Educational Theory

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Agenda

- Learning theory as pertains to curriculum
  - Learning theory
  - Clerkship medium best to enhancing recall/improve transfer?

Traditional Principles of Learning

- readiness
- exercise
- effect
- primary
- recency
- intensity
- freedom
- requirement

Others to consider

- Dual coding
- Cognitive load
- Elaboration theory

Table 1. Learning Techniques

Technique	Description
1. Elaborative interrogation	Generating an explanation for why an explicitly stated fact or concept is true
2. Self-explanation	Explaining how new information is related to known information, or explaining steps taken during problem solving
3. Summarization	Writing summaries (of various lengths) of to-be-learned texts
4. Highlighting/underlining	Marking potentially important portions of to-be-learned materials while reading
5. Keyword mnemonic	Using keywords and mental imagery to associate verbal materials
6. Imagery for text	Attempting to form mental images of text materials while reading or listening
7. Rereading	Restudying text material again after an initial reading
8. Practice testing	Self-testing or taking practice tests over to-be-learned material
9. Distributed practice	Implementing a schedule of practice that spreads out study activities over time
10. Interleaved practice	Implementing a schedule of practice that mixes different kinds of problems, or a schedule of study that mixes different kinds of material, within a single study session

Note. See text for a detailed description of each learning technique and relevant examples of their use.

Dunlosky J, et al. Improving Students' Learning With Effective Learning Techniques: Promising Directions From Cognitive and Educational Psychology Psychological Science in the Public Interest January 2013 14: 4-58

Table 4. Utility Assessment and Ratings of Generalizability for Each of the Learning Techniques

Technique	Utility	Learners	Materials	Criterion tasks	Issues for implementation	Educational contexts
Elaborative interrogation	Moderate	P-I	P	I	P	I
Self-explanation	Moderate	P-I	P	P-I	Q	I
Summarization	Low	Q	P-I	Q	Q	I
Highlighting	Low	Q	Q	N	P	N
The keyword mnemonic	Low	Q	Q	Q-I	Q	Q-I
Imagery use for text learning	Low	Q	Q	Q-I	P	I
Rereading	Low	I	P	Q-I	P	I
Practice testing	High	P-I	P	P	P	P
Distributed practice	High	P-I	P	P-I	P	P-I
Interleaved practice	Moderate	I	Q	P-I	P	P-I

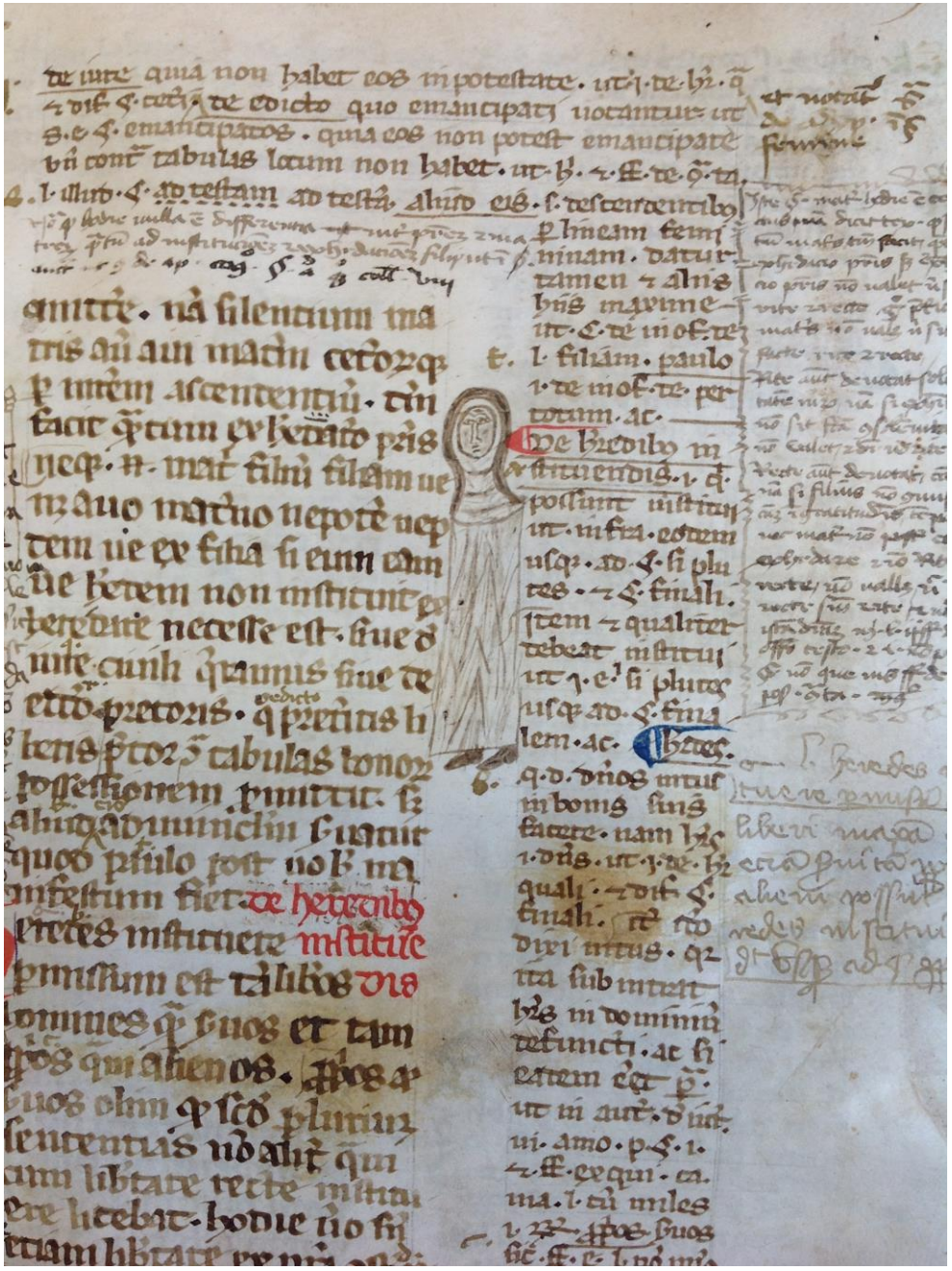
Note: A positive (P) rating indicates that available evidence demonstrates efficacy of a learning technique with respect to a given variable or issue. A negative (N) rating indicates that a technique is largely ineffective for a given variable. A qualified (Q) rating indicates that the technique yielded positive effects under some conditions (or in some groups) but not others. An insufficient (I) rating indicates that there is insufficient evidence to support a definitive assessment for one or more factors for a given variable or issue.

