

Introduction

- At present, heart disease is the leading cause of death in the United States, highlighting the need for affordable and accessible cardiac auscultation models.
- However, the high cost of existing models poses a financial barrier to students and healthcare professionals to practice this essential and necessary clinical skill.
- Cardiac auscultation is an essential skill for all healthcare professionals to learn, regardless of medical specialty.
- The high cost of existing models poses a significant financial barrier for students and healthcare professionals, limiting access to these essential training tools.
- This study examines the feasibility of constructing cardiac auscultation models using readily available materials and mediums.
- Two cardiac auscultation models were fabricated at low and mid-tier price points named, "Economy," and "Deluxe," models.
- Most existing models utilize a specialized stethoscope with built-in speakers, restricting students from practicing with their own equipment.
- To address this limitation, the experimental models incorporate speakers within the chest walls, enabling students to develop confidence and proficiency using their own stethoscopes in a more realistic training environment.
- Production costs of the Economy and Deluxe models proved to be considerably less than the price of pre-fabricated models, at no loss of ability to auscultate abnormal heart sounds.

Methodology

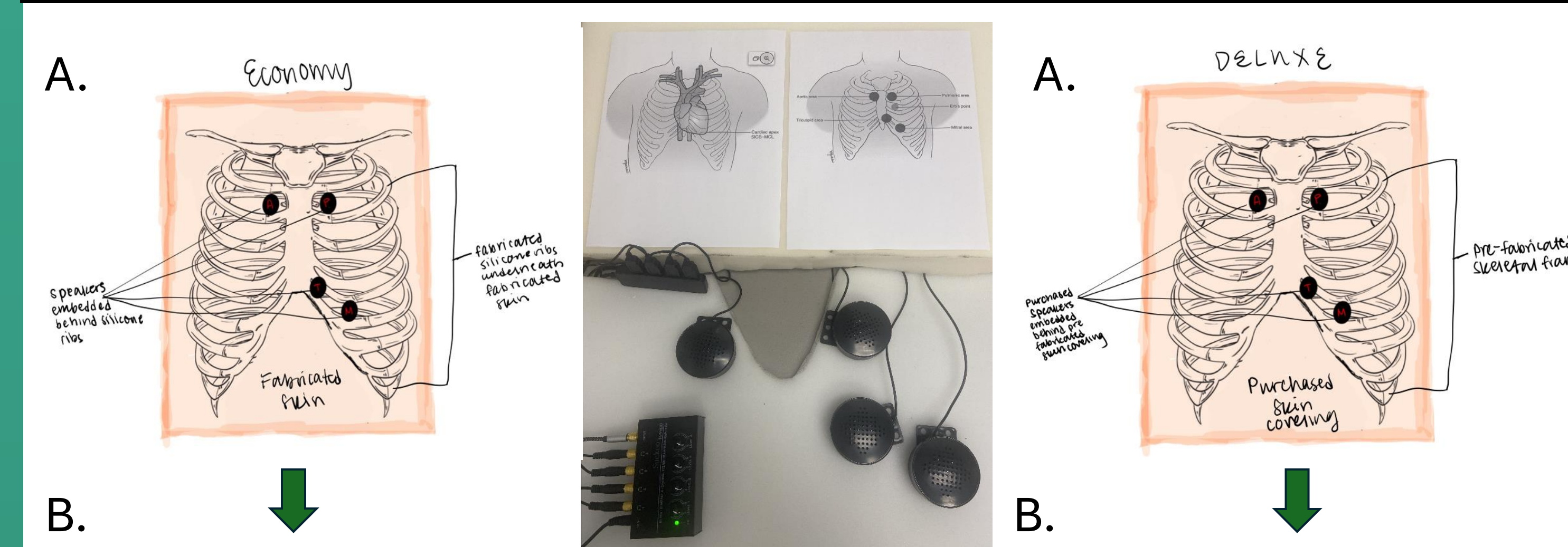


Figure 2: Speakers and switchboard used to play heart sounds. The programmed heart sounds include normal S1/S2, aortic regurgitation, mitral regurgitation, midsystolic click, holosystolic murmur, mitral stenosis, persistent split S2, split S1, transient split S2, tricuspid regurgitation, S4 gallop, ejection click, and pericardial friction rub.

