Past and Future Research in Online Education

Richard E. Clark

clark@usc.edu

Center for Cognitive Technology www.cogtech.usc.edu

Rossier School of Education and Keck School of Medicine

University of Southern California

American Educational Research Association

Annual Convention, Wednesday April 15, 2009

SIG - Online Teaching and Learning

USC

3 Topics

1. Past: Research in online instruction and related questions
2. Present: Cognitive architecture, instruction and online learning
3. Future: The next generation of evidence-based instructional design for online learning

Online Learning Studies

- OTBE: Technology-based online learning instruction is as effective as classroom-based, teacher-led instruction.
  - 6 meta-analyses in 12 years reached similar conclusions.
  - All support the "methods not media" argument.
  - Debate about which methods are most effective for novices and more advanced students (direct or discovery learning).
- Online learning is not necessarily more motivating and can mislead students into investing less mental effort to learn.
  - Saloman (1983) study replicated many times.
  - Need to rethink theories and outcomes in motivational research.

USC

Online Learning Studies

- In past quarter century, the best instruction resulted on only a 20% increase in learning (ES in meta analyses).
- 50% of students are wrong when asked what and how much they learned from instruction.
- 30% of students like instruction from which they learn the least.
- 1/3 of feedback strategies damage learning, another 1/3 have no impact.
- Adjusting teaching for different learning styles does NOT increase learning.

USC

Online Learning Studies

- Requiring students to discover what they need to learn (e.g. by solving problems to learn the solution) results in about 45% less learning than demonstrating how to solve problems. (Sweller, Kirschner & Clark, 2006)
  - Caused by discovery aspects of instruction that overload working memory for lower prior knowledge students.
  - Cowen (2001) studies changed working memory limit from 7 +/- 2 to 4 +/- 1 and discovery overloads working memory.

USC

Online Learning Studies

- Online instruction presenting immersive simulations and serious games are significantly less effective and more expensive for novices than less distracting displays.
  - Reason is discovery instruction and distracting visual and sound elements (O'Neil et al ,2006; Clark, 2008)
  - Cognitive Load Theory (John Sweller; Rich Mayer)
- 11 Principles from CLT for Online Learning by novices
  - Multiple studies with large effect sizes (Mayer, 2009)

USC

Online Learning Studies

11 Principles (Students learn better when …)	ES	Tests
1. Coherence: Eliminate extraneous visuals and sound	.97	14 of 14
2. Signaling: Highlight essential information	.52	5 of 6
3. Redundancy: Graphics and narration – avoid text	.72	5 of 5
4. Visual Contiguity: Text next to graphic it describes	1.19	5 of 5
5. Time Contiguity: Simultaneous words and pictures	1.31	5 of 5
6. Pacing: Learner pacing better than system pacing	.98	3 of 3
7. Pre-training: Advance learning of conceptual information	.85	5 of 5
8. Modality: Graphics + Narration not text + animation	1.02	7 of 17
9. Multimedia: Words + Pictures - not words alone	1.39	11 of 11
10. Personalization: Conversational style - not formal	1.11	11 of 11
11. Voice: Human voice better than machine voice	.78	3 of 3

USC

II. Current Issues in Online Learning

- Our cognitive architecture makes learning (very) difficult
  - Limits conscious processing to 3 or 4 chunks
  - Requires mostly automated and non-conscious cognitive processing to perform complex tasks
  - Protects us from self-destructive learning?
- On the positive side, our architecture permits us to learn and use two very different kinds of knowledge.

USC

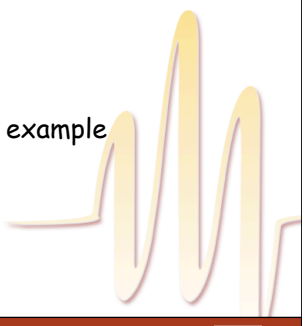
We have two knowledge systems

(1) What and Why (declarative) knowledge

- Conscious, easier to learn and forget, can be wrong.
- Takes up "thinking space" – 3 – 4 item limit.
- Helps us imagine and handle novelty.
- Only 10% - 30 % of adult knowledge.

