation learning to be most useful when used as supplementary material to a traditional, textbook-oriented approach. Additionally, both studies by Lambert and Meier (1992) and Lambert and Lenthall (1998) brought to the surface the idea of a "novelty effect" being experienced by participants in their studies. Although this is a finding worthy of being mentioned, it is a factor that may be less pertinent in the world today. Technology has drastically increased in use for daily entertainment, pleasure, and educational purposes. With both studies being conducted over two decades ago, the potential of a "novelty effect" having a sizable influence on the users of computerized simulation may be slight in today's context. Lastly, both studies in psychology present valuable information in regard to computer-based simulation learning but should be viewed with mindful caution due to their lower-level research designs and threats to validity.

Neurosurgery Residents and Hospital Trainees

Neurosurgery is a field that has also begun exploring the potential benefits of simulated learning in developing professionals. In a 2013 cohort research study conducted by Gasco, Holbrook, Patel, Smith, Paulson, Muns, Desai, Moisi, Kuo, Macdonald, Ortega-Barnett, and Patterson, researchers intended to observe how the use of different forms of simulation learning were perceived by neurosurgery residents. For this study, six neurosurgery residents from the University of Texas Medical Branch were administered the simulation curriculum. The residents were considered junior level if they were one to three years postgraduate or senior level if they were four to six years postgraduate. The simulation curriculum was made up of 68 core exercises that were allocated in sets of 30 during an academic year. Using the simulation curriculum, researchers calculated that a total of 180 procedures were completed by the participants. The procedures consisted of 70 physical simulations, 57 cadaver simulations, and 44 haptic/computerized simulations. All of the simulation curriculum learning was done in a laboratory that was created in close proximity to the resident's work area. Residents reported to this designated area to complete their simulation experiences between June 2012 and April 2013.

Once each participant completed the simulation curriculum learning, they would receive an email that requested their feedback on the Physician Performance Diagnostic Inventory Scale (PPDIS). The residents were to rate themselves using the PPDIS as *unsatisfactory*, *early learning*, *competent*, or *proficient* once they had completed a simulated learning unit. Primarily, researchers were seeking data on how the simulation curriculum affected the resident's perceived self-efficacy in their ability to perform procedures (Gasco et al., 2013).

Results of the current study were acquired through the evaluation of 180 PPDIS surveys completed by the residents. Junior and senior residents reported that cadaver simulations increased self-perceived benefit the most (71.5%), followed by physical simulators (63.8%), and then haptic/computerized simulators (59.1%). Junior residents reported an improvement in proficiency on 82% of simulations, with the highest improvement rate being in cadaver (91.7%), followed by physical simulators (83%), and then haptic/computerized simulations (69.6%). Correspondingly, senior residents reported an improvement in proficiency on 42.5% of simulations. Senior residents improved proficiency was reported most in haptic/computerized (47.6%), trailed by cadaver (44.5%), and then physical simulations (39%). Interestingly, researchers furthered their evaluation of results by using multivariate analysis to determine that senior residents were 83% less likely to improve using the simulation curriculum than junior residents (Gasco et al., 2013).

Discussion around the findings of the Gasco et al. (2013) study presented predominantly positive stances towards simulation learning. Both junior and senior residents reported improvements using the simulation curriculum during the academic year. The authors supplemented this finding by advocating for future research targeting whether or not the perceived benefits of simulation transfer into measures of patient care in the real-life medical setting. Potential measures for determining this could include factors such as decreased operating room time, complications, and length of patient stay. The researchers also spoke directly to the finding that senior residents showed a less substantial improvement on simulations than junior residents. They proposed that an explanation for this finding could be that the learning curve that exists from competent to proficient is much steeper at later stages in academia, as compared to earlier stages. Nonetheless, despite this learning curve, the senior residents still reported benefit from the simulation curriculum without sacrificing patient safety – which is made possible by simulated learning (Gasco et al., 2013).

A rather similar prospective, a study conducted by Prat, Charron, Repesse, Coriat, Bailly, L'her, and Vieillard-Baron (2016) experimentally observed the effects of a computerized, echocardiographic simulator on learning transesophageal echocardiography (TEE) hemodynamic assessment. Transesophageal echocardiography hemodynamic assessment is a skill that is recommended to be part of the curriculum for all trainees and therefore, researchers were interested in examining the effects of learning this procedure. The study was conducted from May 2012 to November 2014 at two, French university hospital medical intensive care units (ICU). Researchers determined that all residents being rotated through the ICU every six months without previous experience in TEE assessment would be included in the study. In the end, 56 trainees (*n*=56), 25 in the intervention group (*n*=25) and 31 in the control group (*n*=31), were analyzed for the study. Trainees were anesthesiologists (62%) and cardiologists (19%)

Trainees in both the intervention and control groups were permitted to perform and interpret TEE examinations online over a six-month period that were monitored under the supervision of an expert in TEE. Also, trainees in both groups also received a two-hour didactic course taught by an expert, which outlined basic echocardiographic ultrasounds at the start of each six-month phase. Trainees in the intervention group additionally received two, three-hour sessions of individual instruction which included an echocardiographic computerized simulation during the first three months. All trainees were evaluated by a supervisor who was considered an expert in advanced TEE, with more than ten years of experience and greater than 200 TEE examinations performed each year. All evaluations were performed by the same expert in each center. Trainees did not receive any feedback or assistance from the experts while completing TEE. The trainees were assessed using a forty-point scale after one, three, and six months. The scale was comprised of four principle sections including practical skill (/14 points), evaluation skill (/10 points), technical skill (/8 points), and interpretation skill (/8 points) (Prat et al., 2016).

Results of the study indicated that mean scores improved more quickly over the six-month period for the intervention group compared to the control group, with a higher score at month one and month three, but not at month six. Trainees in the intervention and control groups reached the same score on average at six months. Competency level for completing TEE assessments was reached after approximately 32.5 supervised sessions in the control group, but after only approximately 13.6 in the intervention group. Moreover, practical and technical skill scores were largely increased at months one and three in the intervention group, but no difference was seen at month six between the intervention and control groups (Prat et al., 2016).

The researchers concluded that computerized simulation could be a worthwhile means of learning for hospital trainees in TEE assessment. The trainees exhibited an accelerated rate at achieving competencies, although both groups ultimately acquired equivalent skillsets by the end of the six-month period. The Prat et al. study exhibited a high-level research design that controlled for many threats. However, the researchers underlined two potential threats to validity of their study: a lack of randomization of subjects and the chance of bias from experts that trained participants being the same individuals that scored trainees using the forty-point scale (Prat et al., 2016).

