Back to the Future: 21st Century Instruction Innovations in Higher Education

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Reasons for rethinking college instruction
Expectations

• Knowledge-based economy

• Technology-enhanced manufacturing

• Credential for professional success

• Energy sector leading US job growth
  ▶ 75% of top new jobs in sector in engineering (USA Today, 10/1/12)
Opportunity…?
Higher Education Inflation

**Figure 2**: Higher education inflation (2001–2010)

Average tuition as % of median earnings

<table>
<thead>
<tr>
<th>Year</th>
<th>Tuition as % of Median Earnings</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>23.2</td>
</tr>
<tr>
<td>2002</td>
<td>26.9</td>
</tr>
<tr>
<td>2003</td>
<td>28.6</td>
</tr>
<tr>
<td>2004</td>
<td>30.3</td>
</tr>
<tr>
<td>2005</td>
<td>31.5</td>
</tr>
<tr>
<td>2006</td>
<td>31.5</td>
</tr>
<tr>
<td>2007</td>
<td>29.7</td>
</tr>
<tr>
<td>2008</td>
<td>33.2</td>
</tr>
<tr>
<td>2009</td>
<td>35.8</td>
</tr>
<tr>
<td>2010</td>
<td>37.7</td>
</tr>
</tbody>
</table>

Median annual earnings:

- 2001: $68,400
- 2002: $61,000
- 2003: $59,500
- 2004: $58,900
- 2005: $58,700
- 2006: $59,700
- 2007: $65,400
- 2008: $59,000
- 2009: $56,900
- 2010: $55,738

Sources: US Bureau of Labor statistics (BLS); IPEDS; Bain & Company and Sterling Partners analysis
Higher Education Inflation

Figure 4: Projected tuition levels based on historical trends

Indexed to 100-year 1983

HEPI > CPI

College tuition

Medical care

Housing

CPI

1x CPI

3.2x CPI

6.5x CPI

Year

1983

2012

2030

Note: Housing costs—owner’s equivalent rent; all metrics based on US city averages and are seasonally adjusted; forecast based on compounded annual growth 1983–2010
Sources: BLS; Bain & Company and Sterling Partners analysis

Source: The financially sustainable university, Bain & Company, July 6, 2012
Reasons for rethinking college instruction

Competition, in-comes and out-goes
Competition

• Commercial Publishers
  ▪ Wiley, Pearson, McGraw-Hill, etc
  ▪ Instructional content, learning practice, assessment
    ♦ On-line, interactive ebooks (underlines, tutorials, quizzes)
    ♦ Practice, HW, and exam problem banks
    ♦ Multi-media lecturettes

• MOOCs
  ▪ edX (www.edx.org)
  ▪ Coursera (www.coursera.org)
  ▪ Udacity (www.udacity.com)
  ▪ Udemy (www.udemy.com)
  ▪ Khan Academy (www.khanacademy.org)
“[student achievement] is not accelerating fast enough for our nation’s children to compete in the knowledge economy of the 21st century.” [SoE A. Duncan, 2012, Referencing US DoE NAEP* measurement of weak growth in math/science]

- Only 45% US high school grads in 2011 ready for college level math, 30% in science [ACT scores] = growth in college remedial instruction
- Pipeline interest gap (especially women and minorities)

*--National Assessment of Educational Progress (8th graders) measurement of weak growth in math/science “Student achievement...
### Out-going

- Increased need for STEM graduates
- Increased need for STEM literacy in college grads as US citizens (infrastructure investment decisions, economics, science, technology)

**NAE Grand Challenges**  
http://www.engineeringchallenges.org/

<table>
<thead>
<tr>
<th>Make solar energy economical</th>
<th>Provide energy from fusion</th>
<th>Provide access to clean water</th>
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</thead>
<tbody>
<tr>
<td>Reverse-engineer the brain</td>
<td>Advance personalized learning</td>
<td>Restore and improve urban infrastructure</td>
</tr>
<tr>
<td>Engineer the tools of scientific discovery</td>
<td>Develop carbon sequestration methods</td>
<td>Engineer better medicines</td>
</tr>
<tr>
<td>Advance health informatics</td>
<td>Prevent (nuclear) terror</td>
<td>Secure cyberspace</td>
</tr>
<tr>
<td>Enhance virtual reality</td>
<td>Manage the nitrogen cycle</td>
<td></td>
</tr>
</tbody>
</table>
Out-going

% US S&E degrees awarded (BS & MS)

Why change college instruction?

- IF it improves student learning
- IF it reduces costs
- IF it increases retention and graduation of STEM students
- IF it increases instructor enjoyment
Why *not* change college instruction?

- IF it diminishes student learning
- IF it increases costs
- IF it reduces retention and graduation of STEM students
- IF it decreases instructor enjoyment
- Base decisions on data and research-verified best practices
Some Critical Reflections on College Instruction
The Amazing Kreskin

- Word Association: Classroom

- Evolution of the classroom:

UW-Madison Lecture Hall, 1949

UW-Madison Lecture Hall, 2011
Origins of this choice?

