Tranforming Education:
The Grand Challenge of a Knowledge-based, Innovation-Centered World

Chris Dede
Harvard University
Chris_Dede@harvard.edu
http://isites.harvard.edu/chris_dede

The Core Challenge We Face

- Shifts in the knowledge and skills society values
- Development of new methods of teaching and learning
- Changes in the characteristics of learners

Emerging information technologies are reshaping each of these—and changing how we learn and know.
Today's children can meet future challenges if their schooling and informal learning activities prepare them for adult roles as citizens, employees, managers, parents, volunteers, and entrepreneurs.
**Dimensions of Advanced Knowledge and Skills**

<table>
<thead>
<tr>
<th>Cognitive Outcomes</th>
<th>Intrapersonal Outcomes</th>
<th>Interpersonal Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive processes and strategies</td>
<td>Intellectual Openness</td>
<td>Teamwork and Collaboration</td>
</tr>
<tr>
<td>Knowledge</td>
<td>Work Ethic and Conscientiousness</td>
<td>Leadership</td>
</tr>
<tr>
<td>Creativity</td>
<td>Positive Core Self-Evaluation</td>
<td>Communication</td>
</tr>
<tr>
<td>Critical Thinking</td>
<td>Metacognition</td>
<td>Responsibility</td>
</tr>
<tr>
<td>Information Literacy</td>
<td>Flexibility</td>
<td>Conflict Resolution</td>
</tr>
<tr>
<td>Reasoning</td>
<td>Initiative</td>
<td></td>
</tr>
<tr>
<td>Innovation</td>
<td>Appreciation of Diversity</td>
<td></td>
</tr>
</tbody>
</table>

**3 Contexts for Learning**

- **Classrooms**
  - Presentation and discussion

- **Richly Contextualized Real World Learning**
  - Internships, apprenticeships

- **Learning Communities**
  - Interpretation and transfer
    - face to face, virtual, blended
National Research Council (2000)

New evidence from many branches of science has significantly added to our understanding of what it means to know, from the neural processes that occur during learning to the influence of culture on what people see and absorb.

4 Dimensions of Design

- **Learner-centered:** preconceptions, needs, preferences, interests.
- **Knowledge/skills-centered:** what is to be taught, why it is taught, and what mastery looks like.
- **Assessment-centered:** diagnostic measures of learners’ thinking and doing that are formative for further instruction and learning.
- **Community-centered:** encouraging a culture of collaborative questioning, respect, and risk taking [a context for the other three]
A Grand Challenge

3 times 4 = 19

3 contexts
4 dimensions of learning
19 types of knowledge and skills
cognitive, intrapersonal, interpersonal

Personalized Learning

…ensuring that a student’s educational path, curriculum, instruction, and schedule be personalized to meet her unique needs, inside and outside of school… through a wide range of resources and strategies appropriate for her learning style, abilities, and interests, as well as social, emotional, and physical situation.
Next-Generation Learning

Personalized

Life-Wide

Transformational

Interfaces for
“Immersive” Learning

- **Multi-User Virtual Environments:** Immersion in virtual contexts with digital artifacts and avatar-based identities
- **Virtual Reality**
  Full sensory immersion via head-mounted displays or CAVES
- **Ubiquitous Computing:**
  Wearable wireless devices coupled to smart objects for “augmented reality”