Three Types:

- Concepts: What is it? Definition and one example
- Processes: How does it work? (in stages)
- Principles: Cause (s) and Effect (s)



USC

We have two knowledge systems

(2) When and How (procedural) knowledge

- Non-conscious, difficult to learn or change.
- Avoid limits on working memory = automated
- About 70% - 90% of adult knowledge.

TWO TYPES:

- Classification: This is an example of X
- Change: This is the way to solve/change x to y

USC

Problems caused by knowledge systems

- We are unaware of procedural knowledge and so we emphasize declarative knowledge during instruction.
  - People do not learn how to classify or solve.
  - They learn 20% and the rest by trial and error.
- Subject matter experts and teachers are only 30% aware of their own mental strategies
  - Instructors only provide 30% of "how" but believe they've given 100%.
  - Most teachers and instructional designers underestimate the difficulty students experience in trying to learn.

USC

Problems caused by knowledge systems

- Instructional design models (e.g. ADDIE) are vague about how to sequence and design lessons and tests.
- Instruction is seldom sequenced as applied.
- Students are generally taught to memorize the definitions of concepts or processes and then expected to classify examples or solve problems.
- We resist providing complete demonstrations of how to solve problems for fear that student knowledge will be "robotic".

USC

Overcoming Architecture: Capturing Unconscious Expertise

The new **Cognitive Task Analysis**

- Interview captures unconscious expertise
- Increase to 80% accuracy (Chao, 94; Clark, 2006)
- When used in teaching, performance impact doubles
  (from 20% to 45% - Lee, 2004)
- Recent evidence that Online dropout decreases
- Results can be commoditized by business and colleges

USC

Capturing Expertise

Two Examples

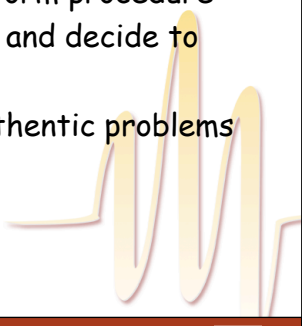
- Neonatal nurses and premature babies with infections (Hoffman, 1998)
  - 50% increase in survival rate
  - Textbooks changed
- Surgery Residents (Velmahos et al, 2002)
  - 50% decrease in decision errors
  - 40% more learning than expert tutoring
  - 25% faster performance

USC

Design training for cognitive architecture

Use 5 Guided Experiential Learning (GEL) elements:

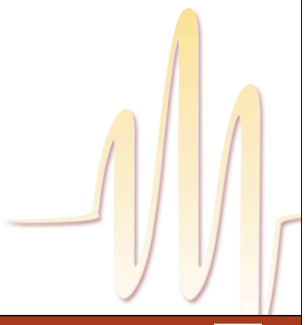
1. Objectives that will close performance gaps
2. Draw on prior knowledge with analogies
3. Conceptual knowledge necessary to perform procedure
4. Demonstrate why, when, and how to act and decide to accomplish goals
5. Give part and whole task practice on authentic problems with strategy feedback



USC

CAUTION

Reverse Expertise Principle: The above principles and design suggestions necessary for novice to intermediate level learners but are not necessary for experts who are learning new information in their area of expertise.



USC

Motivation in Online Learning

- Motivation accounts for between 25 – 35% of learning.
- Motivation theories are fragmented, ideological and largely based on questionable self reporting.
- Best bet is Pintrich & Schunks text and expectancy-control theory.
- All motivation problems are assumed to be caused by a belief that we are denied adequate control and so cannot be effective.
- Different individuals and cultures have very different ideas about the definition of "control" and "effectiveness".

USC

The Big Three Motivation Problems

1. Not starting something new

   Intending but not acting – rationalizing, complaining, procrastinating

2. Not persisting

   Avoiding, arguing, doing something less important, procrastinating

3. Not working smart enough

   Using familiar strategies when new ideas are required and not taking responsibility for lack of achievement

USC

Causes of Motivation Problems

Control beliefs are based on three factors

1. The VALUE of a learning task
   - If no value, students avoids starting or persisting
2. Our sense of CONFIDENCE (self efficacy)
   - If no confidence, we do not start, persist and/or work smart
3. Our EMOTIONAL state
   - Strong negative emotion causes us to avoid starting, persisting and working smart

