

The logo of the Hong Kong Academy of Medicine is a circular emblem. It features a central caduceus (a staff with two snakes) superimposed on an open book. The emblem is surrounded by a red border containing the text 'HONG KONG ACADEMY OF MEDICINE' in white capital letters. Below the circle is a red banner with the Chinese characters '香港醫學專科學院' in white. The entire logo is rendered in a semi-transparent, light yellow/gold color.

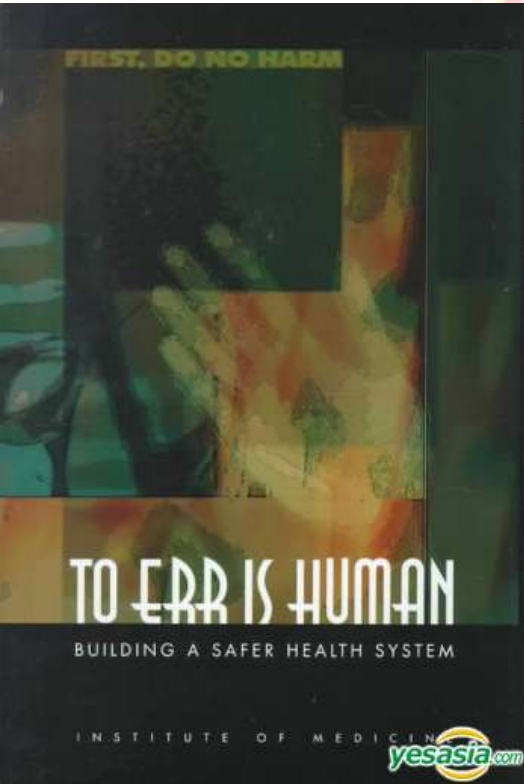
Simulation as a tool to ensure quality in training medical specialists

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HK Academy of Medicine

Challenges to conventional learning

- Information / knowledge explosion
- Trend towards further sub-specialization
- Work hour rationalization
- Patient safety considerations
- Adult learning
- Newer educational concepts

Patient Safety Considerations



- IOM Report: To Err is Human
 - *Recommendation 8.1(c) establish interdisciplinary team training programs, such as simulation, that incorporate proven methods of team management.*
- Risks from Adverse Events (AE)
 - 5th killer in USA
 - Australia: 16.6% associated with AE, 4.9% of AE resulted in mortality (*Wilson. Med J Aust 1995*)
- Learning and Practicing on a patient

Adult Learning (M Knowles)

- Self-directed
- Experience / knowledge base
 - Connectivity and value to the experience base
- Readiness to learn
 - Goal and relevancy oriented
- Orientation to learning
 - Practical, moved from subject centeredness to problem-centeredness
- Motivation to learning
 - Identify internal factors, e.g. social relationships, external expectations, social welfare, personal advancement and cognitive interest

Changing paradigms

- Shift from instructionism to constructionism
- Shift from instructor / teacher centered to learner-centered



Educational concepts

Practice makes perfect

- Ericsson et al (*Max Planck Institute, Berlin*)
 - *"the traditional assumptions of basic abilities and capacities (talent) that may remain stable in studies of limited and short-term practice do not generalize to superior performance acquired over years and decades in a specific domain"*
- Expert requires extended periods of intense training / preparation: “Deliberate practice”
- 10 years or 10,000 hours practice to become expert in a given area
- How can this process be expedited?

Ericsson, K. A., Krampe, R. Th., & Tesch-Roemer, C. (1993). The role of deliberate practice in the acquisition of expert performance. Psychological Review, 100, 363-406.

Gladwell M. Outliers: The story of Success

Why simulation?

Aviation industry

- **Flight Simulation Devices** (*Cohen et al, Gastrointest Endoscopy Clin N Am 2006*).
 - since 1920s, for airline pilot training since 1940s, expand to non-airline training in 1960s
 - Psychomotor and higher-order cognitive functions training (situational awareness, decision making, task management etc)
 - Now for training, skills maintenance and competency assessment. Pilots need to pass assessment every 6 months
- Systemic debriefing as learning tool
- Human factor training
- Crew resource management



The Impact of Flight Simulation in Aerospace

- Much of training previously undertaken in aircraft now conducted in flight simulators
- Flight simulation make a major contribution in improving aviation safety
- Training in flight simulator more effective than airborne training
- Simulation will be pervasive in many industries, and simulators will become essential tools in system design studies



Flight Simulators and Aviation Safety



- General aviation accidents: most are pilot error, caused by “human factors” in cognitive performance
- Feb 2009: fatal crash of Flight 3407 in NY
 - ? insufficient training for the emergency situation that led to its crash (Pasztor 2009)
- Jan 2009: extensive training helped Sully Sullenberger to land safely on Hudson River
- Practice reduces reaction time

<http://www.artscienceillustration.com/simulation-and-patient-safety-lessons-from-aviation-and-the-military/>

Pasztor, A. (May 9, 2009) online.wsj.com, *Airline Safety Gap Sited in Crash Probe*

