A Comprehensive Introduction to Medical Simulation

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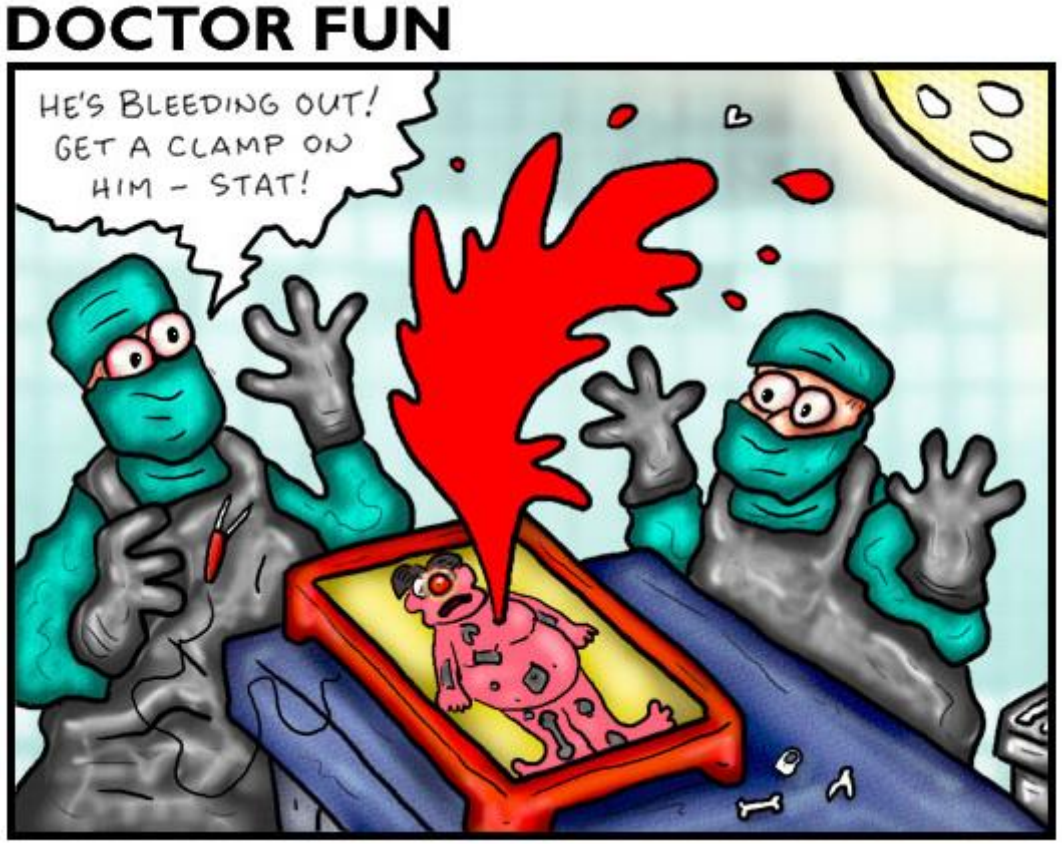
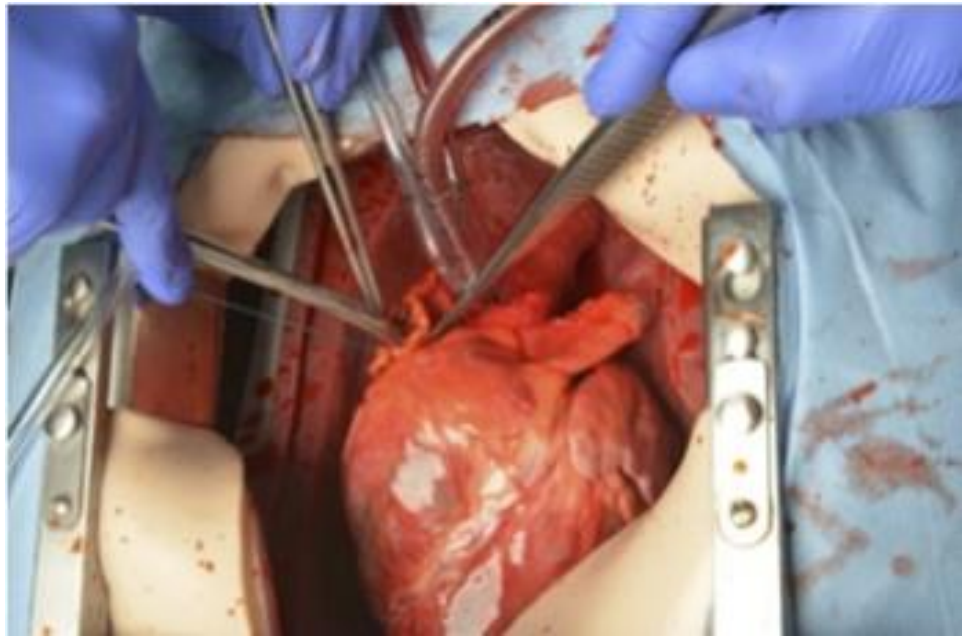
Tutorial Learning Objectives

- Understand the tools and techniques
- Recognize the contribution to patient safety
- Appreciate historical and social forces
- See the patterns in medical simulation
- Ability to evaluate medical simulation devices



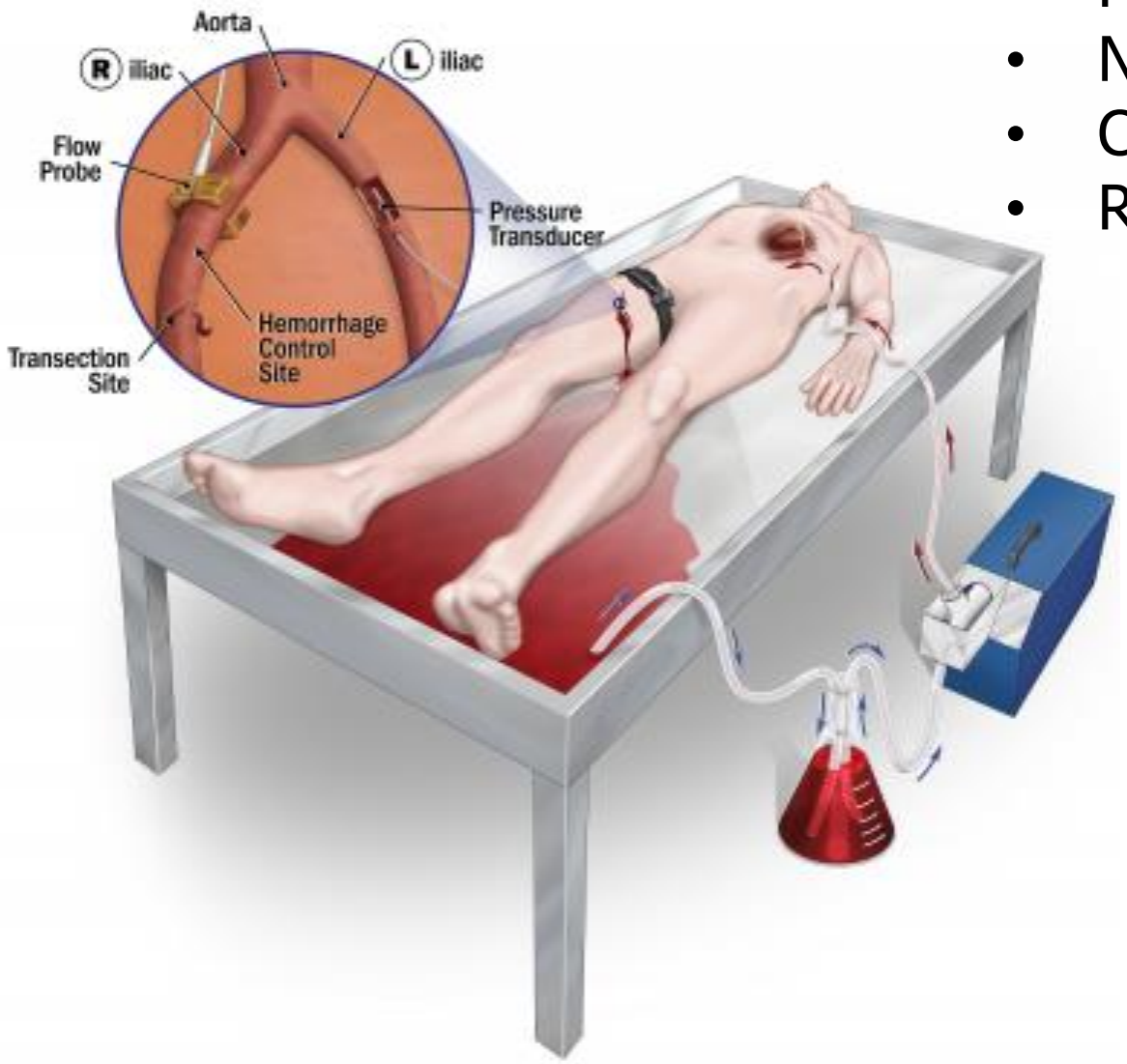
What’s New in Medical Simulation?

Animated Tissue

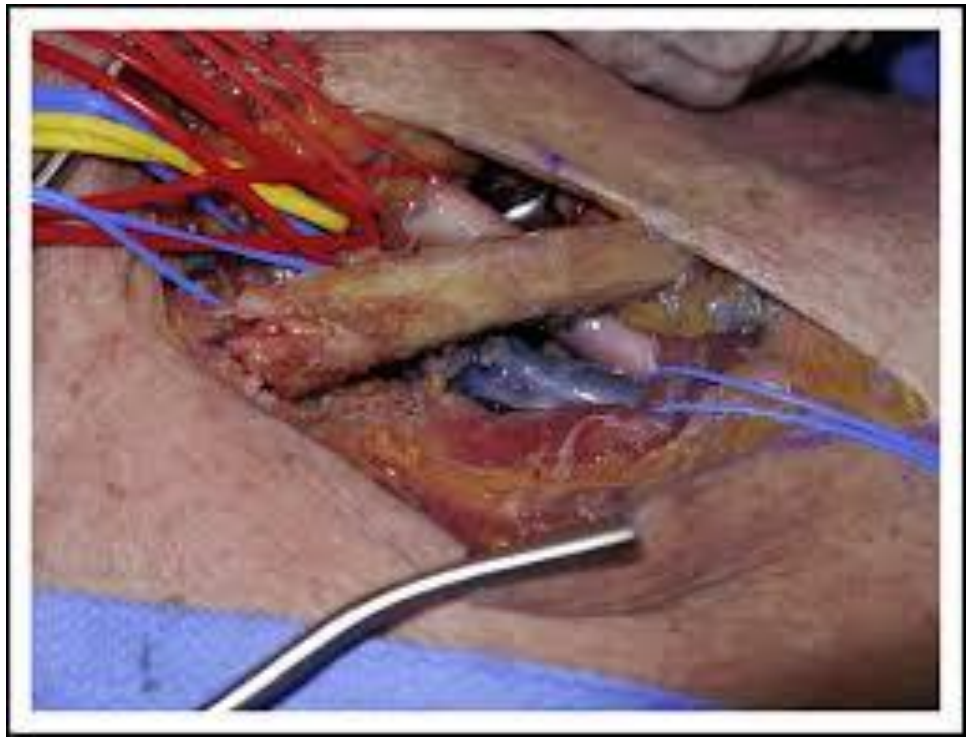


- Excised porcine organs
- Non-clotting blood substitute
- Connected to transfusion pump
- Installed in synthetic body shell

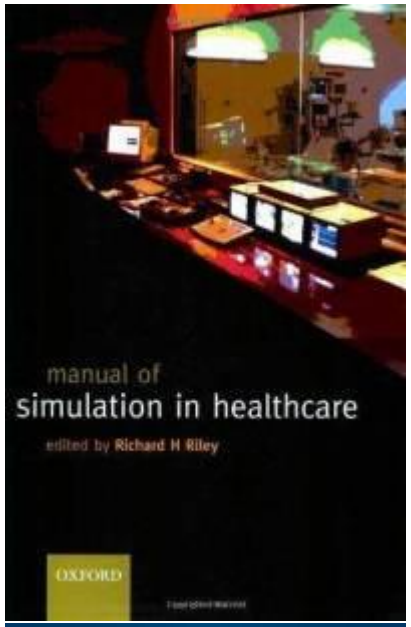
Perfused Fresh Cadavers

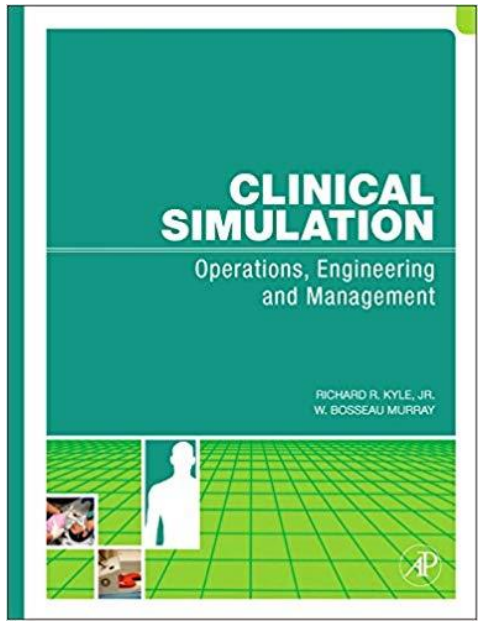


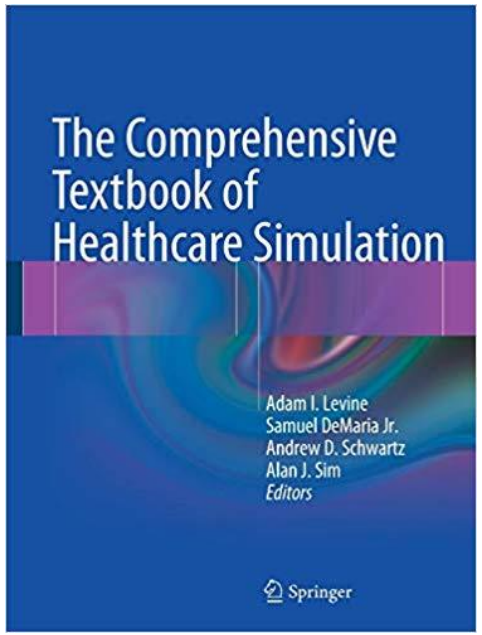
- Fresh cadavers
- Non-clotting blood substitute
- Connected to transfusion pump
- Restores circulation, color, bleeding, active heart