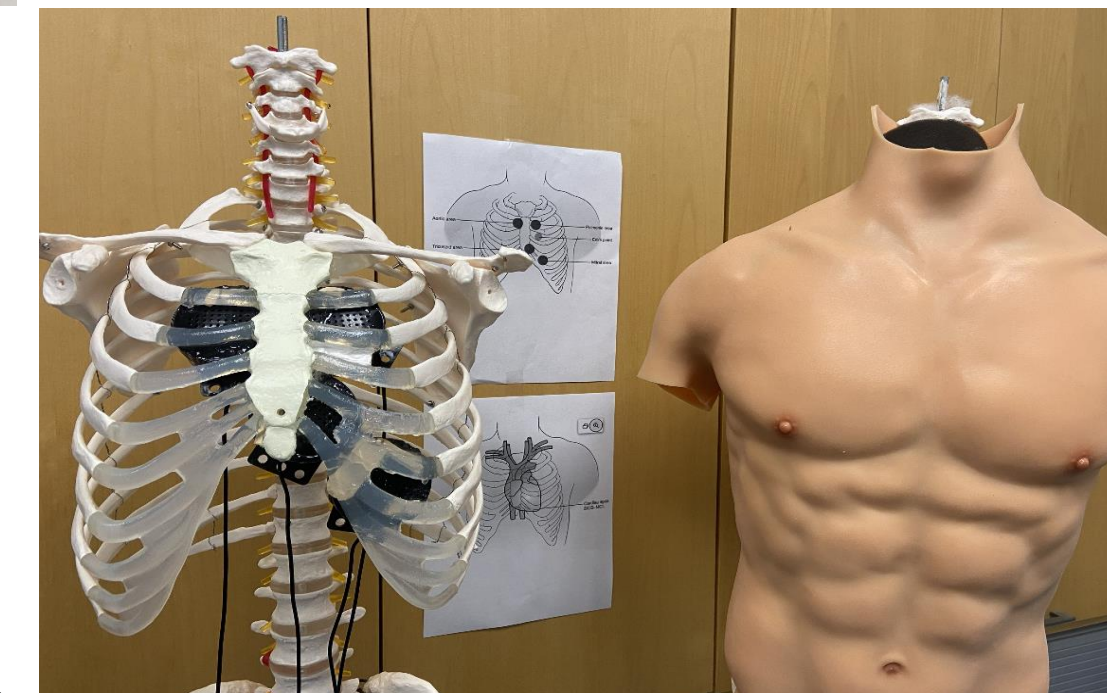


Figure 3: A. initial sketch of the deluxe model. B. The fabricated deluxe model with four speakers in anatomical position of the aortic, pulmonic, tricuspid, and mitral valve. Once speakers were in place, a pre-fabricated skin model of the chest was placed over the skeleton.

Materials



Figure 4: Sculpting a clay model of the economy model skin covering; rib molds were also sculpted with clay (not shown).

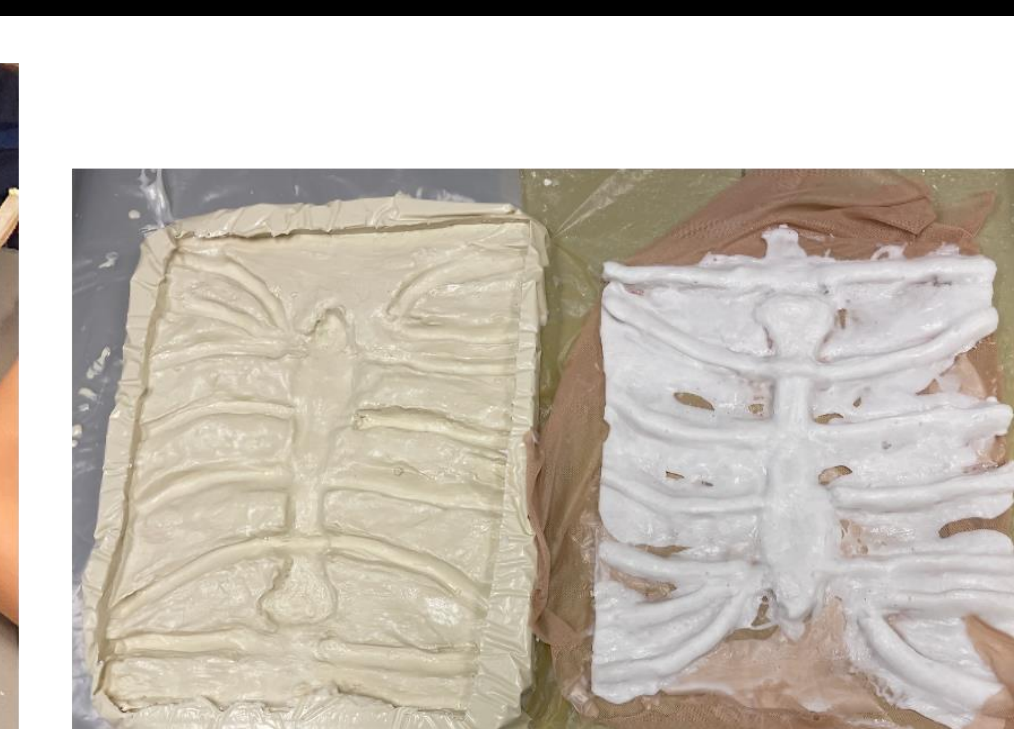


Figure 6: Silicone ribs (right side) casted from permanent plastic rib mold (left side).