Competences expected of Specialists

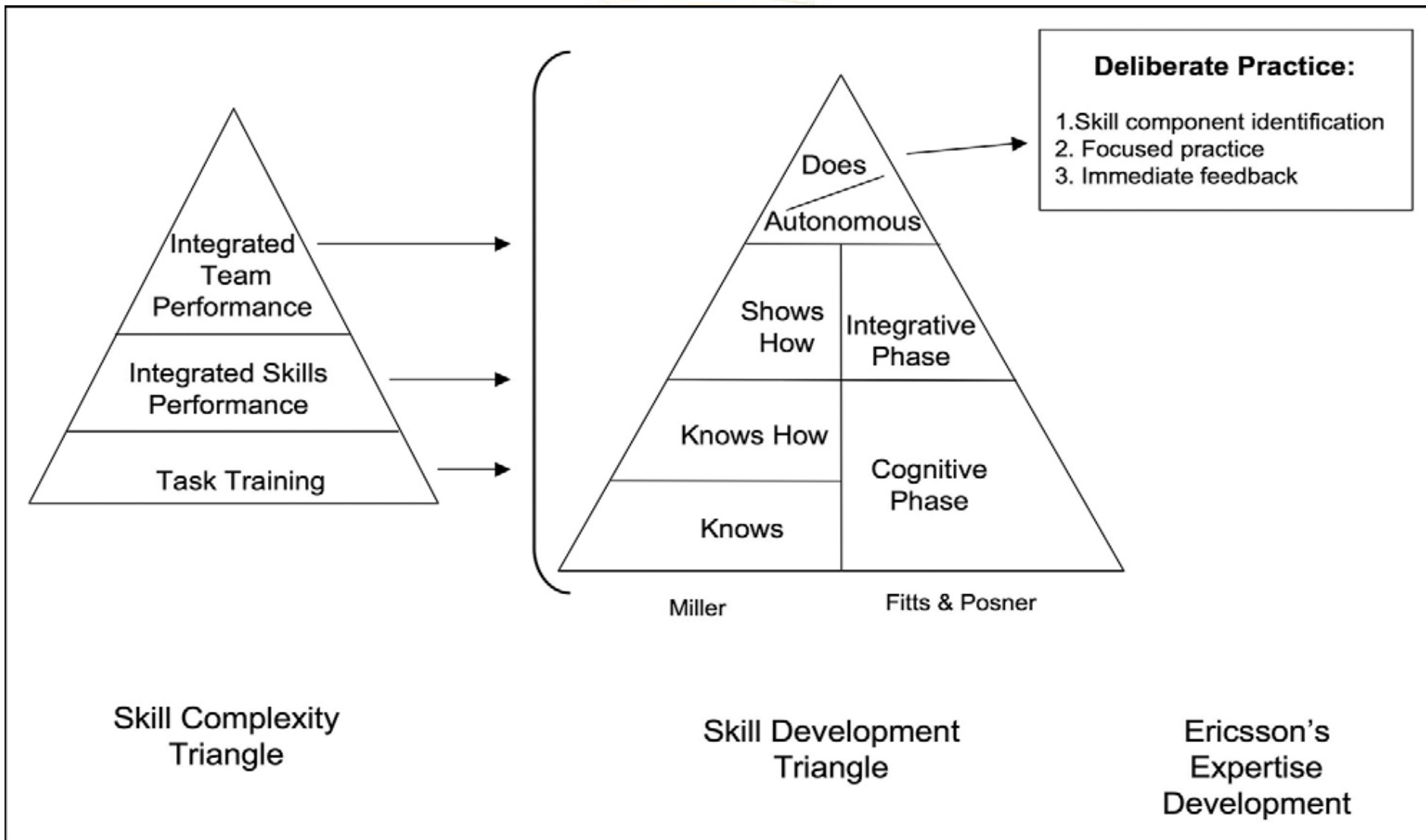
- 
- professional expertise
 - health promoter
 - inter-personal communication
 - team working
 - Academic
 - manager-leader
 - professionalism

Successful clinical outcome

- Task training
- Clinical decision making
- Team working
- Deliberate practice



Stages of skills acquisition



Simulation in medicine

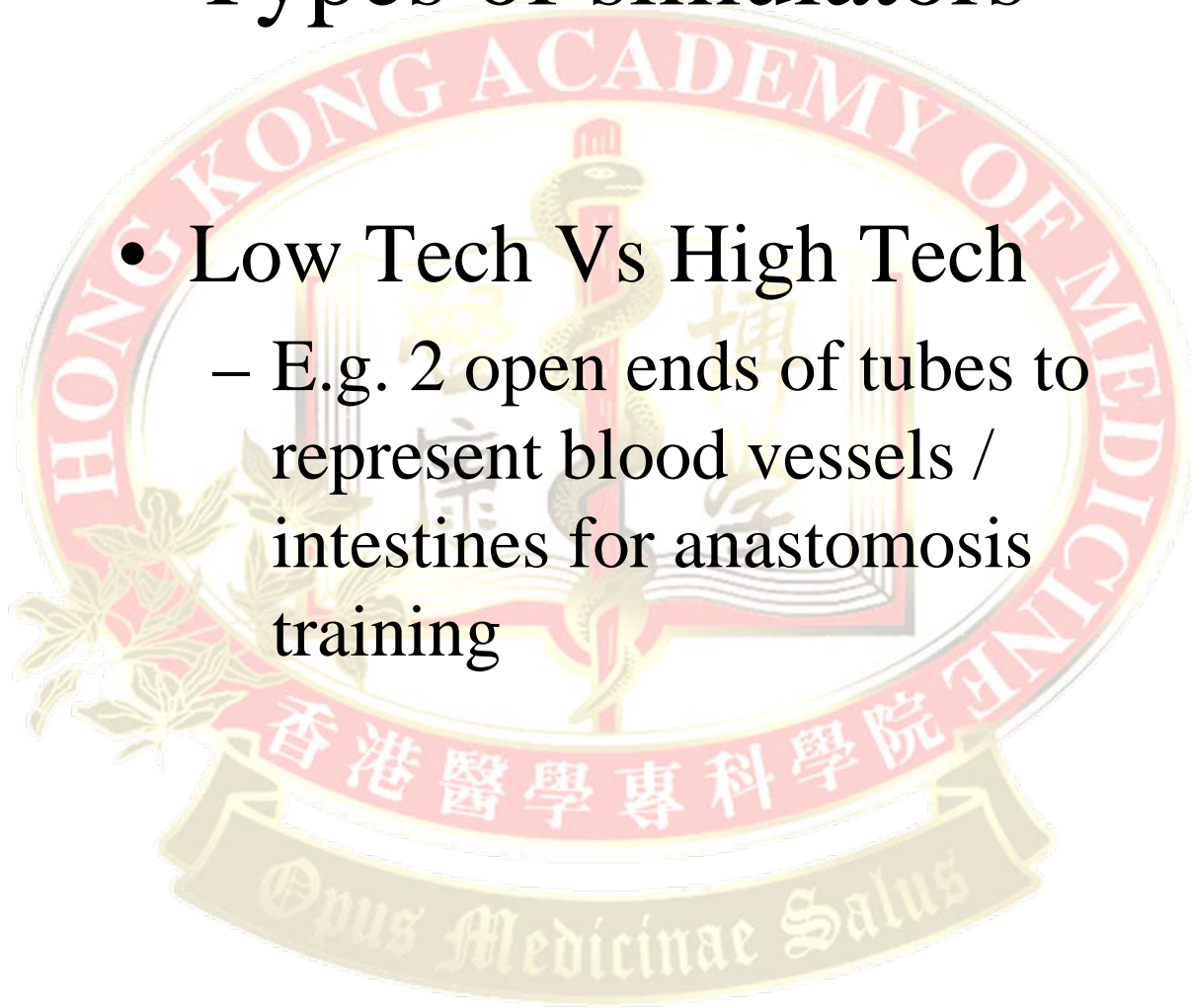
- Use of simulators / simulation not new
- Resuscitation training
 - Resusci-Anne / Intubation trainer
 - Synchronization between ECM and bagging
- Others for a particular purpose
 - Lung Simulator
 - Planning Simulator for radiotherapy