The effects of computerized simulation are strongly supported with both neurosurgery residents and hospital trainees (i.e., anesthesiologists and cardiologists). In the research study by Gasco et al. (2013), computerized simulation was found to be least useful when compared to cadaveric and physical simulation. The researchers explain this finding by suggesting that both cadaveric and physical simulation provide opportunity for exposure to anatomy and require psychomotor skills similar to those in a real-life operating room. This shortcoming is an area of unavoidable limitation to computerized simulation and should be considered when implementing it into course curriculums. The study conducted by Prat et al. (2016) used a research design that employed computerized simulation along with traditional, didactic learning. This method of implementation of both computerized simulation and didactic learning curriculum as a "package" corresponds with that which was encouraged by all studies outlined in dentistry and psychiatry. Remarkably, Prat et al.'s study validated the suggestions by authors that computerized simulation as a supplemental aid to traditional scholastic teaching can be superiorly beneficial for users.

Middle School Science Students

Computer-based, simulation learning has not only been investigated with older students, but also with younger students. In a study by Stern, Barnea, and Shalui (2008), researchers investigated the effect of computerized simulation on seventh grade students' understanding of the kinetic molecular theory. The kinetic molecular theory is very complex in its foundation but is a crucial concept for middle school students to understand because it serves as the basis for more difficult concepts presented at the high school level. The researchers mention that due to its complexity, educators consistently struggle to convey the theory to students so that they may appreciate and utilize its underlying fundamentals for application purposes. Further, the researchers add that although molecular diagrams and models in the classroom can communicate some understanding of the kinetic molecular theory, they postulate that the interactive and dynamic nature of computerized simulation could facilitate more comprehensive understanding. This study mostly focused on how computerized simulation affected the understanding of the kinetic molecular theory by seventh grade students, but also if there were any gender-related differences in outcomes. The authors related their purpose in exploring gender differences related to the topic to previous studies that reported that there appears to be statistically significant differences in the number of Israeli boys that pass science with honors as compared to Israeli girls. In addition, Israeli boys show to have significantly better attitudes towards science as compared to Israeli girls.

The study utilized three teachers and 133 seventh grade students at two middle schools located in the northern part of Israel. The two classes were randomly assigned to either be the control class (n=62), or the experimental class (n=71). Each of the three teachers taught one control class and one experimental class. The study began with the teachers teaching the first several chapters of text related to the kinetic molecular theory over 30 class periods. After the span of 30 class periods, students in both groups were administered a pre-test. Then, another chapter related to the kinetic molecular theory was taught to both groups. During this phase, students in the experimental group received an additional three class periods using a computerized simulation. Next, students in both groups were given a post-test to examine their understanding. Lastly, five students from the experimental group and five students from the control group were interviewed. The researchers also elected to probe students' long-term understanding by analyzing the results of the post-test examination when given a year after instruction (Stern et al., 2008).

Results of the study showed that students in both the experimental and control groups improved in their understanding of the kinetic molecular theory based on pre- and post-test results. However, there was a statistically significant difference in improvement in students in the experimental group compared to the control group (p<.001). Furthermore, the authors conducted a more multifaceted analysis of the results of the post-test and found that on all questions, the experimental group scored higher than the control group ($p<.001$). The researchers also saw no evidence of gender-related differences in the research findings. Interviews with the five students from the experimental group and five students from the control group gave students the opportunity to elaborate on written responses that they had provided on the tests. The researchers observed that the responses of students from both the experimental and control groups nearly mirrored those they had been transcribed on the tests with little variance. However, students from the control group presented with more naïve understanding of concepts related to the kinetic molecular theory when compared to the experimental group. The researchers concluded that this finding could be due to the experimental group receiving the added computerized simulation. Finally, when the post-test was administered to students a year after instruction, the experimental group again scored higher than the control group. Remarkably, the students also referred to the computerized simulation in their responses, as reported by teachers. Although only fifteen students ($n=15$) from the control group and twenty-six students ($n=26$) from the experimental group were available to be tested at this later date, the findings should still be taken into consideration (Stern et al., 2008).

The researchers remarked on the study's findings by stating that computerized simulation can benefit middle school student's understanding of the kinetic molecular theory. There were statistically significant between groups differences. This finding is especially interesting due to the kinetic molecular theory being such a challenging concept to grasp. The researchers also added that the study serves as affirmation for not only the use of computerized simulation, but also its utilization with general classroom curriculum (Stern et al., 2008). This finding continues to stand as a consistent recommendation and finding across all studies present in this review of literature.

The study by Stern et al. (2008) used a high-level research design that controls for most threats. Although its findings can be trusted, the study presents with some minimal threats. One potential threat could be that because different teachers were instructing both an experimental and control group, different teaching styles could have affected how students learned the didactic material. The research also did not report reliability measures for how they compared the experimental and control groups' performance. Given that the post-instruction test was administered by teachers, an instrumentation threat to validity and decreased reliability was introduced.

Management Accounting

A research study conducted by Wynder (2004) employed computer-based simulation learning into a second-year management accounting course. The study can be considered a low-level research design because it merely described the ongoing development of a computerized business simulation. Nonetheless, it served as a source of existing evidence for computer-based simulation. The simulation's development was based on challenges that were experienced and reported by students and faculty using the software over a two-year span (2000 to 2002). In the second-year management accounting course, during which the computerized simulation was utilized, employing knowledge to generate creative solutions to unique, business problems related to business was a vital learning objective. Hence, the study emphasized that the computerized simulation was designed to promote creativity. The stress placed on creativity branched from foundations reported by Amabile (1983), which stated that creativity is a part of life that is analogous to learning because it involves personal discovery and the generation of knowledge that is new to an individual.

The study implemented a computerized, business simulation program called MyMuse. This platform allows its users to enter a micro-world where students become the management accountant for a mail-order business that produces personalized music CDs. During the simulation, students learn about the business, analyze procedures, and identify determinants for improving performance and profit for the business. As users make decisions during the simulated experience, they receive feedback in the form of business memos from the owner of the company. The memos outline customer satisfaction reports, sales, and unfilled orders. The students further received feedback regarding the effectiveness of their decisions in the form of a Profit and Loss Statement, where the degree to which they are helping or hurting the business is quantitatively expressed (Wynder, 2004).

