Thesis Project Portfolio

Development of Hepatic Vasculature Models for Preoperative Planning
(Technical Report)

Investigating the Underlying Reasons for the Adoption of 3D Printed Models into Medical Education
(STS Research Paper)

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Sociotechnical Synthesis

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Both my STS research project and technical capstone focus on advancing medical education and practice in response to evolving healthcare demands. My STS project centers on the use of 3D modeling in medical education, and aims to connect educational practice and the complexities of the healthcare field. More broadly, it reflects how technological advancements can create trends and shifts in medical education. My technical project focuses on enhancing medical education and preoperative planning through the use of 3D models. It proposes the development of a 3D hollow model of the liver so that medical students can practice a complex procedure before performing it on a patient. Together, these projects help to understand the place of physical 3D modeling in the educational community, and emphasize the importance of equipping students with essential skills for modern medical practice.

Medical education has undergone a rapid evolution in response to changing healthcare demands and advancements in technology. Along with this evolution, there has been a constant debate on the balance of scientific knowledge with humanistic qualities in medical education, both of which are essential for effective patient care. As healthcare needs continue to evolve, medical professionals require a more comprehensive skill set that encompasses biological, cultural, and personal knowledge. The shift in medical education towards interactive learning methods, such as hands-on approaches, reflects the necessity of preparing medical students for modern healthcare. The adoption of 3D models into medical curriculum has been an extremely rapid shift. However, despite the integration of this novel teaching tool, studies have yet to demonstrate statistically significant improvements over conventional methods, such as dissections and cadavers. Furthermore, physical 3D models have shown to be more costly than conventional methods as well. My STS research paper employs the Social Construction of Technology (SCOT) and Technology Acceptance Model (TAM) to investigate the underlying reasons for the widespread adoption of 3D printed models in medical education. Through a discourse analysis involving stakeholders such as educational policymakers and 3D printing companies, and users such as students and educators, this project explores the influence of user preferences and social interactions on implementation of this technology. It finds that the reasons for the adoption of 3D models are due to student preferences and ease of use, which comes from students' interactions with stakeholder groups. This analysis shows that the role of student feedback, marketing strategies, and accreditation standards shape medical education practices and reveals a network of influences driving the adoption of 3D printed models in medical schools.

My technical capstone aims to develop a tool for medical training and preoperative planning to help teach medical students about the hepatic (liver) arterial embolization procedure. In this specific procedure, a catheter is navigated through the hepatic vascular system to reach a tumor and deliver drugs to it in order to "downstage" or shrink the tumor. We aimed to do this by creating a detailed 3D printed hollow model of the human hepatic vascular system based on real patient computed tomography (CT) angiography data. Previous research and models had never printed on a scale this small before, so we needed to determine the best process for creating the model. In order to create this model, we first obtained patient CT images from PACS, a clinical software, and then imported those images into 3D Slicer. In 3D Slicer, we performed segmentation and created a threshold so that only the hepatic vasculature would be shown. Then, we cleaned up the model and performed three manufacturing methods to determine the best method of creating the physical model. First, we printed a hollow model in elastic resin from 3D Slicer. For our second model, we printed a solid model in hard grey resin from 3D Slicer and cast it in silicone to create a negative-space model for the catheter to navigate. Lastly, we created a model in which we 3D printed a negative space model from computer assisted design software. The printed hollow model and silicone negative space model had limitations due to the printer and complexity of the vasculature, while the printed negative space model was able to be printed nearly perfectly because it was a block. For this reason, we deemed the printed negative space model to be the most suitable for preoperative planning and teaching purposes. This project is significant due to its potential to enhance medical education by providing realistic, patient-specific organ models that facilitate a complex procedure. By combining advanced imaging technologies with novel 3D printing techniques, the project pushes the boundaries of current medical modeling practices and improves patient outcomes through improved physician training.

By working on both of these projects simultaneously, I have a detailed understanding of 3D models and their place in the educational community. In my technical project, I was able to undertake the role of the main “user” of 3D printed models as an undergraduate biomedical engineering student. I also closely worked with Formlabs, a primary stakeholder of 3D models in medical education. This helped me better understand the societal and educational perspectives of users that influence the adoption of 3D models in medical education, which was what my STS research project aimed to accomplish. Additionally, working closely with a primary stakeholder helped to reveal how critical 3D printing companies are in shaping medical curriculum and the integration of technology. If I had not had these experiences, it would have been much more difficult to determine why understanding the influence of different social groups is important in understanding how technology is accepted by students. Ultimately, my STS research helps put into perspective how and why the model I created in my technical capstone will be accepted and used by educators and students.