

## THE OLD AND THE NEW: A LEARNING REVOLUTION

A PRESENTATION TO THE ASIAN PACIFIC SOCIETY  
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### Slide 1

Thank you. It is a pleasure to speak with you about the future of learning. My presentation today reflects the work of three people -- the two not speaking are my colleagues Catherine Casserly and Phoenix Wang, the latter is here operating the technology and open for questions later. The three of us work at the William and Flora Hewlett Foundation on issues of Open Education Resources and the improvement of opportunities to learn. Our primary goal is to help create powerful, lasting improvements in learning opportunities for all students, all over the world.

I will not discuss marginal changes in the education system and schools that appear to have only a small impact on learning. For example, we know from studies that conventional distance learning using practically any medium for transmission is as effective as conventional teaching. Distance learning should be part of the future, but **we believe that there are ways of increasing the effectiveness and efficiency of distance learning by magnitudes of two or three times. That is an example of powerful improvement.**

My focus will be on ways of using technology to create powerful improvements in learning. **We cannot continue to think of schooling and learning as bounded by what we call our education systems -- four walls, traditional text books, teachers standing in the front of classrooms, grades, exams, all carried out within highly scheduled fixed amounts of time. We have tried improving almost every aspect of the current education system - better, required curricula, more exams, more accountability, more professional development, better alignment of resources - yet we have made only incremental improvements on learning outcomes.**

**One thing I hope you will take away from this talk is that for us to expect significant improvements, we need to consider breaking down the constraints of our current education system.**

**Powerful improvement sometimes requires disruptive change in the conventional order.**

Just as with the experience of other institutions that have used technology to improve productivity, we find that the gains from creating efficiencies in the old processes is only marginal -- to dramatically improve productivity we need to change the processes and practices.

**Some societies and education systems will be more open than others to such change. We suspect that those societies and education systems will succeed, with the important caveat that they change in the right direction, while the others will fail.**

### Slide 3

My discussion builds on the morning talks. We believe that the new economy brought on by the information age requires us to strive to educate all of our children, to make education universal. Our children will need more than reading, writing and arithmetic. Every nation will

need far more workers who are able to take responsibility, work cooperatively, grapple with uncertainty, behave creatively. Many jobs, engineering, the sciences, management, investment, politics, the arts, require the capacity to try, to fail, to try again, often many times over. Creativity thrives in environments that support second chances - think of the CEOs in Silicon Valley (Jim Clark - Netscape and Silicon Graphics, Steve Jobs - Apple)

Advocates of the old basics argue that teachers should be in control, students should work alone, and that problems with a right answer are still important and must be practiced in schools. We agree, though, we argue, they must only be part of the picture.

The new basics -- a combination of gaining a deeper understanding of academic content, and a set of strategies to enable students to "learn to learn," to be creative, and to control their own environment must also become part of the curriculum.

How do we teach both the old and the new basics in the same amount of time that it takes us to teach the old basics? I will suggest some approaches in a moment.

But part of the answer is simple to say and hard to do -- we need to become more student centered and less adult centered. **What does student centered mean? -- it means giving students some control over their learning and going to the students rather than forcing them to learn in the modern world the way that they learned in the 1920s.**

Specifically, we need to use time in school much more effectively and we need to go where the learners are out of school. Only 20% of a child's waking hours between the ages of 5 and 18 are spent in school, and even then they are half asleep -- we need to use at least part of the 80% of the time students are outside of the school for educational purposes.

#### Slide 4

Put in note "apologies to Professor John B. Carroll"

Before we consider the potential uses of technology for learning let's look at a way of thinking about the general conditions that make learning possible. I find the equation Learning is a function of Content, motivation and time is a useful oversimplification of the factors that go into learning.

School learning a function of:

$L=f(\text{Content, Motivation, Time})$

- Content includes teachers (knowledge, energy), curriculum (content and skills), pedagogy
- Motivation has a variety of components including student readiness (health, self-confidence, level of attention, sense of control over learning), cultural and social incentives and disincentives.
- Time refers to the length of time it takes a particular student to learn particular content. Time varies depending primarily on prior knowledge, the knowledge and skills in the area that the student brings to the learning situation.

We have emphasized that we need to change the Content dramatically to include the **new basics**. And, we have suggested that the Time need not be a fixed dimension in schools anymore - in the future the student can carry the school along with her.