Dunlosky J, et al. Improving Students' Learning With Effective Learning Techniques: Promising Directions From Cognitive and Educational Psychology Psychological Science in the Public Interest January 2013 14: 4-58

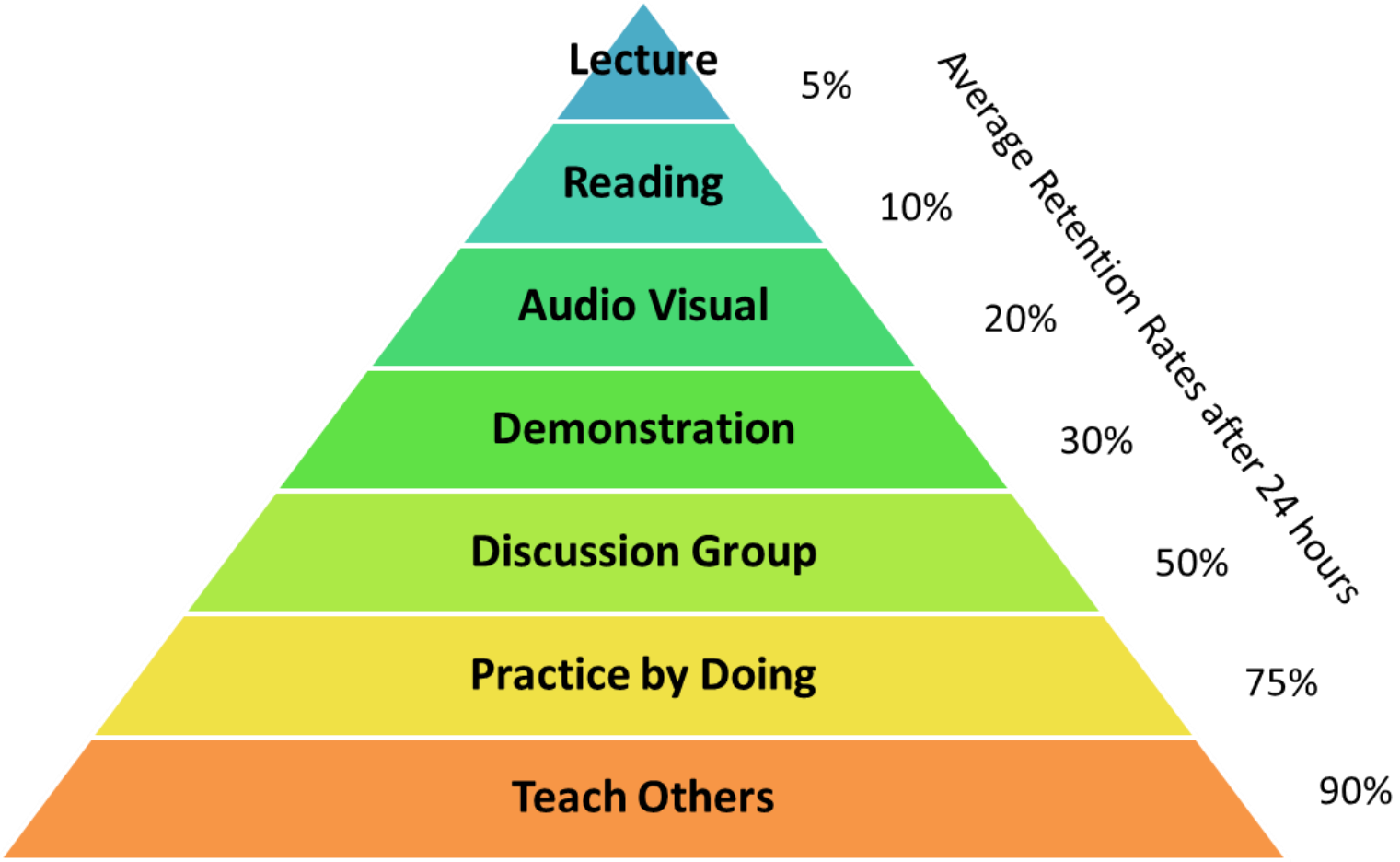
What are we aiming for?

Agenda

- Learning theory as pertains to curriculum
  - Learning theory
  - Teaching medium best to enhancing recall/improve transfer?



The Learning Pyramid



Source: National Training Laboratories, Bethel Maine

Tales of the Undead… Learning Theories: The Learning Pyramid

January 13, 2014 Higher Education, Teaching learning period, learning theories, pedagogy acrlguest

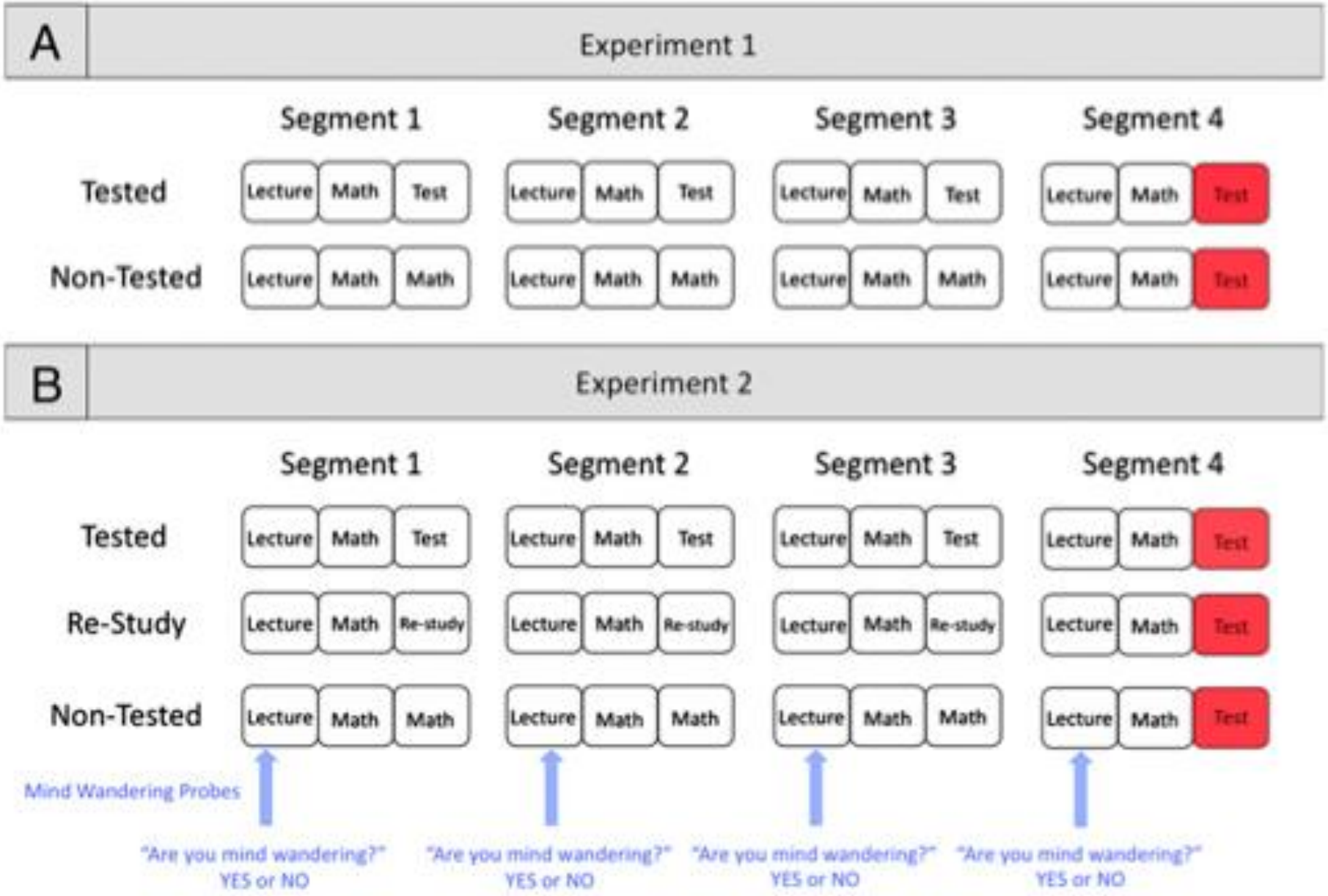
ACRLog welcomes a guest post from Candice Benjes-Small, Head of Information Literacy and Outreach, and Alyssa Archer, Instruction Librarian at Radford University.

