Mastery Learning: A Paradigm Shift in Health Professions Education

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Northwestern Simulation
No Conflict of Interest
“There are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns—the ones we don’t know we don’t know.”

Donald Rumsfeld
Goal: Educate Superb Clinicians

• Effective & Safe
• Quality Patient Care
• Good Patient Outcomes
Simulation Lab

Deep Probe
Knowledge
Skills
Attitudes
Professionalism
Goals of this Presentation

1. Transfer of training pathway from the simulation education lab to patient care settings

2. Address translational science and the role of mastery learning with deliberate practice

3. Highlight features of rigorous simulation-based health professions education (SBHPE)

4. Interpret data from selected research studies on SBHPE transfer of training

5. Coda: effective SBHPE interventions, lessons learned, research opportunities, & academic teams
Medical Education Research as Translational Science

Contributions of *powerful medical education interventions* to T1 – T4 outcomes

<table>
<thead>
<tr>
<th>Focus</th>
<th>Level of Translation</th>
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<tbody>
<tr>
<td>Increased or Improved</td>
<td>McGaghie 2010; Barsuk &amp; Szmuilowicz, 2015</td>
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<td>Target Groups</td>
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<td>Setting</td>
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Key SBHPE Research Concepts

• Mastery Learning

• Deliberate Practice
Mastery Learning

Features

1. Baseline, i.e., diagnostic testing;
2. Clear learning objectives, units ordered by difficulty;
3. Educational activities (e.g., deliberate skills practice) focused on objectives;
4. Minimum passing *mastery* standard (MPS) for each unit;
5. Formative testing → *mastery* of each unit;
6. Advancement if performance ≥ MPS; or
7. Continued practice or study until MPS is reached
8. Time *varies*, outcomes are *uniform*

McGaghie et al., Chest 2009
Deliberate Practice (DP)

Features

1. Highly motivated learners with good concentration;
2. Engagement with a well-defined learning objective or task; at an
3. Appropriate level of difficulty; with
4. *Focused, repetitive practice*; that leads to
5. Rigorous, precise measurements; that yield
6. Informative feedback from educational sources (e.g., simulators, teachers); and where
7. Trainees also monitor their learning experiences and correct strategies, errors, and levels of understanding, engage in more DP; and continue with
8. Evaluation to reach a *mastery* standard; and then
9. Advance to another task or unit
10. Goal: *constant improvement*

Ericsson *Acad Med.* 2004; McGaghie et al., *Chest* 2009
If you practice the way you play, there shouldn’t be any difference, that’s why I practiced so hard.

I WANT TO BE PREPARED FOR THE GAME.

I love the competition of practice. I got that from North Carolina, where Coach Smith would make every drill competitive. That grows on you, so everything we did in practice became competitive.

I TOOK PRIDE IN THE WAY I PRACTICED.
SBHPE Translational Science (TS)
Example *Program*

CVC  T1 → T2 → T3 → T4 ($, R, CE)

Thematic → Sustained → Cumulative
SBHPE-TS Research Example

Central Lines

1. CVC Placement in Simulation Lab & MICU (T1)

2. CVC Insertion → ↓ Complications in MICU (T2)

3. CVC Insertion → ↓ CRBSI in MICU (T3)

4. CVC Insertion → ↑ Cost Savings in MICU (T4)

5. CVC Insertion Skills Retention (T4)

6. Unexpected Collateral Effects (T4)
Use of Simulation-Based Mastery Learning to Improve the Quality of Central Venous Catheter Placement in a Medical Intensive Care Unit

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J Hosp Med. 2009; 4: 397-403
T1 Outcomes

![Bar chart showing comparison of mean percentage correct for Internal Jugular and Subclavian sites.]

- **Internal Jugular**
  - Mean: 48.4%
  - Posttest Mean: 94.8%
  - Improvement: 96%

- **Subclavian**
  - Mean: 45.2%
  - Posttest Mean: 91.1%
  - Improvement: 102%

Sites are compared with pretest and posttest results, indicating significant improvement in posttest performance.
Simulation-based mastery learning reduces complications during central venous catheter insertion in a medical intensive care unit

Barsuk, Jeffrey; McGaghie, William; Cohen, Elaine; OLeary, Kevin; Wayne, Diane

doi: 10.1097/CCM.0b013e3181a57bc1
Clinical Outcomes: Complications

Barsuk et al. *Critical Care Medicine* 2009

<table>
<thead>
<tr>
<th>Complications</th>
<th>Traditionally-Trained</th>
<th>Simulator-Trained</th>
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<tr>
<td>Pneumothorax</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>Arterial Puncture</td>
<td>10%</td>
<td>25%</td>
</tr>
<tr>
<td>CVC Adjustment</td>
<td>20%</td>
<td>10%</td>
</tr>
<tr>
<td>Insertion Failure Rate</td>
<td>30%</td>
<td>50%</td>
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*p-values*
- Pneumothorax: *p* = .757
- Arterial Puncture: *p* < .0005
- CVC Adjustment: *p* = .002
- Insertion Failure Rate: *p* = .005
(T3 Outcomes)