- When was this choice made for universities?
  - Answer: first universities (11th century)
    - Pope Gregory VII, 1079, cathedral schools, educate clergy, secular topics
      - Literacy (Latin), literature, rhetoric, logic, arithmetic, geometry, astronomy, music
      - Managing church property, calculating calendars, leading worship
- Based on learning in Catholic monasteries
- Books rare (Guttenberg ~ 1440)
- Leader reads verbatim, students copy = “text-books”
- Auditorium/sanctuary design + many students = many copies

Pedagogy
“I talk and demonstrate.”
“You listen, record, and respond if prompted”
Features of 11th Century Universitas

- Campus, tuition, classes, courses, lectures, notes, margin(alia), footnote
- Faculty, students, administration, chancellor, provost, dean, professor, associate professor, assistant (professor), sophomore, junior, senior, instructors
- Fees, assignments, laboratory, dormitory, requirements, prerequisites, examinations, texts, grades
- Convocation, graduation, commencement, procession, diploma, alumni association, donations
- University
- All Latin derivatives, little change from medieval origins
- All 11th-12th century origin
Traditional Classroom Learning

- Lecture + HW + testing
- Pros
  - Scalable
  - Efficient (low expert-to-novice ratios)
  - Works
- Cons
  - One size and pace for all
  - Long, continuous lectures inefficient for learning
    (Small “chunks” of content with frequent “testing” better)
  - Limited feedback (personnel budgets)
  - Learning occurs outside lecture w/o expert coaches
    - Less efficient (delayed feedback)
    - Misconceptions ingrained rather than immediately corrected
Underlying theory of learning

- Deliver identical content, HW, exams to all
- Learners sort themselves by their capacity and effort into a “natural bell curve” of capable learners and incapable or unwilling learners
- Analogy: health-care (goal: everyone as healthy as possible) with same medicines and treatments prescribed to all...blame “natural order or patient laziness” for poor outcomes even if patient needed a different treatment or medicine.

Have high cholesterol

doctor

Lipitor

Cholesterol fine, needs stent

Top athletes ready for Olympic training

Cholesterol fine, needs exercise
Research-based understanding of learning
Mechanics of human memory

- Understanding (vs rote memorization) requires *doing stuff* with knowledge
  - not just listening and recording.
  - *More* doing = *More* understanding
- Rudiments practiced = routine not conscious,
  - reduces cognitive load to learn new, higher level content

https://sites.google.com/a/uwlax.edu/exploring-how-students-learn/
http://brainconnection.positscience.com/topics/?main=fa/working-memory4
http://www.screencast.com/users/Teach-Learn_0/folders/Jing/media/cf63a16a-57f6-4963-9928-55a290ccb2bb
http://www.screencast.com/users/Teach-Learn_0/folders/Jing/media/20d6b535-225e-4a0d-86c5-7def169cf6af
21st century, research-based pedagogy

- “Doing” with content rather than passive absorption
  - Processing, analyzing, applying, linking to previous knowledge in chunks
- Frequent, immediate, individualized feedback and “unlimited” practice
  - Immediately graded (feedback) homeworks and assessments
  - Unlimited practice exercise banks
  - Instructors = personal-coaches-in-midst rather than sages-on-stage
- Peer-collaboration
- Personalized learning and instruction
  - Self-pacing
  - Students get their individual questions answered, not “one-size-fits-all”
  - Personalized and detailed data tracking of student engagement & “sticking” points

Challenge

Resources!

• Personnel “bandwidth”
  ▪ Instructors, TAs
  ▪ Grader hours

• Classroom Restrictions
  ▪ Great for lecturing
  ▪ Poor for anything else
Enablers

Pedagogy Research

Instructional Technologies (IT)

21st Century Classroom Design

http://scaleup.ncsu.edu/
http://en.wikipedia.org/wiki/SCALE-UP
http://www.emporium.vt.edu/
http://www.educause.edu/LearningSpaces
http://www.thenCat.org
http://www.wisCEL.wisc.edu
http://www.studioteaching.org/
http://discovery.wisc.edu/home/discovery/recorded-lectures/carl-wieman-32012/
Does the space matter?

- U. Minn., intro (fresh/soph) biology
- Active learning pedagogies employed
- "Expected" grade based upon ACT scores, a historically accurate predictor of freshman/sophomore grades in college.

**Yes!**

<table>
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<th>Expected versus Actual Course Grades in Total Points, by Section (Biology)</th>
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<tr>
<td>502.19</td>
</tr>
<tr>
<td>484.39</td>
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**Fixed Effects Model: Traditional Classroom**

- Lecture
- Group Activity
- Discussion
- At Podium
- On-Task Behavior

**Fixed Effects Model: (ALC)**

- Lecture
- Group Activity
- Discussion
- At Podium
- On-Task Behavior

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The graph on the left shows a comparison of expected versus actual course grades in total points, by section (Biology). The expected grade is 502.19, while the actual grade is 499.33, both above the historically accurate predictor of 484.39. This suggests that the space matters.