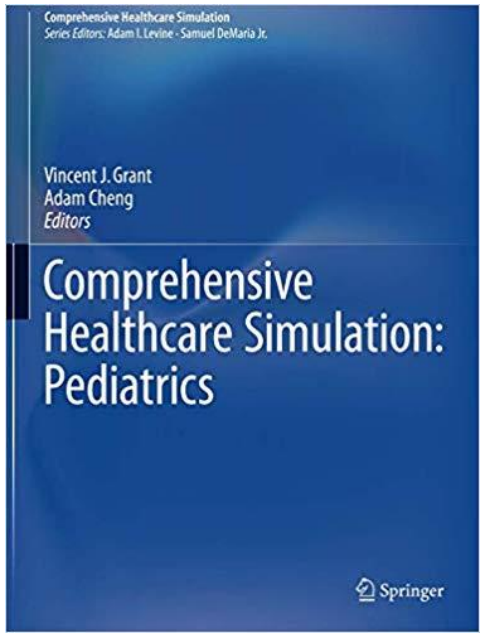


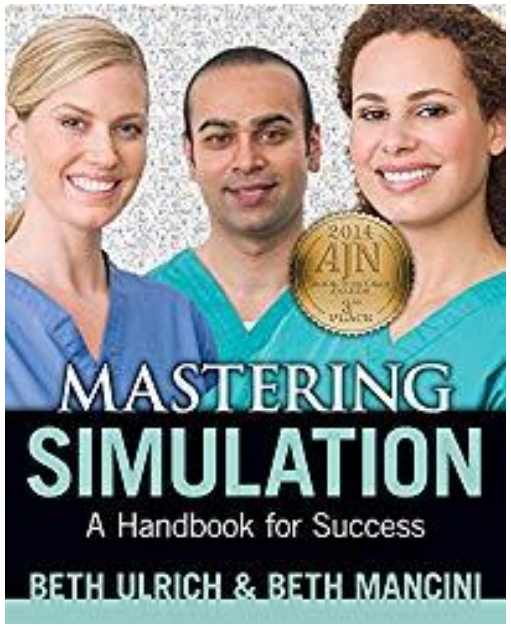
Plentiful Reference Books

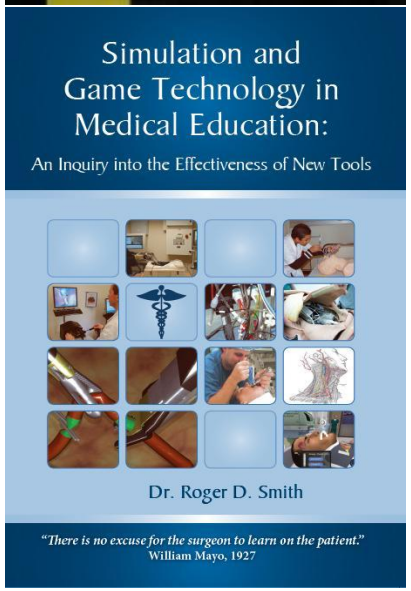


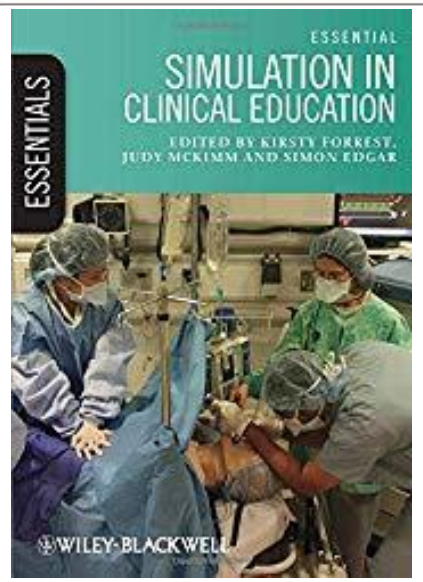


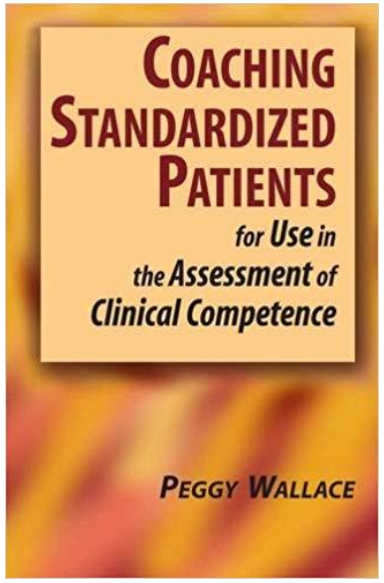


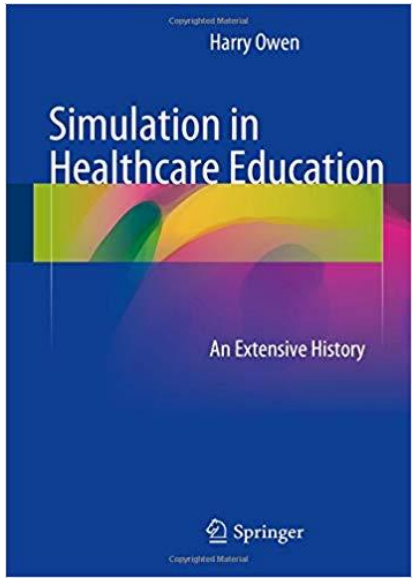


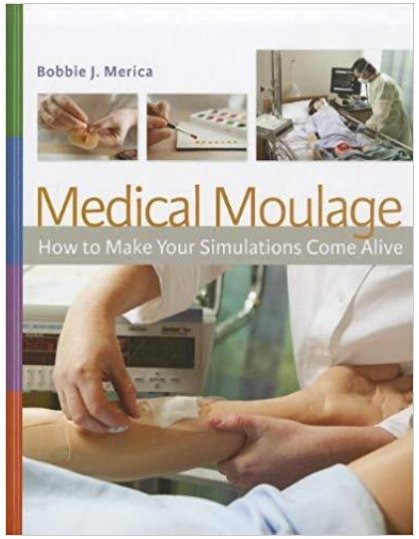












History of Medical Simulation

Static Earth Materials Models

Circa 1900-1600BC

Clay Sheep Liver Model. Diagnosis of disease for health and religious reasons.

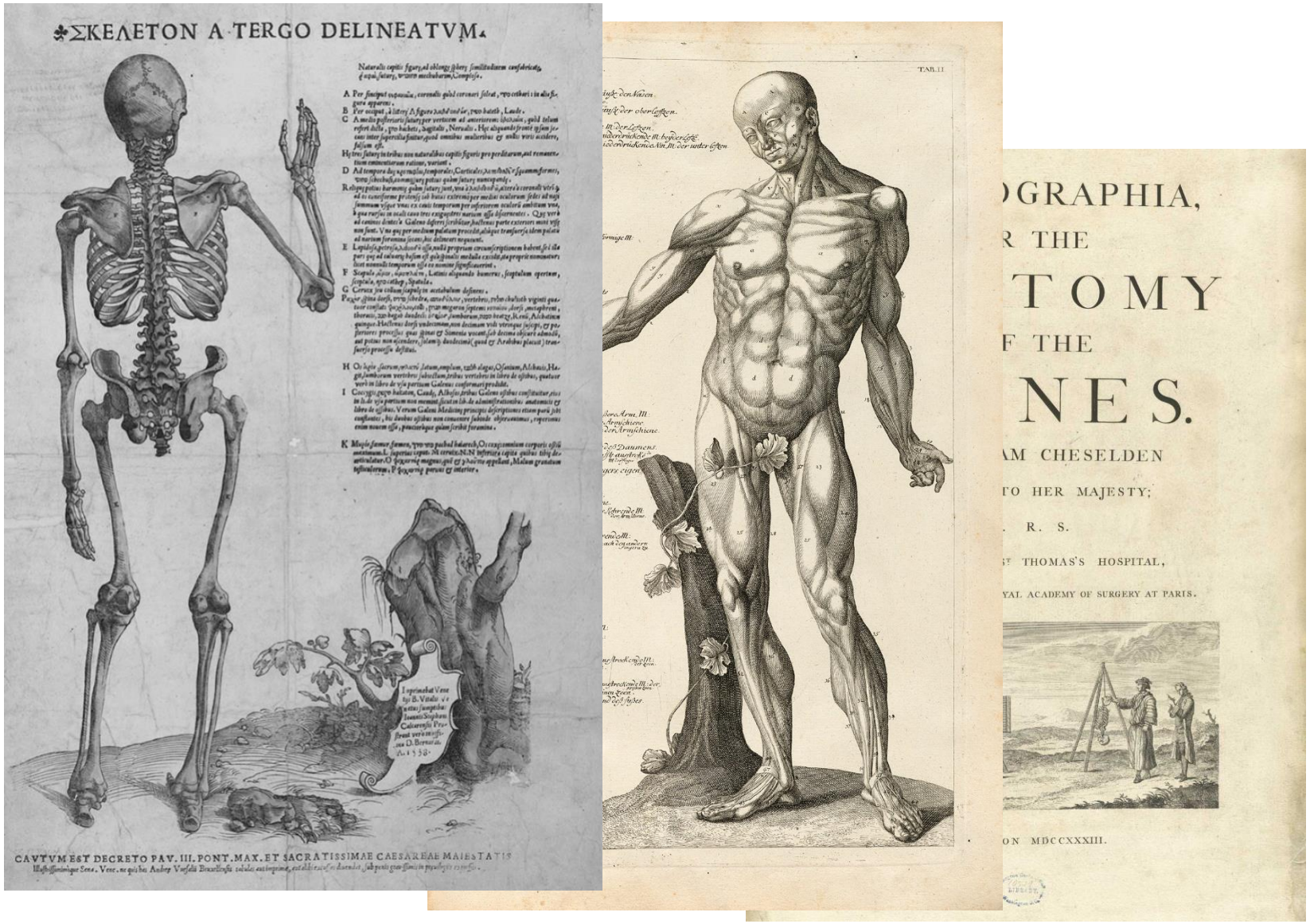
- British Museum

Anatomy Textbooks

Circa 1538AD

"Outline of the Skeleton" a study of anatomy.

- Orfila Museum, Paris



Owen H. (2016) Simulation in Medical Science. In: Simulation in Healthcare Education. Springer, Cham

Cadaver & Animal Models

The Anatomy Lesson of Dr. Nicolaes Tulp, by Rembrandt va Rijn, 1632

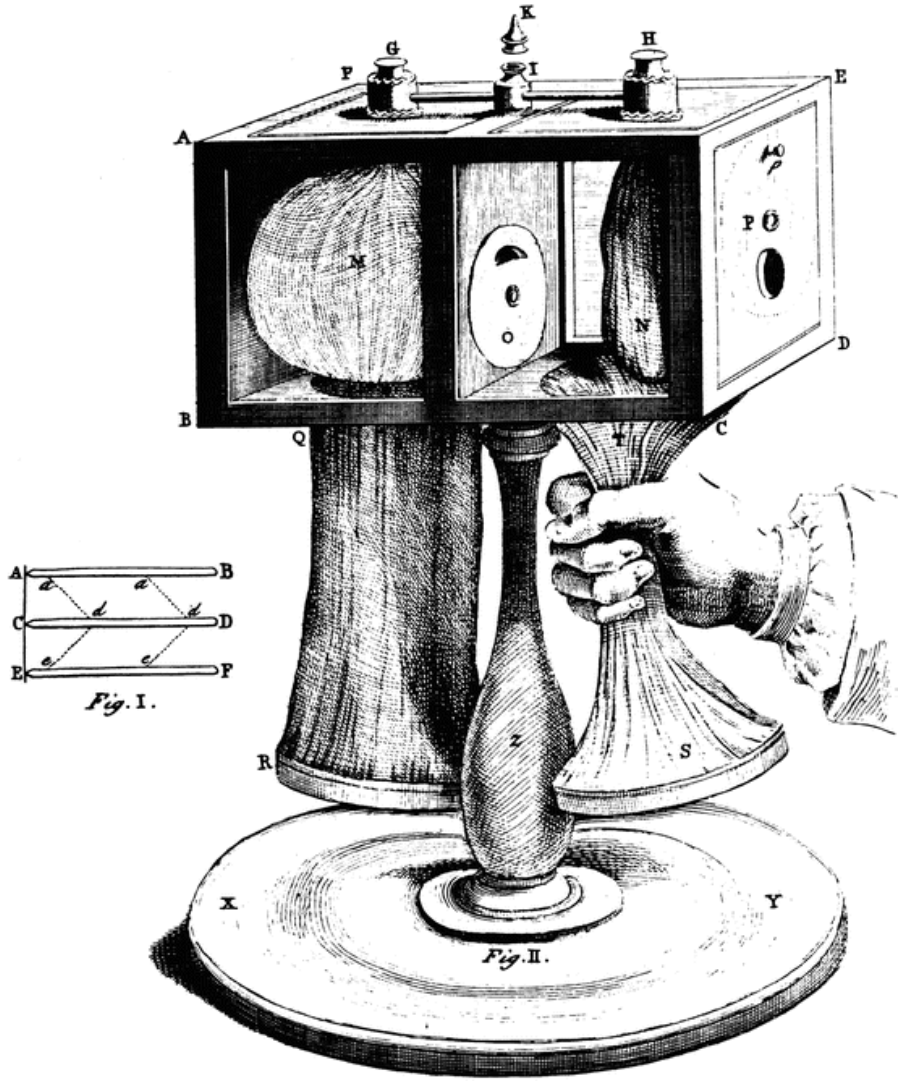
Vivisection performed on a dog, by Emile-Edouard Mouchy, 1832.

