Thesis Project Portfolio

Designing an Affordable Distal Radius Fracture Reduction Simulator for Medical Training

(Technical Report)

Assessing the Barriers to Mechanical Simulator Development

(STS Research Paper)

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Ryan DeLoach

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Department of Mechanical and Aerospace Engineering

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Executive Summary

In the field of orthopedics, is it not uncommon for medical students to train on live patients. For certain procedures, real people are the only readily available training tool. Because this problem is so fundamental to medical training, my capstone focuses on creating a simulator that allows students to train on before practicing on people. We are targeting a distal radius fracture with our simulator, one of the most common types of fractures in young children and older women. For my STS research, I looked into why simulators are not as prevalent as they could be in the medical training field, what barriers could exist to implementing them further, and whether they are actually effective at training. Through my research I was able to determine that simulators can range from marginally effective to very effective, and it all depends on their design and evaluation. My capstone project and STS research are directly related. Learning about simulators through both physical means and literature has allowed me to have both a practical and philosophical perspective on them.

The motivation for my capstone project is very straightforward: medical students should not have to practice on live patients as their first time performing any procedure. Even done under close supervision by an experienced physician, inexperienced students cause inherent risk. Tackling this issue by allowing students to gain experience through simulation has been a growing trend in recent years. For the wrist fracture we tried to simulate, another problem to solve was the cost of the simulator. The high price of existing products made it difficult for organizations to justify buying them. Our goal was to create a low-cost, properly validated simulator.

Validating a simulator can take a long time, as it requires many different people of varying levels to test the device, so unfortunately, we were unable to fully validate our design. However, through our advisor Dr. Forman, and an orthopedic surgeon, Dr. Freilich, our

simulator was tested to some degree of accuracy. The testing of a simulator, especially in the earlier stages, is often based on feel, so feedback from a physician who regularly performs the procedure in question is a decent form of validation. We were able to accurately model a distal radius fracture using 3D printed parts and off-the-shelf components for a cost of around $80 USD. This is significantly less than the original goal of $150 USD. In the future, hospitals and universities should be able to replicate our simulator design cheaply and quickly, which was one of the main goals of the project.

For my STS research paper, I wanted to first whether orthopedic simulators are effective at improving patient outcomes and reducing risk when students perform procedures for the first time on people. Then, I wanted to examine the barriers to creating more simulators that are effective at doing so. This is significant because risk mitigation is an important part of the medical field, both ethically and economically speaking. If opportunities exist in a process or operation that reduce risk to patients, they should be fully explored. My methodology was to conduct a literature review about the testing and design of simulators, and include case studies that showcased effective examples of them.

Through my research I determined that the main issue was that simulators were generally poorly tested, so their true effectiveness was not well known. Simulators that were properly tested showed improvement in patient outcomes, so I focused my research on how to design and test correctly. I was able to construct a general design and testing procedure that all engineering teams should follow in order to be successful in making simulators that benefit patients. I concluded that simulators can help mitigate risk, but not all of them are created equally.