MyMuse was used as a supplemental learning tool to augment traditional teaching measures in the management accounting course. The author crafted a way in which MyMuse reproduced key topics that were accentuated in the course material so that students could exercise creative problem solving while using concepts that were currently being taught to them. After a two-week introduction on the MyMuse software, students reported to a computer lab where they all completed a workshop together that outlined the specific features of the computerized simulation (i.e., investigation, idea generation, and idea validation/communication). After the workshop, the actual simulation experience began in the form of an ongoing assignment. As students worked through the simulation, they were encouraged to submit any questions to instructors by email. If a question was surfaced that might be of interest to other students, an email was sent to all students providing clarification for the question. If instructors noticed a pattern of questions directed toward a specific matter of the MyMuse simulation, it was clarified during in-class lectures. Moreover, for students still experiencing difficulty after clarification, individual tutoring was offered to revisit theoretical and practical application principles related to topics in the course (Wynder, 2004).

Student feedback concerning the MyMuse simulation was gathered from self-ratings of creativity by students' reflection on the computerized simulation. Student progress in applying the learned information from the simulation and objectives from in-class lectures were also assessed when grading assignments. For a more comprehensive analysis, data was compiled from MyMuse itself, email communications between students and faculty, open-ended student comments, focus group discussion, and peer evaluation. Overall, results of student evaluations of the simulation in both 2001 and 2002 reported that the simulation reflected what they were being taught in class, facilitated independent learning, sparked the user's interest, was interesting and encouraging, and that the feedback provided by the simulation was helpful in the learning process. In 2002, an anonymous survey was administered to students that spoke directly to the creativity of the MyMuse simulation. The survey contained a seven-point scale, in which 1 corresponded with "not creative" and 7 with "highly creative." Results of the survey presented an average response of 4.6, with the lowest response being 3, and the highest response being 6. The author concluded that the survey's results provided support that the computerized simulation accomplished its purpose (Wynder, 2004).

Wynder mentioned several difficulties while on his journey in creating and modifying the MyMuse program. He reported that establishing adequate motivators and developing the program's feedback to reflect competence was especially challenging. For MyMuse, Wynder's development of a CD business was intrinsically motivating for students because it was something that they could relate to and be interested in. Also, the utilization of the Profit and Loss Statement further motivated students because they were able to see the direct effects of their decisions in the form of numerical value. Wynder also highly recommended that computerized simulation programs embody the ability to produce helpful and meaningful feedback. He supported this recommendation in saying that students learn by applying their ideas to decision-making, adjusting their decisions (if needed) based on feedback, and then reinforcing the correct knowledge to memory from practice (Wynder, 2004).

Again, despite the current study exposing a low-level research design, its reports are particularly representative of the suggested means of implementing computer-based simulation as complementary to traditional curriculum instruction. Wynder's study outlined the process of creating a platform where both technology and conventional didactic instruction are used for learning purposes. Furthermore, this study can be conceptually accepted as a form of validation to other study's mentions in this literature review that computerized simulation should be utilized amid traditional means of faculty instruction.

Psychiatry

In a 1993 study by Jachna, Powsner, McIntyre, and Byck, the effectiveness of computer-based simulation for teaching consultation psychiatry was investigated. The researchers justified the need for additional practice in the consultation psychiatry setting because it is a setting in which trainees have little experience before embarking on their internship experience. Trainees must learn to obtain medical, psychological, and social information about a patient, integrate and understand the information in the context of the hospital and patients' lives, and acquire information to reach an appropriate diagnosis and create a treatment plan for patients. The process in acquiring and assimilating all of these skills simultaneously has the ability to leave trainees feeling overwhelmed and puzzled. The current study conducted with medical students at the University of Arizona, Tucson implemented a computerized case simulation program to introduce trainees to consultation psychiatry in a way that was realistic, engaging, and did not compromise patient well-being.

A platform called PsyConsult Adventure Simulation was used in the study. PsyConsult Adventure Simulation takes users on a realistic journey that begins at the moment that the simulated healthcare providers walk through the simulated hospital doors. Users are guided through meeting with the hospital secretary to gather client files, finding the doctor who has information regarding the patients, meeting with patients, conducting interviews, consulting with family and caregivers, and finally, reaching a diagnosis and creating a treatment plan. Timely and effective consultations that provide helpful information are rewarded with high points for users as a means of reinforcement. To foster a realistic setting, incorrect choices are monitored and ramifications are implemented by the software program. For example, if a user makes too many extraneous and unneeded selections when conducting an interview with the patient or caregiver, they will be unable to arrive at rounds on time. Each user's simulation experience is monitored and feedback in the form of graphic images, text descriptions, dialogue, and sound effects are provided to users so that an interactive learning experience is achieved (Jachna et al., 1993).

To assess the utility of the PsyConsult Adventure Simulation program, five groups of third-year medical students were permitted to use the simulation in a consultation psychiatry seminar series. The total number of subjects was thirty-eight (n=38) in a single-group design, with two to ten students per group. Before the students were allowed to begin using the computerized simulation program, they were provided with an introduction to the software and asked to answer a set of ten multiple-choice, single-answer questions. Five of the questions covered general issues in consultation psychiatry, while the other five pertained to specific points outlined in the simulation. All students completed the computerized simulation together in the same room. Interaction among students and discussion about issues in the simulation was encouraged to resolve any misunderstandings. After all students had completed the simulation, they were retested on the same questions (Jachna et al., 1993).

Results of the post-simulation retest showed that students' answers generally became more accurate, especially those directly related to the computerized simulation. The degree of improvement for all ten questions from the first to second administration was statistically significant ($p<.05$). Additionally, student responses portrayed a positive reflection on the simulation. The students particularly remarked on the realism and motivation that the PsyConsult Adventure Simulation was able to generate. The researchers concluded based on the results and observations obtained from the current study, that PsyConsult Adventure Simulation could be viewed as a tool for improving student understanding. Further, the researchers also emphasized that bedside teaching will continue to be of crucial importance, therefore, the combination of traditional curriculum and computerized simulation would be most advantageous. This was consistent with the trend that has been seen across all studies in this literature review (Jachna et al., 1993).

Nursing

A pre-test/post-test single group research experiment by Jenson and Forsyth (2012) investigated one university's readiness to adopt the use of a form of virtual reality simulation (VRS) into current curricula by utilizing nursing faculty members as subjects. The VRS software that was being tested was a program that presented images to users in realistic, three-dimensional views. Users are able to interact with patients, colleagues, and resources in a similar fashion as a real-life medical setting. The instruction of this program was standard-based and provided immediate feedback to its users based on the clinical decisions that were made. The authors believed that VRS could better prepare students to treat patients in the most effective way by giving them additional practice on performing healthcare methodologies.