The diagrams illustrate the fixed effects model for traditional classroom vs. (ALC) conditions. The traditional classroom includes lecture, group activity, discussion, at podium, and on-task behavior, with significant effects denoted by *** and **. In contrast, the (ALC) model includes lecture, group activity, discussion, at podium, and consulting, with significant effects also marked by *** and **. The fixed effects model isolates these interactions to understand better.
Best Practices for Learning Spaces

- Large capacity room
- Extended hours access (up to 24/7)
- Furniture configuration supports P2P collaboration
- “Many-coaches-in-midst” vs. “sage-on-stage”
- Flexible usage hours
- Furniture
  - Easy mobility
  - Ample “surface space”
- IT hardware and software for unlimited practice problems with immediate feedback, assessment-when-ready
- Self-paced, unlimited practice opportunity
- Decouple course credit from rigid semester basis …?
Addressing the resource bandwidth

• Leverage peer-peer teaching!

• “Expert lecturers” → tutors, coaches
  - Instructor
  - TA’s → UG student assistants
  - Peers!

• IT
  - infinite practice exercise banks
  - immediate feedback
  - individualized diagnostic and intervention potential
  - Suppresses cheating, reduces proctor needs
Wisconsin Collaboratory for Enhanced Learning

WisCEL
UNIVERSITY OF WISCONSIN–MADISON

John H. Booske, Director
Suzanne Smith, Associate Director
Timeline and Status

- Design effort started 2010 (conceptualization: 2009-10)
- Libraries: College (3rd floor, east) and Wendt (4th floor)
- Costs: space renovations & startup (one time), operations
- Pilot sections: Spring 2011, Fall 2011
- First full scale instruction: Spring 2012
- Fall-Spring 2012-13
  - 77 sections (24 distinct courses)
  - 61 instructors
  - 3 Colleges (L&S, Engr, Bus)
  - > 2700 enrolled students
Learning space features

- Lounge space
- 6-student pods w/ terminals
- 30
- Sign-in and help desk
- Break out or mini-lecture room
- Instructor office
- TA office
- Testing/quiet space
Bringing formal learning to informal spaces

Wendt Commons
WisCEL Center
Moving towards 24 x 7
Supporting new instruction & learning approaches

- Peer collaboration
  - Spontaneous
  - Orchestrated
- Instructor-as-coach models
- Flipped classroom
- Self-pacing opportunities
- Frequent and immediate learning progress feedback
- Increased instructor time with students
- International connectivity
Features of the experience

- Substantial up front cost, reduced operating costs/time
- Students fully engaged *100% of the class time* with learning
  - More time-on-task
  - Frequent & immediate feedback
  - *Prefer* 75 min over 50 min blocks of time!
- Talking to peers spontaneously, getting unstuck
- Agilely interacting with different peers depending on who can best answer the question (instructor/TA last resort, not first)
- Glass walls add value
  - Sound, activity barrier
  - Allow instructors to proctor exam taking in side room while coaching in active learning lab
- Instructor experience: *FUN!*
  - Finding out what students stuck on
  - Success for all (most)
  - Interactions richer, deeper
  - No office hours needed!
  - No lecture prep!
  - No homework set design, no HW grading
Promising Results

ECE 230: intro electric circuits analysis

- Class average score increased from 77 – 83.5% !
- 20% of students moved from < 80% to > 80% !
- Increasing subject mastery = success for all!
Much of this is not “new”

- Socratic model predates Gregorian universitas lecture model
- 1-to-1, 1-to-several, P2P, “doing” vs passive listening
  - Predate lecture-HW-exam model
  - Discipleships
  - Apprenticeships
- Learning commons spaces predate lecture classrooms
- Common K-5 model! Effective learning can be fun
- Individualized instruction
- Decentralized classroom designs = Back to the Future

- What’s changed?
  - Scalability via IT
  - Scientific basis for understanding learning process
Why change college instruction?

- **IF it improves student learning**
  - ✓ Short term gains
    - ▪ Longitudinal impact of learning gains?
- **IF it reduces costs**
  - ▪ Instructional personnel
    - ✓ Time commitment for instructors
    - ✓ SA's vs TA's
  - ▪ IT
    - ◇ Investment in IT, access to online regardless
    - ◇ Cost differentiated by where/how we deploy/configure/use it?
    - ✓ Space usage (24 x 7, leverage library spaces)
- **IF it increases retention and graduation of STEM students**
  - ▪ TBD
  - ✓ IF it increases instructor enjoyment
Summary and conclusions

• Changing instruction
  ▪ Strong driving forces
  ▪ Train leaving (left) station

• Best learning is individualized just like healthcare

• IT
  ▪ Game changer tool
  ▪ Not replacement for expert personalized human coaching

• Physical spaces matter
WisCEL

Combining pedagogies, learning space design and instructional technology deployment to personalize and humanize learning, improve learning outcomes and prepare students for the 21st century knowledge economy

- Preliminary results exciting and consistent with other research
- New challenges!
  - Computerized testing facilities
  - Capacity for demand (instructors, students)
  - Self-pacing challenges
    - Semester-based timetables
    - 3-credit bundling of learning
  - Student and instructor expectations for “always working IT”

Visit our Website: http://www.wiscel.wisc.edu/