Early adopters of aviation simulation

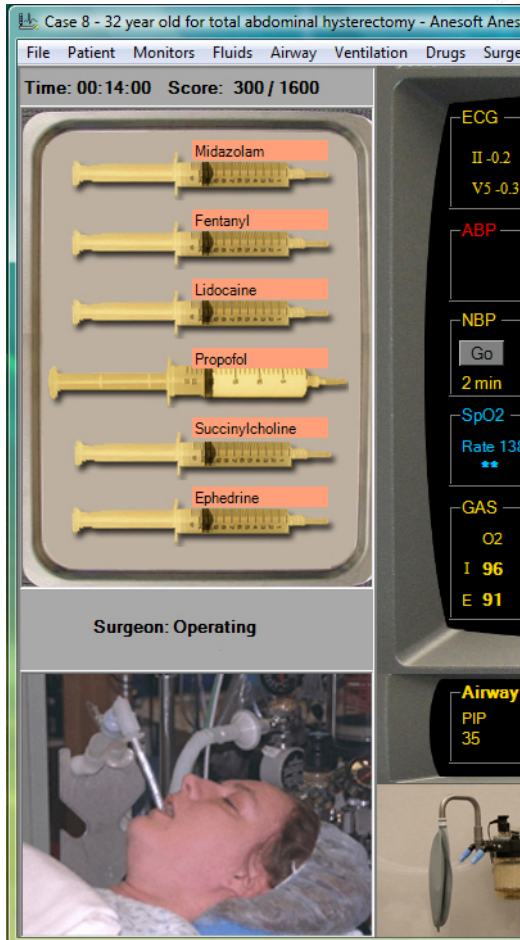
- D Gaba (Stanford) adapted the aviation Crew Resource Management
- Crisis Management in Anesthesia (1994)
- Anaesthesia Crisis Resource Management (ACRM) training using a physiological simulator
- Training crisis management behaviour on top of sound medical knowledge

Types of simulators

- Low Tech Vs High Tech
 - E.g. 2 open ends of tubes to represent blood vessels / intestines for anastomosis training



