Reusable 3D Pelvic Floor Teaching Model For Layered Construction Activities

Preliminary Product Design Specifications

Fall 2026 BME 200/300 Lab 307

Team Name:

SuperModels

Team Members:

Katherine Ahlquist (Co-Team Leader)
Sara Mlodik (Co-Team Leader)
Abigayle Chapman (BWIG)
Karen Pisano (BSAC)
Hiba Shah (BPAG)
Mina Hawkins (Communicator)

Client:

Kelsey Henriquez and Sarah Traynor

Advisor:

Prof. David Dean

September 18, 2026

Problem Statement:

The Physician Assistant anatomy curriculum currently has a pelvic floor anatomy workshop that uses a 2-dimensional paper template of the bony pelvis, on which PA students build pelvic floor musculature and tissues using colored Play-Doh. While the activity promotes hands-on learning, the 2D model does not adequately allow students to develop the three-dimensional spatial relationships required for future clinical practice. The client needs a classroom set of pelvic outlet models that accurately represent the normal adult pelvic anatomy, including anatomical landmarks for muscle and ligament attachment, that can serve as a stable scaffold for students to build pelvic floor musculature. It should be durable enough for repeated classroom use, easy to assemble and store, and allow Play-Doh or another inexpensive modeling material to be adhered and removed without causing residue or degradation.

Client requirements:

- Create a classroom set of at least 30 reusable 3D models of the pelvic outlets
- Be anatomically accurate with each model scaled to represent normal adult pelvic anatomy
- Create a pelvic outlet at the intersection of male and female pelvic anatomy to allow the models to be used interchangeably between the workshops for both sexes
- Include important anatomical landmarks, including but not limited to, the ischial tuberosities, ischial spines, greater sciatic notches, distal sacrum, and muscle attachment sites
- Be compatible with Play-Doh or an inexpensive modeling material, allowing the material to adhere without the model shifting or being damaged
- Consist of multiple pelvis pieces, if necessary, with simple attachment mechanisms such as sliding or latching connections
- Have the combined size and weight of the models be compact and lightweight, respectively, for easy transportation and storage between classrooms
- Be durable enough to withstand repeated classroom use

Design requirements:

1. Physical and Operational Characteristics

a. *Performance requirements*

i. The model must be able to withstand repeated use for multiple hours a day by students in a pelvic floor anatomy workshop, where students will continuously apply, manipulate, and remove Play-Doh from the model. During Play-Doh application and manipulation, the model must provide sufficient structural support, such that the model remains stable on the workspace surface and does not undergo deformation from grip that may reach 63.6 kg (623.9 N) while students build multiple layers of musculature [1]. During Play-Doh removal, the model must maintain its shape and structural integrity as students apply friction and force to remove residue after each classroom session.

b. *Safety*

i. The 3D pelvic floor model must be safe for users in a classroom setting for the duration of operation. All structural components of the device, whether fabricated using 3D printing or plastic molding, must have rounded edges and reasonably smooth surfaces to prevent cuts or injuries to the skin during usage. Since the model will be directly handled and touched, all components and adhesives must be non-toxic, hypoallergenic, and safe for skin contact. Additionally, because play-doh will be used repeatedly on the device, the outside must be non-porous and not susceptible to retaining moisture or residue that could lead to bacterial growth or molding during storage.

c. *Accuracy and Reliability*

i. The model must feature high anatomical accuracy, specifically focused on the main adult pelvic outlet, excluding aspects such as the iliac wings. The essential anatomical landmarks, including the distal sacrum, ischial tuberosities, ischial spines, great sciatic notches, sacrotuberous ligaments, should reflect adult anatomical dimensions within a ±2 mm tolerance [2]. The model must allow students to explore differences in pelvic floor anatomy between the sexes by providing a base diaphragm capable of supporting either configuration of musculature. The device's surface must allow play-doh to adhere firmly during construction processes without slipping, while still allowing for a clean detachment without leaving behind permanent residue or causing degradation of the model over time. Lastly, the model components must remain attached and aligned in their appropriate structure during use, and should withstand pressing forces as the play-doh is molded.

d. *Life in Service*

i. As long-term durability is a high priority for the client over realistic tissue compliance, the model must be capable of enduring repeated use in a classroom setting over a service life of at least 3 to 5 years. With roughly 30 models per class, each prototype must withstand the cycle of re-application of play-doh, molding of musculature, and removal hundreds of times without significant degradation. Finally, considering the need to transport the models between classrooms, the models should be able to sustain minor physical impacts or accidental drops from standard table height (approximately 0.75 meters) onto carpeted or linoleum floors without failure or permanent deformation [3].

