In person simulations vs Virtual reality: Can VR replace in person medical simulations?

Jason Snyder

Department of Information Science & Learning Technologies, University of Missouri

ISLT 9450 Research Methods in Information Science & Learning Technologies

Dr. Danielle Oprean

April 25th, 2021

In person simulations vs Virtual reality: Can VR replace in person medical simulations?

Background and Significance of the Research

Years ago, the landscape of medical education changed dramatically as medical simulations were introduced into the curriculum. These simulations ranged from simulated patient scenarios, low fidelity task trainer sessions, up to very advanced high fidelity simulations with the use of very sophisticated robotic patients. As technology progresses, the medical curriculum is changing again as virtual reality (VR) is becoming more prevalent in an academic setting and simulation companies are pushing the limits of medical simulations. As VR becomes the cutting edge of simulation the question is raised, can a virtual reality modality be a comparable replacement for in person high fidelity simulations with regards to retainment and comprehension of the learning material by medical students and residents.

In regards to this research, the researchers will be focusing on a comparison between an in person high fidelity simulation and the same learning module presented in a virtual reality world. This high fidelity simulation will use an advanced medical simulator to replace the need for a "live" patient, the learner will physically interact with the simulator, which is being controlled by an instructor, along with an in person support team to perform an Advanced Cardiovascular Life Support (ACLS) learning module. In a standard ACLS learning module, the primary learner takes on the leadership role, assessing the situation, and delineating roles to the support team to provide care for the patient. This learning module has been replicated in VR using a VR headset. Capitalizing on the nature of the simulation, the learner interacts with the digital support team via voice commands to assist and provide support for the patient.

This research will provide a direct 1:1 comparison of the two modalities

Problem Statement

There are currently large amounts of data proving the need for medical simulations in medical school curriculums, as well as data identifying the convenience of virtual reality modality in an learning environment. However, the data is lacking a direct 1:1 comparison of in person simulations and virtual reality simulations. As medical schools move forward toward a better learning environment for students, this type of research is needed to help shape the future landscape of medical simulations and objective based learning modalities. Though medical students are the primary population for this research, the proposed question could be presented for other health science professions that use simulations to augment the curriculum.

Purpose of the Study

This mixed methods study will address the gap in research, providing data to help answer the question can a virtual reality modality be a comparable replacement for in person high fidelity simulations with regards to retainment and comprehension of the learning material by medical students and residents. In this study, the learning comprehension of 4th year medical students will be analyzed to find if comprehension and retention is better sublimated by an in person simulation or a Virtual Reality simulation. An explanatory sequential design will be used for this research, both qualitative and quantitative data will be collected and analyzed.

Researchers will divide the population size into samples, each sample will complete either the in person simulation or the virtual reality simulation. Upon completion of the simulation, the groups will perform an exam testing their knowledge of the ACLS process. Those exam scores will then be analyzed, comparing the results to identify if one learning module

performs better than the other. Researchers will continue the research by having the groups perform the opposite simulation to their first encounter, learners will then provide feedback via survey, detailing which simulation they preferred. The intent will be that the survey data will support the exam results providing a more robust justification of each learning modality.

Literature Review

This review is seeking to explore this topic with a collection of articles from Google Scholar, EBSCOhost, and the University of Missouri's library database. The beginning of this review lays the groundwork of past acknowledgement for simulation in the medical curriculum, followed by case studies with comparisons of the two learning modalities. For years, medical simulations were not common place in the medical school curriculum, only with years of research was it proven that simulations were a viable learning modality for medical students. The first section is providing this base understanding of medical simulation and simulation use in the medical school's curriculum. Moving on, the next section will be providing case studies of simulation research as well as the introduction of VR in medical school curriculum. Final section of the literature review identifies the gap in the research, specifically with the lack of a direct 1:1 comparison of the modalities.