Nursing faculty members that taught clinical practice to undergraduate students at a major Midwestern state university were invited to participate in the VRS and respond to a survey afterwards. The VRS platform that was used in the study simulated the insertion of an intravenous (IV) catheter using a computerized program and haptic arm device. The haptic arm device was robotic in nature and was programmed to display touch from the user. The user is able to palpitate the haptic arm veins and virtually insert the IV. The program further requires its users to gather the equipment needed to complete the IV catheter insertion, cleanse the site, and begin the insertion. While completing all tasks in the VRS, users receive immediate feedback and redirection based on their performance (Jenson & Forsyth, 2012).

Eight nursing faculty members at the university agreed to participate in the study (n=8). The faculty members completed the VRS and a seven-question survey regarding satisfaction with using the computerized simulation. The participants were also asked to complete four open-ended questions where they could provide comments about the university adopting VRS. Results of the survey showed that all eight participants either strongly agreed or agreed that VRS would increase students' understanding of the procedure and that using the program for the procedure prior to entering the actual clinical setting would be most effective. Also, most participants reported that VRS increased their awareness of the potential differences in patient responses to the procedure their confidence in inserting the IV increased. Further, four faculty members reported that utilizing VRS for the procedure may be beneficial for students after their clinical rotation for increasing confidence in completing the procedure (Jenson & Forsyth, 2012).

Open-ended responses largely supported the adoption of VRS, mostly due to a wide-range of learning experiences felt by the participants. These learning experience include an increased understanding of the sequence of steps required to correctly complete the procedure, the need to utilize two patient identifiers prior to completing a procedure, and of the importance of being conscious of patient response during the procedure. Overall, the VRS system was viewed by participants as being very intriguing, motivating, and an excellent learning tool. The researchers discussed the results as positive evidence for potentially adopting VRS into existing curriculum for nursing students. A predominant shortcoming that was reported by participants was that the VRS software was incapable of simulating subtle nonverbal cues that are encountered in a real-life clinical setting, such as a patient's response to having an IV being inserted. With this in mind, the researchers concluded, like in all other literature, that VRS should be practically incorporated into traditional curriculum (Jenson & Forsyth, 2012).

Statement of the Problem

To date, there is no existing evidence of the effect of implementing computer-based simulation learning into the field of speech-language pathology. The literature that currently exists provides support for the implementation of computer-based simulation in other disciplines, but a gap is apparent when seeking to obtain evidence for implementing this method of education into speech-language pathology coursework. The current study provided data regarding the effects of a computer-based simulation experience on speech-language pathology students' learning and clinical self-efficacy.

CHAPTER II

PURPOSE

The purpose of the current study was to provide evidence of the effect of computer-based simulation on learning and its influence on feelings of self-efficacy in graduate-level, speech-language pathology students. Such evidence is essential in determining if the implementation of computer-based simulation is advantageous for learning concepts related to speech-language pathology. Although there are no published studies reporting data on outcomes of simulation with speech-language pathology students, there is a wide range of research in other disciplines that provides support for its use and recommendations for how to best integrate computer-based simulation into the curriculum. With this gap in research in mind, the following questions were addressed:

1. What effect does computer-based simulation have on speech-language pathology students' knowledge of the topic?
2. What effect does computer-based simulation have on speech-language pathology students' feelings of self-efficacy in providing clinically competent practice in that topic?

CHAPTER III

METHOD

Design

A randomized controlled clinical trial (RCT) design was used to answer the research questions. Participants were randomly assigned to one of the two groups in this study: either a simulation group or control group. After consenting to participate in the study, each participant's name was de-identified by being assigned a number. The study's faculty advisor randomly assigned each number to one of the two groups by drawing the numbers from a bag and placing them in either the simulation group or control group. Computer-based simulation was the independent variable and participants' knowledge and self-efficacy were the dependent variables.

Participants

The following section introduces the participants of the study and how they were selected.

Selection

Participants included in the study were students in the current, first-year graduate class of speech-language pathology students at Indiana University of Pennsylvania (IUP). All participants were beginning their third semester of a five semester master's program. All participants who met the inclusion criteria read and signed a consent form in order to participate in the study.

Recruitment

Participants were invited to participate in the study via email. Each participant was provided with an *Informed Consent Form* (Appendix A) that thoroughly outlined the study's purpose, procedures, risks, benefits, and requirements for participation. After reading this form, participants were required to sign a *Voluntary Consent Form* (Appendix B) to verify their informed participation in the study. The Indiana University of Pennsylvania Institutional Review Board approved the study, *Informed Consent Form*, and *Voluntary Consent Form* (Log No. 18-125).

Inclusion and Exclusion Criteria

Inclusion criteria required that participants be part of the current, first-year cohort of speech-language pathology graduate students at IUP. Individuals who presented with any of the following were excluded from this study: a) not part of the current first-year cohort of speech-language pathology graduate students at IUP; b) 17 years of age or younger.

Final Sample Size

The target sample size for the study was 21 participants. Due to conflicting schedules, the final sample size included 15 participants between the ages of 22 and 29 years old. All participants were female and part of the current cohort of first-year speech-language pathology graduate students at Indiana University of Pennsylvania.

Procedures

All participants reported to a computer lab at Indiana University of Pennsylvania on June 4, 2018 to complete the research experiment. Upon arrival, participants were divided into a simulation group (*n*=7) and control group (*n*=8) based on the random assignment of the faculty advisor. Those assigned to the simulation group were asked to sit on the left side of the computer lab, while the control group were asked to sit on the right. All participants were then given two forms of assessment on paper; a pre-test consisting of six knowledge-based multiple-choice questions and *The Clinical Self-Efficacy in Patient Centeredness Questionnaire*.

Once participants completed both assessments, participants in the simulation group were instructed to log onto a computer. Once logged in, the principle investigator stopped at each participant's computer to copy five PowerPoints onto them. Each of the five PowerPoints contained a case study and was designed to simulate a patient with difficulties related to swallowing. The PowerPoints provided participants with the patient's past medical history, background on each patient's diagnoses, information about any evaluations that were completed with the patient, and a video simulating a portion of each patient's Modified Barium Swallow Study (MBSS). For one case study, there was also an image provided to simulate the patient's Fiberoptic Endoscopic Evaluation of Swallowing (FEES). As participants worked through each computer-based case module, the PowerPoints required clinical decision making in order to choose the appropriate path of care for each patient. Based on the clinical decisions that participants made, feedback was provided to inform participants if they made a sound clinical choice, or not. The PowerPoints did not permit participants to continue working through each case study until the correct clinical decision was made. The participants were told that they could review each case study as many times as they desired and to raise their hand to indicate to the investigator when they were finished.