Early Mechanical Simulators

Circa 1740AD

"Breathing Venus" Lung Simulator by Benjamin Hoadly.

- Orfila Museum, Paris



Owen H. (2016) Simulation in Medical Science. In: Simulation in Healthcare Education. Springer, Cham

Bio-materials Models

Circa 1763AD

Macchina Anatomica
by Guiseppe Salerno
for teaching
circulation.

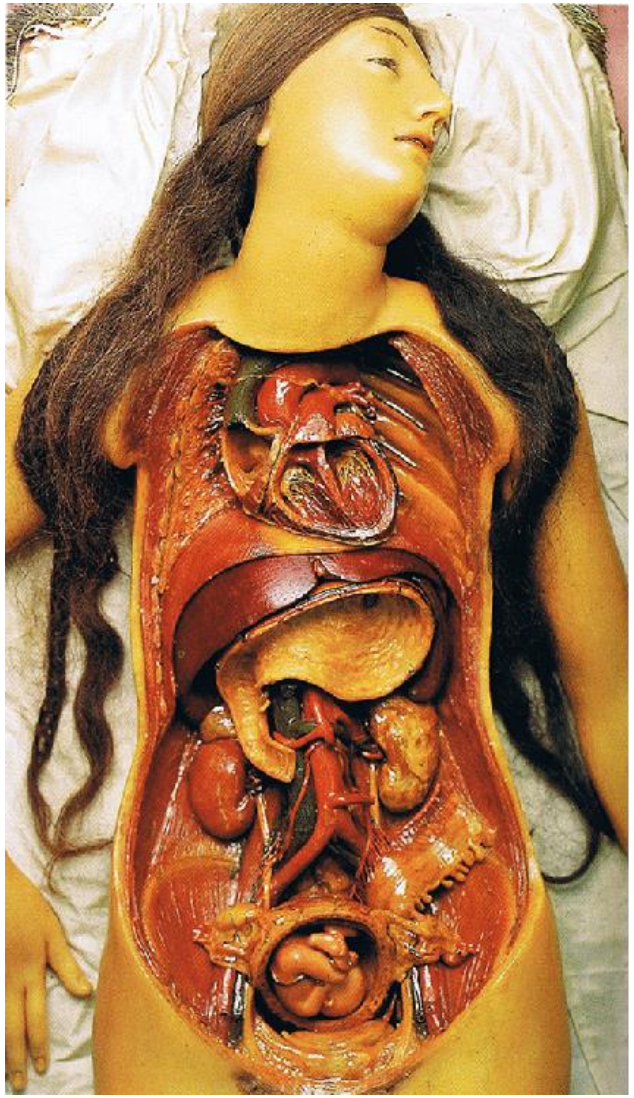
- Museo Cappela Sanservo

Synthetic Anatomical Models

Circa 1798AD

Anatomical Venus by Clemente Susini for teaching anatomy.

- Natural History Museum at the University of Florence



Synthetic Anatomical Models

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Anatomical Venus by Clemente Susini for teaching anatomy.

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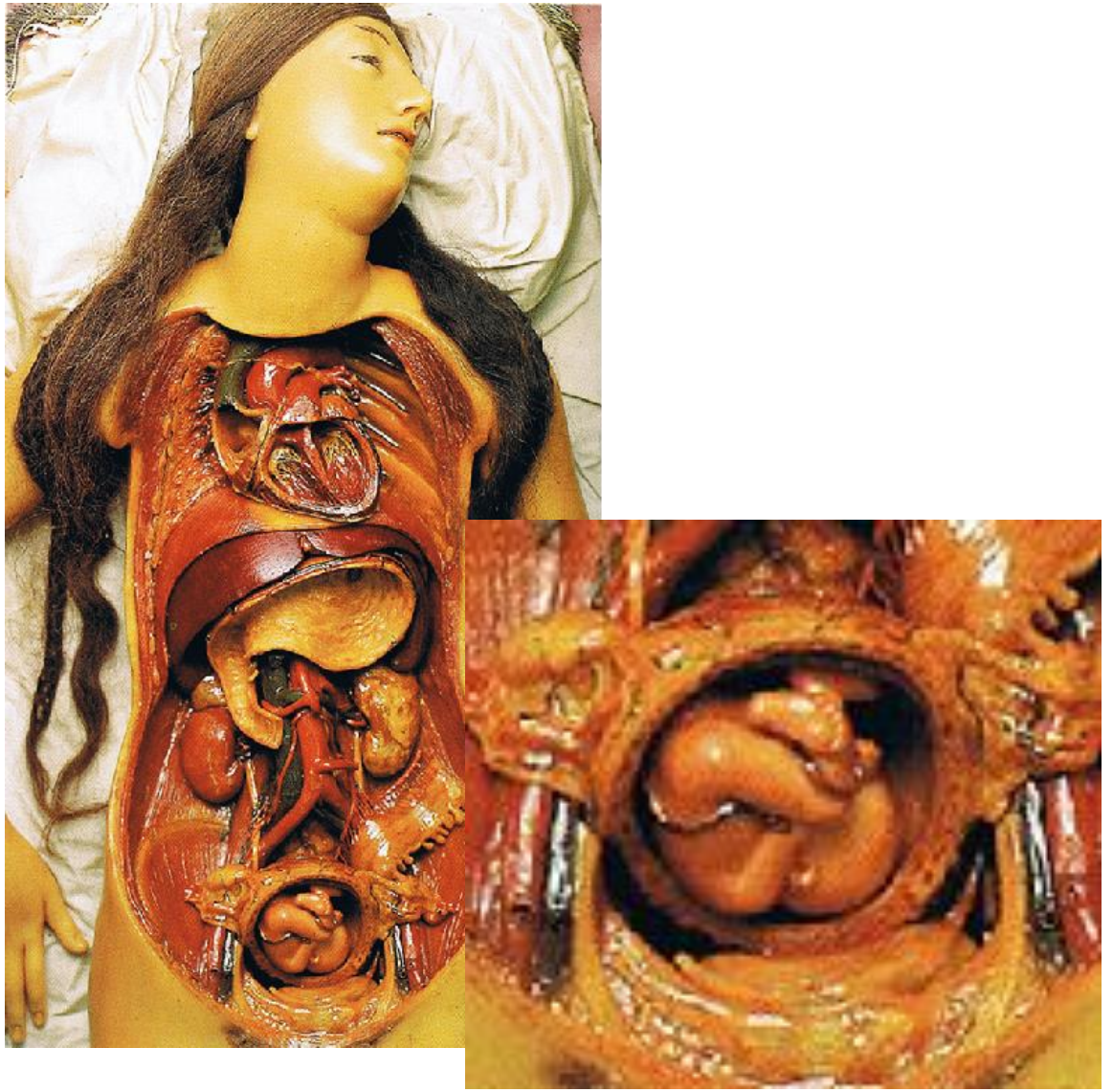


Multi-layered Textbooks

Circa 1876AD

Anatomie Iconoclasticque layered illustrations in book form.