"If I have to sit through YET ANOTHER freaking 'professional development' session based on these cockamamie theories, I am going to pluck my eyeballs out and throw them at whatever charlatan the administration hired to conduct said session."- *professor on an online academic forum discussing learning myths, including the pyramid.*

Some educational myths just can't be killed. Case in point: the learning pyramid.

Lecture

- Advantages
  - Relatively easy to get faculty involved
  - More material can be covered
  - Can be recycled
- Disadvantages
  - Faculty participation variable month to month
  - Dependent on strength of lecturer
  - Student retention generally mediocre (passive learning)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Experiment 1
Segment 1
Segment 2
Segment 3
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Tested
Lecture
Math
Test
Non-Tested
Lecture
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B
Experiment 2
Segment 1
Segment 2
Segment 3
Segment 4
Tested
Lecture
Math
Test
Re-Study
Lecture
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Re-study
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Lecture
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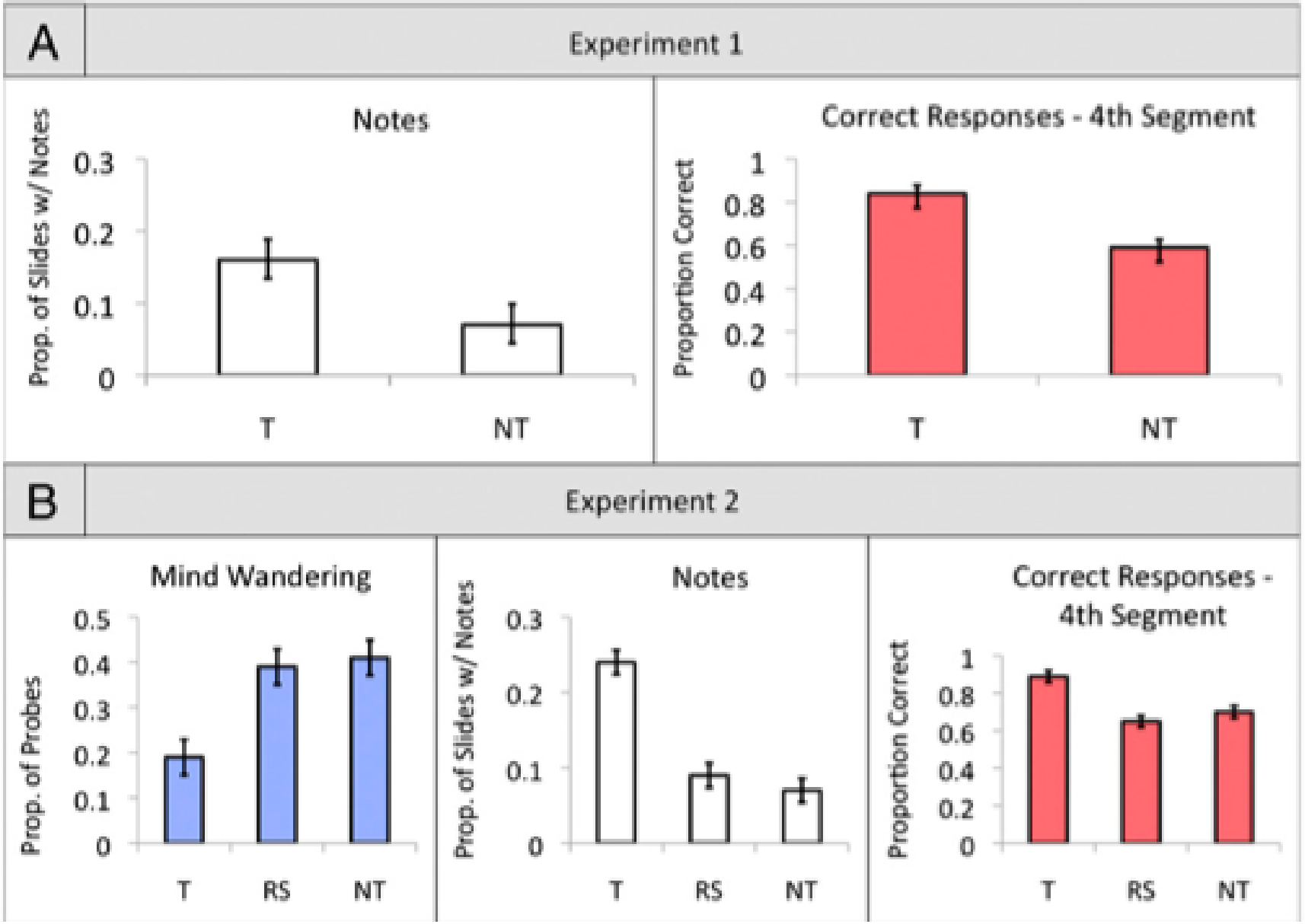
Mind Wandering Probes
"Are you mind wandering?"
YES or NO
"Are you mind wandering?"
YES or NO
"Are you mind wandering?"
YES or NO
"Are you mind wandering?"
YES or NO


A
Experiment 1
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Prop. of Slides w/ Notes
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Correct Responses - 4th Segment
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Experiment 2
Mind Wandering
Prop. of Probes
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Prop. of Slides w/ Notes
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Correct Responses - 4th Segment
Proportion Correct
1
0.8
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RS
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Small groups

Eur J Anaesthesiol. 2007 Dec;24(12):1008-15. Epub 2007 Jan 30.

