2016

Recognizing Pain Using Novel Simulation Technology

Justin C. Grace
University of Central Florida

RECOGNIZING PAIN USING NOVEL SIMULATION TECHNOLOGY

by

JUSTIN C GRACE

A thesis submitted in partial fulfillment of the requirements
for the Honors in the Major Program in Nursing
in the College of Nursing
and in The Burnett Honors College
at the University of Central Florida
Orlando, Florida

Spring Term 2016

Thesis Chair: Dr. Kelly Allred

ABSTRACT

Effective pain management and time to treatment is essential in patient care. Despite scientific evidence and an emphasis on addressing pain as a priority, pain management continues to be an unresolved issue. As a member of the health care team, nurses are integral to optimal pain management. Currently, nursing schools have limited innovative or alternative methods for teaching pain assessment and management. Simulation in nursing education provides a unique opportunity with the potential to expose students to realistic patient situations, allow them to learn and make mistakes, without causing harm. However, modern low- and high-fidelity simulation technology is unable to display emotion, pain, or any facial expression. This limits training and education of conditions that rely on the identification of symptoms based on the alteration of facial appearance, such as pain or stroke. This research explored student nurses' perception of new technology that displayed computer-generated faces, each expressing varying degrees of physical expressions of pain. A total of 15 nursing students participated in the study. Students were asked to interpret four sequential faces on a scale of 0-10, with 0 representing no pain, and 10 representing the most severe pain possible. After scoring the faces as they relate to pain, students were asked to answer four open-ended questions addressing the technology. Results show a majority of nursing students believe the technology should be implemented into nursing curriculum and interacting with the projected faces was more beneficial than traditional teaching methods. Eventually, the potential for increased identification of conditions requiring observation of subtle facial changes will be explored.

DEDICATION

For my loving family, thank you for your encouragement and continued support.

In memory of my grandmother, Patricia Hagen, I hope to be half of the nurse you were, thank you for all the memories.

ACKNOWLEDGMENTS

I would like to express my sincerest gratitude to the individuals that helped make this thesis possible. First and foremost, Dr. Kelly Allred, my thesis chair, professor, mentor, and role model- thank you for the countless hours of guidance through this process. To my committee members: Dr. Laura Gonzalez and Dr. Gregory Welch, thank you for your support and encouragement through the entirety of this thesis. To Salam Daher for your work in developing technology necessary for the study.

Finally, mom, dad, Shanna, and Connor- thank you all for being for me through this adventure. I love you all.

TABLE OF CONTENTS

CHAPTER ONE: REVIEW OF LITERATURE

Pain

Nearly 76 million adults are affected by pain in the United States (American Pain Foundation, 2007). Pain affects more individuals than cancer, diabetes, and cardiovascular disease combined. Researchers define pain as a physiologic response to noxious mechanical, thermal, or chemical stimuli that causes suffering, distress, soreness, or an unpleasant sensation (Romero-Hall, 2014). Despite an emphasis on addressing pain as a priority, proper pain management continues to fall short (Duignan & Dunn, 2009). Regardless of innovative technology and advancement of scientific evidence, pain continues to not be addressed, causing physiologic, psychological, and spiritual complications (Ferrell et. al, 2001). More than one half of individuals that report pain receive inadequate management of their symptoms, leading to a cycle that encompasses a poor quality of life, decreased productivity, and a spike in healthcare expenses (The Texas Pain Initiative 2007).

The physiologic danger of unrelieved pain has an impact on nearly every system of the body. Unrelieved pain will prompt an increase in heart and respiratory rates, which in turn, will increase the demand for oxygen and nutrients to vital organs (O'Hara, 1996). The cardiovascular system will respond to stressors of pain by increasing activity from the sympathetic nervous system. The heart will continue to work to meet the demands of the body, and without an adequate supply of oxygen, ischemia of the myocardium will occur, leading to potential death. Unrelieved pain has the potential for serious side effects, and addressing the issue is essential. The chronic activation of the physiologic response to stressors of the body can lead to multiple system failure (Middleton, 2003.). A combination of prompt, acute pain management, efficient

knowledge of analgesic medications, and understanding the pathophysiology of pain is crucial as a practicing nurse.