USC

Diagnosing Online Motivation Problems

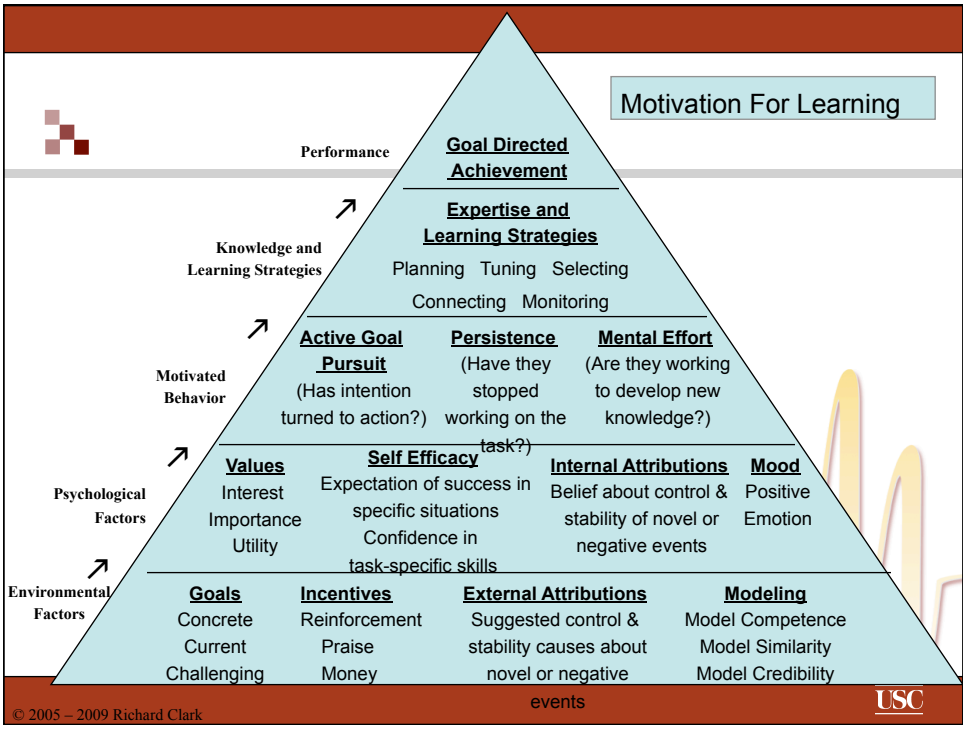
- Not starting by a deadline
  - Use system data: Username and login times
- Not persisting
  - Establish milestone schedules for completing lessons
  - Use system time stamps to capture data i.e. when an exercise or test following a lesson has been started – and finished.
- Not working smart
  - Capture length of time spent on each instructional activity.
  - Questionnaires to capture beliefs and values.
  - Use all practice and assessment scores to capture progress.

USC

Building Value into Online Learning

- Describe benefits and risks for courses and lessons – Target age-appropriate values – do not overstate.
- Require active persistence with frequent scheduled assignments with deadlines.
- Design and collect data on synchronous (instructor/student) and asynchronous (computer) interactions to check persistence.
  - When problems occur – give questionnaire to determine causes.
  - Check relative value (and ask what would increase value); mood (angry/depressed?) and confidence (over/under)

USC



USC

References - Evidence

Evidence for all claims made in this presentation and a review of the research on CTA can be found at: www.cogtech.usc.edu - Access the "Publications" tab and read these two chapters:

- Clark, R. E., Feldon, D., vanMerrienboer, J., Yates, K, and Early, S. (2007). **Cognitive Task Analysis**. In Spector, J. M., Merrill, M. D., van Merrienboer. J. J. G., & Driscoll, M. P. (Eds.) *Handbook of Research on Educational Communications and Technology* (3rd ed.). Mahwah, NJ: Lawrence Erlbaum Associates.
- Clark, R. E., Yates, K., Early, S. & Moulton, K. (In Press). **An Analysis of the Failure of Electronic Media and Discovery-based learning: Evidence for the performance benefits of Guided Training Methods**. In Silber, K. H. & Foshay, R. (Eds.). *Handbook of Training and Improving Workplace Performance, Volume I: Instructional Design and Training Delivery*. Somerset, NJ: Wiley.

USC

Questions/Comments?

USC