Dolls as Training Devices

Circa 1911AD

Josephine Chase Doll
Hartford Hospital, CT

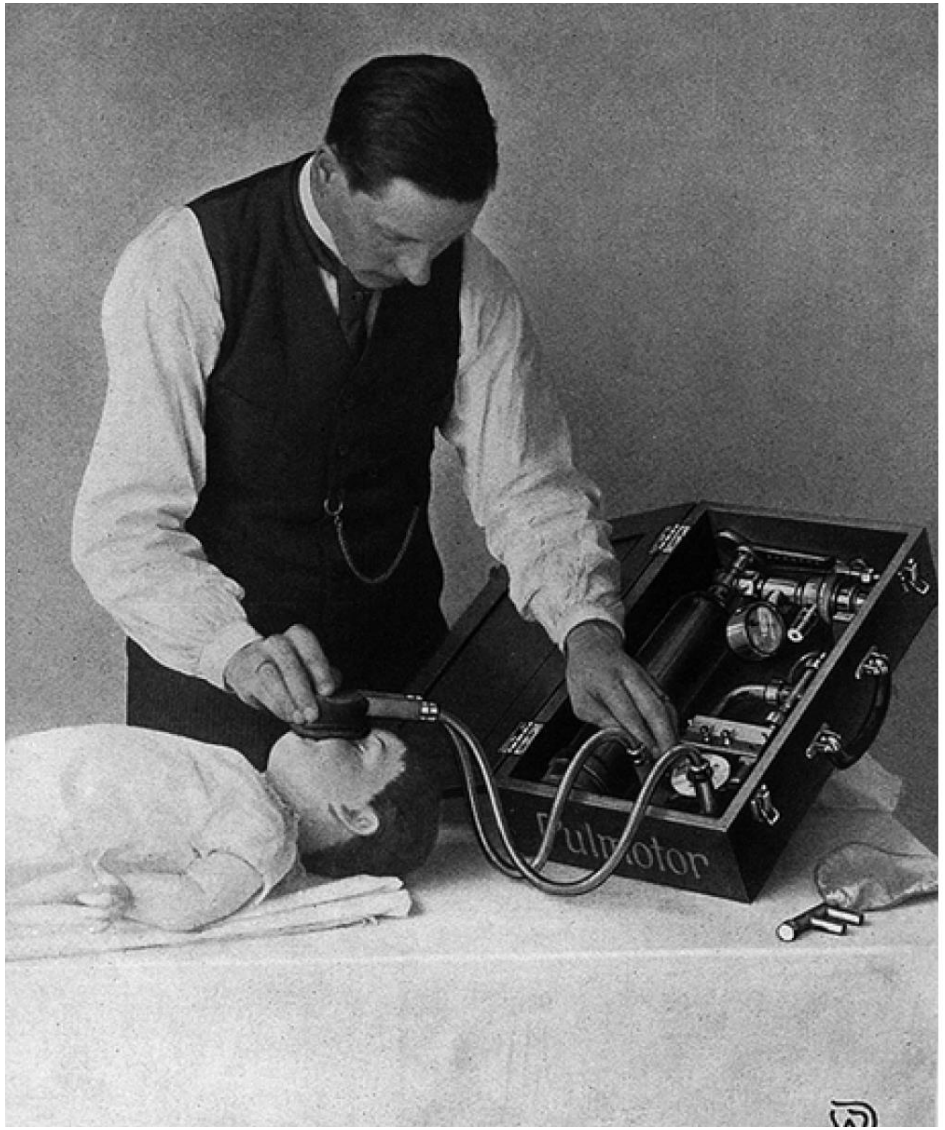
- Hartford Hospital Archives

Machines and Mannikins

Circa 1907AD

Resuscitation ventilator on a doll

- *Drager Co. Ubeck, Germany*

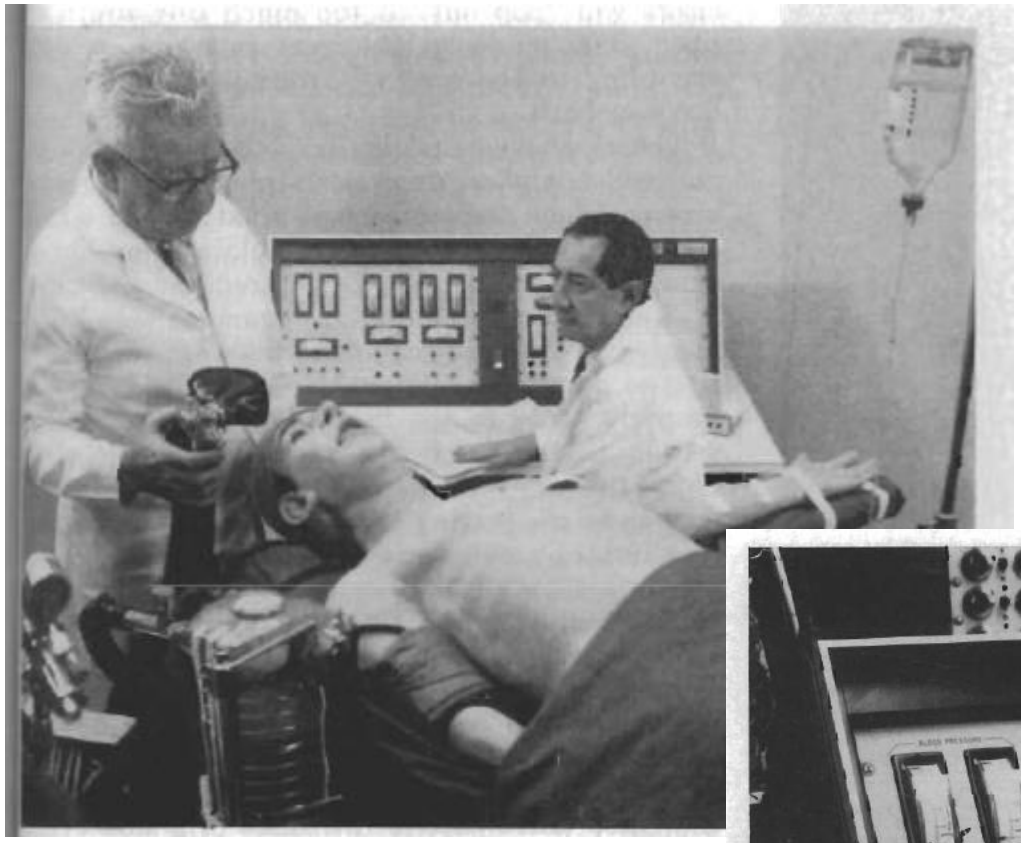


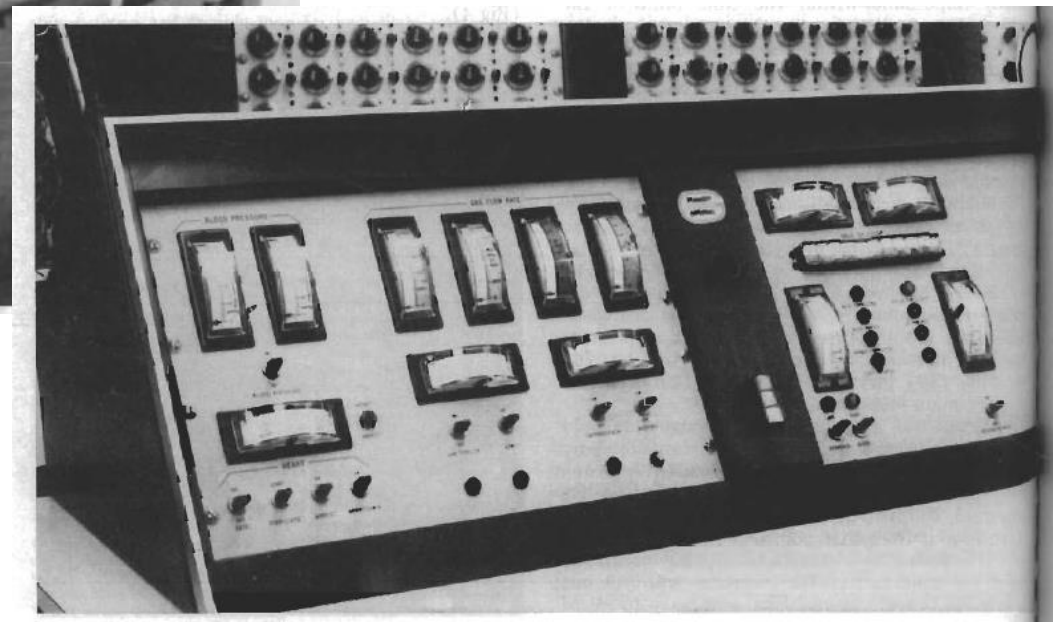
Asmund Laerdal's Resusci-Anne

Computerized Mechanical Simulators

Sim One (1967):
Computers, Mechanics,
& Manikins

Respiration
Heartbeat, Pulse, and BP
Eye Blink
Physiologic Response to Drugs





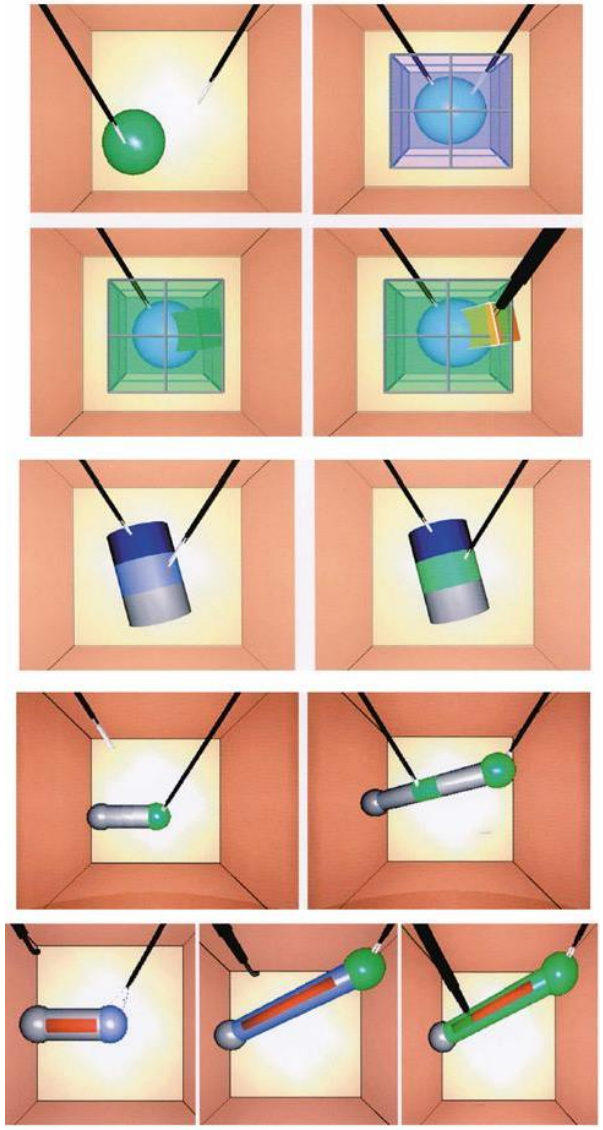
Denson JS, Abrahamson S. A computer-controlled patient simulator. *Journal of the American Medical Association* 1969; 208:504–8.

Virtual Reality Simulators

Circa 1995

Minimally Invasive Surgery Trainer – Virtual Reality (MIST-VR).

- Bob Stone, UK



Simulator Taxonomies

LVCG Military Simulation Taxonomy

Hofer, 1995

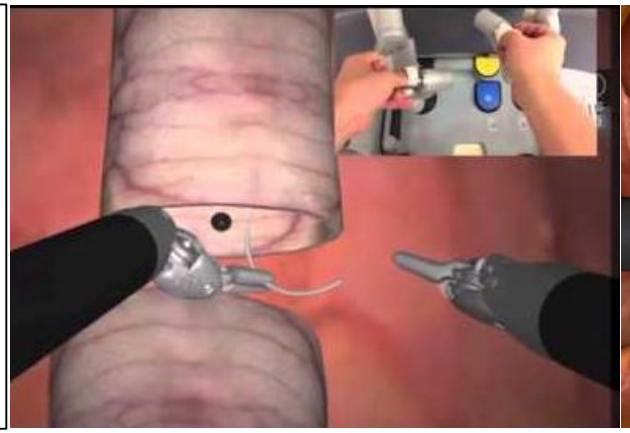
LVCG is not the best fit in healthcare

Progressive Complexity

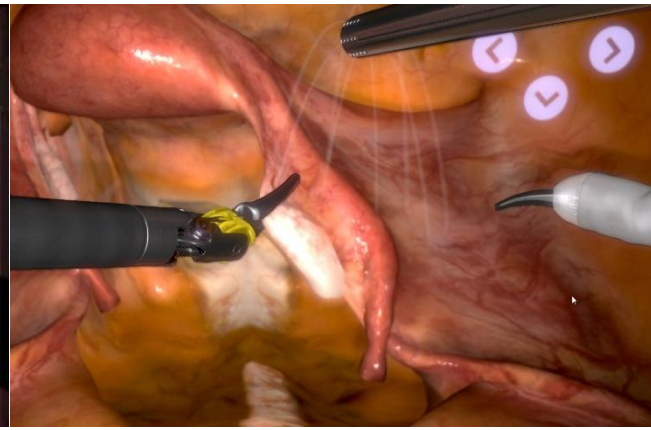
Precision Placement → Simple Manipulation → Complex Manipulation → Integrated Procedure