Pain management education begins in the classroom. A main barrier to proper pain management practice is due to lack of knowledge (Romero-Hall, 2015). Lebovits et. al. (1997) reports, in addition to healthcare providers' lack of knowledge, negative attitudes about pain are also contributing factors to inefficient pain management. Nursing faculty and academia alike have the unique opportunity to address these needs that are costing healthcare nearly $100 billion annually. In a study conducted by Duke, Haas, Yarbrough, and Northam (2013), knowledge of pain assessment and treatment was examined in both nursing students and faculty members. Senior nursing students a semester prior to graduation scored a 68% while faculty scored a 70% on an exam of knowledge and attitudes toward pain. The researchers previously set a benchmark score of 80%. Scores fell short, displaying an inadequate, less-than-desirable knowledge base and attitude for pain assessment and management.

In a similar study conducted by Plaisance and Logan (2006), it was determined that nursing students were unable to answer fundamental questions regarding analgesic routes, actions, and side effects. The nursing student's poor performance and knowledge extended from multiple factors, including outdated learning material, incorrect information from faculty, and a general lack of information presented in the nursing curriculum (Plaisance & Logan, 2006). Research suggests that additional teaching or alternative innovative methods are necessary to enhance nursing student learning and understanding of pain management (Briggs 2010). Such innovative methods might include simulation which can complement time in the classroom and improve the performance of nursing students in effective pain assessment and management.

Simulation

Simulation provides students an opportunity to practice skills and knowledge acquired in the classroom setting safely, without the potential to cause harm. The effective use of simulation to improve teamwork and clinical skills will likely lead to an increase in patient safety (Arthur, Levett-Jones, & Kable), 2012). Recognition of subtle changes in a patient's condition in the clinical setting is crucial to improving overall outcomes. The implementation of simulation, in conjunction with clinical rotations in a nursing school curriculum, allows educators to provide an enhanced learning environment, with opportunities aimed specifically at the nursing student (Przybyl, Androwich, & Evans, 2015). Once a student graduates, they are novice nurses and comprise nearly 10% of a standard hospital's nursing staff (Berkow, Virkstis, Stewart, & Conway, 2009). The novice nurse, many times without support or experience, will have to make critical decisions in potentially life-threatening circumstances. Simulation use in helping prepare the novice nurse for more independent practice could improve patient outcomes.

In a study conducted by Evans and Mixon (2012), they found the emerging pedagogy of simulation to be effective when teaching pain assessment to nursing students. During the simulation, students were required to assess pain levels and manage the pain of an adolescent male appropriately. The Knowledge and Attitudes Survey Regarding Pain (KASRP) was used to assess the students' pain knowledge. The nursing student's KASRP scores were 70.4% +/- 8.6% correct prior to simulation. Students reported preference of traditional lecture and clinical experience to simulation, but preferred simulation over computer modules and readings. Following the encounter, students' post-simulation KASRP scores were greater than prior to the experience. The results of the study suggest educators in nursing schools should encompass pain

assessment and patient education content into simulation

Simulation methods can be described as a continuum ranging from low-fidelity simulation (LFS) to high-fidelity simulation (HFS) (Paige & Morin, 2013). When discussing simulation, it is important to identify the terms in a consistent manner. Fidelity is a term used to describe the 'reality' of an experience. When nursing students enter a simulated experience, they will be faced with physical and psychological fidelity. Physical fidelity, or engineering fidelity relates to how strongly a device or environment mimics the appearance and physical characteristics of a task. Psychological fidelity is used to describe the degree in which the skill is executed realistically (Paige & Morin, 2013). The use of both HFS and LFS can be used to practice procedures and other various nursing tasks. Although the use of LFS and HFS are valuable, there are inadequacies to simulating communication and interpersonal skills. LFS and HFS are unable to physically display emotion or facial expression, thereby limiting fidelity, and limiting the student nurse experience.