Acceptance of Simulation

Guze (2015), In this article, Guze aims to identify the growing need of technology use in medical education and identify how it is a "response to the challenges facing medical education" (p. 1). The article showcases some of the emerging practices at the time with a portion being dedicated to simulation. Accenting the robustness of simulation by saying:

> The use of simulation spans a spectrum of sophistication, from the simple reproduction of isolated body parts through to complex human interactions portrayed by simulated patients or high-fidelity human patient simulators replicating whole body appearance and variable physiological parameters. (p. 5)

Guze lays very good groundwork for the identification of this emerging technology and the importance of embracing these technologies as supportive features to augment medical educators “to transform learning into a more collaborative, personalized, and empowering experience" (p. 8).

This article, Curtis et al. (2012), is a bit older but is a very detailed and in depth look at the concept of simulation and use of it with continuing medical education. The authors do a very deep dive into consideration of initiating simulation for education purposes and help to shape the answer of “why” it would be needed. Throughout the article the authors break down the different types of fidelity to better analyze the benefits of each to allow the reader to make more informed decisions on the different aspects of simulation.

Case Studies: Examples of simulation in use

As the topic of technology in medical education grows and the importance of simulation becomes more focused it is only natural to question the next phase of these modalities. Virtual reality is becoming the emerging answer to “what is next”, in this regard. With the use of current components, Oculus Quest 2 as an example, learners can now be transported into a virtual emergency room or patient room for their learning module.

In the article by Sattar et al. (2020), the author provide a good example of a case study of the effects of virtual reality on medical students and their learning experiences. The article states that

“VR provides a risk- free simulation where users can achieve hands on practice before moving on to the real task" (p. 3). A key take away from this article is the advantage of using virtual reality (compared to other simulation modules) as a learning module with regards to resources, cost, and risk. “Blending curriculum with technological tools such as VR can improve students’ motivation, in turn, affecting their academic and practical performance" (p. 3). The authors used a quantitative approach to the subject and relied on various test result to gauge the comprehension/motivation of the learners in the study.

The authors of this article, Yi-Ju et al. (2019), provide a very good case study of the use of a Virtual world (VW) as a learning module and compared to an “on stage” module. Essentially, using the VW as a tool to re-enforce communication and the importance of it in a medical situation.

In the article, Johnson et al. (2019), Johnson, and others, show a study of using simulation to augment a didactic learning module. Points in the article are proving the importance of simulation in medical education with a major take away being “The introduction and application of simulation in medical education is considered to be one of the most important steps in curriculum development" (p.1). Using a mixed method to attain data measuring the comprehension of the didactic lesson after the introduction of a simulated event, the authors find that the use of simulation will serve as an efficacious alternative to a didactic learning module.

Bakhos et al. (2020), provide a perfect use case study of the comparison of VR to a more traditional way of learning. The authors identify the importance of simulation modalities in medical education but indicate the lack of “simulators directed at developing students’ audiometry skills" (p. 2). Because of this, the study focuses more on the “traditional” method of learning these skills compared to using VR. After the study, the authors conclude that the

findings of the study show improvement from the learners using the VR technology over the traditional learners. They go on to say that “the tested VR training may be a useful tool for audiology education" (p. 7). They further go on to discuss other studies that also prove “VR training offered an advantage for learning theoretical knowledge over traditional, lecture-based education" (p. 8).

Erlinger et al. (2019), provide a very good example of a case study of the comparison of a virtual learning module compared to a high fidelity (in person) learning module. Using this study to answer the question for “recognition of intraoperative myocardial infraction (MI) by SNRAs” (pp. 1-2). Based on the article, the methods used were observational in nature as the researcher(s) were present in the room for the virtual learning and in person sessions. Erlinger and others find that “the use of high-fidelity mannequin simulation led to quicker recognition of intraoperative MI" (p. 4) in second year SRNAs. The article references other research articles that continue this assessment and comparison of a high fidelity simulation compared to a virtual reality simulation, with similar results of learners preferring the high fidelity simulation over the virtual. They conclude that for first- and second-year students, “the use of high-fidelity mannequin simulation would be preferred if possible" (p. 5), though Virtual reality learning modules may be a suitable option if other structural resources are limited.