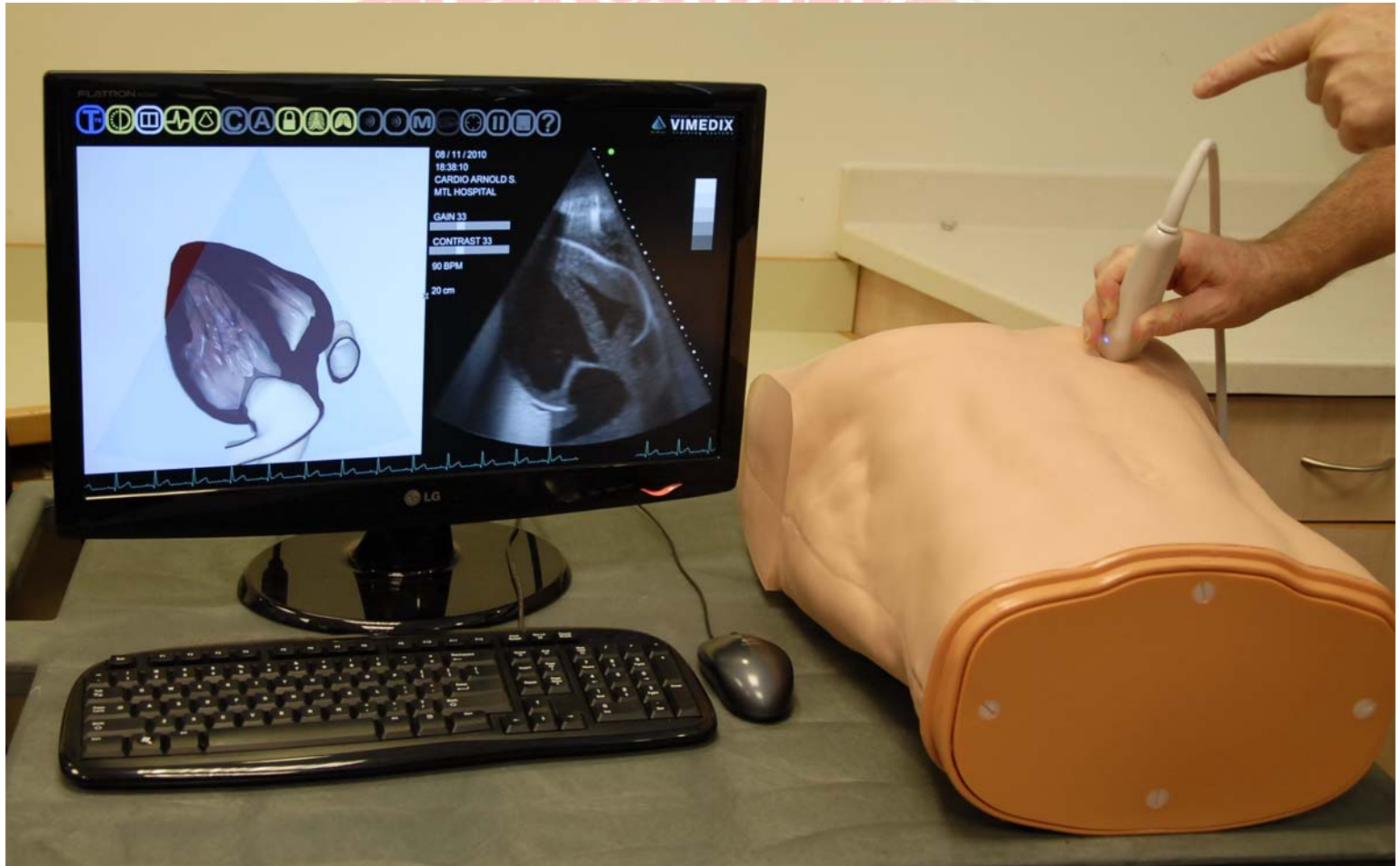
PC / desktop based versus Simulator-based for crisis



Low Fidelity Simulators

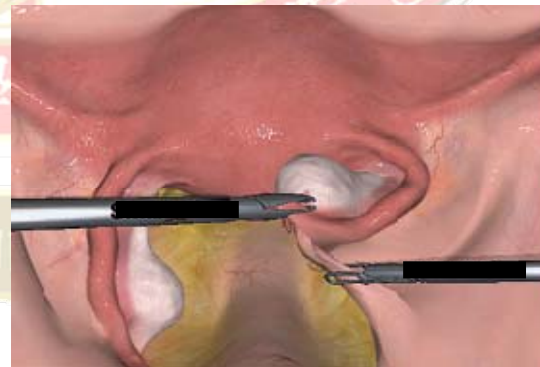
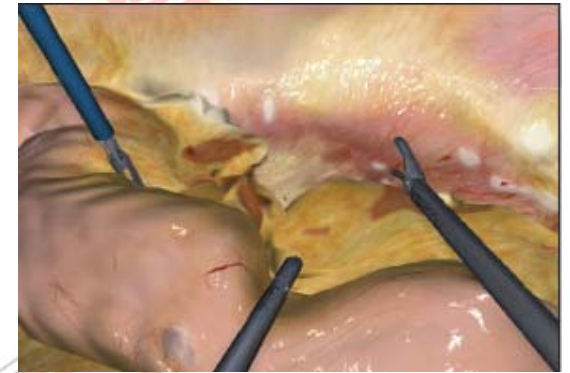


Computer Based Simulators





Virtual Reality



Haptic technology (touch & pressure feedback) improving tactile experience

High-Fidelity Simulators



High-Fidelity Simulators for training transport of critically ill



Scenario training using Hi-fidelity



Evolution of Endoscopic Simulators

(Greenwald & Cohen, 2006)

- Static models
 - E.g. hair dryer tube model and electronic models at training eye-hand coordination
- Ex-vivo artificial tissue model
- Ex-vivo animal tissue model
- Live animal model
- Computer simulation

Gastrointest Endoscopy Clin N Am (2006) 389–406



Simulated Patients (SP)

- Trained actors to serve as patients
- Simulates some physical signs
 - Training history taking and physical examination



Interacts with participants

- Widely used for training communication / behaviour and for assessment

Applications of Simulation

- Learning
 - Psychomotor skills
 - Critical, time constrained procedures
 - Team based behaviour
 - Rarely encountered situations
 - Communication skills
 - Human factor training
- Assessment
 - Routine
 - High stakes examination (*Michelson & Manning 2008*)
 - Objective Structured Assessment of Technical Skills (OSATS, Toronto), Inanimate System for Training and Evaluation of Laparoscopic Skills (McGill), Surgical Assessment Device (Imperial College)



Other Potential roles of procedural simulation

- Credentialing
 - FDA proposed participating physician specialty societies that credentialing for carotid stent placement should include satisfactory completion of a simulation based course for stent placement (*Gallagher JAMA 2004;292:3024–6*)
- IOM
 - advocated that new medical technologies should include its simulation device for training and certification