A physical-virtual head built with projection surfaces has the necessary technology to advance patient simulation. Welch, Hochreiter, Daher, Nagendran, and Gonzalez (2015) describe this technology which includes a unified, multi-touch detection and response on a human head-shaped shell with a 3D projected animated face. The technology uses infrared (IR) cameras, projectors, IR light sources, and a surface to project upon. A prototype exists, and was created with four Point Grey Backfly monochrome cameras with IR filters (780nm), two IR illuminators, and one AAXA P300 pico projector. The monochrome cameras are able to capture images of a human face on the surface. The study describes application of the prototype as it was used as a simulated patient for stroke assessment. This technology has the potential to be used in many

ways, including patient expression, emotion, and changes of the musculature of the face-which are important for the nurse when making clinical decisions for the care of a patient. This technology, beyond the stroke assessment, has yet been evaluated (Welch et al., 2015).

CHAPTER TWO: METHODS

Sample

Approval was obtained from the Institutional Review Board (IRB) at the University of Central Florida. Participants were invited on a voluntary basis to take part in this study while enrolled in the Spring 2016 semester. Participants were able to withdraw from the study at any time without penalty. The sample was a convenience sample of senior nursing students matriculating through a Bachelor of Science program Approximately 180 students were invited to participate in the study. The first 15 students that responded to the request were included in study. Participants in the study must have been at least 18 years of age; have been previously exposed to low and/or high fidelity human patient simulations; and currently enrolled in nursing classes at the University of Central Florida, College of Nursing.

Setting

This research took place on the 6th floor in the patient simulation laboratory, located at the University of Central Florida, College of Nursing in Orlando, Florida. The laboratory was in a quiet location with minimal noise to avoid interruption or distraction.

Procedures

Participants were invited verbally through an announcement made in class. Potential participants signed up based on interest by approaching the investigator of the study. After contact was made, all questions from the potential participant were addressed, and the subject decided if they wished to continue with the study. No subjects opted to not participate after initial contact was made. A mutually agreed time was determined to meet and conduct the research. This research qualified for waiver of the written consent process. The subjects were

given a written explanation of research. All participants were fluent in the English language, so both written and oral instruction was provided in English.

Technology

The computer-generated faces were projected upon a mask that fit on top of a low fidelity mannequin. The mannequin used specifically for this study was a Basic Geri Nursing Skills Elderly-Care Manikin. A mask similar to the one used by Welch et. al (2015) to simulate stroke was used to project imagery and animation of the face with varying degrees of pain. A AAXA P300 projector was fixed using a Manfrotto Arm at the foot of the bed to provide a front projection. The imagery sent to the projector was driven by a Unity3D program that contained a 3D model of the face. The 3D model was created in Maya and rigged to support facial expressions including emotions and pain, then exported to Unity3D where the camera in unity matches the physical position of the projector and renders the scene in reverse order. The interface that controlled the animations was created in Unity3D. The principal or co-principal investigator was able to use click and control capabilities to adjust the severity of the faces with an interface designed specifically for the study. The physical mask can fit on top of any low fidelity or high fidelity mannequin.

Measurement

Each subject stood at the foot-end of a hospital bed which had a low-fidelity mannequin in it with the head of the bed at approximately 30°. The subject was directed to face the direction of the mannequin fixed with the projection technology. The Unity3D program was running with the baseline, simulated face (Appendix A) upon the initial assessment of the subject. Each subject was given a data collection sheet (Appendix B), to which they wrote down a number (0-

10) when presented faces one through four. After seeing the baseline face, subjects were asked to walk away from the equipment to simulate leaving a patient's room. Simulated faces one through four were presented in the same sequence between subjects. Subjects filled out the data collection sheet and then left the simulation lab.

