MIT 6
Gary D Keller

Teaching Online Using Game Technology On a Virtual-Reality Platform

I. Alienated and Delighted Students

Who said, "It was the best of times, it was the worst of times, it was the age of wisdom, it was the age of foolishness, it was the spring of hope, it was the winter of despair, we had everything before us, we had nothing before us, in short a period, being received, for good or for evil, in the superlative degree of comparison only." I'm going to pursue this quote to create a grim scenario, a sort of contemporary *Bleak House,* and I will also sketch out a springtime of hope, call it "a ghost of Christmas yet to come."

I will be extreme in my description of the bleak house. I'm doing this for its dramatic value and its heuristic value. So, if you have hesitations, counter-examples and so on, I no doubt agree with them. But heuristic value in a limited conference session trumps them.

I write here of a condition that runs up the educational ladder, k-16, and it is especially severe at the peak points of the generation gap: high school, and first year of college. Who among our student clients live in the winter of despair?

Those many and increasing populations suffering from generational alienation. Those studying under the rigors and restrictions of the overbearing power and authority that their teachers exercise over them; teachers who exacerbate these negatives with their ignorant and self-centered abuse of that power. Those students cast into a learning environment that is inconsistent with their culture, learning styles, and technological mastery. Who are taught by adults trained in a delivery system based on paper and pencil or chalk, dry lecture notes repeated like mantras over the decades.

All student populations, but disproportionately distributed along ethnic and gender lines, have significant numbers who are so alienated that they have dropped out even though they may be physically present lumps in classroom storage centers. No one notices, or cares unless the frequent disciplinary problems emerge; and for countermeasures to ensure discipline, well here, the educational system has put a great deal of imagination, resources, and innovation.

Student "clients" is a term in vogue, and how I wish it were true, because it is honored in the breach. So called student "clients" have united in contempt for their teachers and the values of conventional culture, and have created a counterculture with behaviors ranging from incessant Twittering and other social networking, language use that is barely intelligible to the mainstream, criminal activities such as drug dealing and new

millennium entrepreneurship such as the construction and sale of digital avatars on various websites.

So at the bleak extreme we have students who are loathe to even be seen carrying books because it is square, who criticized Michelle Obama when she was on her way up for betraying her language and culture and who live largely in a separate alienated-youth reality. But cell phones get in, Ipods, *Second Life, World of Warcraft* and computer games, Facebook, Twitter, and You Tube are in. The *New York Times* need not apply. Actually comments like it's so last millennium are even becoming outmoded because in this world it's simply fallen off the rack.

In these times of unprecedented and extraordinarily disruptive technological change, the intergenerational gap in viewpoints, values, and behaviors is inevitable. The situation is self-correcting. Eventually the luddites retire or lose their perches of power and a newly-trained more with it cadre of educators emerges. But this takes considerable time and in these times of paradigm-shifting change, the conventions of intergenerational handoffs feel glacial. And the country can not wait. Month after month, year after year, to the same drum beat comes the same prediction: America is falling behind many nations in its graduation of competent high school and college students of science, technology, engineering, and mathematics (STEM). A current term in national vogue is that with respect to STEM education, the nation is experiencing "a perfect storm."

It is also important to observe that there are forces that conspire to maintain an elitist status quo that puts a premium on washing out vast numbers of students, in fact the majority out of the educational domain of STEM, There is a group of students who are *enthralled* by the status quo. They are right here at MIT and other elite and selective educational institutions, not only in higher education but at the Bronx School of Science and its analogs all the way down to primary education, all created to privilege a miniscule elite. These are the individuals who have gamed the system and use it to their advantage. The professors and teachers cling to these students to justify their status quo and outmoded teaching. These "mark sharks" get it and they should be the anointed ones. These "mark sharks" validate the unjust system and get a happy face from their teachers and society in general. And the others, the vast unwashed, alienated kids? "Let them eat cake." Let them Twitter through life.

Now, here's a seeming paradox! Most teachers, particularly rookies loathe their jobs. They are becoming as alienated with the system and the *ancien regime* as their students! A recent study suggests that more than a third of the nation's 3.2 million teachers could retire. The problem is aggravated by high attrition among rookie teachers, with one of every three new teachers leaving the profession within five years, a loss of talent that costs school districts millions in recruiting and training expenses, says the report by the National Commission on Teaching and America's Future. To ease the exodus, the report says, one of the primary recommendations is that policy makers should restructure schools.