Motivation is a critical issue in the United States, though we pay little attention to it. I don't know how much of an issue there is about the need for greater student motivation in the Asian nations. But, I suspect that the increase in interesting out of school activities such as computer games and chat rooms poses a threat to student motivation even in Asia. There is a lot of research evidence that student motivation is absolutely critical -- that positive reinforcement, a sense of control over environment and social support are critical. The technology approaches we suggest for learning some of the new basics have student motivation front and center -- they are designed to capture and engage students that have other choices.

**Our bottom line is that we need to substantially alter all three components, content, motivation and time.**

### **Slide 5**

Educational efforts by many governments in the last decade have focused primarily on **increasing access** to technology. Hardware and pipeline issues have dominated. Very little interesting has occurred in the area of technology applications for teaching and learning. In the US, one reason this has happened is that we have left the development of content primarily to the private sector, which, in the US, is slow to change because it is protecting its core business in textbooks and other materials. The result is that technology has had only a small effect on education.

But it is possible that we have not been ready.

We believe that we are now ready for a revolution. One reason is the giant strides in understanding learning and teaching that we have made from recent research on cognitive science, in pedagogy and, for future applications, in research on the brain.

This research base is one key ingredient.

### **Slide 6**

The second key ingredient is the new technology itself and the use of it by young people all over the world.

We now have huge amounts of bandwidth and computers and handheld devices are ubiquitous. Connectivity is everywhere, and capacity and processing power double every 12 to 18 months.

Moreover, given the opportunity, our youth engage in using technology -- they use computers more fluidly and creatively than we do and the handheld device of my granddaughter has greater computing power than the desktops of the late 1990s.

The ubiquity of technology means that formal, structured, engaging open educational materials could be available all of the time (24/7) to everyone. What we learn in school could be reinforced and expanded by high quality digital experiences outside of school. The content that we teach in our schools, language, mathematics, science, art, music, history, philosophy, engineering, public health, and on could be immediately available to anyone, anywhere, anytime.

One major contribution of technology that will significantly change the way we approach education is that it allows us the opportunity to teach and learn anytime, anywhere, and on any device.

This is the second ingredient. We are ready to bake a cake.

### Slide 7

**We will look at six different applications of technology that can help us change all three dimensions that make learning possible. Each of these applications addresses one or more dimensions -- time, content, and motivation.**

**Open access to knowledge of the world** - Open educational resources, such as Library Collections, Books, Video, encyclopedias, data, journals, art, and translators, together enable huge amounts of high quality content available to all, especially those who typically lacked access.

**Creating and Maintaining High Quality open materials:** technology enables us to create fast feedback loops to improve the quality of textbooks, lesson plans, or other instructional material, in timeframes much shorter than what exists today.

**Powerful resources for 24/7, open supplemental and lifelong learning:** The expansive proliferation of educational materials in open archives of books and journals, allows us to rethink schools as 24/7, anytime and anywhere.

**Accelerated Learning:** Why not increase the rate of learning by 2 - 3 - 4 times. Cognitive tutors enable us to shorten the time or the other way to think about it, enable student to double the learning but in the same amount of time.

**Learning by doing:** If we want our students to think and act like a scientist, architect, historian, computer programmer, electrician, then we should consider using technologies that can help us create environments in which students can think and act like scientists.

### Slide 8

**Open access to knowledge of the world:** The big idea here is to bring the knowledge of the world to the smallest villages in Western China, the slums in Nairobi, the barrios of Los Angeles -- to everyone in the world.

One of the best known examples is Open CourseWare, which was started by MIT and has since spread across the world. Open CourseWare is a large-scale initiative to provide free, searchable, access to course materials for educators, students, and self-learners around the world. ([www.ocw.mit.edu](http://www.ocw.mit.edu)) MIT is putting the course materials for all of its more than 1500 courses on the web for free.

Over 100 universities around the world have joined with MIT in an OCW consortium in placing their learning materials openly on the web. This includes the premier universities in China and

Japan, the Paris Technological Institutes, as well as many others. Altogether 3000 courses are published and this number is rapidly increasing. ([www.ocwconsortium.org](http://www.ocwconsortium.org))

The combined websites receives over 1.5 million users a month. The users include faculty, students, and independent learners. China, Japan, India, and Canada are in the top five nations in terms of use.

**For the first time some of the worlds greatest Universities are opening the doors for everyone to the content that had hitherto been reserved only for their students. Six years ago who would have believed this could happen?**

### **Slide 9**

OpenCourseWare is only one of many different types of high quality education materials that are being placed on the web for free. Open Educational Resources include Library Collections, Books, Video, encyclopedias, data, journals, art, and translation and communication tools. All over the world universities, libraries, public television, museums, government agencies, profession organizations and other entities and individuals are placing high quality education content on the web for open use and reuse.

