SIMULATION-BASED MEDICAL EDUCATION IN INTERNAL MEDICINE

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BEFORE I START…

• By the end of my talk, I’d like to convince all of you that participating in simulation-based activities is both essential for trainees and beneficial to teachers.

• Disclaimer: I am no expert in simulation-based education. My goal is to share with you some of the valuable lessons I learned along the way.
BEFORE I START…

• Outline for this hour:
  • what is simulation and what are the types of simulators?
  • why simulation-based training?
  • the core internal med "simulation-based curriculum" and CanMEDS
  • my personal experience with organizing a simulation-based activity and lessons learned
  • moving ahead…
WHAT IS SIMULATION?

Simulation is...

• “a person, device, or set of conditions which attempts to present [education and] evaluation problems authentically. The student or trainee is required to respond to the problems as he or she would under natural circumstances. Frequently the trainee receives performance feedback as if he or she were in the real situation.” (McGaghie, 1999)

• “a training and feedback method in which learners practice tasks and processes in lifelike circumstances using models or virtual reality, with feedback from observers, peers, actor-patients, and video cameras to assist improvement in skills.” (Gulluoglu & Tingoy, 2009)
WHAT ARE THE TYPES OF SIMULATORS?

S1 – patient / disease process
S2 – procedure / diagnostic test / equipment
S3 – physician / professional (learner)
S4 – expert practitioner (instructor)

Passive → to enhance the setting or ‘realism’
Active → change as pre-programmed
Interactive → change in response to external action

Meller’s typology of simulators for medical education (Meller, 1997)
<table>
<thead>
<tr>
<th></th>
<th>Physical body</th>
<th>Automated responses</th>
<th>Performance feedback</th>
<th>Independent learning</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part-task trainer</td>
<td>Some</td>
<td>No</td>
<td>Sometimes</td>
<td>Yes</td>
<td>Low</td>
</tr>
<tr>
<td>Computer-based systems</td>
<td>No</td>
<td>Yes</td>
<td>Sometimes</td>
<td>Yes</td>
<td>Low</td>
</tr>
<tr>
<td>Virtual reality &amp; haptic systems</td>
<td>Some</td>
<td>Some</td>
<td>Yes</td>
<td>Yes</td>
<td>High</td>
</tr>
<tr>
<td>Simulated patients</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Medium</td>
</tr>
<tr>
<td>Integrated simulators</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>High</td>
</tr>
<tr>
<td>Model-driven</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>High</td>
</tr>
<tr>
<td>Instructor-driven</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Medium</td>
</tr>
</tbody>
</table>

... and combinations of modalities

Bradley, 2006
Lane, 2001
Maran et al., 2003
Examples of part-task trainer

S1 – patient / disease process

S2 – procedure / diagnostic test / equipment

S3 – physician / professional (learner)

S4 – expert practitioner (instructor)

http://www.mayo.edu/multidisciplinary-simulation-center

http://www.laerdal.com/us/harvey
An example of integrated simulator

S1 – patient / disease process

S2 – procedure / diagnostic test / equipment

S3 – physician / professional (learner)

S4 – expert practitioner (instructor)

http://www.laerdal.com/us/SimMan3G
**WHY SIMULATION-BASED TRAINING?**

**Advantages of simulation over traditional instructional methods**

<table>
<thead>
<tr>
<th>Advantage</th>
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</thead>
<tbody>
<tr>
<td>Tasks / scenarios can be created to match curriculum objectives</td>
</tr>
<tr>
<td>Standardization of experience</td>
</tr>
<tr>
<td>Standardization of instruction and evaluation</td>
</tr>
<tr>
<td>Instructor can focus fully on the learner</td>
</tr>
<tr>
<td>Safe environment for both learner and patient</td>
</tr>
<tr>
<td>Deliberate practice (with protected time for feedback)</td>
</tr>
<tr>
<td>Individualized training</td>
</tr>
<tr>
<td>Enhanced skill transfer to real situation</td>
</tr>
<tr>
<td>Permit team training</td>
</tr>
</tbody>
</table>

Issenberg et al., 2005
Bradley, 2006
DELIBERATE PRACTICE

- Repetitive performance of target skill(s)
- Reflection-in-action
- Rigorous assessment
- Timely, specific and informative feedback
- Reflection-for-action
- Reflection-on-action