Advantages of Simulation

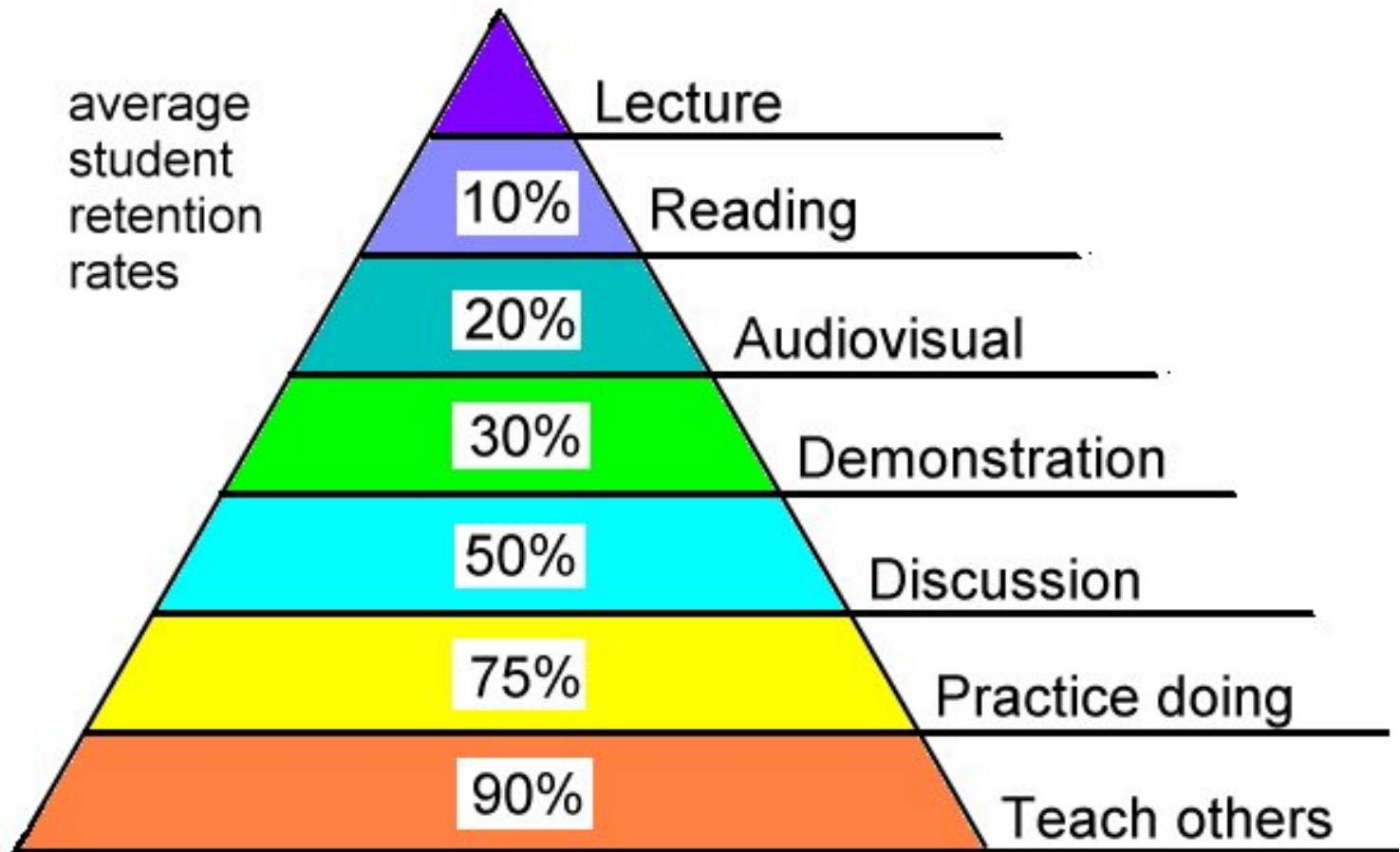
- Safe environment
 - Mistakes tolerated
- Proactive and learning can be controlled
- Reproducible
- Can be repeated as frequently as possible
- Experiential learning
 - Trainee centered
 - Better retention of skills / knowledge

High Fidelity Medical Simulators

- Providing feedback during learning
- Learners engage in repetitive practice
- Integrated into medical curriculum
- Practice with increasing levels of difficulty
- Adaptable to multiple learning strategies
- Able to capture clinical variation
- Embedded in a controlled environment
- Permits individualised learning
- Learning outcomes are defined and measured
- Valid approximation of clinical practice

