

Bed-Mounted Modular Training Surface

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Client: Shannon DiMarco

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Client Information

- I. Shannon DiMarco
 - A. University of Wisconsin-Madison, School of Medicine and Public Health
 - B. Administrative director of the Clinical Simulation Program
 - C. Passionate about developing innovative training equipment that will accommodate the confined space in the clinical simulation lab

Problem Statement

The goal for this project is to create a secure, lightweight, procedural workstation for clinical simulation centers to conduct procedural training. Current solutions lack stability, take up excessive floor space, or exhibit tipping hazards. To resolve this, the team must create a workstation which can be compact for storage, quickly attachable, and meet desired constraints for sanitation and safety.

Motivation

- I. Current hospital workstations do not accommodate for the size of clinical simulation labs.
- II. 424 simulation centers were identified in the US used the healthcare setting. [1]
- III. Simulation training in nurse residency programs led to students experiencing an increased outcome in confidence and knowledge [2]

Background

Clinical Simulation Labs

- Clinical Simulation Lab [3]
 - Dedicated training facility
 - Practice clinical skills on models, virtual patients, and task trainers
 - Teachers and other students watch clinical simulation from separate observation room
 - Improves knowledge, skills, and confidence in real clinical behavior [2]



Figure 1: Image sent by client of pediatric models and materials used on simulation surface



Figure 2: Image from UW-Health Simulation Program Virtual Tour Video

Clinical Simulation Labs

Procedures to be done on Simulation Surface:

- Line insertions
- Suturing
- Laryngeal mask airway insertion
 - Maintains an open airway - allows oxygen and anesthetic gases to reach the lungs without invasive intubation [4]

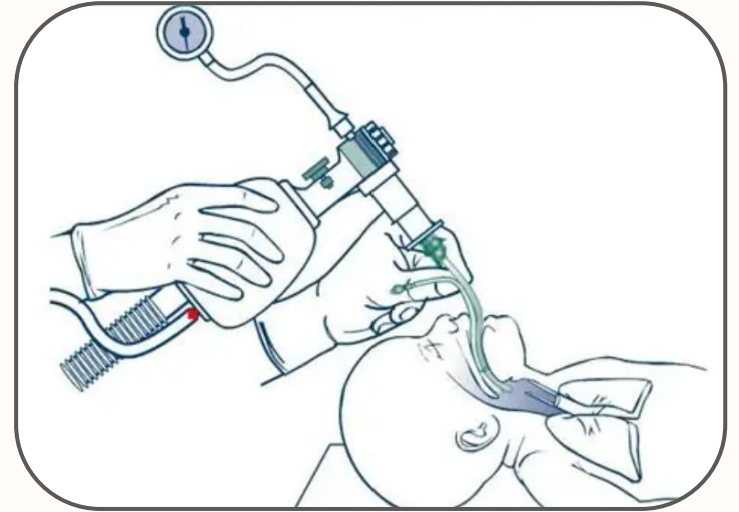


Figure 3: Image depicting a pediatric laryngeal mask airway insertion

Product Design Specifications

- Attach securely to a standard hospital bed
 - Span dimensions (80" x 36")
- Environment
 - Withstand frequent transportation from storage to training sessions
 - Withstand simulated fluids (fake blood, etc.) and sterilization chemicals
 - Shelf life of 5 years
- Performance Requirements
 - Must be foldable and fit in a constrained storage space
 - (reduce to $\frac{1}{3}$ of length, 27")
 - Must be lightweight
 - Under 25lbs

Competing Designs

Simple Folding Table

- Current table utilized by the Clinical Simulation Program
- Currently not meeting the needs of the client:
 - Training rooms are limited on space
 - No convenient place to store



Figure 4: Picture of a similar table used in the Clinical Simulation Program [5]

Wall-Mounted Work Station

- Pros
 - Provide both a workstation and access to a monitor during patient care
 - Wall mounted which removes all floor space
 - Can be implemented anywhere where there is a wall
 - Easily sanitized
- Cons
 - Design seems to focus heavily on record management (recording data from patient) [6]
 - Client requires devices to aid in hands-on procedures
 - Table space is very limited - not ideal for simulations like line insertions, suturing, airway management, and diagnostic taps



Figure 5: Medical Staff using the Wall-mounted Work Station



Figure 6: Wall-mounted Work Station design

Proposed Design Ideas

Trifold Corner Strap

- Three panels, attached by piano joints in alternating directions for optimal compacting
- Thin, flexible silicone sheet to prevent fluid leakage, while remaining foldable
- Elastic strap on each corner to wrap around mattress and secure surface down
- Compact, retractable handle
 - briefcase-like carrying when in folded state
- 36" width, 80" length, and $\frac{1}{4}$ " thickness
- Easy to use
- Most complicated design to develop