At the same time that the simulation group was completing their form of training, the control group was provided with five case studies that contained information identical to that in each of the five PowerPoints that the simulation group was given. However, the information given to the control group was provided only in the form of text on paper to represent traditional didactic learning. The control group was also told to read through each case study as many times as they desired and to raise their hand to indicate to the investigator when they were finished.

When participants from both the simulation group and control group had indicated that they were finished, the principle investigator provided them with the same six question knowledge-based assessment and *The Clinical Self-Efficacy in Patient Centeredness Questionnaire* to complete for post-assessment purposes. The participants in the simulation group were told to exit all computer-based simulation modules and the papers that contained the case studies for the control group were collected from participants prior to beginning both post-assessment measures. Once participants completed both assessments, they were thanked for their participation and free to leave. Later that evening, individuals in the control group and those that were denied participation in the study were offered the computer-based simulation case modules via email so that any learning afforded to the simulation group was made accessible to them that would have been otherwise entitled per participation or different randomization in the study.

Measurement

The six-question, knowledge-based test that was used for pre- and post-assessment measures was created by the principle investigator and consisted of questions pertaining to swallowing in speech-language pathology. Scores for the knowledge-based test were out of six, as there was a total of six questions. *The Self-Efficacy in Patient Centeredness Questionnaire* was a questionnaire made up of 27 questions that required participants to rate themselves on a four-point scale as *not confident at all* to *very* *confident* in their self-perceived ability to provide clinically-competent practice. On the questionnaire, the number 1 corresponded with *not confident at all* and the number 4 corresponded with *very confident*. *The Self-Efficacy in Patient Centeredness Questionnaire* was scored out of 108. Higher scores on both the six knowledge-based questions and *The Self-Efficacy in Patient Centeredness Questionnaire* were assumed to represent that more knowledge and a higher level of self-efficacy were established from training using case modules in both the simulation and control group.

The Self-Efficacy in Patient Centeredness Questionnaire was derived from a study completed by Zachariae, O'Connor, Lassesen, Olesen, Kjaer, Thygesen, and Morcke in 2015 that utilized medical students (*n*=724) and physicians(*n*=108). After reviewing existing literature, the authors elected the questionnaire be created with three, core underlying factors that they believed most clearly defined patient-centeredness care. These factors included "1) considering the patients' needs, wants, perspectives, and individual experiences, 2) offering patients opportunities to provide input into and participate in their care, and 3) enhancing the partnership and understanding in the patient-physician relationship" (2015, p. 3). The authors concluded that *The Self-Efficacy in Patient Centeredness Questionnaire* could be a valuable measure of how clinical training may affect the implementation of patient-centered care.

Use of Data

The data collected from this study were only used for the purpose of this study. All identifying information was seen only by the investigators of this study. Identifying information was not connected to any of the pre- or post-test assessments. All paperwork with identifying information has been secured and may only be accessed by the investigators of this study.

Statistical Analysis

An independent samples t-test was conducted to compare knowledge scores for the simulation group from pre- to post-assessment. Levene's test (*p*= .638) revealed equal variances assumed for the model. There was a statistically significant difference in scores from pre- (*M*= 4.00, *SD*= .82) to post-assessment (*M*= 5.15, *SD*= 1.07; *t*(12)= -2.25, *p*= .04, two-tailed) for the simulation group.

Another independent samples t-test was conducted to compare knowledge scores for the control group from pre- to post- assessment. Levene's test (*p*= .149) revealed equal variances assumed for the model. There was a statistically significant difference in scores from pre- (*M*= 3.88, *SD*= .99) to post- assessment (*M*= 4.88, *SD*= 1.36; *t*(14)= -1.68, *p*= .11, two-tailed) for the control group.

An independent samples t-test was conducted to compare self-efficacy scores for the simulation group from pre- to post- assessment. Levene's test (*p*= .088) revealed equal variances assumed for the model. There was not a statistically significant difference in scores from pre- (*M*=93.14, *SD*=11.39) to post- assessment (*M*=102.74, *SD*=5.47; *t*(12)= -2.00, *p*=.07, two-tailed) for the simulation group.

Another independent samples t-test was conducted to compare self-efficacy scores for the control group from pre- to post- assessment. Levene's test (*p*= .253) revealed equal variances assumed for the model. There was a statistically significant difference in scores from pre- (*M*= 86.63, *SD*= 9.27) to post- assessment (*M*= 96.00, *SD*= 4.78; *t*(14)= -2.54, *p*= .02, two-tailed) for the control group.

Table 1

Simulation Group Differences on Knowledge and Self-Efficacy

	Simulation (n=7)					
	Pre-Assessment		Post-Assessment			
Measure	Mean	Standard Deviation	Mean	Standard Deviation	t (12)	p
Knowledge	4.00	.82	5.15	1.07	-2.25	.04
Self-Efficacy	93.14	11.39	102.74	5.47	-2.00	.07

Table 2

Control Group Differences on Knowledge and Self-Efficacy

	Control (n=8)					
	Pre-Assessment		Post-Assessment			
Measure	Mean	Standard Deviation	Mean	Standard Deviation	t (14)	p
Knowledge	3.88	.99	4.88	1.36	-1.68	.11
Self-Efficacy	86.63	9.27	96.00	4.78	-2.54	.02

CHAPTER IV

RESULTS

Results of independent t-tests served as the statistical determinant to answer both research questions posed in the current study. The first question asked was, "What effect does computer-based simulation have on speech-language pathology students' knowledge of the topic?" Statistical significance was found in both the simulation and control group in scores on knowledge from pre- to post-assessment. Mean scores for knowledge in the simulation group improved from 4.00 to 5.15, while the control group improved from 3.88 to 4.88. Therefore, knowledge scores in the simulation group improved slightly more than in the control group.