Original Investigation

Use of Simulation-Based Education to Reduce Catheter-Related Bloodstream Infections

Jeffrey H. Barsuk, MD; Elaine R. Cohen, BA; Joe Feinglass, PhD; William C. McGaghie, PhD; Diane B. Wayne, MD

Timeline of residents rotating in the medical intensive care unit (ICU) and a comparison ICU

T3 Outcomes

Monthly catheter-related bloodstream infection rates in a medical intensive care unit (MICU) and a comparison intensive care unit (ICU) before and after a simulation-based educational intervention in the MICU


85% ↓ in CRBSI
Cost Savings From Reduced Catheter-Related Bloodstream Infection After Simulation-Based Education for Residents in a Medical Intensive Care Unit

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Anna O’Donnell, RN, BSN;
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Diane B. Wayne, MD

Introduction: Interventions to reduce preventable complications such as catheter-related bloodstream infections (CRBSI) can also decrease hospital costs. However, little is known about the cost-effectiveness of simulation-based education. The aim of this study was to estimate hospital cost savings related to a reduction in CRBSI after simulation training for residents.

Methods: This was an intervention evaluation study estimating cost savings related to a simulation-based intervention in central venous catheter (CVC) insertion in the Medical Intensive Care Unit (MICU) at an urban teaching hospital. After residents completed a simulation-based mastery learning program in CVC insertion, CRBSI rates declined sharply. Case-control and regression analysis methods were used to estimate savings by comparing CRBSI rates in the year before and after the intervention. Annual savings from reduced CRBSIs were compared with the annual cost of simulation training.

Results: Approximately 9.95 CRBSIs were prevented among MICU patients with CVCs in the year after the intervention. Incremental costs attributed to each CRBSI were approximately $82,000 in 2008 dollars and 1.4 additional hospital days (including 12 MICU days). The annual cost of the simulation-based education was approximately $112,000. Net annual savings were thus greater than $700,000, a 7 to 1 rate of return on the simulation training investment.

Conclusions: A simulation-based educational intervention in CVC insertion was highly cost-effective. These results suggest that investment in simulation training can produce significant medical care cost savings.

(Sim Healthcare 5:98-102, 2010)

Key Words: Simulation, Education, Cost-effectiveness, Infection, Intensive care unit.)
Cost Savings

Compared with the cost of the intervention ($111,916) the net savings ranged from $704,034 to $711,248.

7-1 ROI
Long-Term Retention of Central Venous Catheter Insertion Skills After Simulation-Based Mastery Learning
Jeffrey H. Barsuk, Elaine R. Cohen, William C. McGaghie, and Diane B. Wayne

Abstract
Background
Simulation-based mastery learning (SBML) of central venous catheter (CVC) insertion improves trainee skill and patient care. How long skills are retained is unknown.

Method
This is a prospective cohort study. Subjects completed SBML and were required to meet or exceed a minimum passing score (MPS) for CVC insertion on a posttest. Skills were retested 6 and 12 months later and compared with posttest results to assess skill retention.

Results
Forty-nine of 61 (80.3%) subjects completed follow-up testing. Although performance declined from posttest where 100% met the MPS for CVC insertion, 82.4% to 87.1% of trainees passed the exam and maintained their high performance up to one year after training.

Conclusions
Skills acquired from SBML were substantially retained during one year. Individual performance cannot be predicted, so programs should use periodic testing and refresher training to ensure competence.
T4 Outcomes
T4 Outcomes

Figure 1  Individual residents’ internal jugular (IJ) and subclavian (SC) checklist scores at pretest, posttest, six-month, and one-year follow-up. Pass rate (PR) is reported for each interval, and minimum passing score (MPS) is indicated for each checklist.
“Deliberate practice is a concept that is not currently found in the nursing lexicon.”

(Clapper & Kardong-Edgren, 2012)

Clinical Simulation in Nursing
Simulation and education

Effects of monthly practice on nursing students' CPR psychomotor skill performance

Marilyn H. Oermann\textsuperscript{a,}\textsuperscript{*}, Suzan E. Kardong-Edgren\textsuperscript{b}, Tamara Odom-Maryon\textsuperscript{b}

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\textsuperscript{b} Washington State University, College of Nursing, Box 1495, Spokane, WA 99210 USA
• Randomized trial
• 6-min. monthly practice sessions
• Voice-activated manikin (VAM)
• Sig. improvement in Practice vs. Control group

• Clinical outcome measures
Clinical Outcome Measures

• Compression rate and depth
• Percent of compressions performed with adequate depth
• Percent performed with correct hand placement
• Ventilation rate and volume
• Percent of ventilations with adequate volume
Key Result

“By practicing only 6 min. a month, students maintained or improved their CPR skills over the 12-month period.”