Experiential learning and Retention Rate

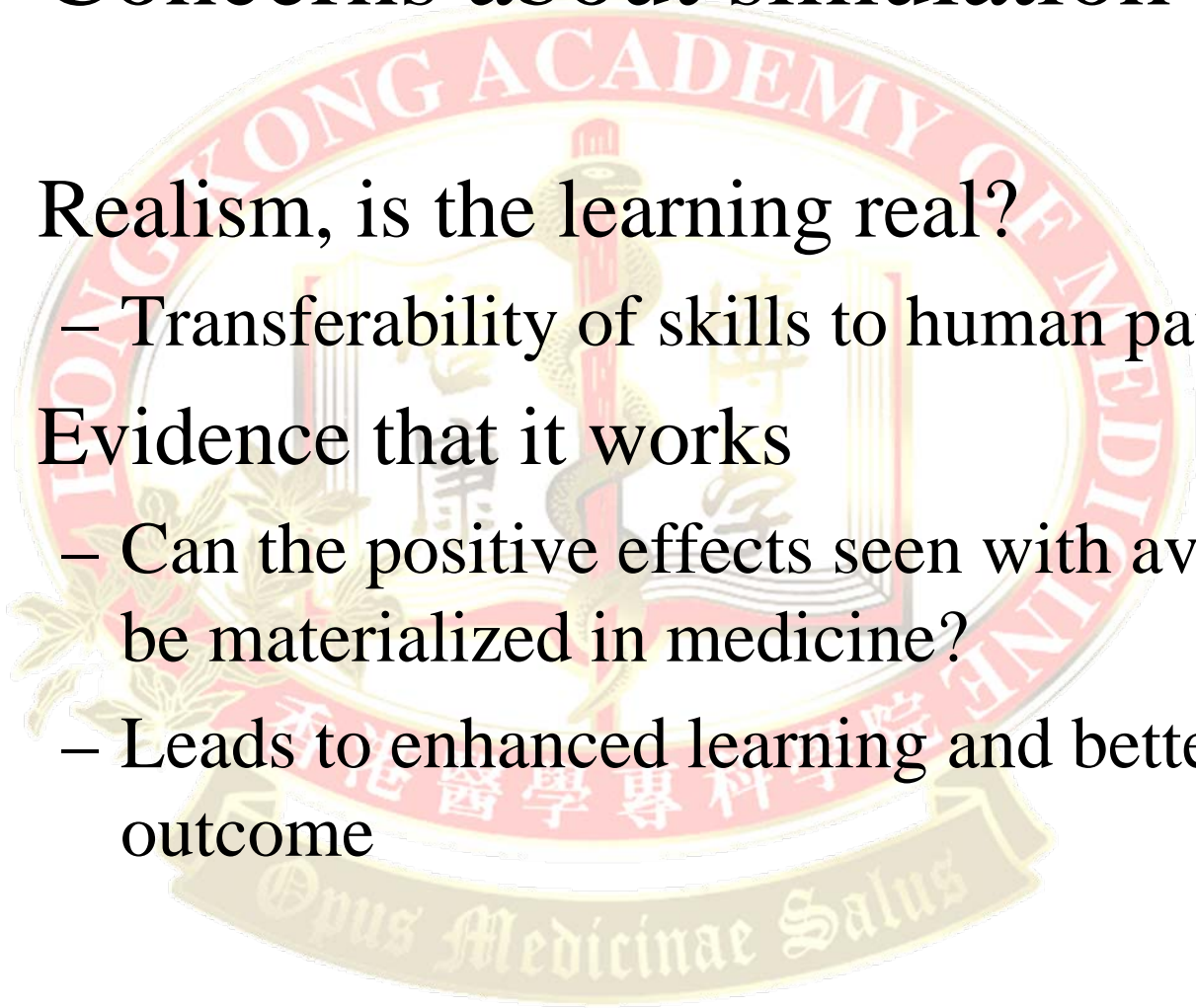
Learning Pyramid



Source: National Training Laboratories, Bethel, Maine

Concerns about simulation

- Realism, is the learning real?
 - Transferability of skills to human patients
- Evidence that it works
 - Can the positive effects seen with aviation be materialized in medicine?
 - Leads to enhanced learning and better outcome



Is the Learning Real?

- Fidelity dependent
- Learner attitude dependent
 - Issues about “hypervigilance”, “simulator-itis” and cavalier attitudes
- Validity of tasks being broken down
- Varying level of expertise
 - Matched with complexity / fidelity of simulators?
 - E.g. Virtual Reality more for novice

Matching Experience with device

(Sedlack 2006)

The optimal simulation model for various stages of endoscopic training

Level of training	Procedure	Computer	Animal		Other	
			Live	Ex vivo	Anesthesia Mannequins	Scope location device
Novice fellow	Colonoscopy	+		±		±
	EGD	+		±		
	Sedation/ complication				±	
Intermediate fellow	Hemostasis /complex		+	+		
Advanced fellow	ERCP		±	±		
	EUS	±				
Staff	Research		+	±		
	New skills		+	+		
	Maintenance		+	+		
Assistants	Devices/ Procedures		+	+		
	Sedation/ monitoring				±	
	Abdominal pressure					±
Nurse practitioners	Flexible sigmoidoscopy	+		±		

Real patient or simulator evaluating after video viewing

- For ATLS initial assessment station
- Ability to hear breath sounds in simulator, and witness the haemodynamic changes
- Cost is an issue

	Instructor (32)	ATLS Student (64)
Both models satisfactory for teaching / testing ATLS skills	32	64
Rated simulator more realistic, interesting, challenging	30	62
Patient more realistic	2 (same)	2

Mannequin or SP

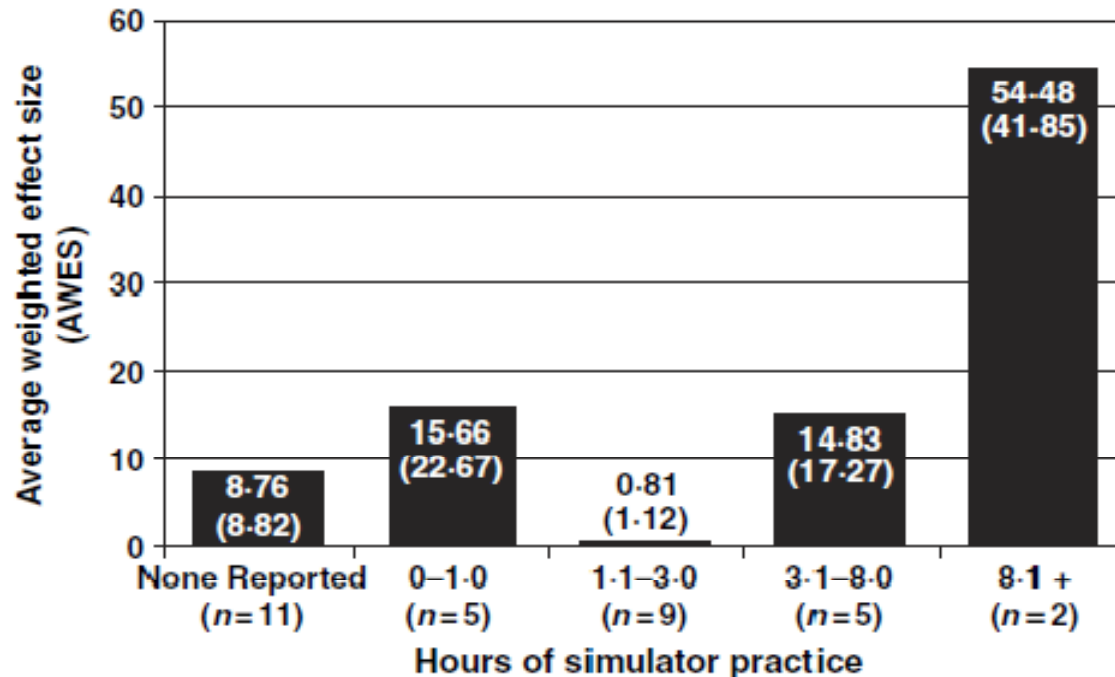
- Random exposure to SP or mannequin for trauma team
 - 104 team members participated
- Participants' assessment
 - High educational outcome unrelated to order of appearance of patient model.
 - No differences in assessment of realism and feeling of embarrassment
 - Focus groups: participants felt choice between educational modalities determined by the simulated case, e.g. if demands high interaction with team: SP more suitable.
- For communication, co-operation and leadership training within the team, both Mannequin or SP good