Photo from McGill cIM CRM half-day

Boud et al. 1985
Ericsson, 2004
Schon, 1983
McGill core Internal Medicine residency training program simulation-based curriculum (lead developers: T Maniatis, P Willemot)
<table>
<thead>
<tr>
<th></th>
<th>Medical Expert</th>
<th>Communicator</th>
<th>Collaborator</th>
<th>Manager</th>
<th>Health Advocate</th>
<th>Scholar</th>
<th>Professional</th>
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</thead>
<tbody>
<tr>
<td>Advocacy</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>RC-style OSCE</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
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<td>X</td>
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<tr>
<td>Communication and ethics</td>
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<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
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<tr>
<td>Crisis Resource management</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Harvey</td>
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<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Intubation</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LP + knee arthrocentesis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airway basics</td>
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<td></td>
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<tr>
<td>Central + art. line insertion</td>
<td></td>
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<tr>
<td>Procedural ultrasound</td>
<td>X</td>
<td></td>
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</tbody>
</table>
Challenges

- Organization and tracking of resident participations
- Limited faculty resources
- Limited availability of simulation centre facilities
- Session development is time and energy-intensive

Driving / enabling factors

- Extensive faculty development
- Curriculum integration and competency mapping
- Growing appreciation of simulation-based learning
- Addresses pressing educational needs
- Move towards competency-based education

from T. Maniatis and P Willemot
UNEXPECTED ‘SIDE EFFECT’ FOR THE INSTRUCTORS

- Advocacy
- CRM (medical knowledge)
- CRM (leadership / CRM skills)
- LP + Knee (physical exam skills)
- LP + Knee (procedural skills)
- OSCE (physical exam)
- OSCE (clinical knowledge / reasoning)
- Ethics & Comm (communication skills)
- Ethics & Comm (ethical reasoning)
MY PERSONAL EXPERIENCE AND LESSONS LEARNED

Crisis Resource Management (CRM) Half-Day

• Core Internal Medicine training program
• PGY1 to PGY3
• Arnold and Blema Medical Simulation Center
• High-fidelity simulation environment
• CRM skills + Medical Expert competencies
• Acutely deteriorating patients / “Code Blues”

Photo from McGill cIM CRM half-day
Personal (in)experience in managing Code Blues

Sharing of personal concerns with a colleague

Inspiration from an attending MD

Local needs assessment

Start of a project idea

2009...
CRISIS (CREW) RESOURCE MANAGEMENT

• Team-based training
  • A group of people perfectly competent at performing their individual tasks ≠ a competent team
  • “Most medical errors result from problems in the systems of care rather than from individual mistakes.” (Bogner, 1994)
  • IOM report: “health care organizations should establish team training programs for personnel in critical care areas [...] using proven methods such as crew resource management techniques [...] including simulation” (Kohn et al., 1999)
2009-2010...

Specifying / refining learning objectives

- Choosing simulation modality
- Programming the scenarios
- Building simulation scenarios
- Help from process experts
- Help from content experts
- Faculty development

Help from training program leadership
2010-2012…

1. New scenarios
2. Case developer teams → 1\textsuperscript{st} draft
3. Content experts → medical content
4. Process experts → programming
5. Dry-runs and refinement
6. Ancillary documents
7. Faculty development package
8. Logistics and faculty recruitment
9. Instructional delivery
10. Quality control and improvement
   + sustainability
NOW...

• Bank of 10 high-fidelity simulation scenarios
  • from 15 resident case developers
  • to be rotated on a 3-year cycle
• One plenary lecture on CRM principles
• Three high-fidelity scenarios per afternoon x 5 half-days per year to accommodate all cIM trainees
• Growing pool of faculty and near-peer debriefers / facilitators
• Fully developed and standardized faculty development package
• Platform for scholarly work
• Main challenges: high demand on faculty resources
CRM HALF-DAY AS PLATFORM FOR RESEARCH

• 2010-2011 – Preeti Anand et al.
  • to investigate whether CRM self- and collective efficacy improved with participation in CRM training simulations and whether they correlated with CRM performance during simulation scenarios
  • found that CRM self- and collective efficacy perceptions improve with the training sessions but found no correlation between CRM self- and collective efficacy scores and CRM performance
CRM HALF-DAY AS PLATFORM FOR RESEARCH

- 2012-2013 – Melissa C. Duffy et al.
  - to examine the nature of cognitive, metacognitive, and affective processes during team-based simulation training for medical emergencies
  - found that team members exhibited lower-order cognitive and metacognitive process (e.g., summarizing, providing information) more often than higher-order processes (e.g., evaluation, reasoning), and expressed negative emotions (e.g., anxiety) more often than positive emotions (e.g., enjoyment). Negative emotions were significantly more frequently preceded by lower-order processes compared to higher-order processes
LESSONS I LEARNED...