The second question asked was, "What effect does computer-based simulation have on graduate students' feelings of self-efficacy in providing clinically competent practice on the topic?" Statistical significance was found in self-efficacy scores in the control group from pre- to post-assessment but was not for the simulation group. However, both the simulation and control groups' scores on self-efficacy improved from pre- to post-assessment. Mean scores for self-efficacy for the simulation group improved from 93.14 to 102.74, while the control group improved from 86.63 to 96.00. It is important to mention that although statistically-significant change was not achieved in the simulation group, self-efficacy scores obtained from the simulation group were higher than the control group at both pre- and post-assessment.

CHAPTER V

DISCUSSION

Summary

Currently, there is no published data on computer-based simulation in the field of speech language pathology. The research that does exist on computer-based simulation has been completed in other disciplines. However, the existing research in other disciplines has been mostly consistent in reporting that computer-based simulation is advantageous when implemented into existing, didactic learning curriculums as supplemental training to assist in developing skills. Given positive findings in other disciples, the current study sought to fill the void in the absence of data regarding the implementation of computer-based simulation in speech-language pathology. The research team collected data on how computer-based, simulated case modules in the form of interactive PowerPoints compared to text on paper case modules for the outcomes of knowledge and self-efficacy. Results revealed that knowledge and self-efficacy increased in both the simulation and control groups from pre- to post-assessment. However, the data revealed that the improvement was slightly greater in the simulation group as compared to the control group.

Statistical significance was found on the outcome of knowledge for both the simulation and control group, therefore, computer-based simulation seems to achieve positive changes in knowledge. Statistical significance was found in the control group on self-efficacy, but not in the simulation group. The reason that the simulation group did not reach statistical significance from pre- to post-assessment on self-efficacy may have been due to the limited sample size of this study or that the simulation group's self-efficacy scores were higher at pre-test. The simulation group had a mean of 102 at pre-assessment, which is close to the maximum score of 108, therefore, there may have been a ceiling effect. Future research would be needed to explore this difference.

Results of the current study parallel several findings of research experiments outlined in the literature review. Specifically, in the field of dentistry, LeBlanc et al. 2004 found that participants in both their simulator and control group significantly improved with respect to completion of various dental procedures. Although both groups improved, the simulator group achieved higher scores in the end. Similarly, in the 2008 study by Stern et al. with middle school science students, significant change was documented in both the experimental and control groups regarding understanding of the kinetic molecular theory but was slightly greater in the experimental group. All studies outlined in the literature review section ultimately support the implementation of computer-based simulation which is supported by statistical findings of improvement when this form of training is utilized in a pre-existing didactic learning curriculum. Similar to existing literature on the effects of simulation on learning, the current study supports computer-based simulation as an effective tool for improving knowledge and clinical, self-efficacy skills.

Limitations

Before computer-based simulation should be used as supplementary means of education in speech-language pathology, additional research should be conducted. Although the current study yielded data in support of computer-based simulation on knowledge and self-efficacy in speech-language pathology graduate students, there were some limitations to consider. One chief limitation to the study for consideration is the small sample size. The sample size for the current study was 15. Although this sample size was similar to sample sizes used in research by Lambert and Meier (1992) and Lambert and Lenthall (1998), a larger sample size would improve the confidence in this study's results.

A second limitation to this study is that on the day that the study was completed, all participants attended a three-hour course that taught information related to swallowing in speech-language pathology prior to the research study. Although the information covered in the swallowing course did not directly address topics outlined in the simulation and paper-based cases, it is impossible to determine if the information presented in the class assisted participants in answering the knowledge-based questions or had any effect on perceptions of self-efficacy. Therefore, the three-hour course poses a potential confounding variable. Future studies should control this variable at the outset and conduct the training prior to instruction of the topic.

Further, another potential limitation to this study is a test practice threat. For pre- and post-assessment measures, the same six knowledge-based questions and *Clinical Self-Efficacy in Patient Centeredness Questionnaire* were given to participants on the same day. Having been given the same assessments, there is a chance that participants became more familiar with the questions and that results were affected by a test practice threat to internal validity.

Additionally, the current study was rather short in duration from start to finish. On average, participants took approximately 90 minutes to complete the research experiment. The researcher created somewhat condensed case modules to be used in this study, therefore, they were not lengthy in duration. If more elaborate information would have been provided to extend duration of participant's training, there is a chance that results of the study could have been altered. Future research should address this by presenting more cases over a longer period of time.

Implications

The current study provides the first evidence of the effect of computer-based simulation on knowledge and self-efficacy in speech-language pathology. The results of the research study provide the framework for the potential use of computer-based simulation to supplement traditional didactic learning and development of clinical skills needed by speech-language pathologists. Future research in this area should explore reproducing this study with an increased sample size and increased duration of training to determine effects on the results. Similarly, future research should explore the effects of simulation with mannequins/simulated patients on knowledge and self-efficacy in speech-language pathology, as well as the amount of time that computer-based and/or mannequin/simulated patient simulations needs to be implemented. Additionally, conducting a research experiment earlier in a graduate program, such as during the second or third semester, could produce results to determine when computer-based simulation should be implemented to yield the best learning outcomes. Finally, including more knowledge-based questions and implementing higher-level, computer-based simulation technology in training could produce a wider range of scores, and therefore, manufacture more comprehensive results on how computer-based simulation can facilitate learning and be most advantageous in the development of clinical competence.

References

Amabile, T. M. (1983). The social psychology of creativity: A componential conceptualization. *Journal of Personality & Social Psychology, 45*(2), 365-376. doi:10.1037/0022-3514.45.2.357

Bearnson, C., & Wiker, K. (2005). Human patient simulators: A new face in baccalaureate nursing education at Brigham Young University. *Journal of Nursing Education*, *44*(9) 421-426.

Cheng, A., Kessler, D., Mackinnon, R., Chang, T.P., Nadkami, V.M., Hunt, … & Auerbach, M. (2016). Reporting guidelines for health care simulation research: extensions to the CONSORT and STROBE statements. *Simulation Healthcare, 11*(4) 238-248. doi:10.1097/SIH.0000000000000150

Coyle, J., Easterling, C., Lefton-Greif, M., & Mackay, L. (2007). Evidence-based to reality-based dysphagia practice: Three case studies. *The ASHA Leader*, *12*, 10-32. doi:10.1044/leader.FTR2.12142007.10

Duta, M., Amariei, C., Bogdan, C., Popovici, D., Ionescu, N., & Nuca, C. (2011). An overview of virtual and augmented reality in dental education. *Oral Health and Dental Management, 10*(1), 42-49.