Needle placement for blood draw

Ultrasound wand manipulation



Anastomosis suturing



Multiple steps of hysterectomy

Fits very specific types of treatment

Satava, 2001

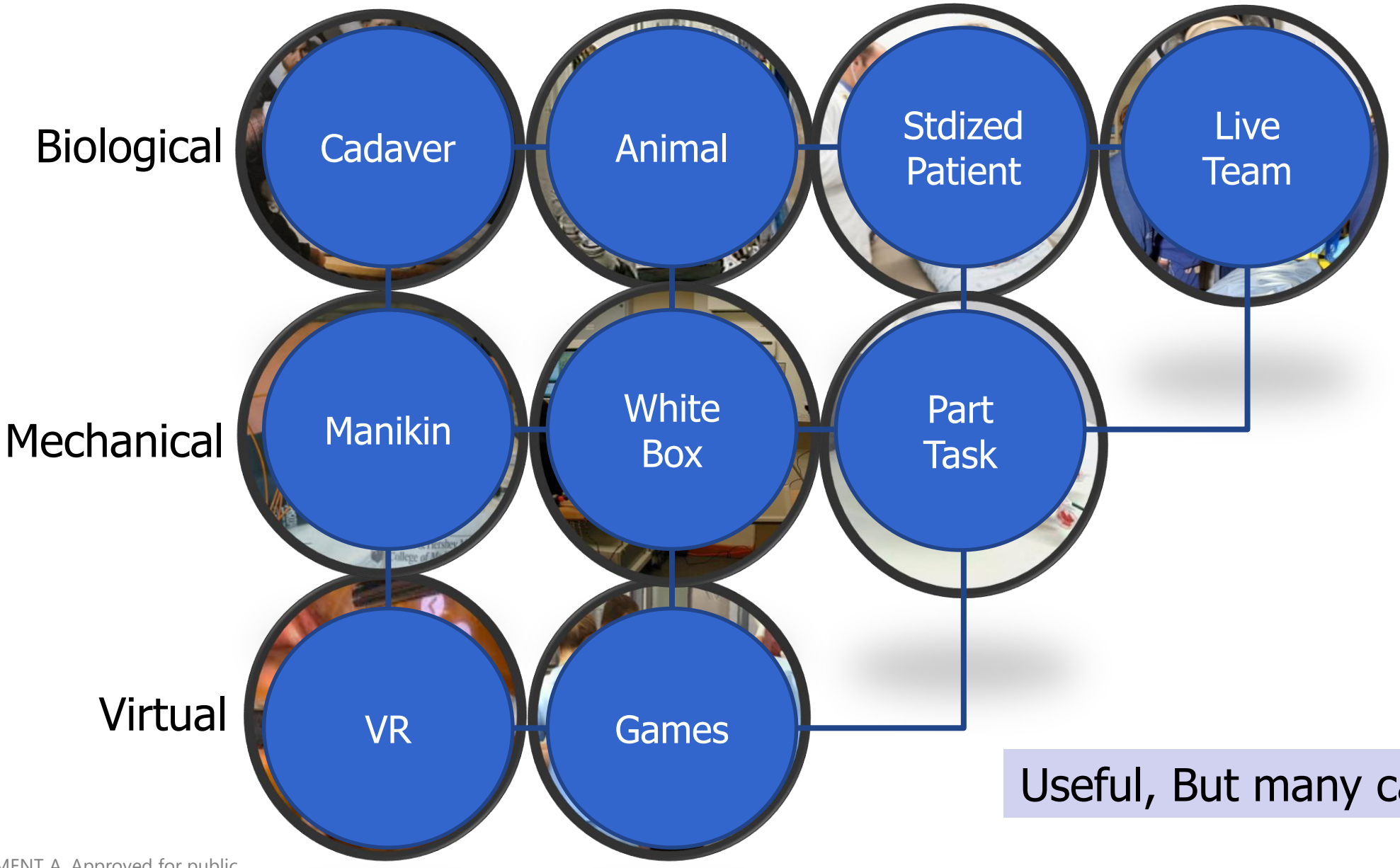
Taxonomy of Mechanism and Application

Biological

Mechanical

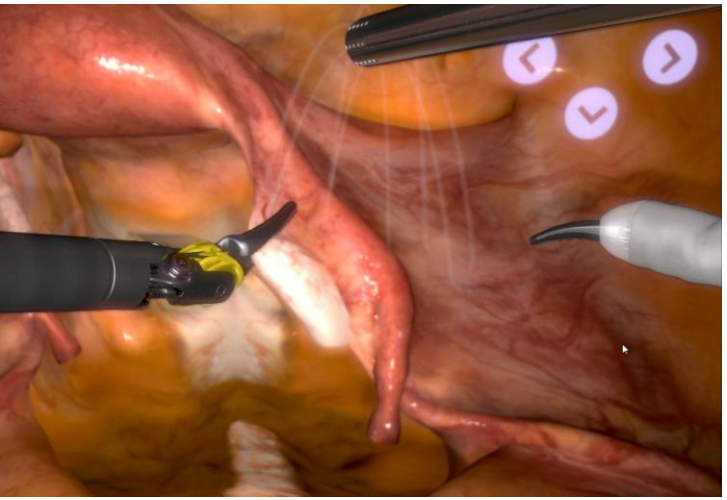
Virtual

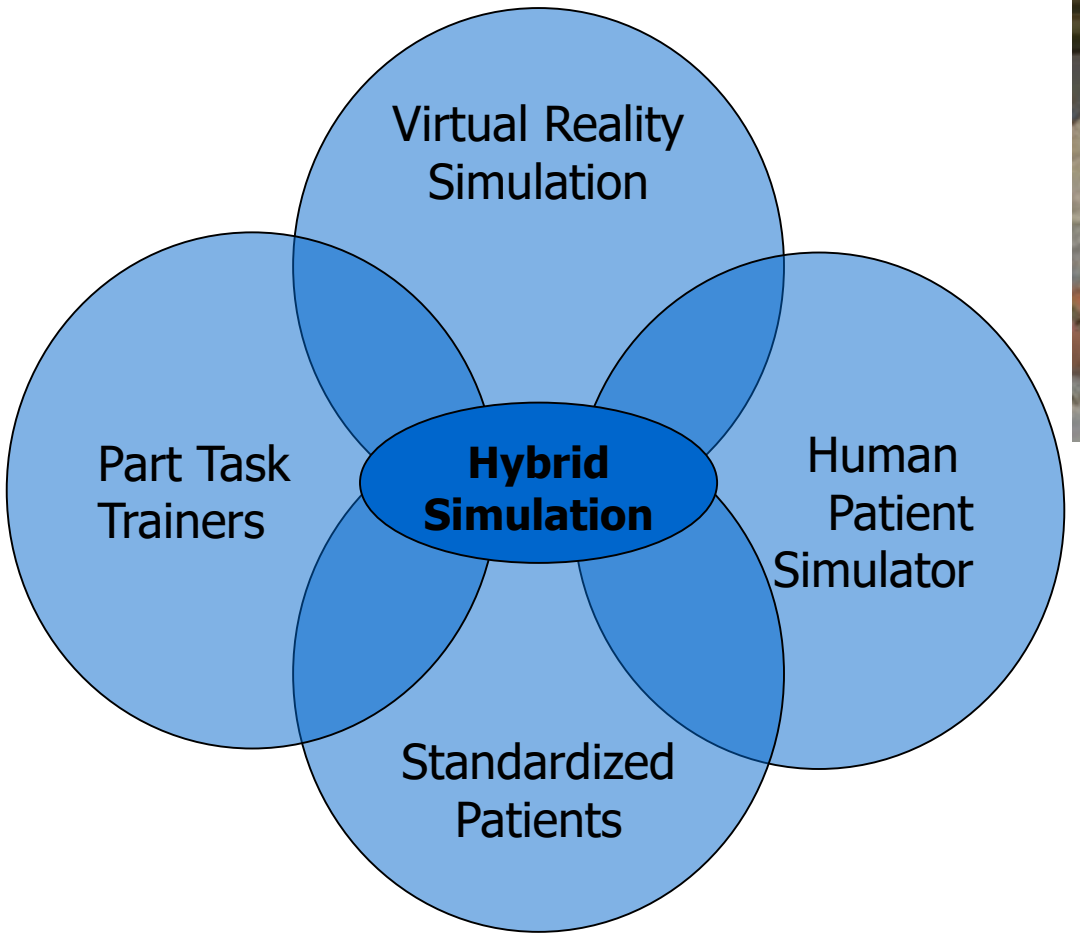
Taxonomy of Mechanism and Application

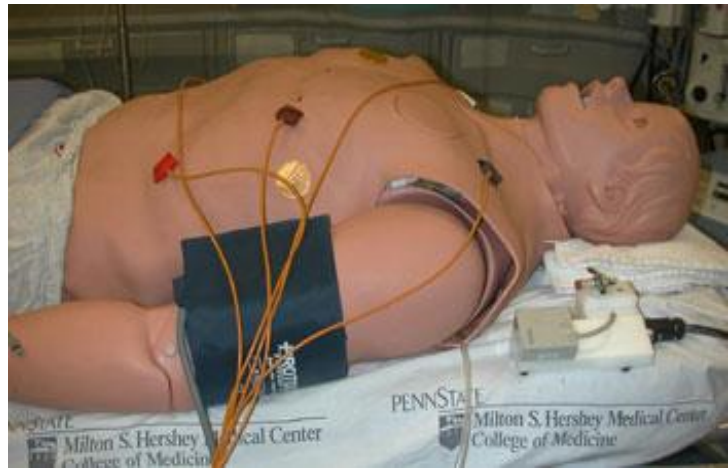


Useful, But many categories

Healthcare Simulation Modalities







Modified from: Chiniara, G, et al. (2013) Simulation in healthcare: A taxonomy and a conceptual framework for instructional design and media selection, *Medical Teacher*, 35:8

Learning Theory

Progression Through Education

Didactic Learning

Partial Task Trainer

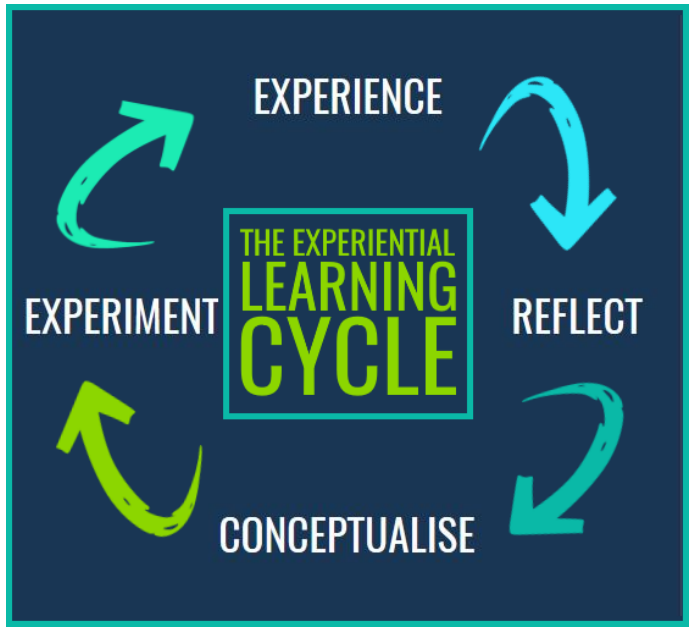
Human Patient Simulator

Team Training

Aligns with Satava's Taxonomy of Complexity

Experiential Learning Theory

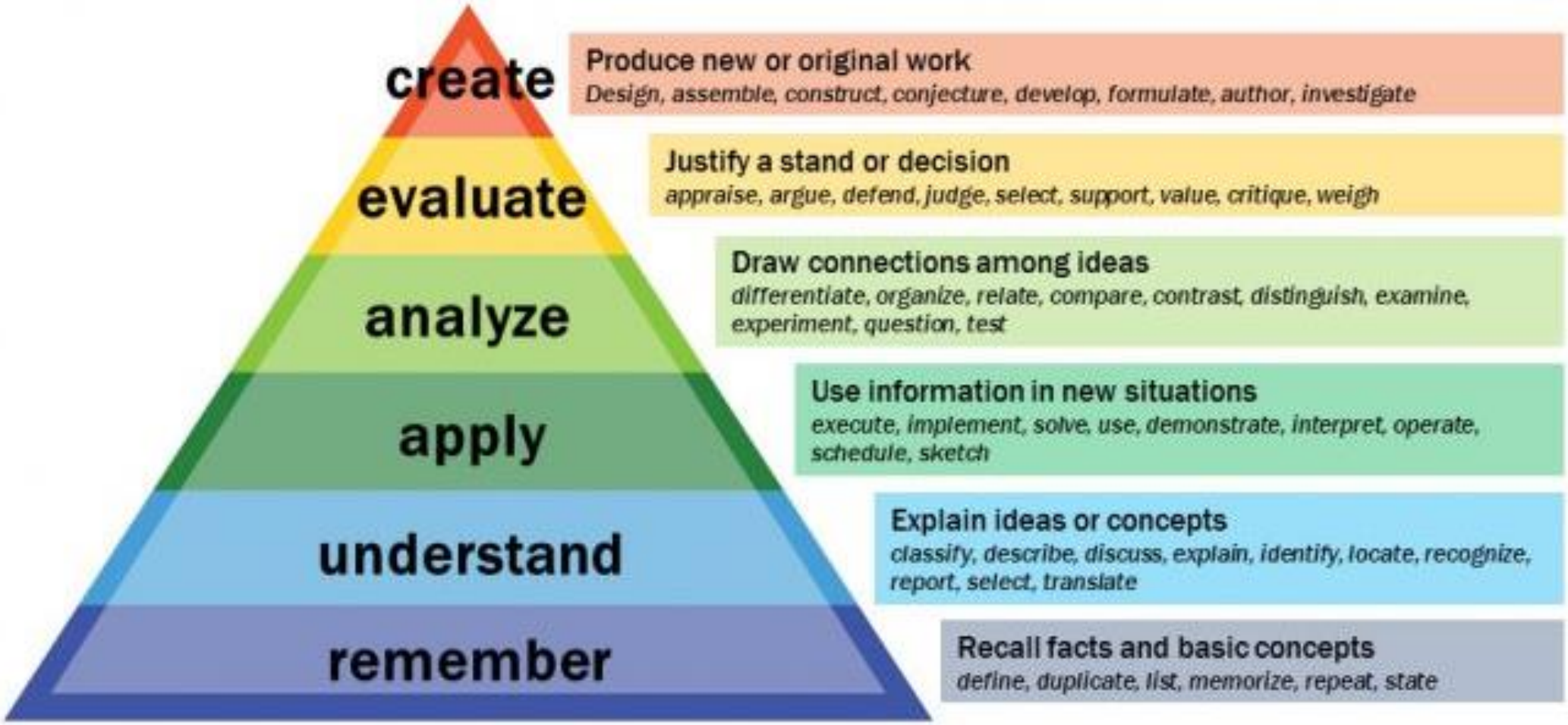
1. Engaging students in a process that enhances learning.
   - Feedback on the effectiveness of their learning efforts
   - Focus on the process, not the outcome.
2. Students have prior beliefs and ideas.
   - Draw out these beliefs & ideas, re-examining & re-testing them against the topic
   - Forming new ideas will lead to learning
3. Learning is a process which cycles between reflection and action,
   - "Conflict, differences, and disagreement are what drive the learning process"
4. Learning happens in interactions between the person and the environment
5. Learning is more than memory; it also involves reasoning, feeling, perceiving, and behaving.



https://www.growthengineering.co.uk/what-is-experiential-learning/

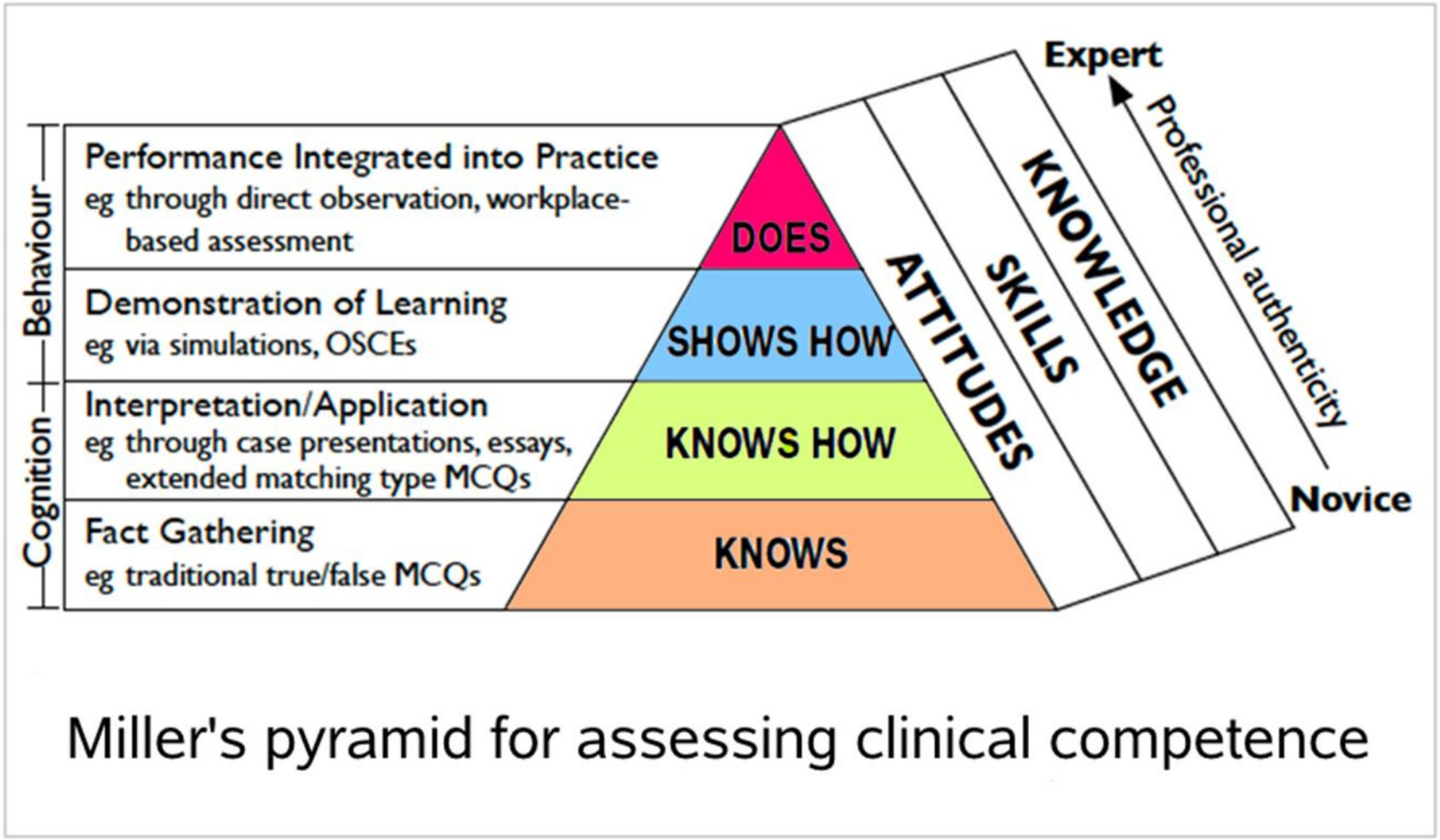
Kolb, A.Y. & Kolb, D.A. (2005). Learning Styles and Learning Spaces: Enhancing Experiential Learning in Higher Education. *Academy of Management & Learning Education*, 4(2), 193-212.

Bloom's Taxonomy of Learning



Bloom, B. S.; Engelhart, M. D.; Furst, E. J.; Hill, W. H.; Krathwohl, D. R. (1956). *Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain*. New York: David McKay Company.