CHAPTER THREE: RESULTS

Quantitative Data

Research participants filled out the data collection form while watching the computer-generated faces. They did not assign the baseline face a number on the pain scale. Subsequent faces received a pain assignment based on the numeric pain scale 0 to 10, with 0 representing no pain and 10 representing the worst possible pain. This quantitative data can be found in Table 1 (Appendix C).

Qualitative Data

Following the collection of the numeric values for each simulated face, subjects were asked a series of four, open-ended questions. The first question asked participants about their overall feelings towards the technology. A majority of the participants felt both “comfortable” interacting with the simulated faces, and “interested” in the new technology. One subject stated, “it made me feel like my practice or clinical experience was more valued”.Another reported “it’s a significant improvement from traditional simulation technology”.

The second open-ended question addressed the overall fidelity of the technology was stated “how realistic do you believe the faces were? Are there any parts of the face that was less realistic than other parts? How does this technology compare to other low and high fidelity simulators that you have been exposed to in the nursing curriculum”? Nine out of fifteen students mentioned the eyes in their response, while six out of fifteen mentioned the mouth. These two structures were the most talked about, and had varying responses. Most of the subjects recalled the eyes as the least realistic feature of the faces. One participant reported that the eyes were overall, “a bit blurry”, while another, “[had] a hard time being able to tell if the eyes were

squinting or just resting with the lids shut". Recalling the realism of the mouth from other parts, one subject believed that, "the side of the mouth seemed as if it was always in a smiling position" which made the subject question if the face could accurately depict pain. Conversely, another subject felt that the mouth was, "probably the closest part of the face that was most accurate with a real, human mouth". Participant perceptions clashed at times with specific facial features, but overall, the majority believed that the simulated faces were far better than their previous interactions with low and high fidelity static mannequins. One subject reported the overall fidelity of the technology was, "Significantly better [than typical simulation mannequins]. The faces can actually show some sort of an expression, based on the faces that we have currently, which are fixed, and don't do anything- so this is a massive improvement from where we've been, or what we have."

The third open-ended question asked students to describe potential uses for this technology in a nursing curriculum. While some subjects stated that the technology could be used as it was during the current research (for pain assessment), other students included specific conditions that they believed could be taught using this specific technology.

The fourth question, "is there anything else that you would like to discuss regarding the research" was asked to allow subjects the opportunity to add any other feedback or comments. Most subjects stated they had nothing further to discuss.

CHAPTER FOUR: DISCUSSION

The aim of this study was to evaluate the use of a novel kind of simulation technology to teach nursing students about the assessment of non-verbal pain cues. Research subjects were tasked with the challenge of rating the pain of the computer-generated faces without verbal input. Subjects were specifically asked, “On a scale of 0-10 with 0 being no pain and 10 being the worst possible pain, where would you rate the patient’s pain based on the face presented”? Subjects relied on assessment skills and nursing judgment to quantify the degree of pain the faces were displaying.

The simulated faces were designed to have mild, mild-moderate, moderate-severe, and severe pain. This was the sequence of faces shown to the subjects. Designs were created based on widely-used clinical assessment tools, such as the revised faces pain scale. The subjects rated the first face designed to represent mild pain with an average pain rating of 1.87 on the 0 to 10 scale. The next face designed to represent mild-moderate pain received an average pain rating of 4.8 on the 0 to 10 scale. The third face designed to represent mild-severe pain received an average pain rating of 7.3 on the 0 to 10 scale. The fourth face designed to represent severe pain received an average pain rating of 8.5 on the 0 to 10 scale. Results of the numeric scoring section of the study indicate that nursing students seem to rate pain similarly to the traditional pain scales that exist with facial representations when using a computer-generated facial representation of pain. If a patient is unable to speak to give a self-report of pain, then accurate or consistent scoring among healthcare providers is a important. As reflected by the minimum and maximum scores recorded for each facial representation of pain, one person’s interpretation of pain may be

significantly different another. This idea is consistent with the notion that nurses have different interpretations when assessing clinical presentations of pain, especially in the face.