The materials are available to everyone in the world via computer and an internet connection. They carry a license that allows open use. In the US institutions that are part of this include Harvard, Yale, Rice, the Smithsonian and the Library of Congress - in England the BBC and the Open University of the United Kingdom.

Even private sector organizations are giving educational materials away for free. GOOGLE expect to shortly be providing access to well in excess of a million open books.

In British Columbia, Canada their premier university is building a web site of open materials for their teachers and students. The World Bank has a web site pointing to open materials across the web. The National Science Digital Library supported by the US National Science Foundation is a huge repository of open materials supporting the teaching of science in the pre-collegiate years. The National Institute for Multi-Media Education in Japan has put together a repository of mostly open digital objects supporting teaching and learning. Australia and England and many others have similar sites.

**These are the beginnings of a universal world library of high quality education materials of extraordinary size and scope, a library that will be available to every child in Kenya or the Philippines that has access to a handheld connected to the world wide web. This establishes the real possibility for all of learning on demand, whatever you need to learn at a given time.**

### **Slide 10**

**This category includes textbooks; lesson plans; examples of best practice on video; assessments and lots of other things. You may ask why am I talking about such a dull topic?**

The fact is that the tools of teaching and learning in schools all too often are created by people outside of the classroom and almost never rigorously tested in the classroom. Almost every K-12 student in the world has a text book, most teachers use lesson plans, almost every nation has high stakes assessments -- what do we know about the quality of the textbooks? the effectiveness of the lesson plans? the validity of the assessments? The fact is we know almost nothing of use about all of these areas.

A glaring exception to my generalization is a practice used in Japan (and other nations) of taking teacher built lesson plans and having other teachers try them and critique them and improve them. The process of lesson study is a process of continuous improvement, a practice made popular on the manufacturing lines of Japanese industry.

This form of continuous improvement cycle can be widely, cheaply, and powerfully **accelerated by modern technology!!** It can be applied to textbooks, lesson plans, workbooks, professional development, assessments of various forms and other types of teaching materials.

**The big idea here is to use the web to create fast feedback loops to dramatically improve the quality and usefulness of the materials by engaging teachers and students who are users of the materials!!!!**

#### Slide 11

Many college and secondary school students stay up late at night and wake up groggy in the morning. It is in their genes. Yet our libraries, lectures, and professors are available in the morning and not in the middle of the night. Middle aged people who work during the day cannot attend college during conventional hours. Or maybe they don't want to go back to school - rather they want to sit in their home and bone up on algebra and biology so they can do a better job in their current occupation.

**The big idea here is that we need to build a virtual world comprised of a large number of structured learning materials. The world would open to all on the web for use by anyone, anytime, anywhere. The materials that would comprise such a world is rapidly growing but as of yet they are scattered throughout the web.**

These materials include stand alone multi-media and lecture courses with fully developed content and instructional capacity; modules for home study, homework helpers and other supports, and **language learning tools (CHENGO)**. Over 100 such courses are already available for free in English and some are being translated into Spanish and Chinese. They cover such areas as calculus, algebra, world history, biology, chemistry, programming in C++ and others. In a short time we expect 200-300 such courses to be available along with many thousands of other useful digital objects. Homework helpers provide support for all learners by bringing specific knowledge to bear to help students learn a concept.

**"So far the site is helpful. I have worked through sample questions and used it yesterday to study for my chapter test in algebra. I will use it for other subjects as well. Sorry it has taken so long to get back to you but I have been very busy."**

**A variety of models are springing up. In the Netherlands the Open University is placing some courses open on the web for use by anyone, anytime with the aim of attracting**

students to take officially take courses in a degree program. The effort is being supported by the government in the hopes of stimulating an increase in the overall college population.

One particularly interesting example of a lifelong learning resource is in the area of language learning. The technology of voice recognition, language translation and machine language production has improved dramatically. With a language training program a student has the chance to practice and learn on her own, fail and then receive feedback and support, practice and repetition in an immersive language environment.

The Chinese and US governments signed an agreement some time ago to create programs to teach Chinese to English speaking students and English to Chinese native language students. CHENGO, or Chinese and English on the Go, is a highly innovative R&D project that uses online technology to deliver foreign language instruction, 24/7, open, and accessible from anywhere. The system is designed to deliver 35, one-hour English language lessons by integrating the technologies of gaming, animation, and voice recognition via the Internet with a structured immersion pedagogy.