Miller's Taxonomy of Clinical Assessment



Based on work by Miller GE, The Assessment of Clinical Skills/Competence/Performance: Acad. Med. 1990:65(9): 63-67
Adapted by Drs. R. Mehay & R. Burns, UK (Jan 2009)

Standardized Patients

Danielle Julian

Standardized Patient Models

Human as living model

Human as concerned family

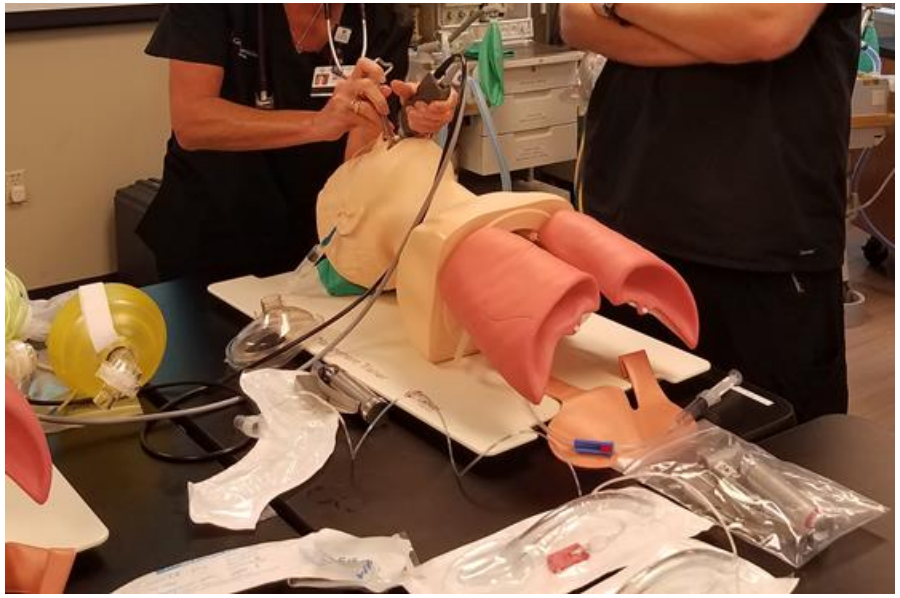
Human as host for moulage

Hybrid Simulators

Healthcare's equivalent of the trauma cut suit

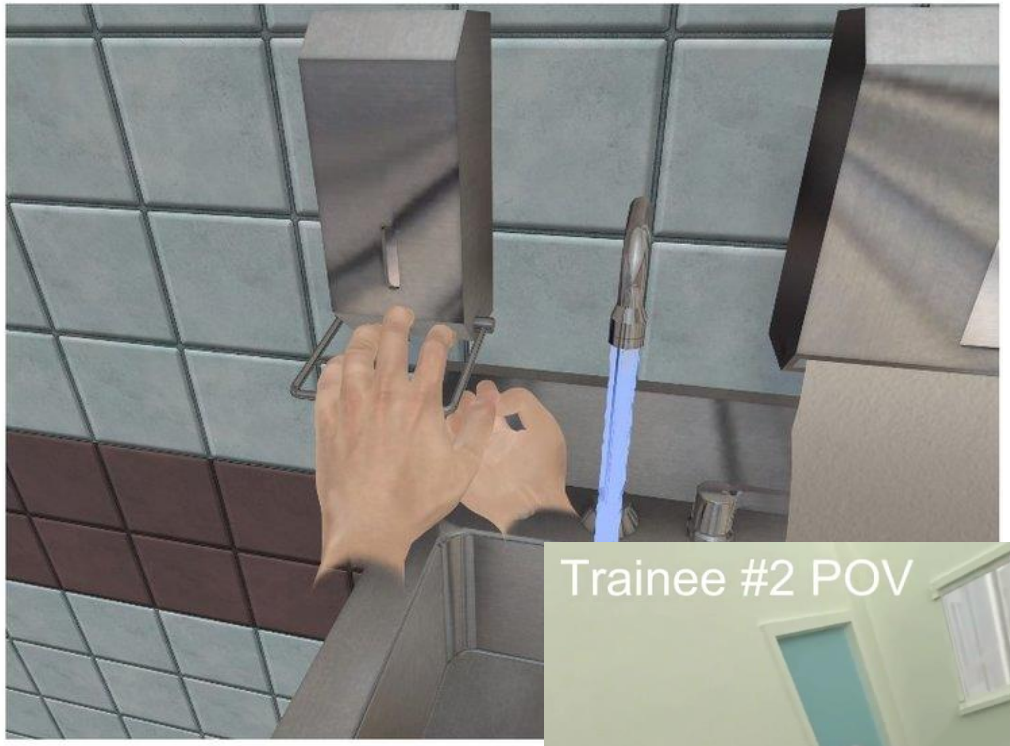
Part Task Trainers

Part-Task Trainers



High Fidelity Patient Simulators

"Screen Based" Simulation



- Manikin, bed, equipment in VR
- Retaining immersion
- Physically performing steps
- Ease of access
- Staff support for system

Team Training

Team Training

Cooperative teamwork in ER, OR, and Delivery

Teamwork Standards

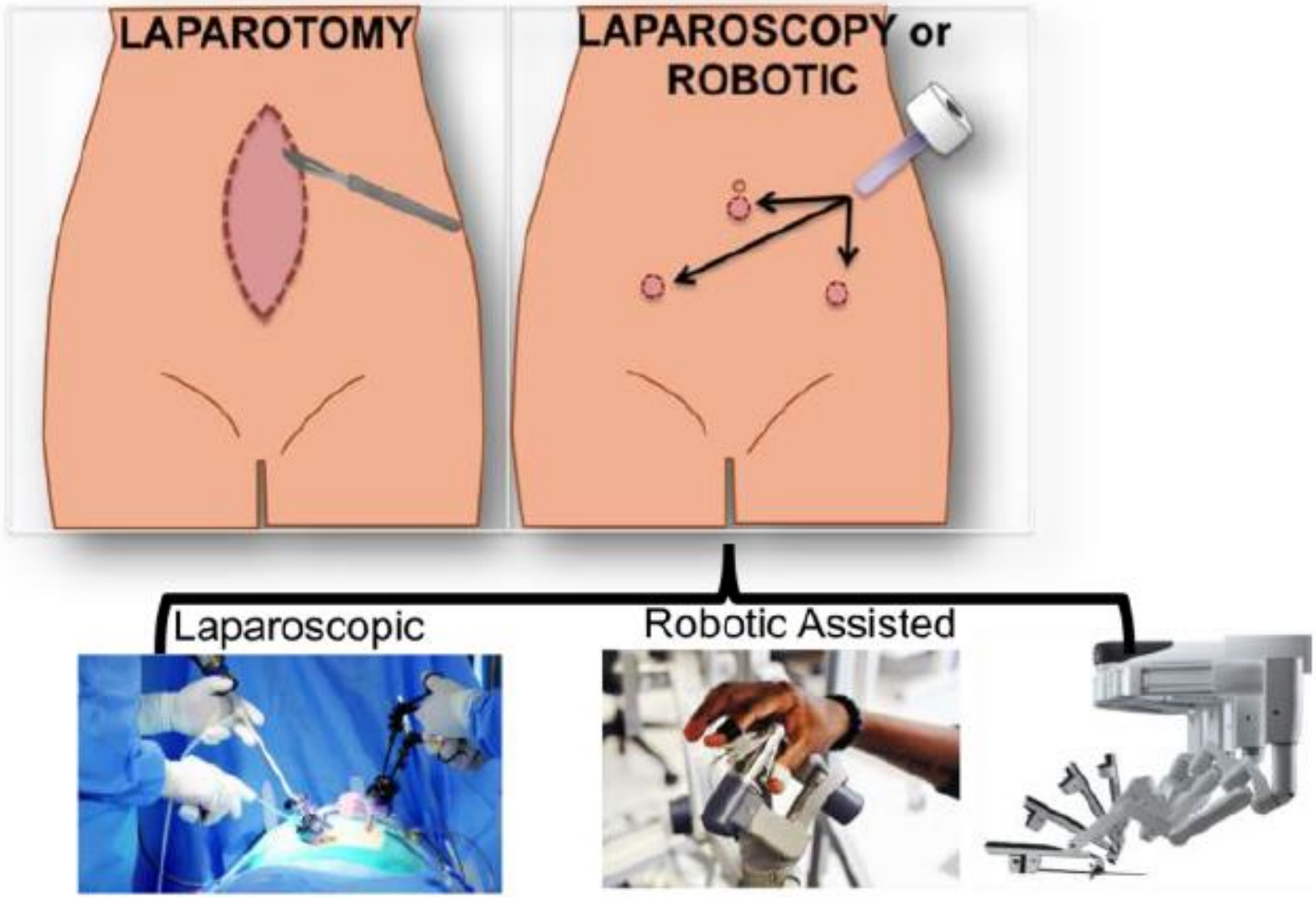
CRISIS RESOURCE MANAGEMENT

TeamSTEPPS

Strategies & Tools to Enhance Performance and Patient Safety

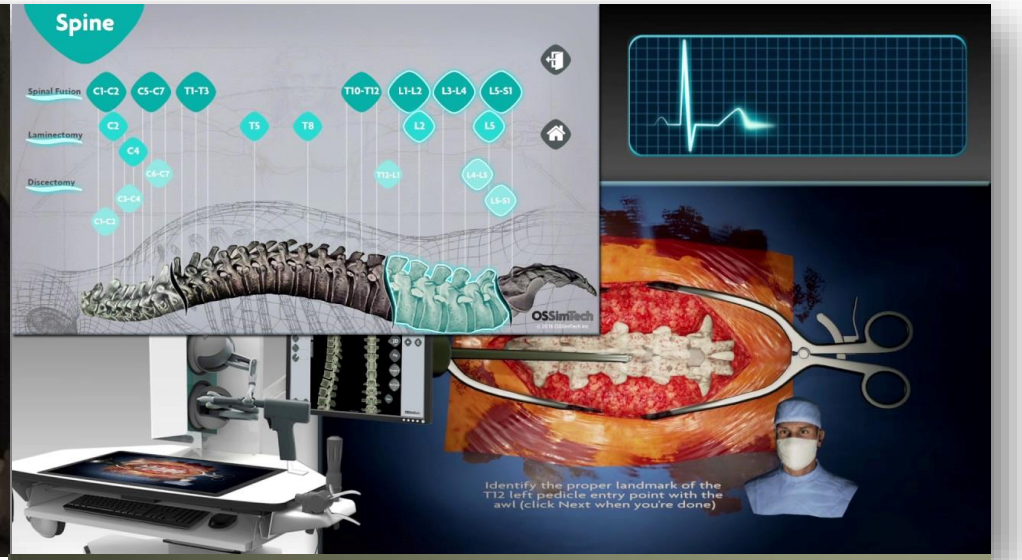
Surgical Simulators (Dry, Wet, & VR)