Recordings of the open-ended question responses were transcribed and reviewed by two researchers. Positive comments were color-coded in green, neutral comments were black, and negative comments were red. Each question was analyzed separately. The color coding of comments seemed logical at the start of data analysis, but some research participants had a mixture of positive and negative comments to the questions, making it a bit more difficult to come to a consensus for each participant. Of most interest is 13 out of the 15 participants reported multiple ways they can see this technology being used in a nursing curriculum. One student who did not think it was right for pain assessment reported "…pain is something that's not objective, it's definitely subjective, and you can't really make an assumption for a patient. The patient is the one that's going to tell you what their pain level is, and what they're going through." Others reported uses for this technology in the nursing curriculum could be "…as it's using in this example, to assess pain. It could be used to assess stroke. It could be used to help with mentally disabled people. It could be used to assess drug overdose with pupil size. It could be used to diagnose ptosis or drooping or cranial nerve issues. It could be used to assess face fractures, skin issues, mouth-or oral issues. It could be used to assess hypoxemia, cyanosis, it could also be used to assess and look for signs of abuse."

When asked about how the technology made them feel, some research participants were positive, some negative, and some were a little of both. One specifically negative comment, "-It was a little distracting, the quality of the image. I almost feel like the texture of the skin was making it hard for me to see if there was actually like stress on the muscles of the face." Another comment was

more positive about how the technology made them feel, “It felt comfortable, it felt more real seeing what a person’s natural expressions would look like in regards to pain.”

When asked about the realistic nature of the computer-generated face, one student reported “It was more believable seeing the [projected] face than the mannequins that we usually use.” But more typical was the comment having both negative and positive parts to their response, such as “its pretty realistic, maybe the eyes were a little weird, probably the least realistic I would say and then I do think it’s better than the mannequins that we use, just because it does look like a more realistic face using the graphics, whereas the mannequins can only do so much, they usually come with their expression, and you can’t change it.”

After reviewing the transcripts carefully, one can conclude there are mixed feelings and thoughts of research participants. Further refinement of the faces is necessary to increase overall fidelity. Further refinement of facial features to directly express other specific conditions or signs and symptoms will give educators more options in which to use this technology for teaching.

Limitations

Student participants were recruited using the convenience method due to limited resources and time of the primary investigator and co-investigator. The first 15 students who responded to the request for participation were invited to take part in the study. All 15 participants were students within the same university and cohort. These limitations may have impacted the study by decreasing the diversity among potential participants. The results of the study are reflective of this university, but may not be consistent with opinions and viewpoints of nursing students from other schools throughout the state or nation.

The researcher's status as a student within a studied population may have skewed the results. Subjects may not have fully disclosed their thoughts or opinions, or may have felt inclined to answer positively due to their potential relationship with the researcher.

Technology was another limitation faced during this study. The mask used in the study could have been specifically created for the head of a designated low, or high fidelity mannequin, but instead, was nonspecific. The visual appearance and aesthetic may have been compromised.

Recommendations for Nursing Education

Nursing education is constantly growing and changing. Conventional methods of lecture-based teaching have been the mainstay of nursing schools. Due to advances in technology and research, innovative and alternative methods of teaching have become more widely adopted in the nursing community. Nursing students show a range of preferences to different teaching strategies, including simulation. By utilizing a balance of lecture based learning, simulation, and clinical practice, nursing students will develop a well-rounded education. Pain assessment and returning to the basics of a physical exam is essential in identifying negative health outcomes or adverse complications. Projection technology is an innovative method to compliment current nursing curricula, and provide nursing students with the tools they need to succeed inside and outside of the classroom.