Oermann, Kardong-Edgren, Odom-Maryon

*Resuscitation* 2011; 82: 447-453
DELIBERATE PRACTICE of MOTOR SKILLS in Nursing Education: CPR AS EXEMPLAR

Marilyn H. Oermann, Suzan Kardong-Edgren, Tamara Odom-Maryon, Beth F. Hallmark, Debbie Hurd, Nancy Rogers, Carol Haus, Jacqueline Keegan McCollan, Catherine Snelson, Sharon Wilson Dowdy, Leandro A. Resurreccion, Dawn R. Kuerschner, Jerrilee Lamar, Monica Nelson Tennant, and Denise A. Smart
CPR Skill Retention

Chest compressions goal: depth of at least 38 mm
- Control group: ~½ compressions adequate depth
- Practice group: sig. more compressions adequate depth

Ventilation goal: volume greater than 500 ml
- Control group: ventilation skills ↓ over 1 year
- Practice group: maintained ventilation skills over 1 year

Deliberate Practice Works!
Coda *(Secret Sauce)*

- Effective SBHPE interventions
- Lessons learned
- Research opportunities
- Productive academic teams
Interventions = Products of Context
Healthcare System × Curriculum Integration × Trained Simulation Instructors × Motivated Learners × Training Resources (Simulator) = Effective Simulation Intervention

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Issenberg (2006)
Unexpected Collateral Effects of Simulation-Based Medical Education

Jeffrey H. Barsuk, MD, MS, Elaine R. Cohen, Joe Feinglass, PhD, William C. McGaghie, PhD, and Diane B. Wayne, MD

Abstract

Purpose
Internal medicine residents who complete simulation-based education (SBE) in central venous catheter (CVC) insertion acquire improved skills that yield better patient care outcomes. The collateral effects of SBE on the skills of residents who have not yet experienced SBE are unknown.

Method
In this retrospective, observational study, the authors used a checklist to test the internal jugular and subclavian CVC insertion skills of 102 Northwestern University second- and third-year internal medicine residents before they received simulation training. The authors compared, across consecutive academic years (2007–2008, 2008–2009, 2009–2010), mean pretraining scores and the percent of trainees who met or surpassed a minimum passing score (MPS).

Results
Mean internal jugular pretest scores improved from 46.7% (standard deviation = 20.8%) in 2007 to 55.7% (±22.5%) in 2008 and 70.8% (±22.4%) in 2009 (P < .001). Mean subclavian pretest scores changed from 48.3% (±25.5%) in 2007 to 45.6% (±31.0%) in 2008 and 63.6% (±27.3%) in 2009 (P = .04). The percentage of residents who met or surpassed the MPS before training for internal jugular insertion was 7% in 2007, 16% in 2008, and 38% in 2009 (P = .004); for subclavian insertion, the percentage was 11% in 2007, 19% in 2008, and 38% in 2009 (P = .028).

Conclusions
SBE for senior residents had an effect on junior trainees, as evidenced by pretraining CVC insertion skill improvement across three consecutive years. SBE for a targeted group of residents has implications for skill acquisition among other trainees.
Pretest Pass Rate

- 2007: 7%, 11%
- 2008: 16%, 19%
- 2009: 38%, 38%

$p = .004$ for Internal Jugular and $p = .028$ for Subclavian.
(T4 Outcomes)

APPLIED RESEARCH

Raising the Bar: Reassessing Standards for Procedural Competence

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Nine Lessons Learned

1. **ML with DP** is a key feature of SBHPE programs aimed at boosting skill and knowledge acquisition among medical learners at all levels—*strong, integrated, sustained*

2. Robust measures yielding *reliable data* that permit *valid decisions or inferences* are a key feature of SBHPE

3. Rater training and constant calibration are *essential*

4. No correlation between medical knowledge (USMLE scores) and clinical skill acquisition

5. **ML** model depends on setting high MPSs

6. Self-assessments are biased, poor relation to performance measured objectively

7. **ML with DP** cannot be done “on the cheap.”

8. Follow-up testing and remediation are needed to *assure retention*

9. Implementation science

McGaghie (2008)
Ten Research Opportunities

1. Rely on randomized trials? No, mastery learning!
2. Stretch the measurement endpoint: T1 → T2 → T3 → T4 ($, R, CE)
3. Study DP features and quality
4. Rigorous research designs
5. Measurement [metric] development
6. SBHPE affective consequences
7. Skill maintenance
8. Faculty development
9. UTOST model: unit + treatment + observation + setting + time
10. Team science

McGaghie (2008)
Attributes of Productive Academic Teams

- Shared goals—common mission & vision
- Functional diversity
- Clear leadership—may change or rotate
- Shared mental models & language
- High standards, recognition, & credit
- Sustained hard work / commitment
- Physical proximity
- Minimize status differences *within* the team
- Maximize status *of* the team
- Shared activities that breed trust

Six Challenges for the Health Professions

1. Technology works!
2. Power of inertia
3. Hard work
4. SBHPE: more than skill acquisition
5. Fun & exciting
6. Scholarship opportunities
References