Comparison between lecture-based approach and case/problem-based learning discussion for teaching pre-anaesthetic assessment.

Carrero E[1], Gomar C, Penzo W, Rull M.

Author information

Abstract

BACKGROUND AND OBJECTIVE: The case/problem-based learning discussion method was recently introduced into the theory-based training program for residents run by the Catalan Society of Anaesthesiology. This study was designed to assess and compare its effectiveness with that of the lecture-based approach for teaching pre-anaesthetic assessment, applying an objective tool for knowledge evaluation before and after teaching.

METHODS: A prospective randomized study of two consecutive year groups of first year anaesthesiology residents was conducted. Twenty-nine residents attended a lecture, and 25, a case/problem-based learning discussion session. Their knowledge of pre-anaesthetic assessment was assessed before and after the teaching session with tests on four different clinical cases measuring six fields: (1) 'recognizing clinical data with anaesthetic implications'; (2) 'reasoning clinical data with anaesthetic implications'; (3) 'ASA class'; (4) 'Mallampati class'; (5) 'choice of anaesthetic technique'; (6) 'reasoning choice of anaesthetic technique'.

RESULTS: Before the teaching session, the lecture group scored significantly higher on field 1 (P = 0.006). Both teaching methods improved scores on fields 1, 2 and 4. The case/problem group also improved on fields 3 and 6. After the teaching session, the field 1 score was still significantly higher in the lecture group (P = 0.005), and the field 3 score was significantly higher in the case/problem group (P = 0.044).

CONCLUSIONS: The effectiveness of lecture and case/problem-based learning discussion differed little in terms of improving participants' immediate knowledge of 'pre-anaesthetic assessment'.

Randomized Trial of Problem-Based versus Didactic Seminars for Disseminating Evidence-Based Guidelines on Asthma Management to Primary Care Physicians

Marc White, PhD, Gaëtane Michaud, MD, FRCPC, George Pachev, PhD, David Lirenman, MD, FRCPC, Anna Kolenc, and J. Mark FitzGerald, MB, FRCPC

Abstract

Introduction: *This randomized controlled trial (RCT) investigated the effectiveness of and satisfaction with small-group problem-based learning (PBL) versus a didactic lecture approach to guideline dissemination in asthma management controlling for confounders common in comparative educational interventions.*

Methods: *Sites were selected as either lecture or PBL using simple randomization. All participants were exposed to similar educational resources to ensure treatment equivalency. Instruments included standardized program/speaker evaluation forms and a validated case-based questionnaire with a visual analogue scale measuring the level of confidence of responses. The latter was presented immediately pre- and post-intervention and 3 months later. The statistician was blinded to intervention groups.*

Results: *Overall, 52 family physicians agreed to participate, 23 in the PBL sessions (mean 4.6 per group) and 29 in the didactic lecture sessions (mean 7.25). There was no significant difference between the groups with respect to the knowledge gained at each test administration. Participants rated the lecturer or facilitator equally well as having established a positive learning environment. PBL participants rated the perceived educational value of the program higher than did lecture participants (4.36 vs. 3.93; p = .04). Both groups experienced a significant increase in asthma-related knowledge post-intervention. Attrition rates for the 3-month post-test were 14% for PBL participants versus 32% for lecture-based participants.*

Discussion: *PBL was as effective in knowledge uptake and retention as lecture-based continuing medical education (CME) programs. Further study is warranted to investigate whether the assessment of higher educational value or an increase in response rate to delayed testing is replicable in other RCTs addressing common confounders and if these factors influence future CME participation, changes in physician clinical behavior, or patient health outcomes.*

Small group for clerkships

- Advantages
  - More retention than lecture
  - Requires reasoning, not just facts
- Disadvantages
  - Requires advance student preparation
  - Less efficient coverage of material
    - Important topics may be missed
  - Requires preparing cases

Web based modules

Internet-Based Learning in the Health Professions
A Meta-analysis

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Sarah Garside, MD, PhD
Denise M. Dupras, MD, PhD
Patricia J. Erwin, MLS
Victor M. Montori, MD, MSc

Context The increasing use of Internet-based learning in health professions education may be informed by a timely, comprehensive synthesis of evidence of effectiveness.

Objectives To summarize the effect of Internet-based instruction for health professions learners compared with no intervention and with non-Internet interventions.

Data Sources Systematic search of MEDLINE, Scopus, CINAHL, EMBASE, ERIC, TimeLit, Web of Science, Dissertation Abstracts, and the University of Toronto Research and Development Resource Base from 1990 through 2007.

Figure 2. Random-Effects Meta-analysis of Internet-Based Learning vs No Intervention: Knowledge Outcomes

Subgroup	No. of Interventions	Pooled Effect Size (95% CI)	*P* for Interaction
All Interventions	126	1.00 (0.90-1.10)	
Design			
Posttest-only	25	0.66 (0.53-0.78)	<.001
Pretest-posttest, 2-group	25	0.88 (0.67-1.08)	
Pretest-posttest, 1-group	76	1.18 (1.04-1.32)	
Design			
Randomized	17	0.83 (0.62-1.04)	.53
Nonrandomized 2-group	33	0.75 (0.59-0.90)	
Setting			
Classroom	35	0.91 (0.74-1.08)	.29
Practice	90	1.02 (0.91-1.13)	
Participants			
Medical students	36	0.97 (0.78-1.16)	
Physicians	58	1.02 (0.88-1.15)	
Nurses	21	0.88 (0.69-1.06)	
Other	32	1.20 (0.98-1.43)	
Interactivity			
High	79	0.98 (0.85-1.12)	.65
Low	44	1.03 (0.89-1.17)	
Practice exercises			
Present	89	0.95 (0.82-1.09)	.34
Absent	54	1.05 (0.91-1.18)	
Repetition			
Ongoing access	77	0.95 (0.82-1.07)	.19
Single instance	49	1.08 (0.93-1.23)	
Duration			
≤1 wk	48	1.00 (0.85-1.16)	.65
>1 wk	61	1.05 (0.90-1.21)	
Tutorials			
Yes	108	1.06 (0.95-1.17)	<.001
No	18	0.65 (0.51-0.80)	
Online discussion			
Present	34	1.12 (0.94-1.30)	.15
Absent	91	0.96 (0.85-1.08)	
Synchronous			
Yes	5	1.32 (0.61-2.02)	.38
No	121	0.99 (0.89-1.09)	
Outcome assessment			
Objective	110	1.01 (0.90-1.11)	.45
Subjective	16	0.91 (0.69-1.14)	
Quality Newcastle-Ottawa scale rating			
High (≥4)	20	0.71 (0.51-0.92)	.003
Low (≤3)	106	1.07 (0.96-1.18)	