Recommendations for Future Research

Future research should study the potential uses of the projection technology. The current study should be expanded to include other nursing schools, and a larger number of research

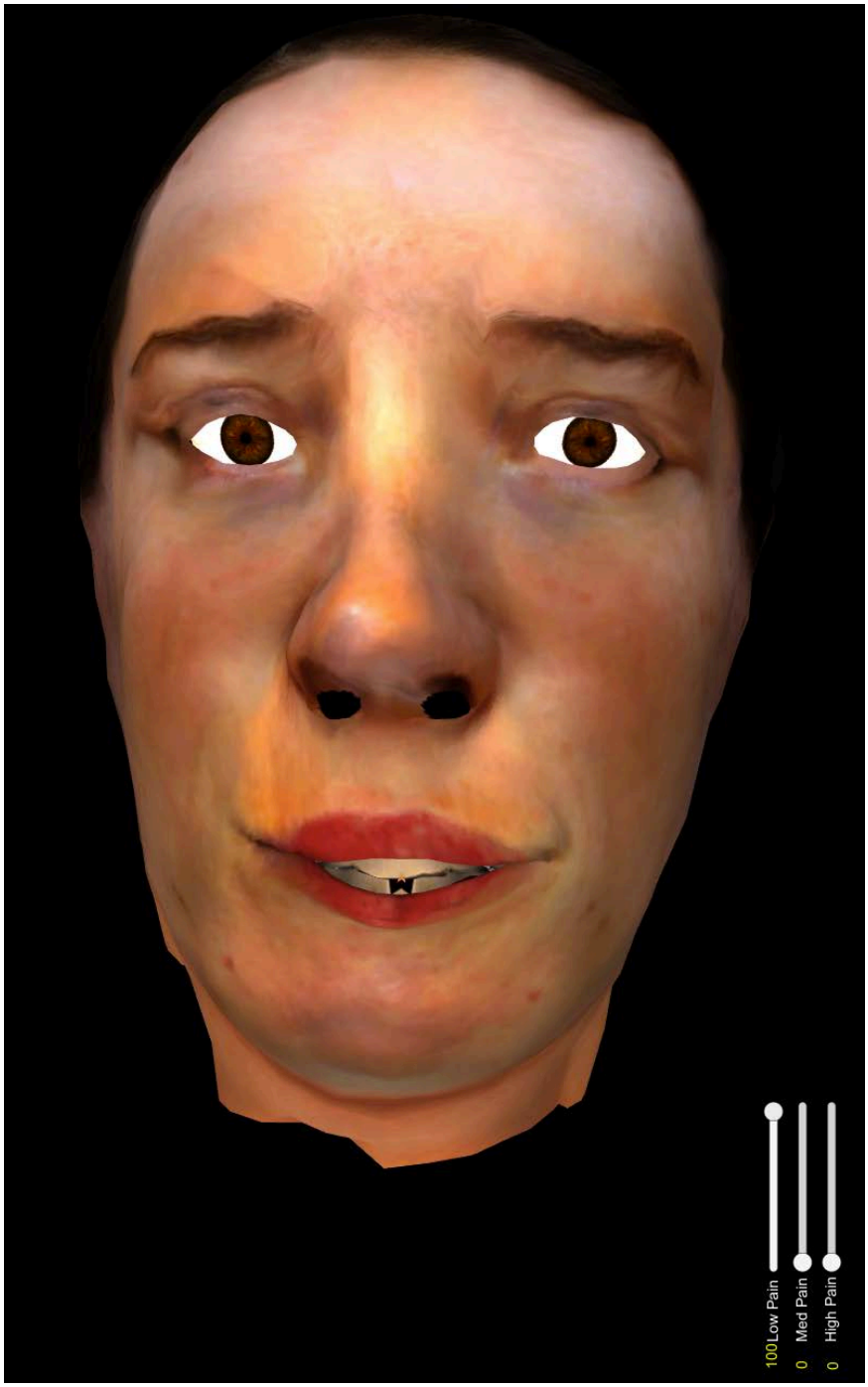
participants. Refinement of the computer-generated faces to more accurately reflect the nonverbal expression of pain in the face is needed. Rear projection technology, and a mask to specifically fit on the low or high fidelity mannequin used in research may increase fidelity, and impact results. To determine the effectiveness of the technology for pain assessment specifically, it should be tested further with nursing students, while pain management practices should also be directly observed in the clinical setting. Students would be able to report if the projection technology aided in identifying subtle indications of pain, or an increased time to treatment can be determined pre- exposure to the technology and then post-exposure.