Surgical Modalities



Open Surgical Simulation

Cadaver

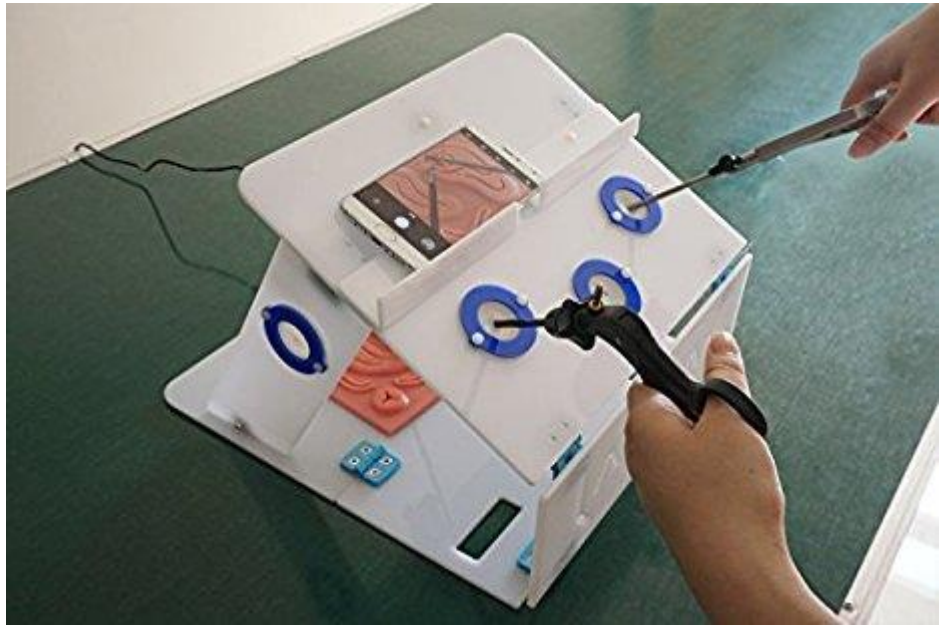


VR

Bench Models

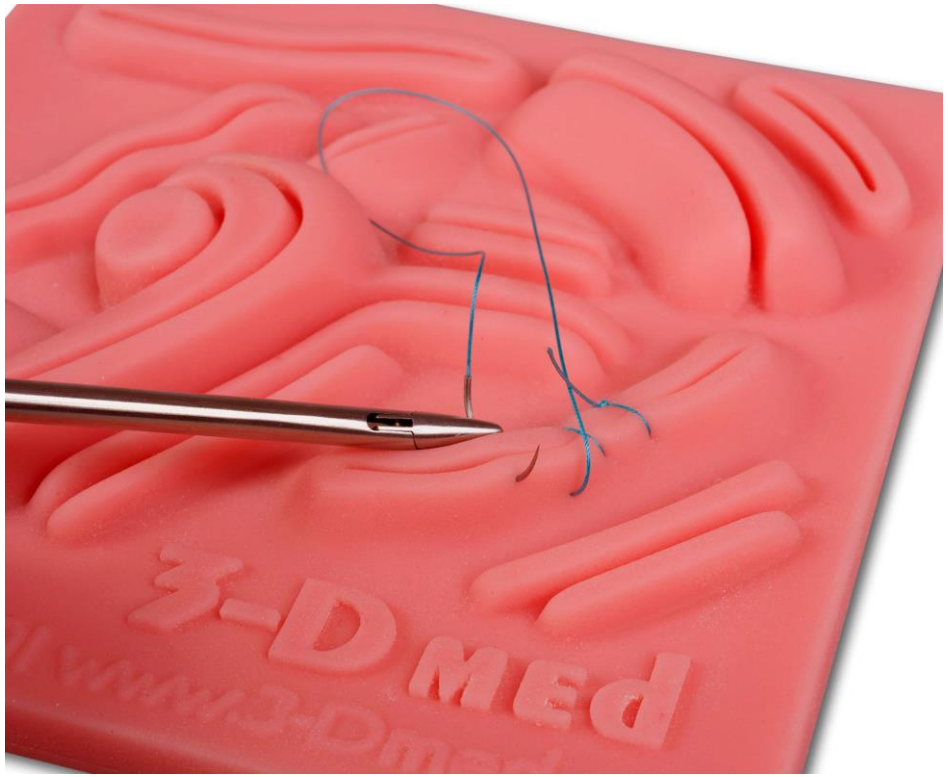
Animal

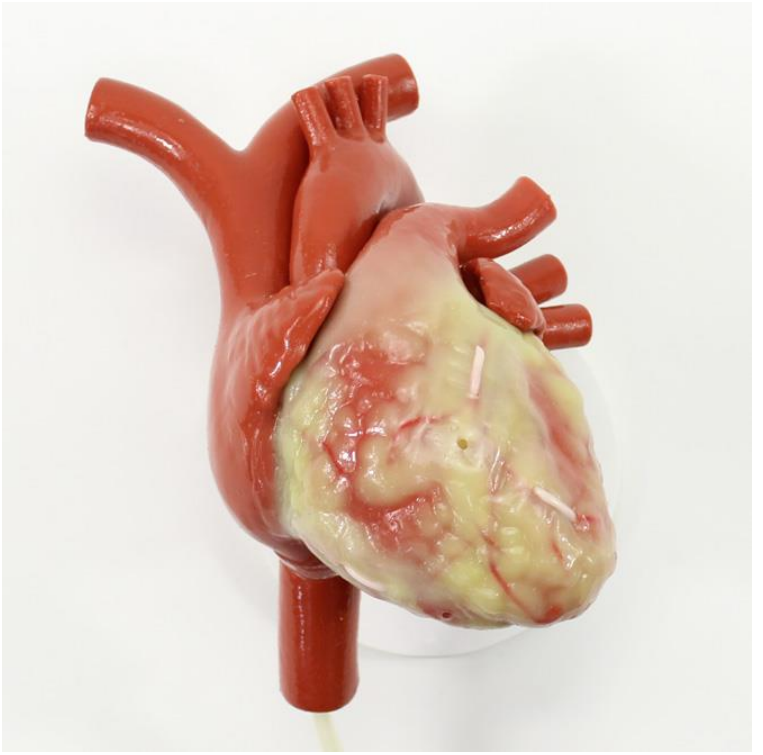
Laparoscopic Surgery Simulators



- Simulation explosion in laparoscopy
- Enabled by disintermediation of surgeon by instruments and monitors
- Motivated by extreme difficulty of tasks

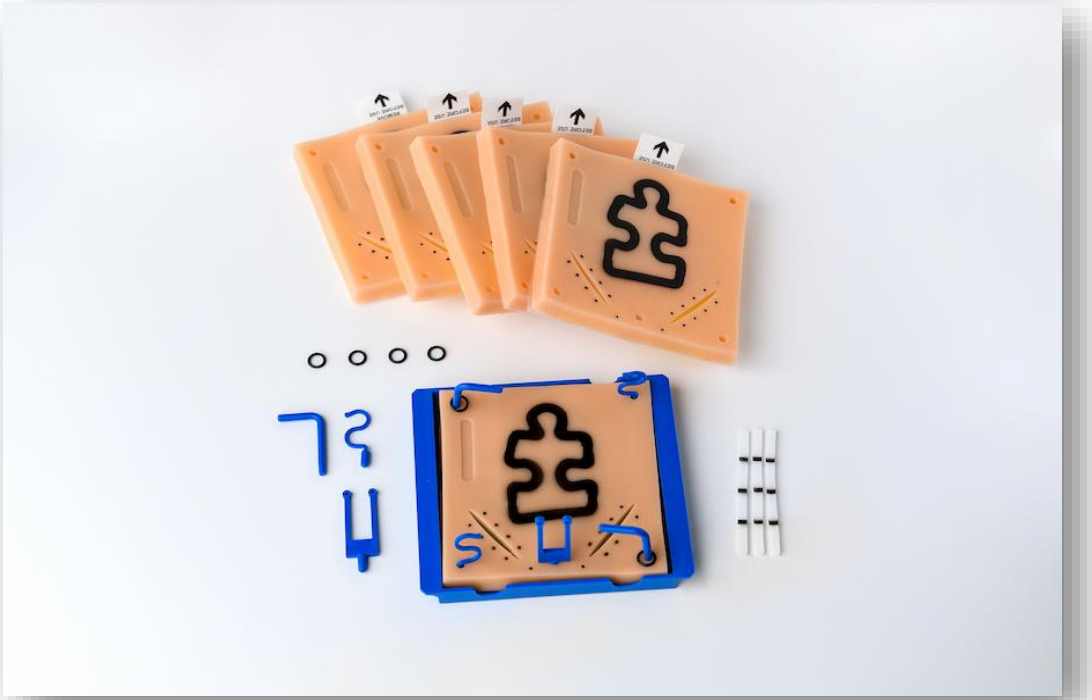
Surgical Skill Trainers - Dry





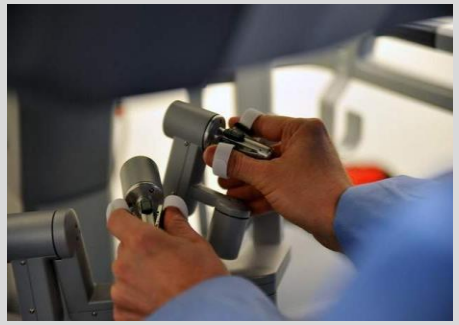
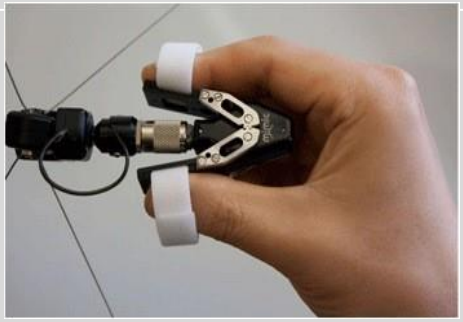
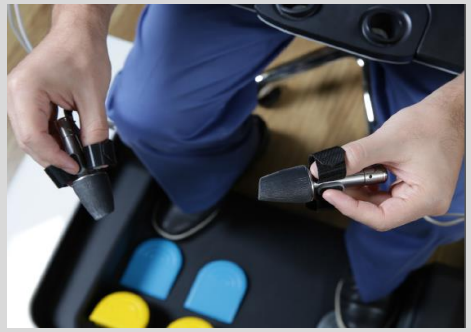
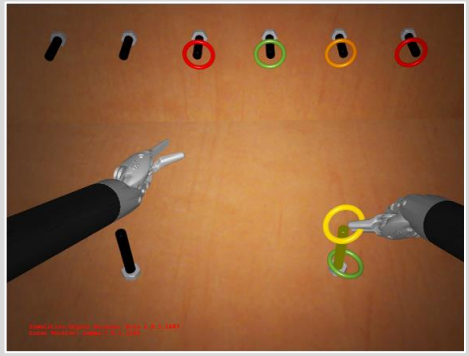
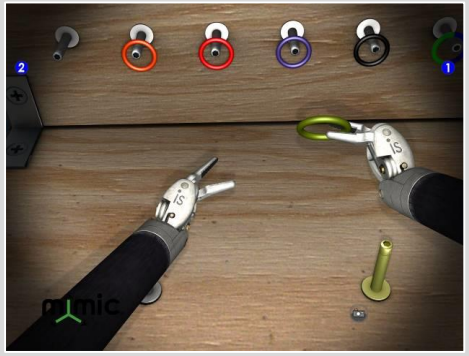
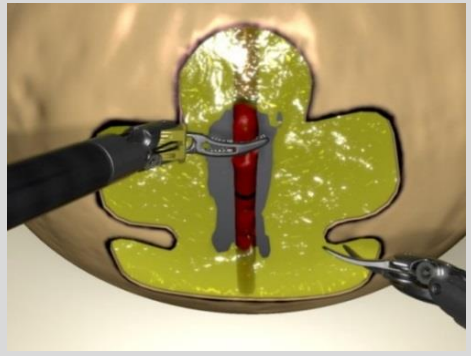
Part Task Trainers for Surgeons

Surgical Skill Trainers - Dry



Surgical Skill Trainers - Wet

Robotic Surgery Simulators

Intuitive DVSS	Mimic dV-Trainer	Sim Surg RoSS	Simbionix Robotix Mentor
			
			
			

Robotic Surgery Simulator Assessments

- Computers are good at objective metrics.
- But what you can measure and what you want to measure are not always the same.

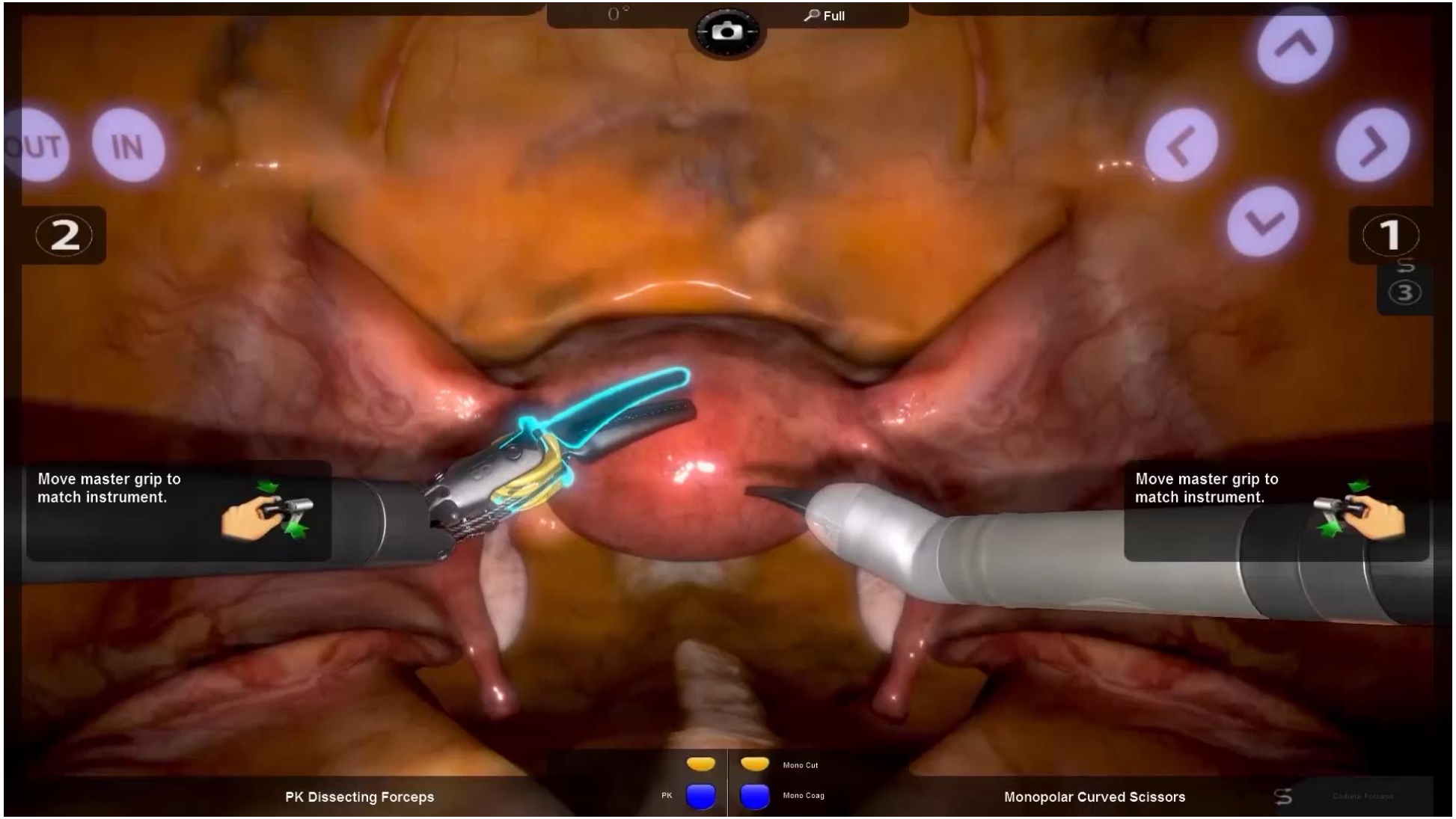
Da Vinci Skills Simulator

dV-Trainer

RoSS

RobotiX Mentor

Simulating Internal Anatomy

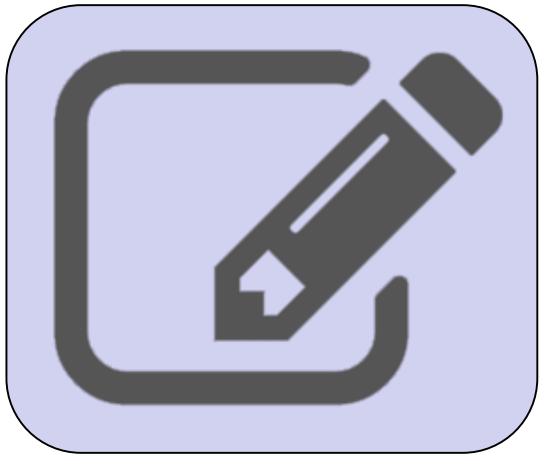


Medical Simulation Certification

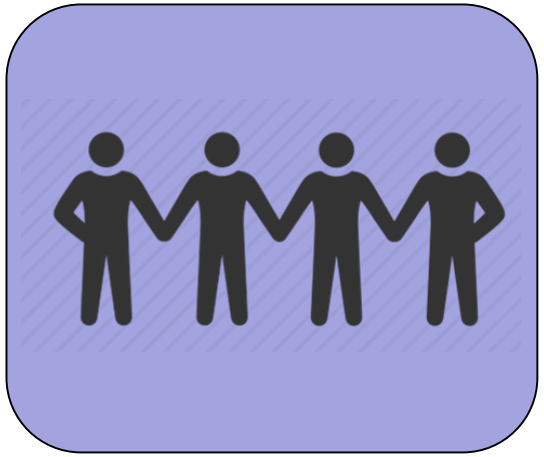
Simulation Program Standards and Processes