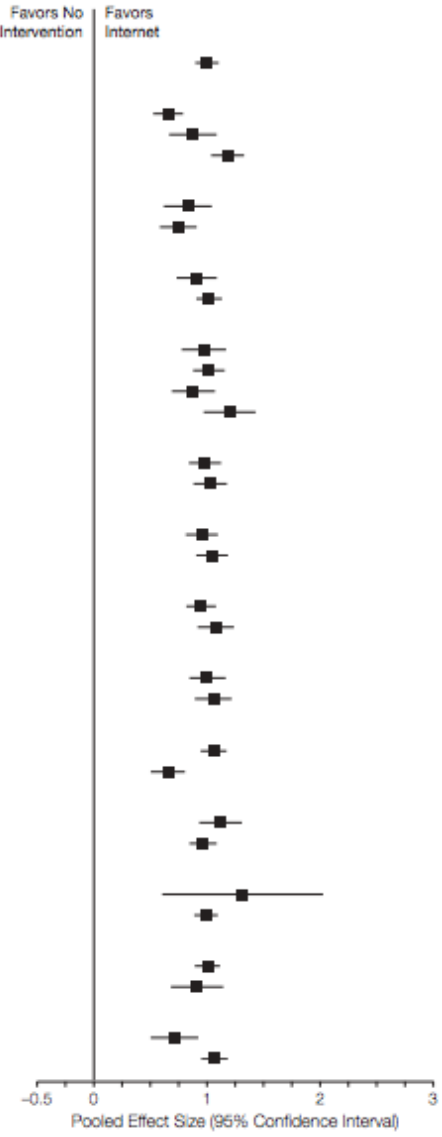
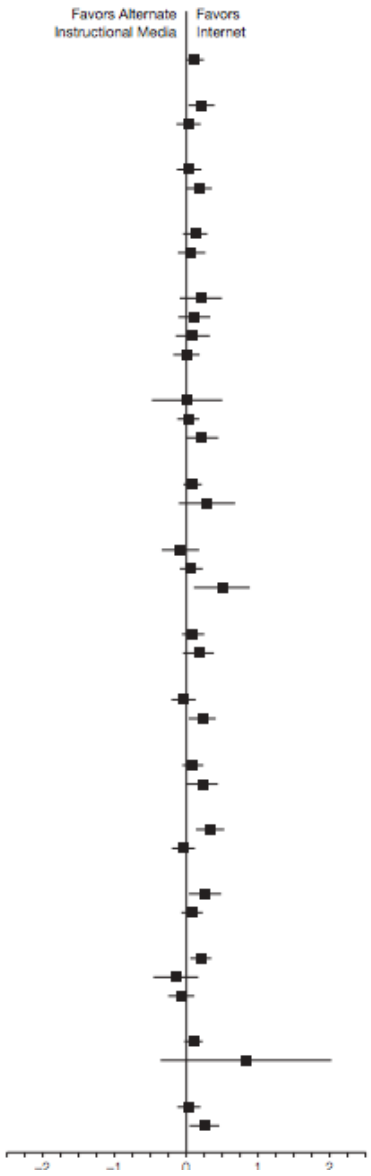


Figure 6. Random-Effects Meta-analysis of Internet-Based Learning vs Alternate Instructional Media: Knowledge Outcomes

Subgroup	No. of Interventions	Pooled Effect Size (95% CI)	*P* for Interaction
All Interventions	63	0.12 (0.003 to 0.24)	
Design			
Posttest-only	34	0.21 (0.04 to 0.39)	.14
Pretest-posttest	29	0.04 (−0.12 to 0.20)	
Randomization			
Yes	24	0.04 (−0.12 to 0.21)	.25
No	39	0.18 (0.01 to 0.35)	
Setting			
Classroom	38	0.12 (−0.04 to 0.29)	.71
Practice	24	0.08 (−0.10 to 0.26)	
Participants			
Medical students	16	0.21 (−0.08 to 0.49)	
Physicians	9	0.12 (−0.10 to 0.33)	
Nurses	17	0.09 (−0.13 to 0.32)	
Other	26	0.01 (−0.17 to 0.18)	
Interactivity			
Comparison > Internet	4	0.01 (−0.47 to 0.49)	.29
Equal	30	0.03 (−0.11 to 0.18)	
Comparison < Internet	23	0.23 (0.01 to 0.44)	
Practice exercise			
Equal	43	0.09 (−0.03 to 0.21)	.32
Comparison < Internet	14	0.29 (−0.09 to 0.67)	
Discussion			
Comparison > Internet	9	−0.08 (−0.33 to 0.17)	.03
Equal	39	0.07 (−0.08 to 0.22)	
Comparison < Internet	10	0.50 (0.12 to 0.88)	
Repetition			
Equal	40	0.10 (−0.05 to 0.24)	.57
Comparison < Internet	23	0.17 (−0.04 to 0.38)	
Duration			
≤1 wk	31	−0.04 (−0.20 to 0.12)	.03
>1 wk	28	0.23 (0.05 to 0.40)	
Internet: tutorial			
Yes	52	0.10 (−0.04 to 0.23)	.29
No	11	0.23 (0.02 to 0.43)	
Internet: online discussion			
Present	27	0.34 (0.15 to 0.52)	.002
Absent	34	−0.04 (−0.19 to 0.11)	
Internet: synchronous			
Yes	12	0.26 (0.05 to 0.48)	.17
No	51	0.09 (−0.05 to 0.23)	
Comparison intervention			
Face to face	48	0.21 (0.07 to 0.34)	.07
Paper	12	−0.14 (−0.45 to 0.16)	
Other	3	−0.07 (−0.23 to 0.10)	
Outcome assessment			
Objective	61	0.10 (−0.02 to 0.22)	.23
Subjective	2	0.83 (−0.35 to 2.01)	
Quality Newcastle-Ottawa scale rating			
High (≥4)	36	0.04 (−0.11 to 0.19)	.09
Low (≤3)	27	0.25 (0.05 to 0.46)	



Bedside teaching

Active learning on the ward: outcomes from a comparative trial with traditional methods

Hegla Melo Prado, Gilliatt Hannois Falbo, Ana Rodrigues Falbo & José Natal Figueirôa

CONTEXT Academic activity during internship is essentially practical and ward rounds are traditionally considered the cornerstone of clinical education. However, the efficacy and effectiveness of ward rounds for learning purposes have been under-investigated and it is necessary to assess alternative educational paradigms for this activity.