January 2009 issue of *Science*
Module 1: Pond Ecosystem

Modeled after Black’s Nook Pond in Cambridge, MA

http://ecomuve.gse.harvard.edu

<table>
<thead>
<tr>
<th>Naturalist</th>
<th>Microscopic Specialist</th>
<th>Water Chemist</th>
<th>Private Investigator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observe pond for similarities to EcoMUVE</td>
<td>Observe duckweed</td>
<td>Observe pond for similarities to EcoMUVE</td>
<td>Talk to virtual golfer</td>
</tr>
<tr>
<td>Observe virtual fish</td>
<td>View 3D model of duck</td>
<td>Measure dissolved oxygen</td>
<td>Observe storm water pipe overlay</td>
</tr>
<tr>
<td>Calculate fish population size</td>
<td>Video of starch decomposition by bacteria</td>
<td>Video of how oxygen dissolves in water</td>
<td>Find inlet and outlet of pond</td>
</tr>
<tr>
<td>Collect macroinvertebrates</td>
<td>Observe virtual bacteria</td>
<td>Measure water temperature</td>
<td>Talk to young girl about what a watershed is</td>
</tr>
<tr>
<td>ID macroinverts and calculate tolerance index</td>
<td>Measure pH</td>
<td>Measure phosphates</td>
<td>Measure turbidity</td>
</tr>
</tbody>
</table>

Work together to create video that summarizes the health of the pond based on whole team’s observations
Actions as Basis for Assessments

Logfiles Indicate with Timestamps

- Where students went
- With whom they communicated and what they said
- What artifacts they activated
- What databases they viewed
- What data they gathered using virtual scientific instruments
- What screenshots and notations they placed in team-based virtual notebooks
- What hints they accessed
- What mathematical representations they created

Logfiles: Events, Chats, Notebooks...

Database of Logdata - Track students' behaviors: where they went, what data they collected, path to solve problem
Match In-world Interactions to Rubrics

<table>
<thead>
<tr>
<th>Question</th>
<th>Skill</th>
<th>observable variable</th>
<th>Evidence</th>
<th>score</th>
</tr>
</thead>
<tbody>
<tr>
<td>question 1 final</td>
<td>Claim/Reasoning</td>
<td>20</td>
<td>claim pollution</td>
<td>0</td>
</tr>
<tr>
<td>question 2 final</td>
<td>Evidence</td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>add item 21 Evidence</td>
<td>31</td>
<td>dead bee</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>add item 21 Evidence</td>
<td>4</td>
<td>green bee</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>add item 21 Evidence</td>
<td>9</td>
<td>green larvae</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>add item 21 Evidence</td>
<td>10</td>
<td>lab nectar</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>add item 21 Evidence</td>
<td>12</td>
<td>green nectar</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>question 3 final</td>
<td>Experiment: Water</td>
<td>22</td>
<td>green nectar</td>
<td>5</td>
</tr>
<tr>
<td>question 3 final</td>
<td>Experiment: Water</td>
<td>10</td>
<td>lab nectar</td>
<td>2</td>
</tr>
<tr>
<td>question 4 final</td>
<td>Experiment: DNA</td>
<td>13</td>
<td>no DNA results</td>
<td>5</td>
</tr>
<tr>
<td>question 4 final</td>
<td>Experiment: DNA</td>
<td>4</td>
<td>green bee</td>
<td>2</td>
</tr>
<tr>
<td>question 4 final</td>
<td>Experiment: DNA</td>
<td>1</td>
<td>six bee</td>
<td>2</td>
</tr>
<tr>
<td>question 5 final</td>
<td>Experiment: Blood</td>
<td>24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>question 5 final</td>
<td>Experiment: Blood</td>
<td>4</td>
<td>green bee</td>
<td>5</td>
</tr>
<tr>
<td>question 5 final</td>
<td>All Data: Evidence Tepope</td>
<td>6</td>
<td>green larvae</td>
<td>5</td>
</tr>
<tr>
<td>question 6 final</td>
<td>All Data: Evidence Frogs</td>
<td>4</td>
<td>green bee</td>
<td>5</td>
</tr>
<tr>
<td>question 6 final</td>
<td>All Data: Experiment: Wet</td>
<td>13</td>
<td>green nectar</td>
<td>5</td>
</tr>
<tr>
<td>question 9 final</td>
<td>All Data: Experiment: CM</td>
<td>60</td>
<td>no DNA results</td>
<td>5</td>
</tr>
<tr>
<td>question 9 final</td>
<td>All Data: Experiment: CM</td>
<td>4</td>
<td>green bee</td>
<td>5</td>
</tr>
<tr>
<td>question 9 final</td>
<td>All Data: Experiment: CM</td>
<td>1</td>
<td>six bee</td>
<td>2</td>
</tr>
<tr>
<td>question 10 final</td>
<td>All Data: Experiment: Blo</td>
<td>12</td>
<td>six bee</td>
<td>2</td>
</tr>
<tr>
<td>question 10 final</td>
<td>All Data: Experiment: Blo</td>
<td>4</td>
<td>green bee</td>
<td>5</td>
</tr>
</tbody>
</table>