Characteristics of a Simulation Program

Four main domains of a simulation program:



Curriculum/
Assessment



Instructor/
Personnel

Equipment/
Technology

Supporting
Infrastructure

Summary of Characteristics

Organization	Format Focus				
	Curricula and Learners	Instructor/ Personnel Requirements	Equipment and Technology	Organization and Infrastructure	Other
Society for Simulation in Healthcare	✓	✓	✓	✓	✓ **Research, system integration**
American College of Surgeons	✓	✓	✓	✓	
American Society of Anesthesiologist	✓	✓	✓	✓	
American Congress of Obstetricians and Gynecologists	✓		✓	✓	✓ **Shared curricula**

Summary of Characteristics

Organization	Scope (General vs. Specific)			
	Physician	Medical Students	Nurses	Other Health Care Professionals
Society for Simulation in Healthcare	✓	✓	✓	✓
American College of Surgeons	✓	✓	✓	✓
American Society of Anesthesiologist	✓			
American Congress of Obstetricians and Gynecologists	✓			

Military Medical Simulation Systems

Roger Smith

Military Medical Treatment Chain

Role 1

Casualty Evacuation
1 Hour

Role 2
(e.g., Army Forward Surgical Team)

Tactical Medical Evacuation
1-24 Hours

Role 3
(e.g., Combat Support Hospital)

Strategic Aeromedical Evacuation
24-72 Hours

Role 4
Definitive Care
(e.g., Landstuhl Regional Medical Center, Germany)

72 Hours Plus

Role 5
Major U.S.-based military hospital

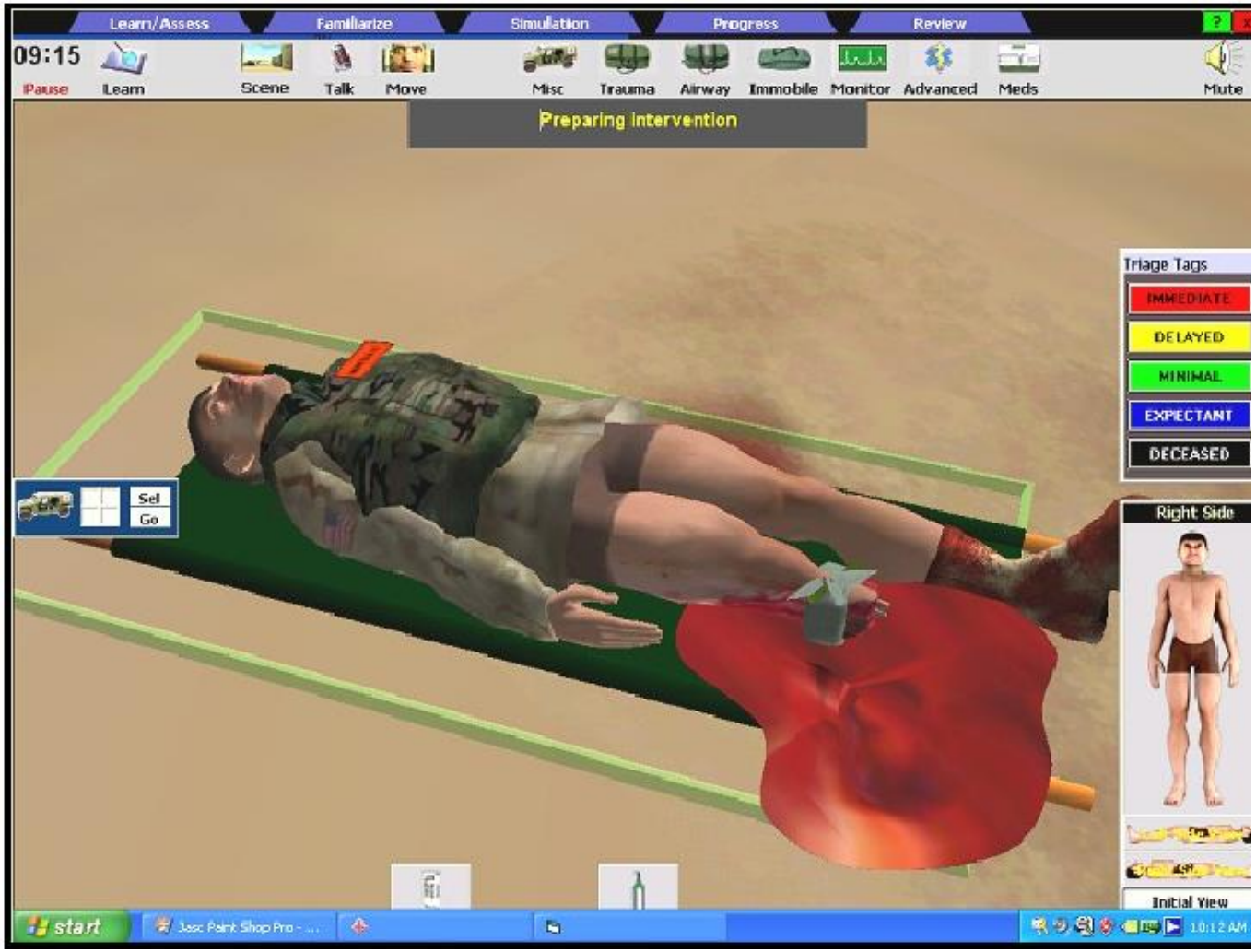
Post-Acute Care

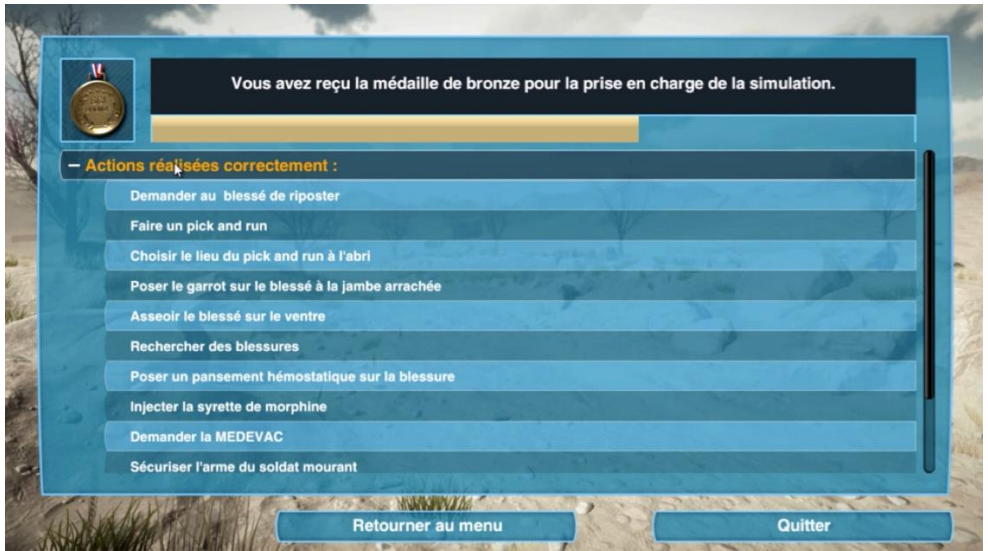
U.S. Department of Veterans Affairs

Medical Simulation Training Centers

Medical Simulation Training Center
Joint Base Lewis-McChord, WA

TC3 Simulation





TC3 Simulation

CBRN & HAZMAT Training Events

Future Directions

Fork in the Road - Synthetic & Virtual

SynDaver Inc., Tampa Florida

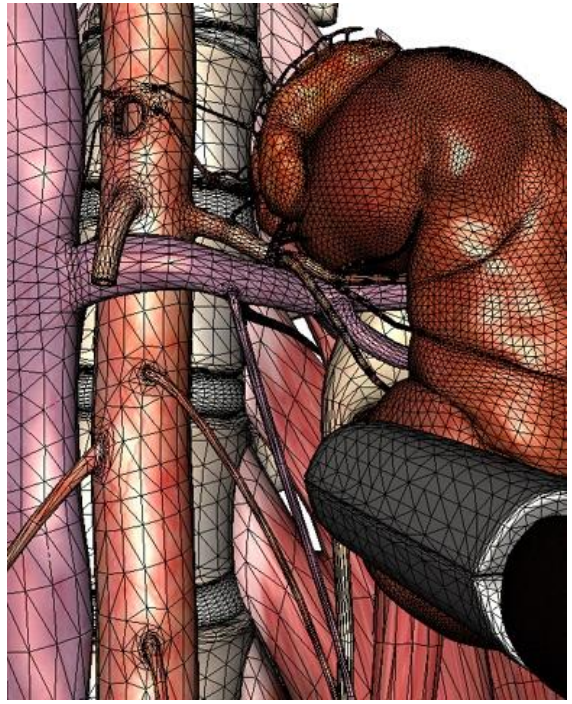
Envision Experience.com

Integrated Simulators

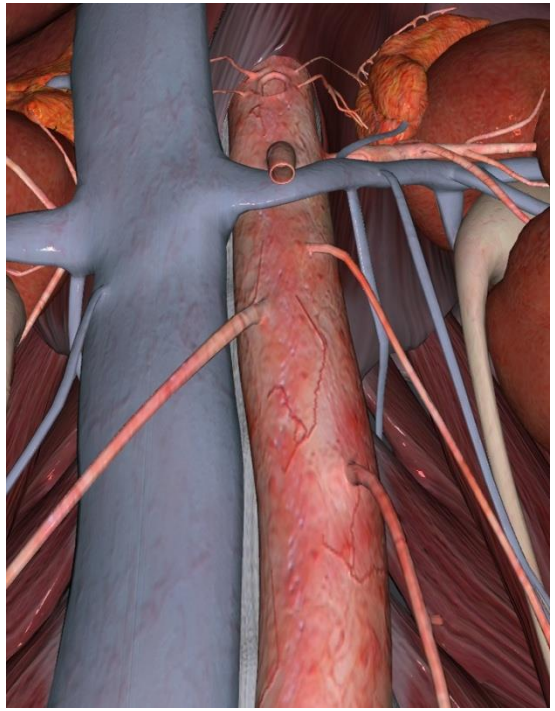
Robotic surgical platforms are natural hosts for VR simulation

Still Looking for the Holy Grail

Geometry
- Complex
- Non-linear
- Non-uniform



Appearance
- Layered
- Translucent
- Dense



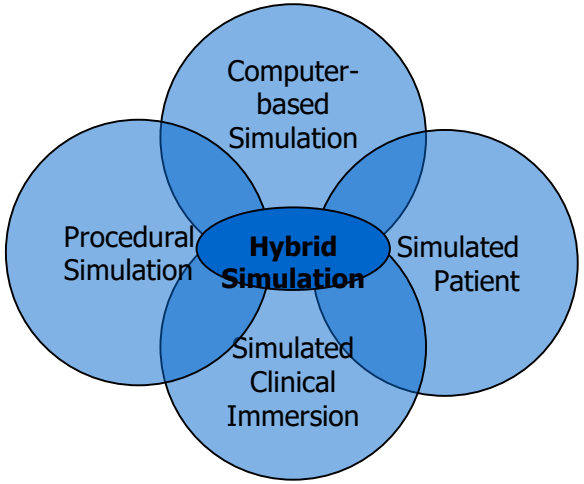
Dynamics
- Nerve movement
- Blood flow
- Elasticity

Center for Research in Education and Simulation Technologies, Rob Sweet, MD

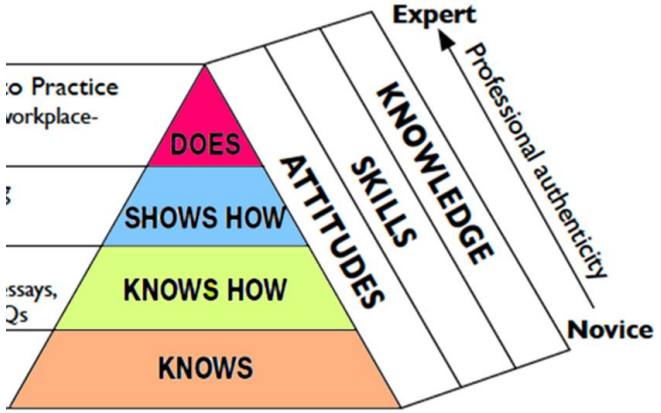
Summary

History

Taxonomies



Learning Theory

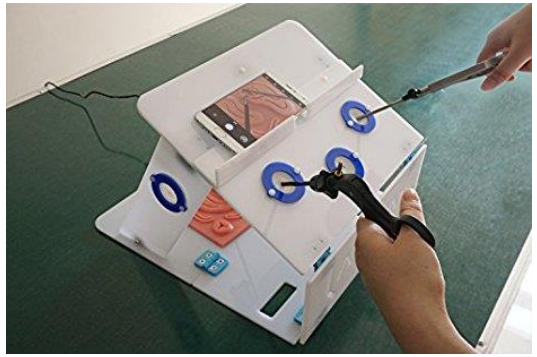


Patient Simulators

Standardized Patients

Team Training

Surgical Simulators



Best Practices

Audience Questions

Thank You

The journey continues …

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