OBJECTIVES This study aimed to compare the educational effectiveness of ward rounds conducted with two different learning methodologies.

METHODS Student subjects were first tested on 30 true/false questions to assess their initial degree of knowledge on pneumonia and diarrhoea. Afterwards, they attended ward rounds conducted using an active and a traditional learning methodology. The participants were submitted to a second test 48 hours later in order to assess knowledge acquisition and directed learning and their opinions on the two learning methodologies used.

RESULTS Seventy-two medical students taking part in a paediatric clinic rotation were enrolled. The active methodology proved to be more effective than the traditional methodology for the three outcomes considered: knowledge acquisition (33 students [45.8%] versus 21 students [29.2%]; $p = 0.03$); self-directed learning (38 students [52.8%] versus 11 students [15.3%]; $p < 0.001$), and student opinion on the methods (61 students [84.7%] versus 38 students [52.8%]; $p < 0.001$).

CONCLUSIONS The active methodology produced better results than the traditional methodology in a ward-based context. This study seems to be valuable in terms of the new evidence it demonstrates on learning methodologies in the context of the ward round.

Simulation

American Journal of Pharmaceutical Education 2014; 78 (8) Article 153.

INSTRUCTIONAL DESIGN AND ASSESSMENT

Comparing Effectiveness of High-Fidelity Human Patient Simulation vs Case-Based Learning in Pharmacy Education

Ken Lee Chin, MPharm, BCPS, Yen Ling Yap, MScCPIPP, BCPS, Wee Leng Lee, PhD, and Yee Chang Soh, MPharm, BCPS

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Submitted October 31, 2013; accepted January 21, 2014; published October 15, 2014.

Objective. To determine whether human patient simulation (HPS) is superior to case-based learning (CBL) in teaching diabetic ketoacidosis (DKA) and thyroid storm (TS) to pharmacy students.
Design. In this cross-over, open-label, single center, randomized control trial, final-year undergraduate pharmacy students enrolled in an applied therapeutics course were randomized to HPS or CBL groups. Pretest, posttest, knowledge retention tests, and satisfaction survey were administered to students.
Assessment. One hundred seventy-four students participated in this study. The effect sizes attributable to HPS were larger than CBL in both cases. HPS groups performed significantly better in posttest and knowledge retention test compared to CBL groups pertaining to TS case ($p<0.05$). Students expressed high levels of satisfaction with HPS sessions.
Conclusion. HPS was superior to CBL in teaching DKA and TS to final-year undergraduate pharmacy students.

Keywords: human patient simulation, case based learning, diabetic ketoacidosis, thyroid storm, pharmacy education

2013; 35: e1003–e1010 MEDICAL TEACHER

WEB PAPER

High-fidelity simulation is superior to case-based discussion in teaching the management of shock

KEITH E. LITTLEWOOD, ASHLEY M. SHILLING, CHRISTOPHER J. STEMLAND, ELISABETH B. WRIGHT & MARK A. KIRK

University of Virginia, USA

Abstract

Background: Case-based discussion (CBD) is an established method for active learning in medical education. High-fidelity simulation has emerged as an important new educational technology. There is limited data from direct comparisons of these modalities.

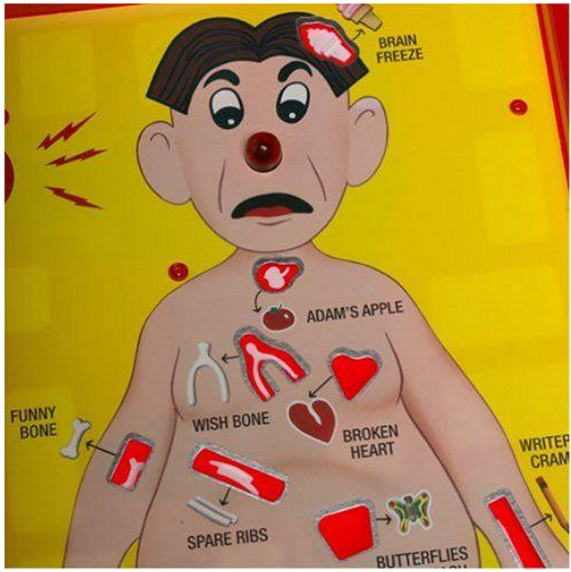
Aims: The primary purpose of this study was to compare the effectiveness of high-fidelity medical simulation with CBD in an undergraduate medical curriculum for shock.

Methods: The subjects were 85 third-year medical students in their required surgery rotation. Scheduling circumstances created two equal groups. One group managed a case of septic shock in simulation and discussed a case of cardiogenic shock, the other group discussed septic shock and experienced cardiogenic shock through simulation. Student comprehension of the assessment and management of shock was then evaluated by oral examination (OE).

Results: Examination scores were superior in all comparisons for the type of shock experienced through simulation. This was true regardless of the shock type. Scores associated with patient evaluation and invasive monitoring, however, showed no difference between groups or in crossover comparison.

Conclusions: In this study, students demonstrated better understanding of shock following simulation than after CBD. The secondary finding was the effectiveness of an OE with just-in-time deployment in curriculum assessment.