Gasco, J., Holbrook, T., Patel, A., Smith, A., Paulson, D., Muns, A., … & Patterson, J. (2013). Neurosurgery simulation in residency training: Feasibly, cost, and educational benefit. *Congress of Neurological Surgeons, 73*(4)*,* S39-S45. doi:10.1227/NEU.0000000000000102

Jachna, J., Powsner, S., McIntyre, P., & Byck, R. (1993). Teaching consultation psychiatry through computerized case simulation. *Academic Psychiatry, 17*(1), 36-42. doi:10.1007/BF03341504

Jenson, C., & Forsyth, D. (2012). Virtual reality simulation using three-dimensional technology to teach nursing students. *Computers, Informatics, Nursing, 30*(6)*,* 312-318. doi:10.1097/NXN.0b013e31824af6ae

Lambert, M., & Lenthall, G. (1998). Using computerized case simulations in undergraduate psychology courses. *Teaching of Psychology, 15*(3)*,* 132-135. doi:10.1207/s15328023top1503_5

Lambert M., & Meier, S. (1992). Utility of computerized case simulations in therapist training and evaluation. *Journal of Behavioral Education, 2*(1)*,* 73-84.

LeBlanc, V., Urbankova, A., Hadavi, F., & Lichtenthal, R. (2004). A preliminary study using virtual reality to train dental students. *Journal of Dental Education, 68*(3)*,* 378-383.

Marshall, J. R., Fleming, P., Heffernan, M., & Kasch, S. (1982). Pilot study of the use of PMPs. *Medical Education*, *16*(6), 365-366.

Plessas, A. (2017). Computerized virtual reality simulation in preclinical dentistry: Can a computerized simulator replace the conventional phantom heads and human instruction? *Society for Simulation in Healthcare, 12*(5)*,* 332-338. doi:10.1097/SIH.0000000000000250

Prat, G., Charron, C., Repesse, X., Coriat, P., Bailly, P., L'her, E., & Vieillard-Baron, A. (2016). The use of computerized echocardiographic simulation improves the learning curve for transesophageal hemodynamic assessment in critically ill patients. *Annals of Intensive Care, 6*(27)*,* 1-8. doi:10.1186/s13613-016-0132-x

Stanton, M. (2004). Hospital nurse staffing and quality of care. *Professioni Infermieristiche, 58*(2) 1-7.

Stern, L., Barnea, N., & Shalui, S. (2008). The effects of a computerized simulation on middle school students' understanding of the kinetic molecular theory. *Journal of Science Education and Technology, 17*(305)*,* 305-315. doi:10.1007/s10956-008-9100-z

Suvinen, T.I., Messer, L.B., & Franco, E. (1998). Clinical simulation in teaching preclinical dentistry. *European Journal of Dental Education, 2*(1) 25-32.

Urbankova, A. (2010). Impact of computerized dental simulation training on preclinical operative dentistry examination scores. *Journal of Dental Education, 74*(4)*,* 402-409.

Wynder, M. (2004). Facilitating creativity in management accounting: A computerized business simulation. *Accounting Education, 13*(2)*,* 231-250. doi:10.1080/0963928041000l676639

Zachariae, R., O'Connor, M., Lassesen, B., Olesen, M., Kjaer, L., Thygesen, M., & Morcke., A. (2015). The self-efficacy in patient-centeredness questionnaire – a new measure of medical student and physician confidence in exhibiting patient-centered behaviors. *BMC Medical Education*, *15*(150), 1-13. doi:10.1186/s12909-015-0427-x

Appendix A

Informed Consent

Project Title: The Effect of Computer-Based Simulation on Learning and Self-Efficacy in Speech-Language Pathology Graduate Students

You are invited to participate in this research study. The following information is being provided to you so that you may make an informed decision whether or not you would like to participate. If you have any questions at all, please do not hesitate to ask. You are eligible to participate in this study because you are part of the current first-year cohort of speech-language pathology graduate students.

The purpose of this study is to determine how computer-based simulation effects your learning. I also would like to observe how computer-based simulation effects your feelings of self-efficacy in providing clinically competent practice. You will be randomly assigned to one of two groups – a group that participates in a computer-based simulation module and a group that participates in text-based case modules. Before and after you complete your assigned means of training, you will be asked to complete a pre- and post-test to assess your knowledge, and a Clinical Self-Efficacy questionnaire to assess your self-perceived abilities to perform practice that is clinically competent. Participation in this study will require approximately 3 hours of your time to complete all training and assessments. The pre- and post-test measures will each take approximately 20-minutes. The text-based and computer-based simulation modules will take approximately 2 hours. If you choose to participate in this study, it is asked that you do not communicate with other members of your cohort regarding your participation in this study.

All data gathered in this study will be held in strict confidence. There will be no personally identifying information associated with you in this study. The information of this study may be published in scientific journals or presented at scientific meetings, but your identify will be kept confidential. There are no known risks associated with this research study. Potential benefits of this research study include exposure to training that speaks directly to specific knowledge within your scope of practice and awareness of the self-efficacy concepts that support clinically competent performance. No other forms of compensation are available for your participation.

Your participation in this research study is **voluntary**. At any point, you may withdraw from this study with no penalization in any way. Please contact me directly if you wish to be withdrawn. Your refusal to participate in this study will not result in any loss of benefits to which you are otherwise entitled. If you request to withdraw from this study, any data collected concerning you will be destroyed. If you have any questions or concerns, please feel free to contact the principal investigator or faculty advisor of this study:

Emilie Okopal

Principal Investigator
Speech-Language Pathology Graduate Student
Indiana University of Pennsylvania
(724) 599-7414
wypt@iup.edu
Lori E. Lombard, PhD
Faculty Advisor
(724) 357-2450
llombard@iup.edu

THIS PROJECT HAS BEEN APPROVED BY THE INDIANA UNIVERSITY OF PENNSYLVANIA INSTITUTIONAL REVIEW BOARD FOR THE PROTECTION OF HUMAN SUBJECTS (PHONE 724-357-7730)

Appendix B

Voluntary Consent

I have read and understand the information provided on the Informed Consent Form and I consent to volunteer to be a participant in this study. I understand that there will be no personally identifying information connected to me in the study and that I am entitled to withdraw from the study at any time. I have been provided a copy of the Informed Consent Form to keep for my records.

Name (please print): ____

Signature: ____

Date: ____

I certify that I have explained to the above individual the nature, purpose, potential risks, and potential benefits of the current research study. I also certify that I have answered any questions and have witnessed the signature above.