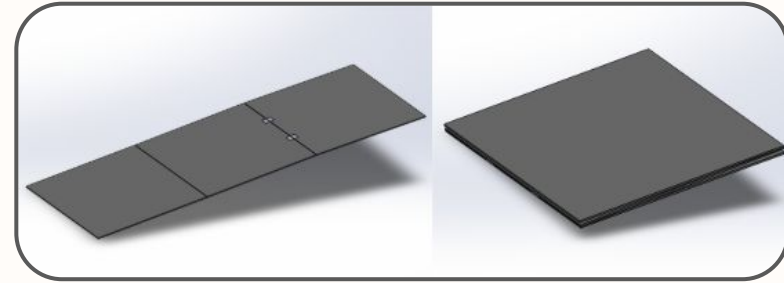


Figure 7: Drawing of Tri Fold Corner Strap model with top view and folded side view

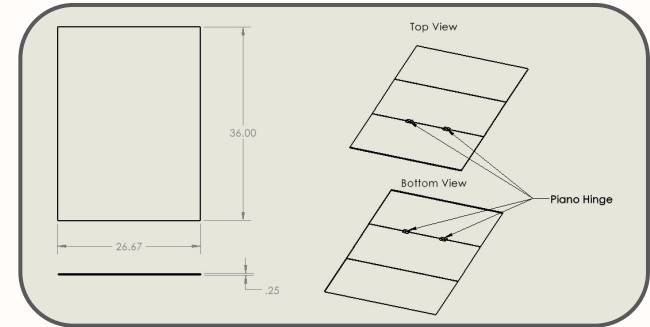


Figure 8: Fabrication diagram with dimensions of each segment

Bifold Mattress Cover

- Thin sheet that spans height, width, and length of bed
- Single piano hinge at center
 - Compacts to half of length
- Winged ends that fold under mattress
- Slides over the length of the mattress for easy set up
- Topped with sterilizable surgical cover
- Less universal due to variations in mattress depth
- Easy to fabricate

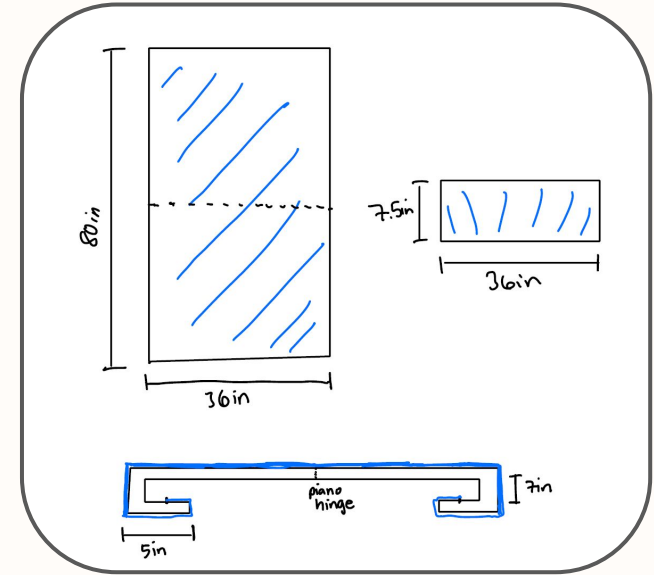


Figure 9: Drawing of Bifold Mattress Cover Model from 3 viewpoints

Buckle Bed Frame

- Three ¼" thick polypropylene panels sewn into sterilizable fabric
- Panels fold along internal hinges for compact storage
- Features four buckle components along corners
 - Loop around and tighten to bed frame
- Not as secure due to attachment to frame instead of mattress
- Slightly complicated fabrication

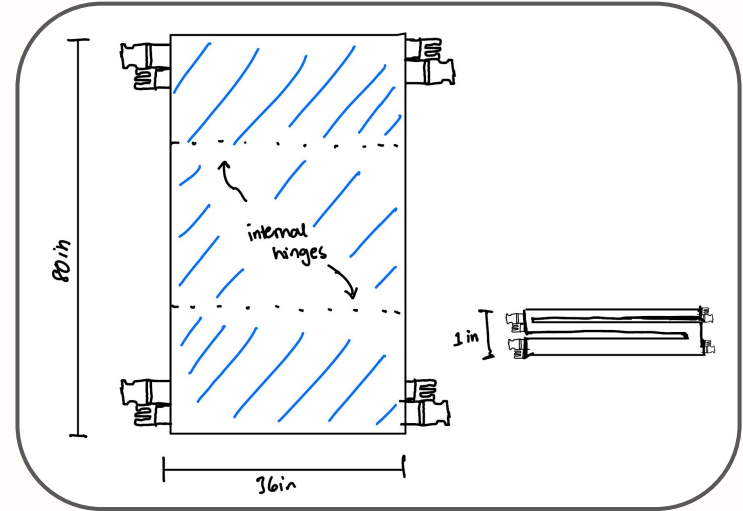


Figure 10: Drawing of Buckle Bed Frame Design Feature Top View and Compact View

Product Design Matrix

Criteria	Weight	<u>Design 1</u> Trifold Corner Strap		<u>Design 2</u> Bifold Mattress Cover		<u>Design 3</u> Buckle Bedframe	
		Score (5 max)	Weighted Score	Score (5 max)	Weighted Score	Score (5 max)	Weighted Score
Compactibility	30	5	30	3	18	5	30
Ease of Use	25	4	20	2	10	3	15
Secureness	20	3	12	5	20	3	12
Ease of Fabrication	15	3	9	3	9	4	12
Safety	10	5	10	5	10	5	10
Total	100	81		67		79	