Formative/Diagnostic

- Formative diagnostic assessment provides *more leverage for improvement* than summative measures
- Formative diagnostic assessment is *richer and more accurate* than summative measures
- Potentially, formative diagnostic assessment could *substitute for* summative measures.
What Can We Inculcate and Assess?

- Inquiry skills?
- Collaboration?
- Leadership?
- Self-efficacy?
- Metacognition?

Next-Generation Learning

- Personalized
- Life-Wide
- Transformational

Plan for transforming education with technology in response to new understandings about learning and the urgent need to remain competitive in a global economy.

The Plan Treats Learning as Life-long and Life-wide

*Image of a diagram showing life-long and life-wide learning.*

LIFE Center, 2007
Community: Social Media

- **Sharing**
  - Social bookmarking
  - Photo–video sharing
  - Social networking
  - Writers’ workshops and fan fiction
- **Thinking**
  - Blogs
  - Podcasts
  - Online discussion forums
  - Twitter
- **Co-Creating**
  - Wikis–collaborative file creation
  - Mashups–collective media creation
  - Collaborative social-change communities

May 2009 *Educational Researcher*

Jenkins’ Framework for New Literacies

- **Play** — Experimenting with one's surroundings in problem solving
- **Performance** — Adopting alternative identities for improvisation and discovery
- **Simulation** — Interpreting and constructing dynamic models of real-world processes
- ** Appropriation** — The ability to meaningfully sample and remix media content
- **Multitasking** — Scanning one’s environment and shifting focus to salient details
- **Distributed cognition** — Fluently using tools that expand mental capacities
- **Collective intelligence** — Pooling knowledge with others toward a common goal
- **Judgment** — Evaluating the reliability and credibility of different information sources
- **Transmedia navigation** — The ability to follow the flow of stories and information across multiple modalities
- **Networking** — The ability to search for, synthesize, and disseminate information
- **Negotiation** — The ability to travel across diverse communities, discerning and respecting multiple perspectives, and grasping and following alternative norms
Augmenting Real World Ecosystems
http://ecomobile.gse.harvard.edu

GoPro Cameras Capture EcoMOBILE Experience
Interface for Your Digital Life

IN THE FUTURE YOUR MOBILE PHONE WILL ACT AS YOUR DIGITAL "6TH SENSE"

SENSES
Local Content and Services

DISCOVERS
Things Relevant to You

LEARNS
What You Like

FILTERS
Out the Irrelevant

KNOWS
You and What is Around You

INTERACTS
With Networks

Next-Generation Learning

Personalized

Life-Wide

Transformational
A Different Model of Pedagogy

- Experiences central, rather than information as pre-digested experience (for assimilation or synthesis)
- Knowledge is situated in a context and distributed across a community (rather than located within an individual: with vs. from)
- Reputation, experiences, and accomplishments as measures of quality (rather than tests, papers)
Core Principles of Professional Development

- Teachers teach as they were taught.
- The important issue is not technology usage, but changes in content, pedagogy, assessment, and learning outside of school.
- Continuous peer learning is the best strategy for long-term improvement.