Chengo creates an environment where learner can learn at his or her own pace and practice as long and as often as necessary.

#### Slide 12

**Accelerate learning.** The title of this presentation in the agenda is "Can we Learn 2 to 3 times faster". We believe that the answer to that question is yes in many subjects. The big idea here is that interactive on-line courses, developed by content experts who are informed by recent knowledge from cognitive science, can enable students to learn faster than they learn from regular, high quality lectures delivered in our world's greatest universities. Our preliminary hypothesis is that students can learn twice to three times as fast using the on-line courses.

Carnegie-Mellon University is developing such a set of college level courses for delivery on the web. The courses are based on current theories and data from cognitive sciences and the course content in each is exactly the content of a corresponding lecture course in the university. The University course takes one traditional semester of lectures. Carnegie - Mellon calls their technology courses Cognitive Tutors. They provide all of the content necessary to successfully complete the course. They are 24/7 cognitive tutors that are capable through effective use of feedback loops to create personalized experiences. 24/7 personalized cognitive tutors - this is going to the student with highly motivating material under their control and reactive to their needs. Who can ask for anything more?

Carnegie Mellon is embarking on a set of experiments to determine whether the 24/7 cognitive tutors can accelerate learning. They already know from other studies that the cognitive tutors work as well as the lecture approach when both groups are given a full semester to learn the material.

In the new experiments the 24/7 cognitive tutor students will only have one-half the semester to take the course before the end of course examination while the lecture class students will have the full semester. The scores of the students in the two groups on the common end of course exam will be compared. Our money is riding on the 24/7 cognitive tutor students.

#### Accelerate Learning Slide: CMU's Static Tutor

*The OLI MiniTutors* are grounded in studies that have attributed the sizeable learning gains that students achieve with human tutors to the feedback the tutor gives in the problem solving context.

This tutor is in a section of the Statics Course on Effects of Multiple Forces and helps students learn how to calculate moments using components. It is intended to be an opportunity for students to do a "self-check" to make sure they understand the concept. However, if the student is unsure of the procedure for solving the problem, the first hint provides a link which, when clicked, expands the tutor into the various steps needed to solve the problem.

The tutor provides scaffolding to support the student to learn the steps of the procedure when needed.

The hints and feedback change depending on which part of the exercise the student is attempting. Notice that the hints are given in three levels with the first level of hint orienting the student in general terms, the second level of hint restating the rules, strategies or equations that the student should apply in solving the problem, and the final level of hint, or "bottom out hint" gives the student the solution for that step in the process. The student's answers are green when they are correct and red when they are incorrect. This demonstrates the methodology of a cognitive tutor: making comments when the student errs, answering questions about what to do next, and maintaining a low profile when the student is performing well.

The tutor recognizes when a student has used the scaffolding and hints and when the student gives the correct answer after having used the scaffolding and hints; the tutor suggests that the student try another problem without scaffolding and hints. The graph, the problem statement, hints, feedback and answers are dynamically-generated. The student can work through the tutor multiple times, receiving a different problem each time, until the student is confident that he or she understands the concept. This provides the student with virtually unlimited opportunities for supported practice.

#### **Slide 13**

**If we want our future workforce to have the skills and knowledge to adapt to the rapidly changes brought on by globalization, then what better way to learn than to simulate the kinds of challenges that one might encounter? Rather than memorizing facts, why not start early and help students practice doing what a scientist, architect, doctor, dentist, historian, computer programmer, or electrician does? Technology has made it easier to create simulations for job-training, and, some instances, to give students the chance to actually carry out real work.**

Some examples:

iLab at MIT supports a network of users who from a distance can manipulate high-end laboratory equipment to teach science. This is not virtual laboratory -- it is the real thing. The lab names are

- Dynamic signal analyzer
- Shake table for Civil Engineering
- Polymer crystallization for Chemical Engineering
- Microelectronics device characterization for Electrical Engineering
- Heat exchanger for chemical engineering

In Australia an observatory has opened windows of its time to students and amateur astronomers who wish to explore and solve the kinds of problems that professional astronomers think about. Students create hypotheses, for example, predicting where a black hole might be, reserve the right time for the telescope to be focused on a particular part of the universe, and then analyze the results of their investigation. And, all of the images are open source, allowing anyone else to examine and study their importance.

Discover Babylon teaches a user to be an archeologist with accurate historical and scientific information in 3D photorealistic simulations that allow the user open-ended exploration and discovery.