e. *Shelf Life*

i. While not being actively used, sets of approximately 30 models will be kept in indoor classroom storage. The device materials should remain stable under slightly variable storage conditions, including temperatures from 20 to 25°C and humidity within the range of 20-60% [4]. Assuming the device will not be exposed to harsh outdoor elements or UV light exposure, the main structure of the device and polymers should possess a minimum shelf life of 10 years without turning brittle or warping. Extended periods without use should pose no complications for the device performance.

f. *Operating Environment*

i. The device will be used by many students throughout the academic year during class periods. It must be durable enough to withstand being dropped from tables and repeated pressure when students apply clay. The device will be stored in classroom storage rooms at temperatures ranging from 20°C to 25°C [5]. It must also be easy to clean by washing or wiping away excess clay, with materials that are resistant to corrosion and mold.

g. *Ergonomics*

i. The device should be handled with care to prevent parts from breaking off. It should not be slammed against tables or walls and should be passed around carefully. Students should apply clay gently to avoid damaging the device.

h. *Size*

i. The device should be approximately the same size as an average human pelvis to help students visualize and understand pelvic anatomy. The average female pelvis is approximately 13 cm wide, 11 cm deep (front to back), and 13.5 cm diagonally across. It is approximately 25% wider than a male pelvis [6].

i. *Weight*

i. The device should be lightweight, allowing students to easily carry and rotate it during hands-on learning activities. The device should weigh approximately 1–2 lbs to ensure comfortable handling while studying the pelvis.

j. *Materials*

i. Play-Doh best sticks to porous, high-friction materials such as cardboard, matte paper, untreated wood, or heavily textured plastics. Applying a coat of primer or sealant to a material, an example being Mod Podge or matte primer, can act as a porous layer the Play-Doh can grip onto.

ii. TPU is a flexible filament with a high-friction rubbery surface that Play-Doh will stick to, however, lacks the support needed for the main bony pelvic structure. TPU could however be an effective material for the perineum.

iii. Standard 3D printing materials, PLA or PETG, naturally repel Play-Doh, but are optimal to use for stamps, rollers, or molds.

iv. Smooth plastics, silicone, glass, or foil should be avoided as the Play-Doh will release from these materials easily.

k. *Aesthetics, Appearance, and Finish*

i. The shape will be anatomically accurate to a bony pelvis within the median subpubic angle between that of a male and female pelvis, allowing the student to decide whether they choose to construct male or female pelvic floor anatomy. A female pelvis has a subpubic angle generally within 90 - 100 degrees (obtuse angle), and a male pelvis has a subpubic angle within 50 to 80 degrees (acute angle) [7]. Our model therefore should represent a subpubic angle of approximately 85 degrees.

ii. We will design a textured surface that allows the Play-Doh to grip onto the 3D printed pelvic model. Cross-hatching, deep ridges, or score marks will be incorporated into the design where the Play-Doh is intended to be attached, according to the Pelvis and Perineum Workshop.

iii. Potential to incorporate color and texture difference between ligaments, bone, and muscle. Skeletal muscle will be depicted as striated whereas smooth muscle will not, but the client is not focused on the level of detail in this aspect.

2. Production Characteristics

a. *Quantity*

i. Our client needs 1 unit per group of 2-3 students in a class size of 56 students. To meet this requirement, a minimum of 30 units are needed.

b. *Target Product Cost*

i. Our target manufacturing cost is between \$3-\$7 per unit, with a total budget between \$100-\$200. This budget will need to cover all material costs for prototyping, testing, and final fabrication.

ii. Similar products currently on the market start around \$100 per unit [8].

3. Miscellaneous

a. *Customer*

i. This pelvic floor model's target audience is anatomy students learning about standard pelvic floor anatomy and anatomy instructors.

ii. The model must be lightweight, durable, anatomically accurate, easily transportable, and cost-effective.

iii. The model must allow Play-Doh to easily attach, hold its form, and detach from the model.

iv. The model must be easily cleanable with standard sanitizing wipes.

b. *Patient-related concerns*

i. The model must be lightweight and easily transportable between classrooms.

ii. The model must be durable for long-term classroom use.

iii. The model must allow Play-Doh to easily attach, hold its form, and detach from the model.

c. *Additional optional patient requests*

i. The model could use color coding or different materials to help differentiate between muscles, bones, and ligaments.

ii. The model could be easily foldable or compressed to make transportation easier.

iii. The model could include textured detailing that students can mold their Play-Doh onto, providing a visual and hands-on representation of muscle texture as they build during the workshop.