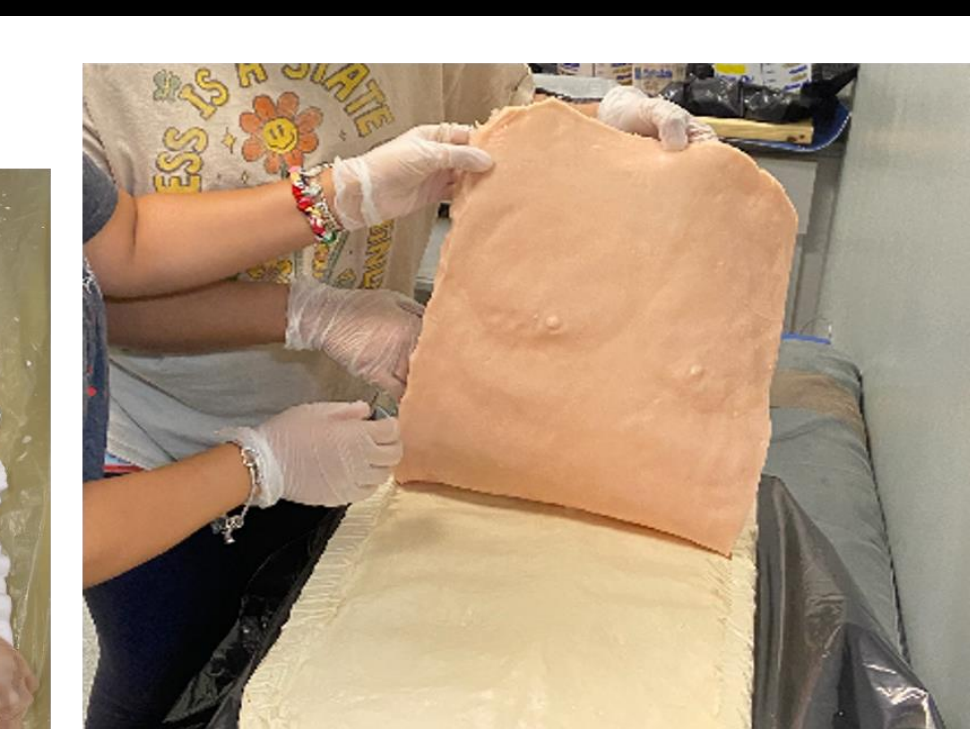


Figure 8: Final silicone skin covering being peeled off of plastic chest mold.