Professional Development: Communities of “Unlearning”

- Developing fluency in using emerging interactive media
- Complementing presentational instruction with collaborative inquiry-based learning
- Unlearning almost unconscious assumptions and beliefs and values about the nature of teaching, learning, and schooling
Transformation of Formal Education
The Promise of MASSIVE

- Serves a broader range of learners
  - increased human capital
  - greater diversity in co-learners
- Wider opportunities for social capital and for links to workplace and life
- Self-improving via research and continual feedback
- Excellent return on investment by learners and by society

*If effective (mastery, full range of skills)*

National Science Foundation (2013)

Advances in technology and in knowledge about expertise, learning, and assessment have the potential to reshape the many forms of education and training past matriculation from high school.
Rethinking Educational Processes

- Credentialing/certification based on competency rather than time
- Many sources of accredited learning, based on alternative business models and new marketplaces
- Continuous improvement via analytics applied to rich databases and embedded A/B experiments
- Generic tools and media repurposed for learning

Types of Problems in Health Care

- **Simple**: building a hospital
- **Complicated**: developing a vaccine
- **Complex**: improving the health of a particular group
  
  (dynamic, nonlinear, and counter-intuitive, driven by multiple independent factors that interrelate in rapidly shifting ways)

  Snowden & Boone, 2007
Strategy for Change

- Evolution
- Transformation
- Disruption

New Models for Financing

- Attract 0.5% of the 1B people who are looking for learning experiences over twelve months
- Start a new session of 10,000 people
  50 weeks of the year
- $5 a person for a twelve hour experience over six weeks
- $2.5M annual revenue
How technology can empower teachers to personalize learning (customizing to each student’s strengths, interests, and needs) in the group setting of the classroom

Digital Teaching Platforms (2012)

8 Aspects of 21st Century Classrooms

1. Interactive digital infrastructure
2. Teacher administrative tools
3. Student tools
4. Course authoring tools
5. Differentiated curriculum content
6. Diagnostic assessments linked to curriculum, formative for instruction
7. Support for classroom monitoring and management
8. Support for a range of instructional methods, including creative problem-solving, project work, brainstorming, team work, collaboration, and solution sharing
Evolution of Digital Instructional Tools

- 1985: Computer Labs
- 2000: Electronic Whiteboards
- 2010: In-class Computing
- 2012: Print to Digital
- 2012: Next Gen

Traditional Learning Management System Instructional Loop

- Content Management
- Assessment
- Grade Book
- SIS
Open-Ended, Collaborative Learning
Changing Metaphors for Education

<table>
<thead>
<tr>
<th>Work</th>
<th>Factory</th>
<th>Learning Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognition</td>
<td>Warehouse</td>
<td>Process</td>
</tr>
<tr>
<td>Learning</td>
<td>Information Transfer</td>
<td>Thinking Skills</td>
</tr>
<tr>
<td>Student</td>
<td>Clerk</td>
<td>Symbolic Analyst</td>
</tr>
<tr>
<td>Unit</td>
<td>Individual</td>
<td>Team</td>
</tr>
<tr>
<td>Content</td>
<td>Curriculum</td>
<td>Project</td>
</tr>
<tr>
<td>Teacher</td>
<td>Lecturer</td>
<td>Facilitator</td>
</tr>
<tr>
<td>Assessment</td>
<td>Multiple Choice</td>
<td>Authentic/Portfolio</td>
</tr>
</tbody>
</table>
Virtual Performance Assessments

http://vpa.gse.harvard.edu

- Funded by Institute of Education Sciences & the Bill and Melinda Gates Foundation
- Grades 6-8
- Summative tasks
- Proof of concept
- ~3000 students

Measuring Scientific Inquiry

- Contextualize a problem
- Students take on identity of scientist
  - Conduct their own experiments
  - Gather their own data
  - Develop their own hypotheses
  - Come up with their own claims based on data they gathered
Organizational Strategies for Adoption and Scale

- Develop authentic assessments based on outcome objectives
- Select initial innovations carefully so that strong models of learning are implemented
- Emphasize user-friendly interfaces
- Study design strategies for effective media that have scaled
- Accomplish tasks instructors/institutions want to relinquish
- Use organizational development strategies to change culture