• Must confirm that educational objectives are achievable using simulation
• Engineer / physical fidelity ≠ psychological / functional fidelity
• There are different options to run high-fidelity simulation...
  • Free-form (i.e. no script)
  • Ad hoc (i.e. loose script + improvise)
  • Programmed trends
  • Trends + event handlers
• Content / process proficiency of faculty members must be taken into account
• Proper orientation to facility and equipment is key ensure that the technology instructs rather than impedes
LESSONS I LEARNED…

• Must limit number of learning objectives (especially with more novice learners)
• Two ways of providing learners with feedback
  • Simulated response → not everything can be simulated, nor should it
  • Debriefing → almost everything can be debriefed but often limited by time constraints
• Debriefing is key for complex learning tasks
• Scenario design and debriefing guides must be aligned with learning goals
• Must balance desire for naturalistic representation of complex case with educational goals and resource requirement
• Cognitive load must be taken into careful consideration in order to optimize learning…
COGNITIVE LOAD THEORY

- Working memory is finite and can only hold 7-9 elements and process 2-4 interacting elements.
- Long-term memory is infinite.
- Learning occurs as new information are organized and assimilated into long-term memory in the form of “schemas” (each containing a number of interacting elements).
- Each schema can then be accessed and processed by working memory as a single element, thus liberating working memory space to handle additional elements.
- Expertise develops as number & complexity of cognitive schemas stored in long-term memory increase.

Brewer, 1987
Cowan, 2001
Evans et al., 2003
Schneider et al., 2003
COGNITIVE LOAD THEORY

• Any given educational task imposes a cognitive load on the learner
• This load is divided into:
  • Extraneous cognitive load (imposed by ineffective instructional delivery)
  • Intrinsic cognitive load (imposed by the learning task)
  • Germane cognitive load (devoted to processing of information, generation and automation of cognitive schemas) → LEARNING

Brewer, 1987
Cowan, 2001
Evans et al., 2003
Schneider et al., 2003
Controlled (slow)  
Automated (fast)  

System 1  
System 2  
System 3  

Schema automation  
Activation, inhibition, maintenance, supervision, updating, manipulation  
Schema acquisition  

Total cognitive load  
Intrinsic cognitive load  
Extraneous cognitive load  
Germane cognitive load  

Working memory capacity  

Expertise  
Learning  

Brewer, 1987  
Cowan, 2001  
Evans et al., 2003  
Schneider et al., 2003  

Total cognitive load  
Extraneous cognitive load  
Germane cognitive load  
Intrinsic cognitive load  

Working memory capacity  

Expertise  
Learning  

Brewer, 1987  
Cowan, 2001  
Evans et al., 2003  
Schneider et al., 2003
• Inefficient instructional delivery
• Inadequate learner orientation to instructional format and logistics

Extraneous CL  Intrinsic CL

• Case complexity (element interactivity) too high for the novice learner

Extraneous CL  Intrinsic CL

• Optimal instructional delivery and case complexity for learning

Extraneous CL  Intrinsic CL  Germane CL

Learning in form of cognitive schema formation

Working memory capacity of the learner
Internal Medicine CRM half-day

Plenary lecture on CRM principles

Orientation to simulation environment and mannequin

Scenario 1
- On-site facilitator provides support with logistics
- On-site facilitator takes over the role of nurse and/or RT
- Senior residents participate as team leader
- Junior residents participate only as team member or observer
- Faculty facilitates to overcome specific knowledge gaps

Debriefing

Scenario 2
Debriefing

Scenario 3
Debriefing

Iterative cycles of performance and feedback

Components of cognitive load theory

Managing high intrinsic cognitive load
- supportive information

Reducing extraneous cognitive load

Performance

Reducing extraneous cognitive load

Reducing extraneous cognitive load

Managing high intrinsic cognitive load
- (access to more) cognitive schemas

Managing high intrinsic cognitive load
- worked example effect

Managing high intrinsic cognitive load
- just-in-time information

Feedback

Young et al., 2014
Van Merriënboer et al., 2003
Van Merriënboer et al., 2010
IN SUMMARY AND MOVING FORWARD…

• Recognize the value of simulation-based learning
• Let learning objectives dictate the best simulation modality / technology to use
• Employ adult learning theories and principles to build sound learning activities (i.e. scholarship of application)
• Integrate simulation activities into overall residency curriculum for CanMEDS competencies
• Continue to collaborate with educational researchers (i.e. scholarship of discovery)
• Bring the “culture of simulation” (direct observation, timely feedback) back into workplace through faculty exposure to simulation-based learning
• Decentralization of simulation-based learning to counter resource constraints and to facilitate realistic multidisciplinary team training

Contributions from T. Maniatis and P Willemot
ACKNOWLEDGEMENT

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- CRM half-day development team
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- The Arnold and Blema Medical Simulation Center personnel
THANK YOU!

QUESTIONS?