Wisbog et al. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine* 2009, 17:59

Evidence that simulation works



Effect of practice on learning outcomes



- Dose response relationship: the more learning the better the outcome
- Studies on effectiveness did not enough quality and rigour to yield useful results

McGaghie et al. Medical Education 2006; 40: 792-797

Effectiveness of learning

Tuttle et al (Respir Care 2007;52(3):263–270)

Table 4. Performance Scores on the Simulation Test for the Mini Bronchoalveolar Lavage Procedure

Phase	Mean \pm SD %	Median %	Maximum %	Minimum %
I	73 \pm 10	74	93	57
II	77 \pm 11	79	100	50
III	95 \pm 5	96	100	79
IV	92 \pm 7	95	100	72

BAL = bronchoalveolar lavage

- Respiratory therapists learning mini-bronchoalveolar lavage
- Simulator based assessment
- Phase I: after conventional learning
- Phase II: web-based enhanced learning
- Phase III: simulation training
- Phase 4: 1 month after Phase III for retention assessment

Endoscopic Simulators *(Gerson 2006)*

- Flexible Sigmoidoscopy Simulator
 - Distinguishes novice from experts
 - Benefits for endoscopic training not seen
 - Might have less discomfort
- Colonoscopy simulators
 - Distinguishes novice from experts
 - 10 hours of simulator training
 - Benefits seen from 21-80 procedures
 - No evidence of reduced patient discomfort
- ERCP
 - No validation studies yet

Haycock et al

(Gastrointest Endosc 2009;70:835-45.)

- Randomised study
- Hands-on skills training significantly improved performance in 3 therapeutic endoscopic modalities, where knowledge-based teaching alone has no measurable effect
- Strongly support the benefit of intensive hands-on, simulation-based courses for endoscopic skills training

Lap VR training

- Lengthy learning curve exists for novices
- Benefits seen throughout 30 repetitions and beyond
- Performance plateaus not reliably determine training endpoints
- significant & variable amount of training required to achieve maximal benefit
- Neither predetermined training duration nor arbitrary number of repetitions may be adequate to ensure laparoscopic proficiency
- Standards to define performance-based endpoints be established

Some more on transferability

- Weller *et al.* (Anesthesia 2009; 64:126 –30)
 - Using simulator based scenario to test impact of presence of trained assistants during anaesthesia
 - Significant fewer errors with presence of trained assistants.
- Domuracki *et al.* (Resuscitation 2009; 80:346 –9)
 - Application of cricoid pressure during intubation
 - Medical students receiving simulator training with feedback were more accurate in applying cricoid pressure in a patient in the correct range force range (38% vs 19%)

Identification of latent threats

- In situ simulation in actual environment of care to identify latent environmental threats to patient safety
- 2 phased experiment for chest pain
 - emergency department
 - catheterization laboratory, using a patient manikin, a high-definition camcorder, and software for annotating the video in real time.
- 3 latent environmental threats identified
 - procedures for transporting patients between 2 units
 - managing handoff process
 - organizing cardiac catheterization process
- Threats identified by simulation participants & supervisors during debriefing as being sufficiently common and dangerous



Simulators need to be good enough before efforts spent on validation (Cohen et al, 2006).

.... Only a few studies have shown direct improvements in clinical outcomes from the use of simulation for training., more studies are needed to see if simulation training improves patient outcomes. Okuda et al. Mt Sinai J Med. 2009;76:330-43.

Simulation as assessment: general

- Able to test certain competencies only that are not easily tested historically, e.g. communication
- Quality assurance, outcome based assessment
- Validity concerns
 - Face
 - Construct / content
- Reliability
- Ability to differentiate good from bad
 - Trainee from specialists
 - Within specialists



Simulators as assessment tools

- Hatala et al (Acad Med. 2005; 80:554–556):
 - assessed candidates on both traditional SP stations (4) and one new station combining SP with digitized cardiac auscultation video in high stakes examination
 - mean scores / mean discrimination indices for both types of stations were similar
 - Combining an SP with simulator can help to assess clinical competence in high-stakes testing situations.
- Moorthy & Darzi (2006):
 - Simulated Operating Theatre, with simulated bleeding to test both technical and non-technical skills of surgeons
 - 2 levels of expertise