Table 1: Design Matrix of Design for Bed-mounted Modular Training Device

Material Design Ideas

HDPE

- HDPE is a strong, chemically resistant thermoplastic made from polymerized ethylene
- Tensile strength: 31.7Mpa [7]
- Density: 0.95g/cm³ [7]

Pros	Cons
● Chemically resistant ● Low cost ● Accessible ● Light weight	● Creep resistant ● Lower stiffness/flexural modulus ● Low thermal resistance

Table 2: Pros and Cons list of HDPE

Polypropylene

- Polypropylene (PP) is a lightweight, semi-rigid thermoplastic polymer made by polymerizing propylene
- Tensile strength: 30-50MPa [8]
- Density: 0.9g/cm³ [8]

Pros	Cons
● Light weight ● Low cost ● High stiffness/flexural modulus ● Chemically resistant ● High thermal resistance ● Creep resistant	● Can be flammable ● Can be difficult to bond to adhesives

Table 3: Pros and Cons list of Polypropylene

6061-T6 Aluminum

- Aluminum is a lightweight metal used in construction, transportation, and everyday products due to its high strength, corrosion resistance, and ductile properties
- Tensile strength: 310MPa [9]
- Density: 2.7g/cm³ [9]

Pros	Cons
● High strength ● High stiffness ● Chemically resistant	● Heavy ● Expensive

Table 4: Pros and Cons list of 6061-T6 Aluminum

Material Design Matrix

Criteria	Weight	<u>Material 1</u> HDPE		<u>Material 2</u> Polypropylene		<u>Material 3</u> Aluminum (6061-T6)	
		Score (5 max)	Weighted Score	Score (5 max)	Weighted Score	Score (5 max)	Weighted Score
Sterilizability	35	5	35	5	35	5	35
Weight	25	5	25	5	25	2	10
Durability	20	3	12	4	16	5	20
Cost	10	5	10	5	10	2	4
Ease of Fabrication	10	5	10	5	10	3	6
Total	100	92		96		75	

Table 5: Design Matrix of material used for the base of the sim surface.

Final Design Choice

- Final Design is the Tri Fold Corner Strap Model using Polypropylene for the interior base of the surface.
 - This design and material combination allows for students to experience hospital-like environment while taking up no floor space
 - Surface can easily be produced and reused
 - Surface can be compact and stored in limited space
 - Surface is at a reasonable cost

Future Work

Future Work

- **Fabrication:**
 - Order materials through client
 - Fabricate prototype using materials
- **Testing:**
 - Perform tensile testing on elastic straps to confirm yield strength
 - Survey students after using surface to receive feedback for any complications, faults, ease of use with the design
- **Presentation:**
 - Present final design to client and advisor
 - Provide client with final prototype to be used in future clinical simulation settings.
- **Expansion:**
 - Integrate an electrical source component to the device

Conclusion

- Final Design: Tri Fold Corner Strap
 - High compatibility score
 - High ease of use score
- Final Material: Polypropylene
 - High strength / flexural modulus
 - High chemical resistance
 - Low weight
- Future Work
 - Incorporating electrical source
 - Procuring materials
 - Fabrication
 - Testing

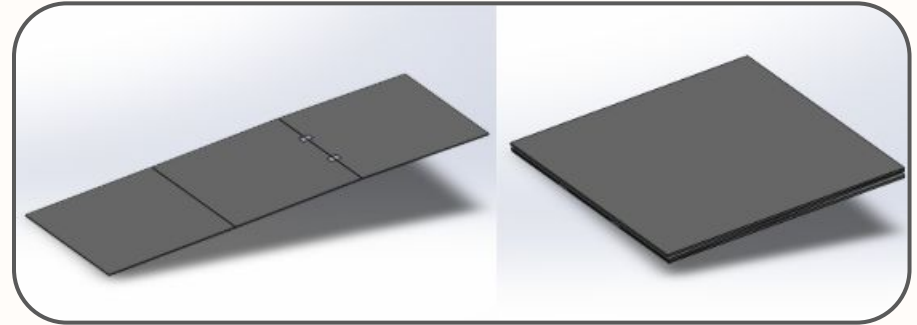


Figure 11: Tri Fold Final Design

Acknowledgments

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