Surgery Simulator shown here is a high-fidelity laparoscopic surgery simulator that enables surgeons to practice complex operative tasks before entering the operating room. The device emulates, with a high degree of accuracy, the anatomy of organs and tissues.

#### **Slide 14**

**Where do many of our children and young people spend their extra time? Games!! And coming on strong are non-gaming immersive environments!! On the computer, on the handheld device, at home, on the playground, on airplanes, autos, wherever they are kids 5 to 30 there are games. The games and immersive environments may have one or two or three or up to many thousands of participants. Something on the order of 25 million people play World of Warcraft and there are over 1 million inhabitants of Second Life. The gaming industry is larger than the movie industry. Parents all over the world worry that their children (and sometimes their spouses) are spending too much time playing these games. Yet there are very few powerful games designed for education purposes available for our schools and colleges.**

**The irony here is that the Defense Department in the US and, I am sure other countries, already employ games and immersive environments for learning and training activities, as do multiple large private corporations around the world. What do they know that we do not know?**

**They know that these environments foster learning to be take control of your learning, be creative, solve problems, and manage complexity, through competition, collaboration, engagement in games and virtual worlds.**

**The big idea here is that personalized, engaging, challenging game activities provide an extraordinary opportunity to teach both the old and new Basics.**

**Some games for social and educational purposes are already in circulation.**

Games exist for science, defense, health, conflict resolution, and social change. Their sophistication, target audience, and message vary. The Federation for the Advancement of

Science developed *Immune Attack* to allow high school students to experience the challenge of defending the human body against invading antigens; *PeaceMaker*, a game created by students at Carnegie Mellon University, lets Palestinians and Israelis switch roles to better understand each other's plight (I will add image of this); and the U.N. World Food Program's *Food Force* teaches kids about the difficulties of delivering aid to the developing world. Food Force had had 4 million downloads in 15 months (Time Magazine, August 2006).

(Demo Food Force Trailer) Each player is a member of a rookie team sent to complete six missions. Each mission represents a part of the process of delivering food aid to an area in crisis. The final mission shows you how food aid can help people rebuild their lives in the years following a disaster.

### Slide 15

What does this sample of opportunities created by technology offer us?

- Open access to a massive library of knowledge for all
- Learn structured education material anytime, anywhere, and on any device
- User-centric improvement of education materials
- Accelerate learning -- learn 2 - 3 times faster
  
- Motivate students by learning to be professionals
- Promote creativity, problem solving, control of learning through games, immersive environments
- And these are only examples of categories of opportunities.
- What might be done to make these opportunities real?

### Slide 16

What are our options for governments and other funding agencies? The obvious one is to do nothing special. Continue to dabble on the edges of the education system. Don't alienate adults and special interests that are embedded in the education system.

What would happen? I believe that the open education resources movement has enough impetus and support around the world to continue growing though special interests will create barriers and slow the movement down. The well to do will still have access to it as well as to material that has a price. The losers, of course, will be those who cannot pay and fight back. Maybe the private sector would step up but their materials would be closed to all who cannot pay -- again the losers are not in this room.

### Slide 17

Invest now in what we know how to do - develop 24/7 cognitive tutors in twenty key areas, build a new generation of textbooks that achieve validity through user feedback, create a library of open games, simulations and better education materials. The cost of a government funding this would be an astonishingly small fraction of the overall cost of the schooling in their government. Suppose, for example, that using US prices for labor it cost 1 billion dollars -- that would be 2% of one year's cost of California's K-12 education system. The savings could be massive.

How about embedding the entire curriculum of secondary schools with these extraordinary tools? How about a massive site with multi-player games, simulations, data collection and analysis tools in multiple languages for middle school students all over the world in the area of global warming? How about? -- you fill in the blanks.

For the long run we need R&D on more complex immersive environments to support creativity and deep problem solving.

And we need to change incentives in the system: For example.

- To cede more control to students and to support the use of technology reward coaching as a model of teaching rather than the "sage on the stage" model.
- Give course credit without seat-time to those who learn on their own.
- Reduce length of school for those who can accelerate through the system.
- Change national testing and college entrance requirements to include measures of creativity, deep problem solving, and experience with problems that do not have a "right" answer.

**There are real impediments and considerable costs to changing the status quo. In this case, we believe that the costs of not changing are far greater.**

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E|E's Web site describes—generally approves, and advocates—the quite radical changes now appearing in K-12 education. But, be aware that its perspectives do depart somewhat from conventional thinking.