Human Factors

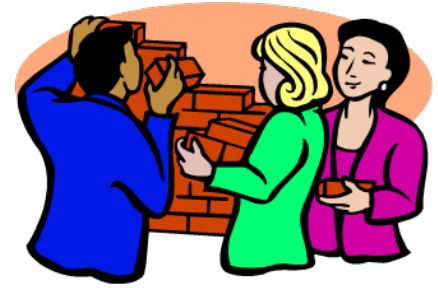


TABLE 2. Nontechnical Skills Assessment

Category	Element
Communication and interaction	<ul style="list-style-type: none"> (a) Instructions to assistant/scrub nurse; clear and polite (b) Awaits acknowledgment from the assistant/scrub nurse (c) Assistance sought from team members
Vigilance/situation awareness	<ul style="list-style-type: none"> (a) Monitored patient's parameters throughout the procedure (b) Awareness of anesthetist (c) Actively initiates communication with anesthetist during crisis periods
Team skills	<ul style="list-style-type: none"> (a) Maintains a positive rapport with the whole team (b) Open to opinions from other team members (c) Acknowledges the contribution made by other team members (d) Supportive of other team members
Leadership and management skills	<ul style="list-style-type: none"> (a) Adherence to best practice during the procedure, eg, does not permit corner cutting by self or team (b) Time management eg appropriate time allocation without being too slow or rushing team members (c) Resource utilization, ie, appropriate task-load distribution and delegation of responsibilities (d) Authority/assertiveness
Decision-making crisis	<ul style="list-style-type: none"> (a) Prompt identification of the problem (b) Informed team members; promptly, clearly, and to all team members (c) Outlines strategy/institutes a plan, ie, asks scrub nurse for suction, instruments, suture material (d) Anticipates potential problems and prepares a contingency plan, eg, asks anesthetist to order blood, calls for help (e) Option generation; takes the help of the team (seeks team opinion)

Moorthy & Darzi et al (2006)

- Face validity: realism
- Variability in performance
- Senior surgeon better in technical skills, diagnosed bleeding earlier, achieve control and blood loss (construct validity: difference between groups)
- No difference in team / human factor skills
- One of the models only

Simulation based skill assessment in managing anaesthesia equipment failure



Table 2. Scenario Overall Mean Key Action Scores, Key Actions, and Overall Time-Based Scores

Scenario	1st yr resident (<i>n</i> = 12)	2nd yr (CA-1) resident (<i>n</i> = 14)	3rd yr (CA-2) resident (<i>n</i> = 14)	4th yr (CA-3) resident (<i>n</i> = 16)
Overall key action (mean ± SD)	2.1 ± 0.4	2.7 ± 0.5	3.0 ± 0.2	3.1 ± 0.4
ETT cuff leak	1.9 ± 0.9	2.8 ± 1.2	3.35 ± 0.6	3.25 ± 0.6
Leak in circuit	2.4 ± 1.2	3.3 ± 0.8	3.3 ± 0.9	3.3 ± 1.0
O ₂ failure	2.25 ± 1.0	3.1 ± 0.9	3.2 ± 0.6	3.2 ± 0.4
CO ₂ canister Leak	2.0 ± 1.1	2.0 ± 0.8	2.6 ± 0.8	2.7 ± 0.7
Obstructed ETT	2.6 ± 1.2	2.9 ± 1.1	3.6 ± 0.8	3.75 ± 0.40
Monitor (pulse/CO ₂) disconnect	2.75 ± 0.6	2.8 ± 0.8	2.4 ± 0.6	3.0 ± 0.7
Anesthesia overdose	0.7 ± 0.8	2.0 ± 0.7	2.3 ± 0.9	2.4 ± 0.9
Inspiratory valve damage	2.0 ± 0.8	2.8 ± 0.8	3.0 ± 0.7	3.2 ± 0.9
Overall time (sum of time to complete)	834 ± 85 s	651 ± 105 s	583 ± 65 s	570 ± 120 s

(1) Wide range of skills within each year (2) and between each year

Waldrop et al. Anesth Analg 2009;109:426 –33

Simulation for formal assessments

- Define pertinent skills & choosing tasks
- Establish metrics
 - Explicit: checklists: order and timing
 - Implicit: rated as a whole, more flexibility, for non-tech skills evaluators need to be trained in contrast to content raters

Simulation for formal assessments

- Determine source of measurement errors
 - Internal consistency, inter-rater reliability
 - Task sampling variance
 - Multiple scenario with broad content domain
 - Communication / team work require less performance samples
- Evidence to support validity of test scores
 - Available but never complete
 - Scores valid for one but not other purpose
 - Reality check with experience
 - QA process to reassure public on fitness to practice, scenario based scores are valid and reproducible
 - Long term Predictive relationship not yet established

What the hi-fidelity cannot do that impacts on assessment

- Some physiological changes cannot be mimicked (sweating, response to pain, skin colour changes)
- Electro-mechanical responses & multiple drug intervention: unpredictable simulator response, making assessment result not as reliable
- Improperly scripted / complex scenario

What simulator adds

- Pick up those common but difficult to evaluate situations: with difficulty / skills deficits in handling crisis, setting priorities, planning and reasoning



Hi Fidelity for performance assessment

- Qualitative Review of 412 articles, 50 selected
- Generalizability theory used in 18%
- Assessment of predicative
 - low across the majority of studies
 - usability and practicality of testing occasions and tools not vigorously tested

How to set standards

- Angoff method
 - Panel of experts defines the minimal score for each item
- Hofstee method
 - experts define acceptable upper / lower limits for both passing scores and failing rates, then apply these to the known testing data to determine passing score
- Best Evidence Medical Education Collaboration
 - Linked to clinical outcome
 - Setting a realistic benchmark
 - Need more extensive and evidenced based better delineated benchmarks

Costs

- Set-up costs
- Costs of consumables / maintenance
- Time Costs of instructors in course design and course running
- Affects sustainability



Conclusion

- Simulation can complement learning but never replace conventional learning (*MaGaghie et al, 2009*)
- Reap benefit of experiential learning
- Curriculum design
- Increasing used in assessment
 - Quality assurance of training
 - Shortcomings
 - More rigorous research into this area
- Cost considerations