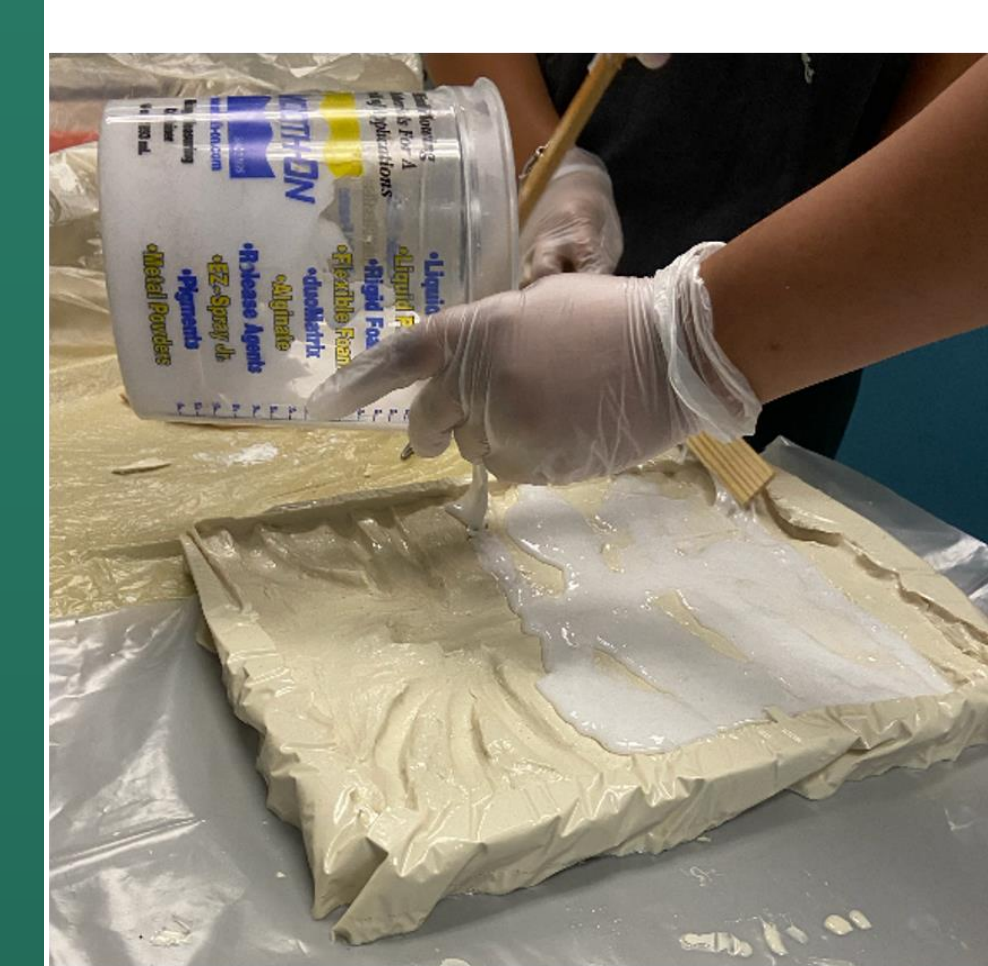


Figure 5: Silicone being poured into plastic mold to create ribs for Economy model



Figure 7: Plastic being poured to make permanent plastic mold for the chest wall of economy model.



Figure 9: Final fabricated Economy model (See inside of model in Figure 1).

Discussion & Future Directions

- Post-fabrication, both the economy and the deluxe model allowed for auscultation of the programmed heart sounds.
- Existing cardiac auscultation models sell for up to \$29,500¹. Compared to this, our economy model costs \$29,135 less and our deluxe model costs \$28,820 less. Even when compared to the cheapest auscultation model on the market, which goes for \$1,540², our economy and deluxe models are \$1,240 and \$860 cheaper, respectively (Table 1).
- Fabrication of the economy model is more time and labor intensive than fabrication of the deluxe model; this is something to take into consideration when evaluating time and cost benefits between either model.
- The deluxe model features a pre-fabricated skin and skeletal mold (Fig. 3), whereas the economy model's skin and skeletal mold were fabricated from clay, silicone, and plastic (Fig. 1).
- Of note, economy model skin and skeletal plastic molds are permanent and are a one-time investment post-fabrication, allowing for the duplication of multiple economy models at a lower price.
- The pre-programmed switchboard (Fig. 2) can be connected to any laptop/tablet, an additional consideration for either model.
- We plan to assess the effectiveness of the cardiac auscultation models in enhancing student proficiency via student survey.
- Surveys will be given to medical students prior to and following cardiac examination lab in their Clinical Examination course to assess self-reported confidence in auscultating heart sounds.
- A form of standardized evaluation of improvement in proficiency following use of the models will be evaluated.
- A "Super-Deluxe" model will be fabricated where normal and abnormal heart sounds will play simultaneously to enhance realism of the simulated cardiac examination.

Conclusion

By proving the feasibility of fabricating cardiac auscultation models, this study has the potential to enhance medical education, particularly in resource-limited settings, by improving access to hands-on training for health professional students for development of competency in cardiac assessment.

References

- <https://limbsandthings.com/us/products/91100-care-trainer-dst>
- https://www.3bscientific.com/us/hal-adult-heart-and-lung-sounds-skills-trainer-torso-1019857-w45099-gaumard-s315200l_p_148_5314.html?utm_source=google&utm_campaign=gmc_feed&gQT=1
- <https://www.reynoldsam.com/product/>

Comparison of Cost

	Commercial Model	Deluxe LECOM Model	Economy Model
Skeleton Frame	Included	Pre-Fabricated \$ 200.00	Fabricated \$ 25.00
Speakers (set of four)	Included	Purchased \$ 40.00	Purchased \$ 40.00
Electronics (splitter; mixer)	Included	Purchased \$ 40.00	Purchased \$ 40.00
Skin Covering	Included	Purchased \$ 300.00	Fabricated \$ 25.00
Sound-Proofing	Included	Purchased \$ 100.00	Purchased \$ 25.00
POST-DEVELOPMENT COST	\$29,500	\$ 680.00	\$ 155.00
Development Costs	Included	\$ 400.00	\$ 300.00

Table 1: Breakdown and comparison of cost of commercial, deluxe, and economy cardiac auscultation models by skeleton frame, set of four speakers, electronic splitter and mixer, skin covering, sound-proofing, and housing. Cost of materials may vary³.