Brim et al. (2010), The authors in this article write about the long-term experience of simulation, specifically high-fidelity simulation, over the course of a 6-year study. This article, like many others, is more of an article justifying the “need” of simulation in medical education. Possibly using a mixed method approach the authors provided great results in the positive effects of a simulation-based learning module introduced to the curriculum. In their conclusion the

authors clearly state the importance of simulation in the medical curriculum by saying “For some students, simulation provides otherwise unavailable exposure to core content material" (p. 1).

Identified Gap

In the article, Samadbeik et al. (2018), the authors provide a scoping review which “aimed to identify virtual reality applications in training medical groups" (p. 2). There is a point in the article that states “in several studies and specialties no positive effects are noted regarding the use of virtual reality compared to the control group" (p. 4). Yet the conclusion of the article indicates that VR is a good supplement to medical education and could have great benefits.

The article, Pottle (2019), focuses on what VR is and how it can be used to evolve the medical education field. Pottle recognizes the current standard of medical education with the use of “in person” simulations and how important this type of curriculum has become. The authors focus seems to be identifying the importance of VR and encapsulates the essence of the concept by saying “VR has a unique power, more than any other technology that has ever existed, to make users believe they are in a different environment" (p.1). Pottle does a very good job of also pointing out the “drawbacks” of VR and to the point of this research, identifies that:

> VR simulation is not a panacea. Rather, it is a tool used to accomplish a defined set of learning outcomes and should be deployed as such, integrated within an institution’s curriculum and pedagogy to ensure effective use (p. 3).

Conclusion

For this review articles were chosen that represented comparisons between typical simulation standards and a comparable version in a virtual reality setting. Looking back to the proposed question, can a virtual reality modality be a comparable replacement for in person high fidelity simulations with regards to retainment and comprehension of the learning material by medical students and residents, the review identifies that though a VR learning module is an excellent modality for advanced learning, it is not a feasible replacement for in person high fidelity simulation. It could be further identified that there is a gap in research of a direct 1:1 comparison of a high fidelity simulation and an equal representation of that simulation in a VR setting.

Methodology

Current literature identifies the importance of medical simulation as a reliable source to advance the Medical school curriculum (Guzem, 2015; Curtis et al, 2020;). With a multitude of case studies showing the standard practice of high-fidelity (or in person) simulation as being the ideal methodology (Brim et al., 2010; Johnson et al., 2019), the rising advancement in technology is now introducing the use of Virtual Reality (Sattar et al., 2020) as a possible replacement. However, based on literature most have only compared the two modalities in a sense of augmenting the curriculum (Yi-Ju et al., 2019; Bakhos et al., 2020; Erlinger et al.,2019). Little research shows a direct 1:1 comparison of a high-fidelity simulation in relation to a similar learning objective in a virtual reality environment, leaving the question, can a virtual reality modality be a comparable replacement for in person high fidelity simulation with regards to retainment and comprehension of the learning material be medical students and residents, unanswered.

Method and Rationale

If the idea of methods is that qualitative research is more focused on words rather than numbers and quantitative research is driven by the numbers, this study will utilize a mixed methods approach. Mixed Methods resides in the middle of this continuum because it incorporates elements of both qualitative and quantitative. (Creswell & Creswell, 2018)

The first part of the study will incorporate quantitative methods with pre and post simulation test. These tests will be used to quantify the knowledge base of the learners and compared to the same test given to the learners that will be running through the simulation in a VR setting. This data will be used to help identify if either modality shows a gap in learning comprehension, material retention, or a clear difference in the deliverable content.