Investigators' Signature: ____

Date: ____

Appendix C

Pre-/Post-Test

a. What observation during a beside evaluation would necessitate a FEES preferable over a
MBS?
    a. Frequent throat clearing/coughing while eating
    b. Wet vocal quality
    c. Requiring multiple swallows to clear all bolus consistencies

b. You are reviewing a medical chart for a patient whom you are about to complete a MBS evaluation with. You notice that the client has chronic obstructive pulmonary disease (COPD), what should this diagnosis lead you to expect to see during the MBS evaluation?
    a. Pooling in the valleculae
    b. Silent aspiration
    c. Laryngeal penetration

c. A new patient on your case load has been recently diagnosed with ALS. You are aware that dysphagia independent of the time of onset or duration of disease occurs in all patients with ALS. You want to gather information about this patient; what evaluation should be completed first?
    a. Modified Barium Swallow (MBS)
    b. Bedside Evaluation
    c. FEES

d. Swallowing therapy has been being provided to a man for several weeks now. He is positively responding and utilizing the strategies being taught to him during treatment sessions. The SLP entered the hospital room today, and the client was persistently refusing treatment. When asked to complete the swallowing strategies that he had been taught, he appeared disoriented and confused. This behavior is most consistent with symptoms of which condition?
    a. Dementia
    b. General fatigue
    c. Personality disorder

e. A patient has recently been intubated and extubation for a surgery. The SLP enters the patient's hospital room post-surgery to visit with the patient several times, The SLP notices a persistent wet vocal quality throughout the day in the patient's voice. Which of the following is most likely the cause of the SLP's observation?
    a. Vocal fold paralysis
    b. Assensation
    c. Delayed swallow initiation

f. What response type is the most ethically and professionally responsible?
   a. Explicitly direct and overly cautious
   b. Very positive and favorable, but unrealistic
   c. Cautious, supportive, and explicitly truthful

Appendix D

Text-Based Case Module Example

Case 2

Overview:

65-year-old man was referred because of gradual onset of hoarseness, occasional coughing on salvia, fatigue while chewing, feelings of ”tongue thickness”, increased difficulty speaking in the evening, and bilateral lower-extremity muscle-twitching with mild proximal muscle weakness in the right leg. ALS requires diagnostic confirmation by an experienced neurologist noting the presence and progression of upper (UMN) and lower motor neuron (LMN) findings. Therefore, after performing diagnostic electromyography, the diagnosis of amyotrophic lateral sclerosis (ALS) was confirmed.

Background on ALS:

ALS is a progressive neurodegenerative disease that is the most common adult-onset motor neuron disease. Due to its progressive nature and the lack of a known cure for ALS, each patient is evaluated and managed by a multidisciplinary team. Members of the team include physical, occupational, and respiratory therapists, SLP,s neurologists, nurses, social workers, chaplains, dieticians, and pulmonologists. This multidisciplinary approach is designed to improve quality of life through prevention and relief of suffering. The team often uses ALSFRSR, a 12-item functional inventory, to assess the patient’s level of self-sufficiency in feeding, grooming, ambulation, and communication, while monitoring disease progression and predicting survival time.

ALS and Dysphagia:

Patients are evaluated for signs and symptoms of dysphagia, as all patients with ALS experience dysphagia independent of the time of onset or duration of disease. Signs and symptoms include tongue weakness, fasciculations, and dysarthria following by pharyngeal weakness, and finally unilateral or bilateral facial weakness. Disorders of the oropharyngeal phase occur because of degeneration of cranial nerve XII motor nuclei as well as degeneration of cranial nerve IX and X motor nuclei, resulting in decreased bolus containment, increased transit times, decreased or ill-timed laryngeal elevation, soft-palate elevation, and decreased swallow pressures.

What should be completed first?

A bedside evaluation should be completed before any other evaluations to gather as much information about the patient as possible.

Bedside Evaluation Findings:

The multidisciplinary evaluation determined that the patient had mild right upper and bilateral lower extremity weakness and fasciculations. Pulmonary function testing

revealed 90% vital capacity. During the cranial-nerve exam, right-tongue weakness and fasciculations were noted.
Speech was mildly dysarthric with increased articulatory imprecision in conversation related to fatigue. The patient coughed on his saliva while speaking. When given a cookie to chew, the patient complained of fatigue and requested liquid to help him clear the cookie from his mouth.

What should be completed next?

Based in the information gathered from the bedside evaluation, a modified barium swallow (MBS) should be completed next to assess the patient's swallow function.

MBS Findings:

Prolonged but functional oral phase with slow bolus manipulation for all consistencies and volumes and slow mastication. Piecemeal bolus movement into the pharynx with uncontrolled bolus movement over the tongue base with thin liquid. Inconsistent predeglutitive aspiration of thin liquids secondary to delayed pharyngeal swallow. Spontaneous cough resulting in bolus clearance from the laryngeal vestibule and trachea of thin liquid aspirant. Mild to moderate postdeglutitive residue on the tongue base and in the valleculae. Predeglutitive aspiration secondary to bolus movement into the pharynx prior to superior and anterior hyolaryngeal excursion. Patient sensed aspiration and spontaneously coughed to successfully clear aspirant.

Does the patient have dysphagia?

Yes, the patient is presenting with symptoms that suggest that he does have dysphagia.

Compensatory Strategies for Swallow:

The following compensatory strategies were used during the MBS evaluation:

Chin tuck effectively eliminated predeglutitive aspiration of thin liquids

The chin tuck posture effects the pharyngeal swallow by improving airway protection through narrowing of the airway entrance, positioning the tongue base and epiglottis towards the posterior pharyngeal wall, widening the vallecular space, decreasing distance between the larynx, hyoid, and mandible, and reducing the potential depth of penetration and aspiration of materials.

Alternating liquid and solid boluses effectively eliminated postdeglutitive tongue base residue.

Effortful swallow was effective in decreasing the postdeglutitive residue; however, the maneuver was fatiguing for the patient.

Should the patient receive services to teach him how to use to compensatory strategies used during the MBS?

Yes. The patient should absolutely be provided treatment to better teach him the compensatory strategies to improve his swallow. The MBS verified that the strategies were effective for the patient. Also, because the patient has a motor-neuron disease, exercise is contraindicated.

Does the patient require re-evaluation?

Given the patient's swallowing abilities and comorbid issues, a re-evaluation should be completed after approximately 6-8 weeks to monitor any functional change.

(Coyle et al., 2007)