This technology is novel and catches the attention of the traditional nursing student. If further development of the images can increase fidelity and show signs and symptoms of specific conditions, this could help in the education of the identification of these conditions when seen in the acute care setting. Stroke identification is one specific condition that warrants exploration since the diagnosis often involves assessing specific facial features. The cost of this technology should also be considered as it is further considered for wider application. Overall, the possibilities of using it for education is worth further exploration and has the potential to provide nursing students exposure to specific situations requiring nurses attention to facial features. This further has the potential to positively impact patient outcomes by enhancing the education of the student.

APPENDIX A: SIMULATED FACES

Baseline Face

Face One



Face Two

Face Three

Face Four

APPENDIX B: DATA COLLECTION INSTRUMENT

Data Collection Instrument

Participant Number:

1st face:

On a scale of 0-10 with 0 being no pain and 10 being the worst possible pain, where would you rate the patient's pain based on the face presented? _____

2nd face:

On a scale of 0-10 with 0 being no pain and 10 being the worst possible pain, where would you rate the patient's pain based on the face presented? _____

3rd face:

On a scale of 0-10 with 0 being no pain and 10 being the worst possible pain, where would you rate the patient's pain based on the face presented? _____

4th face:

On a scale of 0-10 with 0 being no pain and 10 being the worst possible pain, where would you rate the patient's pain based on the face presented? _____

The following questions will be audiotaped; you do not have to write the answer.

1.) Overall, how did this technology make you feel?

2.) How realistic do you believe the faces were? Are there any parts of the face that was less realistic than other parts? How does this technology compare to other low and high fidelity simulators you have been exposed to in the nursing curriculum.

3.) Describe uses for this simulation technology in a nursing curriculum.

4.) Is there anything else you would like to discuss related to this research?

APPENDIX C: TABLE 1 QUANTITATIVE DATA

	Face One	Face Two	Face Three	Face Four
Student One	3	4	6	8
Student Two	0	0	8	8
Student Three	3	4	7	9
Student Four	0	2	7	4
Student Five	0	4	6	5
Student Six	2	7	8	9
Student Seven	3	7	7	8
Student Eight	4	7	8	10
Student Nine	6	8	9	10
Student Ten	1	8	5	9
Student Eleven	0	1	6	8
Student Twelve	0	8	7	10
Student Thirteen	4	8	10	10
Student Fourteen	3	0	7	9
Student Fifteen	0	4	8	10
Average	1.87	4.8	7.27	8.47
Minimum	0	0	5	4
Maximum	6	8	8	10

Table 1

APPENDIX D: UNIVERSITY OF CENTRAL FLORIDA IRB APPROVAL

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Human Research

From: **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To: **Kelly D. Allred** and Co-PI: **Justin Charles Grace**

Date: **February 03, 2016**

Dear Researcher:

On 02/03/2016 the IRB approved the following human participant research until 02/02/2017 inclusive:

Type of Review:	Submission Response for UCF Initial Review Submission Form Expedited Review
Project Title:	Recognizing Pain Using Novel Simulation Technology
Investigator:	Kelly D Allred
IRB Number:	SBE-16-11950
Funding Agency:	
Grant Title:	
Research ID:	N/A

The scientific merit of the research was considered during the IRB review. The Continuing Review Application must be submitted 30days prior to the expiration date for studies that were previously expedited, and 60 days prior to the expiration date for research that was previously reviewed at a convened meeting. Do not make changes to the study (i.e., protocol, methodology, consent form, personnel, site, etc.) before obtaining IRB approval. A Modification Form **cannot** be used to extend the approval period of a study. All forms may be completed and submitted online at https://iris.research.ucf.edu .