d. *Competition*

i. "The 3D Pelvic Floor - Nature" is a handmade wool-felt model priced at €195 that represents three layers of pelvic floor musculature, the coccyx, soft tissue bridge, and three pelvic organs: the bladder, uterus, and rectum [9] . While it provides a tactile representation of pelvic anatomy, the pre-cut musculature limits students' ability to actively construct and explore the anatomical structures, and its high cost may make it less accessible for classroom use. Our design builds on this concept by allowing students to mold and construct the pelvic floor muscles layer-by-layer, creating a more interactive and affordable learning experience.

ii. The Medi-Cross Female Pelvic Floor Anatomy Model is a PVC model priced at £159, making it a costly option for classroom use [10]. While its removable organs help students visualize pelvic anatomy, the muscles are already constructed. Our design allows students to actively build the muscle layers, creating a more hands-on learning experience.

iii. The Female Pelvis Skeleton Model is an anatomically accurate model priced at $114.00, featuring the hip bones, sacrum, coccyx, lumbar vertebrae, and movable symphysis [8]. However, it includes more skeletal anatomy than needed for the scope of our pelvic floor workshop and is not designed for easy portability. Our design focuses specifically on the pelvic floor while being more compact and portable for classroom workshops.

References

[1] “International norms for adult handgrip strength: A systematic review of data on 2.4 million adults aged 20 to 100+ years from 69 countries and regions - PubMed.” Accessed: Sep. 15, 2026. [Online]. Available: https://pubmed.ncbi.nlm.nih.gov/39647778/

[2] J. S. Eggleton and B. Cunha, “Anatomy, Abdomen and Pelvis, Pelvic Outlet,” StatPearls Publishing, 2023. Accessed: Sep. 14, 2026. [Online]. Available: https://www.ncbi.nlm.nih.gov/books/NBK557602/

[3] “BIFMA G1-2013 Ergonomics Guidelines | PDF | Chair | Anthropometry.” Accessed: Sep. 14, 2026. [Online]. Available: https://www.scribd.com/document/929848178/Bifma-g1-Ergonomics-Guideline-for-Furniture

[4] “Reiteration of Existing OSHA Policy on Indoor Air Quality: Office Temperature/Humidity and Environmental Tobacco Smoke | Occupational Safety and Health Administration.” Accessed: Sep. 14, 2026. [Online]. Available: https://www.osha.gov/laws-regs/standardinterpretations/2003-02-24

[5] “Storage Temperatures.” Accessed: Sep. 16, 2026. [Online]. Available: https://scrippslabs.com/storage-temperatures/

[6] Taim Talks Med, *Pelvis & Hip Bone: Parts, Landmarks & Articulation | Anatomy*, (Aug. 20, 2025). Accessed: Sep. 16, 2026. [Online Video]. Available: https://www.youtube.com/watch?v=c6-38CMgaPo

[7] “7.7E: Comparison of Female and Male Pelves - Medicine LibreTexts.” Accessed: Sep. 15, 2026. [Online]. Available: https://med.libretexts.org/Bookshelves/Anatomy_and_Physiology/Anatomy_and_Physiology_(Boundless)/7%3A_Skeletal_System_-_Parts_of_the_Skeleton/7.7%3A_The_Hip/7.7E%3A_Comparison_of_Female_and_Male_Pelves

[8] “Anatomical Teaching Models | Plastic Human Pelvic Models | Female Pelvic Skeleton Model.” Accessed: Sep. 14, 2026. [Online]. Available: https://www.3bscientific.com/us/human-female-pelvic-skeleton-model-3b-smart-anatomy-1000134-a61-3b-scientific,p_31_124.html?utm_source=adwords&utm_campaign=QT_PMAX_General_Branded_3BScientific&utm_medium=ppc&adpos=&scid=scplp&sc_intid=&utm_term=&hsa_acc=7327396469&hsa_cam=23273393892&hsa_grp=&hsa_ad=&hsa_src=x&hsa_tgt=&hsa_kw=&hsa_mt=&hsa_net=adwords&hsa_ver=3&gad_source=4&gad_campaignid=23278443065&gbraid=0AAAAAD_WC-FMmUwj8Eo3YEgjy0uYxFwVr&gclid=Cj0KCQjwk5nVBhDiARIsAHNGqaf7aePsJcRIf5u_W_m1cM-jCPdHfmvpr8JkeV_5BW11TmXdcFm83ZgaAussEALw_wcB

[9] “Muskel levator ani | Beckenbodenmodell,” 3-D Beckenboden/Körpermodell. Accessed: Sep. 14, 2026. [Online]. Available: http://www.beckenbodenmodell.de/m-levator-ani/

[10] M. Johnson, B. Davis, G. Guillot, E. Porta-Miller, and J. Brueckner-Collins, “Creating a novel 3D-printed model for teaching pelvic floor anatomy,” *Anat. Sci. Educ.*, vol. 18, no. 11, pp. 1196–1202, 2025, doi: 10.1002/ase.70101.