The second part of the study will be focused on the qualitative aspect of the mixed methods approach. The learners will run the simulations again however, this time the study will not focus on the advancement of knowledge but will focus on how the learners perceive each simulation modality and preferences between them. The data will be collected through a survey at the end of the simulation. This data will point out the preference between the modalities, as well as provide substance to the quantitative data collected. The inclusion of both methods will create an explanatory sequential design to this research topic, with the intent to justify the use of one modality over the other.

Research Questions

Examples in the research have shown that both simulation modalities have merit in the medical school curriculum. High fidelity simulations being the older and more prominent

method thus having a bigger "foot hold" in the curriculum. As technology is advancing, VR is becoming a very comparable replacement due to ease of access and lower "up front" cost associated with devices. A research gap has emerged with lack of a direct comparison of the two modalities. In that regard, the following questions are posed:

1. Will learners have the same level of learning comprehension completing a virtual reality simulation compared to an in-person simulation, thus proving that one modality is a better learning environment than the other?
2. Will the medical school curriculum become more robust by incorporating a VR modality and lessening the in-person simulation modality?

Concepts

In this study, the 4th year medical students will the independent variable with comprehension and retention being the dependent variables. The dependent variables will be quantified after the subjects have completed either an in person simulation or a Virtual Reality simulation. The learner experience will be directly affected by the simulations and the difference between the learning modalities. For the quantitative part of this mixed methods study, learner retention and comprehension will be identified. The qualitative section will focus on idea of preference and used to identify personal experience. As the gathered data is analyzed more results may be identified.

Sample

The population for this study will be the 4th year medical students associated with the School of Medicine. Sample size for this research will be no more than 10 students. All

participants will participate in the research as a part of a 8 week simulation elective in their curriculum. Currently as a part of this elective, learners learn the functionality of simulation, interacting with various faculty members to gain a better understanding of the use of simulation in a medical institution. Incorporating this research into this existing elective will help elicit a better understanding for the learners of simulation as well as the proposed research questions.

Permissions will be obtained from the institution and the course director of the elective to ensure the inclusion of the research subject is acceptable. Informed consent will be collected from each learner participating in the elective and subsequent research.

Data Collection

As a part of the elective, the learning objectives will be discussed in a "class like" session. Learners will then be asked to take a pre-test before completing either of the present simulation modalities. As a part of the quantitative section of the study, these pre-tests will be compared between the in person simulation and the VR modality to gather an understanding of each learner's comprehension of the material before going into the simulation. These test scores should not show much difference in learners but can help lead to a conclusion of comprehension when compared with the post test scores.

Immediately after the simulations, each learner will then complete a post test evaluation of the learning objectives. Again, these test scores will be compared. Two days after the simulations, learners will then be asked again to participate in a review test to further gather information on comprehension and retention of the learning objectives. The second post test will be unannounced to avoid learners from purposely studying the material to augment their retention.

A week following the quantitative data gathering, each learner will be asked to complete both simulation modalities again. After completion of the second simulation, they will be given a survey that will ask specific questions comparing the two modalities. This data gathering will be focusing more on the learners' perceptions of the modalities and which one they perceived to be a better learning resource. Retention or their performance in either modality will not be the focus and questions of that nature will be avoided in this evaluation.

Ethical Considerations

In the research study it will be imperative to indicate that participation in this study will have no effect on the outcome of their documented grade associated with the elective. This study, though a part of the elective course, is merely an individual module of an 8-week course and will have no grade associated with it.

Though the study will be a part of the elective course, the gathering of the data will be considered voluntary, and the learners will not be required to participate in that process. Consent to record their simulations will be obtained, as is the normal practice of the Simulation Center, consent will also be obtained for their participation in the research study.

Researchers will need to take extra precautions to avoid leading the learners toward a perceived outcome or imposing theories for expected outcomes. Researchers will also need to take precautions to prevent the course faculty from passively subjugating the learners to their own opinions on the difference of the learning modules.

Data Analysis

All data gathered through the quantitative methods will be compiled into an appropriate software to compare the answers and the data points. This data will be measured across both modalities to create a matrix comparing the high and low points for each learner. Analyzing this data will help to identify if one of the simulations produces a better performance in learning comprehension and retention.