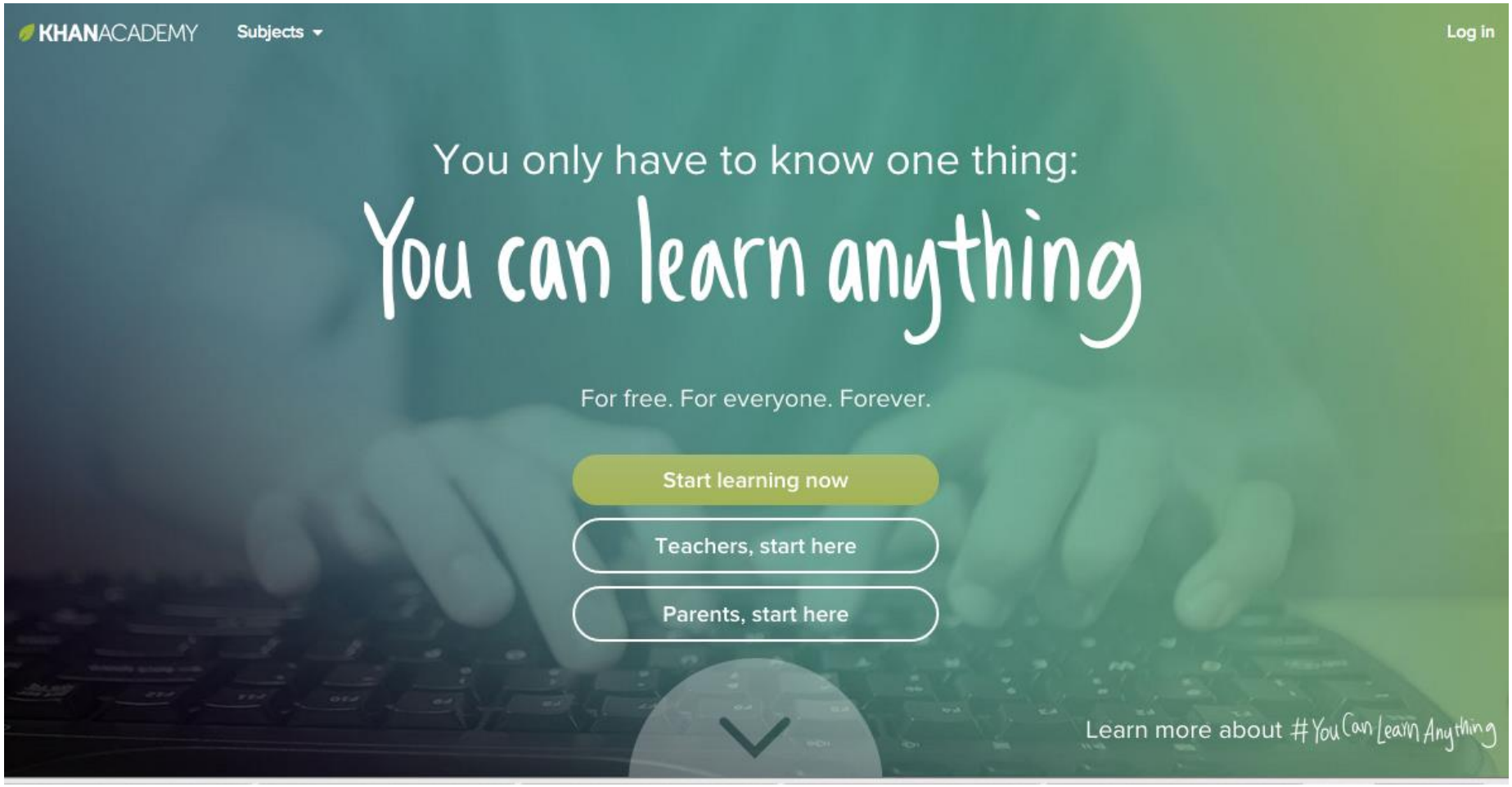
Simulation



- Advantages
  - Better for procedures
  - More reality based thinking
  - Better retention?
- Disadvantages
  - Models can be absolutely ridiculous and embarrassing
  - Better in small groups
  - Requires dedicated faculty

Simulation

- Lends itself well to neurologic emergencies and LP
- Would work well for
  - Stroke
  - Status epilepticus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Flipped Learning

The Opinion Pages

Opinionator

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FIXES

Turning Education Upside Down

By TINA ROSENBERG OCTOBER 9, 2013 11:45 AM 360 Comments

Fixes looks at solutions to social problems and why they work.

Three years ago, Clintondale High School, just north of Detroit, became a "flipped school" — one where students watch teachers' lectures at home and do what we'd otherwise call "homework" in class. Teachers record video lessons, which students watch on their smartphones, home computers or at lunch in the school's tech lab. In class, they do projects, exercises or lab experiments in small groups while the teacher circulates.

Clintondale was the first school in the United States to flip completely — all of its classes are now taught this way. Now flipped classrooms are popping up all over. Havana High School outside of Peoria, Ill., is flipping, too, after the school superintendent visited Clintondale. The principal of Clintondale says that some 200 school officials have visited.

It's well known by now that online education is booming. You can study any subject free in a MOOC — a massive open online course — from single-digit addition to the history of Chinese architecture to flight vehicle aerodynamics. Courses are being offered by

PREVIOUS POST Anger Can Be Power

NEXT POST A Cupboard of My Own

Fixes explores solutions to major social problems. Each week, it examines creative initiatives that can tell us about the difference between success and failure. It is written by David Bornstein, author of "How to Change the World," and co-founder of the Solutions Journalism Network, and Tina Rosenberg, contributing writer for The New York Times magazine and author of "Join the Club: How Peer Pressure Can Transform the World." Readers with ideas for future columns can write to the authors at fixes@nytimes.com. To receive e-mail alerts for Fixes columns, sign up at solutionsjournalism.org »
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April 10, 2015

When a General Kills a General

What led Confederate Gen. George Baylor to kill his commander on April 6, 1865?
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BECOMING A PHYSICIAN

Lecture Halls without Lectures — A Proposal for Medical Education

Charles G. Prober, M.D., and Chip Heath, Ph.D.

The last substantive reform in medical student education followed the Flexner Report, which was written in 1910. In the ensuing 100 years, the volume of medical knowledge has exploded, the complexity of the health care system has grown, pedagogical methods have evolved, and unprecedented opportunities for technological support of learners have become available. Yet students are being taught roughly the same way they were taught when the Wright brothers were tinkering at Kitty Hawk.

It's time to change the way we educate doctors. Since the hours available in a day have not increased to accommodate the expanded medical canon, we have only one realistic alternative: make better use of our students' time. We believe that medical education

PERSPECTIVE

can be improved without increasing the time it takes to earn a medical degree, if we make lessons "stickier" (more comprehensible and memorable) and embrace a learning strategy that is self-paced and mastery-based and boosts engagement.

Research has elucidated the factors that make ideas sticky.[1] For instance, messages are stickier when they are unexpected enough

the form of television shows like *House* and *Grey's Anatomy* or from the *New York Times* "Diagnosis" column. When possible, we should seize that curiosity — the perfect fuel for learning.

Messages also become stickier when they come in the form of a story that elicits emotion in readers or listeners. Patients' stories are what make the acquisition of medical knowledge compelling

ing simulation exercises. Students would welcome more opportunities for case-based, problem-based, and team-based exercises — strategies that activate prior knowledge. Teachers would be able to actually teach, rather than merely make speeches.