If continuing review approval is not granted before the expiration date of 02/02/2017, approval of this research expires on that date. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

Use of the approved, stamped consent document(s) is required. The new form supersedes all previous versions, which are now invalid for further use. Only approved investigators (or other approved key study personnel) may solicit consent for research participation. Participants or their representatives must receive a copy of the consent form(s).

All data, including signed consent forms if applicable, must be retained and secured per protocol for a minimum of five years (six if HIPAA applies) past the completion of this research. Any links to the identification of participants should be maintained and secured per protocol. Additional requirements may be imposed by your funding agency, your department, or other entities. Access to data is limited to authorized individuals listed as key study personnel.

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

REFERENCES

American Pain Foundation. (2007). Retrieved on June 12, 2009, from: http://www.painfoundation.org/page.asp? file1⁄4Newsroom/PainFacts.htm.

Arthur, C., Levett-Jones, T., & Kable, A. Quality indicators for design and implementation of simulation experiences: a Delphi study. *Nurse Education Today, 33*(11), 1357-1361.

Berkow, S., Virkstis, K., Stewart, J., & Conway, L. (2009). Assessing new graduate nurse performance. *Nurse Educator, 34*(1), 17-22.

Briggs, C.L. (2010). What were they thinking? Nursing students' thought processes underlying pain management decisions. *Nursing Education Perspectives, 31*(2), 84-88.

Duignan, M., & Dunn, V. (2009). Perceived barriers to pain management. *Emergency Nurse, 16*(9), 31–35.

Duke, G., Haas, B., Yarbrough, S., & Northam, S. (2013). Pain management knowledge and attitudes of baccalaureate nursing students and faculty. *Pain Management Nursing 14*(1), 11-19.

Evans, C., & Mixon, D. (2012). The evaluation of undergraduate nursing students' knowledge of post-op pain management after participation in simulation. *Pain Management Nursing.*

Ferrell, B. R., Novy, D., Sullivan, M. D., Banja, J., Dubois, M. Y., Gitlin, M., … Livovich, J. (2001). Ethical dilemmas in pain management. *Journal of Pain, 2*(3), 171–180.

Lebovits, A.H., Florence, I., Bathina, R., Hunko, V., Fox, M.T., & Bramble, C.Y. (1997). Pain knowledge and attitudes of health care providers: practice characteristic differences. *Clinical Journal of Pain, 13,* 237-243.

Middleton, C. (2003). Understanding the physiological effects of unrelieved pain. *Nursing Times, 99*(37), 28-31.

O'Hara, P., & Campling, J. (1996). *Pain management for health professionals.* London: Chapman & Hall.

Paige, J., & Morin, K. (2013). Simulation fidelity and cueing: a systematic review of the literature. *Clinical Simulation in Nursing, 9*(11), 481-489.

Plaisance, L., & Logan, C. (2006). Nursing students' knowledge and attitudes regarding pain. *Pain Management Nursing 7*(4) 167-175.

Przybyl, H., Androwich, I., & Evans, J. (2015). Using high-fidelity simulation to assess knowledge, skills, and attitudes in nurses performing CRRT. *Nephrology Nursing Journal, 42*(2), 135-147.

Romero-Hall, E. (2015). Pain assessment and management in nursing education usingcomputer-based simulations. *Pain Management Nursing, 16*(4), 609-616.

The Texas Pain Initiative (Ed.). (2007). *The Politics of Pain: Balancing Vigilance and Compassion*. Austin, Texas: American Cancer Society.

Welch, G., Hochreiter, J., Daher, S., Nagendran, A., & Gonzalez, L. Touch Sensing on non-parametric rear-projection surfaces: a physical-virtual head for hands-on healthcare training. Proceedings of IEEE Virtual Reality 2015, pages 69–74. Arles, France, March 23–27, 2015.