Data for the quantitative section will be compiled and presented in written form through a post simulation survey. Identifying any themes or reoccurring responses that become prevalent across the learners. After gathering the qualitative data, comparisons will be made with the quantitative data, to determine if there are any strong results indicting a superior methodology. Because the qualitative data will be more subjective to the learners preference, it will be used in combination with the test scores to hypothesize the research data. Both sets of data will be combined to give a representation of the content and used to show where each set of data either supports or contradicts the proposed hypothesis.

Timeline

Based on cohort of medical students and their movement into their 4^{th} year, along with the offering of the simulation elective, the full study will be best spread across several academic years but not to exceed 4. The data gathered in Year 1 would allow for any subsequent changes before entering Year 2 and beyond. At the ending of Year 3, enough data should be collected to allow for Year 4 to be used to compile and analyze the data. It is conceivable, with acceptance from all parties involved, to create a secondary elective or specific research cohort to allow for more data to be gathered in the same time frame.

Summarizing Paragraph

At the start of this research proposal the question, can a virtual reality modality be a comparable replacement for in person high fidelity simulations with regards to retaining and comprehension of the learning material by medical students and residents, was raised. Literature has proven the necessity of medical simulations in the medical school curriculum as well as the advancement of that learning modality with the introduction of virtual reality. However, a gap in the research has identified that, though the research for the importance of both modalities is prevalent, there is little to no research done that does a direct comparison of in person simulations and virtual reality simulations. With the proposed research, a direct comparison of the two will be executed resulting in data supporting the use of one modality over the other for learning comprehension and material retention. Furthermore, this research will help to justify the use of either modality in a medical school, or other health sciences, curriculum.

References

Bakhos, D., Galvin, J., Aoustin, J., Robier, M., Kerneis, S., Bechet, G., Montembault, N., Laurent, S., Godey, B., Aussedat, C. (2020). Training outcomes for audiology students using virtual reality or traditional training methods. *PLoS ONE, 15*(12), 1-12. https://doi.org/10.1371/journal.pone.0243380

Brim, N. M., Venkatan, S. K., Gordon, J. A., & Alexander, E. K. (2010). Long-term educational impact of a simulator curriculum on medical student education in an internal medicine clerkship. *Simulation in Healthcare, 5*(2), 75-81. https://doi.org/10.1097/SIH.0b013e3181ca8edc

Curtis, M. T., DiazGranados, D., & Feldman, M. (2012). Judicious use of simulation technology in continuing medical education. *Journal of Continuing Education in the Health Professions, 32*(4), 255-260. https://doi.org/10.1002/chp.21153

Erlinger, L. R., Bartlett, A., & Perez, A. (2019). High-Fidelity mannequin simulation versus virtual simulation for recognition of critical events by student registered nurse anesthetists. *AANA Journal, 87*(2), 105-109.

Guze, P. A. (2015). Using technology to meet the challenges of medical education. *Transaction of the American Clinical and Climatological Association, 126,* 260-270. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4530721/

Johnson, S. M., Owens, T. L., & O'Neil, J. N. (2019). Making the clinical connection from textbook to bedside during MDY1: an integrative approach for medical physiology education employing human simulation. *Advance in Physiology Education, 43*(2), 128-133. https://doi.org/10.1152/advan.00109.2018

Sattar, M., Palaniappan, S., Lokman, A., Shah, N., Khalid, U., & Hasan, R. (2020). Motivating medical students using virtual reality based education. *International Journal of Emerging Technologies in Learning(iJET), 15*(2), 160-174. https://www.learntechlib.org/p/217172/article_217172.pdf

Yi-Ju, A. W., Yu-Yu, L., Sin-Bao, P. H., & Yen-Ting, R. L. (2019). Enhancing medical students' communicative skills in a 3D virtual world. *Journal of Education Technology & Society, 22*(4), 18-32.