Digital media make video lectures relatively easy to create, offer flexibility so that students can watch at their own pace and on

Flipped Learning

- A meta-analysis published by the Department of Education “on average, students in online learning conditions performed modestly better than those receiving face-to-face instruction,”
- Larger effects if the online learning was combined with face-to-face instruction.

http://www2.ed.gov/rschstat/ eval/tech/evidence-based-practices/finalreport .pdf

Flipped Learning

- Watch a “chalk talk” or lecture prior to meeting with instructor
- Work through problems with instructor present
- Instructor gives feedback

Active learning increases student performance in science, engineering, and mathematics

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To test the hypothesis that lecturing maximizes learning and course performance, we metaanalyzed 225 studies that reported data on examination scores or failure rates when comparing student performance in undergraduate science, technology, engineering, and mathematics (STEM) courses under traditional lecturing versus active learning. The effect sizes indicate that on average, student performance on examinations and concept inventories increased by 0.47 SDs under active learning (n = 158 studies), and that the odds ratio for failing was 1.95 under traditional lecturing (n = 67 studies). These results indicate that average examination scores improved by about 6% in active learning sections, and that students in classes with traditional lecturing were 1.5 times more likely to fail than were students in classes with active learning. Heterogeneity analyses indicated that both results hold across the STEM disciplines, that active learning increases scores on concept inventories more than on course examinations, and that active learning appears effective across all class sizes—although the greatest effects are in small ($n \leq 50$) classes. Trim and fill analyses and fail-safe n calculations suggest that the results are not due to publication bias. The results also appear robust to variation in the methodological rigor of the included studies, based on the quality of controls over student quality and instructor identity. This is the largest and most comprehensive metaanalysis of undergraduate STEM education published to date. The results raise questions about the continued use of traditional lecturing as a control in research studies, and support active learning as the preferred, empirically validated teaching practice in regular classrooms.

constructivism | undergraduate education | evidence-based teaching | scientific teaching

225 studies in the published and unpublished literature. The active learning interventions varied widely in intensity and implementation, and included approaches as diverse as occasional group problem-solving, worksheets or tutorials completed during class, use of personal response systems with or without peer instruction, and studio or workshop course designs. We followed guidelines for best practice in quantitative reviews (*SI Materials and Methods*), and evaluated student performance using two outcome variables: (*i*) scores on identical or formally equivalent examinations, concept inventories, or other assessments; or (*ii*) failure rates, usually measured as the percentage of students receiving a D or F grade or withdrawing from the course in question (DFW rate).

The analysis, then, focused on two related questions. Does active learning boost examination scores? Does it lower failure rates?

Results

The overall mean effect size for performance on identical or equivalent examinations, concept inventories, and other assessments was a weighted standardized mean difference of 0.47 (Z = 9.781, $P << 0.001$)—meaning that on average, student performance increased by just under half a SD with active learning compared with lecturing. The overall mean effect size for failure rate was an odds ratio of 1.95 (Z = 10.4, $P << 0.001$). This odds ratio is equivalent to a risk ratio of 1.5, meaning that on average, students in traditional lecture courses are 1.5 times more likely to fail than students in courses with active learning. Average failure rates were 21.8% under active learning but 33.8% under traditional lecturing—a difference that represents a 55% increase (Fig. 1 and Fig. S1).

"Flipping" the Introductory Clerkship in Radiology:

Impact on Medical Student Performance and Perceptions

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Rationale and Objectives: Among methods of "blended learning" (ie, combining online modules with in-class instruction), the "flipped classroom" involves student preclass review of material while reserving class time for interactive knowledge application. We integrated blended learning methodology in a "flipped" introductory clerkship in radiology, and assessed the impact of this approach on the student educational experience (performance and perception).

Materials and Methods: In preparation for the "flipped clerkship," radiology faculty and residents created e-learning modules that were uploaded to an open-source website. The clerkship's 101 rising third-year medical students were exposed to different teaching methods during the course, such as blended learning, traditional lecture learning, and independent learning. Students completed precourse and postcourse knowledge assessments and surveys.

Results: Student knowledge improved overall as a result of taking the course. Blended learning achieved greater pretest to post-test improvement of high statistical significance (*P* value, .0060) compared to lecture learning alone. Blended learning also achieved greater pretest to post-test improvement of borderline statistical significance (*P* value, .0855) in comparison to independent learning alone. The difference in effectiveness of independent learning versus lecture learning was not statistically significant (*P* value, .2730). Student perceptions of the online modules used in blended learning portions of the course were very positive. They specifically enjoyed the self-paced interactivity and the ability to return to the modules in the future.

Conclusions: Blended learning can be successfully applied to the introductory clerkship in radiology. This teaching method offers educators an innovative and efficient approach to medical student education in radiology.

Key Words: Flipped classroom; blended learning; radiology education; clerkship; e-learning.

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INSTRUCTIONAL DESIGN AND ASSESSMENT

Vodcasts and Active-Learning Exercises in a "Flipped Classroom" Model of a Renal Pharmacotherapy Module

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Objective. To implement a "flipped classroom" model for a renal pharmacotherapy topic module and assess the impact on pharmacy students' performance and attitudes.

Design. Students viewed *vodcasts* (video podcasts) of lectures prior to the scheduled class and then discussed interactive cases of patients with end-stage renal disease in class. A process-oriented guided inquiry learning (POGIL) activity was developed and implemented that complemented, summarized, and allowed for application of the material contained in the previously viewed lectures.

Assessment. Students' performance on the final examination significantly improved compared to performance of students the previous year who completed the same module in a traditional classroom setting. Students' opinions of the POGIL activity and the flipped classroom instructional model were mostly positive.

Conclusion. Implementing a flipped classroom model to teach a renal pharmacotherapy module resulted in improved student performance and favorable student perceptions about the instructional approach. Some of the factors that may have contributed to students' improved scores included: student mediated contact with the course material prior to classes, benchmark and formative assessments administered during the module, and the interactive class activities.

Keywords: active learning, process-oriented guided inquiry learning, instructional design, pharmacotherapy, renal therapeutics

Flipped Learning for clerkships

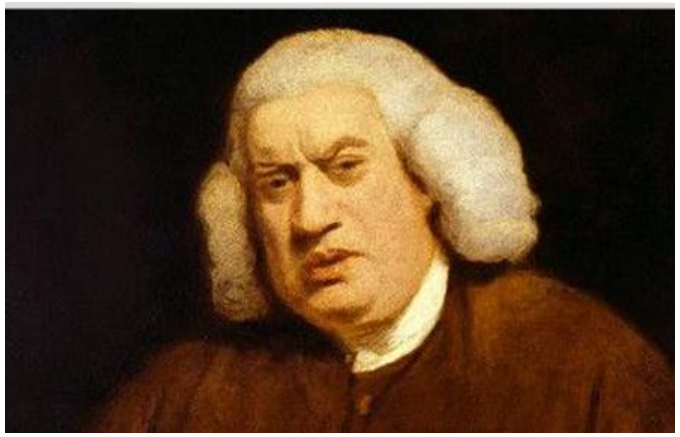
- Advantages
  - Enduring materials
  - Better retention
- Disadvantages
  - Less material covered
  - Requires material preparation and case preparation

Flipped Mastery

- Flipped classroom but with individual emphasis
- Modules at own pace
- Individual problem solving with guidance

Samuel Johnson

The True Art of Memory is the Art of Attention



No substitute