Let's look at one more brick in this bleak house: missed opportunities for the internet. We have reviewed the current state of internet education in calculus and our conclusion in two words: It sucks! Some examples in the area of calculus follow:

- The MIT math and science internet website, pitched in great part to high school students. Some of the material in here could be in a National Lampoon parody of *Revenge of the Nerds.* If this website is what we are going to rely on to inspire all but the mark-sharking uber nerd, we are dead in the water. The video demonstrations on this site are nothing more than amateur videotapes of professors lecturing. http://ocw.mit.edu/OcwWeb/hs/home/home/index.htm
- The Sage website is open software. Nevertheless, this cooperative work by mathematicians nationally and internationally does not offer sophisticated visualization and it has just been released. A few of the participating professors in Sage would be good recruits into our proposed program to provide principles and problem sets that we would put to life with the help of inspired students of this generation of high schoolers.. Home url: http://sagemath.org/
- The AP Calculus internet website provides numerous links to all sorts of uninspired resources on the internet with no particular organization or system to find information and which offer mostly tips about graphing calculators. http://www.hsd.k12.or.us/glencoe/staff/abel/homework/hwresource.html

So most of what does exist is lifeless and bloodless. And adding insult to injury, most of it is proprietary, expensive, and operated by obscure companies! Conclusion: There is a vast chasm between what exists on the internet and what could be developed given the advances of the last decade. A quick review of current games or websites such as *Second Life, Entropia Universe,* or *Halo 3* gives one an ample sense of what can be accomplished for education with the deployment of tools developed for entertainment. But hey, precisely because of this dismal state of affairs, there is a splendid opportunity, and only one place to go: up.

II. Break a Deal, Face the Wheel

Fine, let's leave the predictions of rain and the pious ringing of hands to others. We're not here to predict rain but to build arks.

Isaac Asimov, the noted science popularizer and science fiction writer created a construct called Second Foundation based on psychohistory and enviable science fiction technology to save the declining Roman, oops I mean galactic empire from 10,000 years of obscurantism. We have less exalted goals, but we love Isaac Asimov. And we want to accelerate learning exponentially through student-centered activities and technology.

Arizona State University, the College Board, and Google is creating *APWorlds,* mathematics instruction based on virtual-reality, game-style technology using the brand-new platform developed by Google, now in beta form. Our project is envisioned to begin in middle school and run through first-year college calculus in tandem with honors AP

high school calculus. Student performance is evaluated with the College Board's examinations beginning with introductory algebra through calculus.

APWorlds stands conventional pedagogy on its head. Technologically, it constructs a virtual-world platform that is a supercharged, interactive form of life, the known universe and all the elements of mind and matter that can be included in knowledge, imagination, hypothesis, fantasy and science fiction. Culturally, we script a compelling variety of life and fantasy dilemmas, challenges, cooperative moments, and competitions. Pedagogically, in mathematics education for example, we seamlessly wed the great scripts with the key mathematical concepts and the supporting problem sets that students need for success. This heightened, interactive, and virtual pedagogy is diametrically opposed to conventional mathematical pedagogy which is recipe, rote and drill driven

This project is timely. Actually it's a good decade overdue. Already initiatives exist on Linden Lab's *Second Life* or MindArk's *Entropia Universe* that have been entered into by several sovereign countries and institutions of higher education. However, none of these initiatives have the breadth, scope, originality or educational rigor of *AP Worlds.* A well-known observation in film entertainment is that "movies are just like life, but with the all of the boring parts taken out." Games extends that model to edutainment over the net.

We recruit script writers from the ranks of seasoned and motivated high-school and college gamers themselves. Their scripts will be, not only to paraphrase *The Maltese Falcon,* "the stuff of which dreams are made."

At the heart of the project is dramatic storyline. We live or die on this one. The Project is designed to create courses produced by an extraordinary team: at the center will be dramatic script writers of cooperation and confrontational stories that will attract the gamers among our youth. In fact, kids will write the first drafts of these stories and critique them for excitement. But the kids will be given guidance from math education that they must write stories that address a certain situation, and that situation will embody certain key mathematical concepts such Their stories will encapsulate key mathematical principles which if solved also solve the gaming, virtual-reality challenge and propel the student singly or in teams to the next level. Mathematics educators will create problem sets derived from the scripts, and software writers will create the visual apparatus for this reality, and this game set within this virtual reality: a game that vies to meet the obsessive thirst for this sort of play at the same time it teaches the key mathematical principles needed for academic success.

Here is an example. The story line that govern this key calculus problem is taken from the most popular, best-selling calculus text book follows.

A. The tide removes sand from Sandy Point Beach at a rate modeled by the function R. A pumping station adds sand at a rate modeled by the function S. How much sand will the tide remove from the beach during this six hour period? Find the rate at which the total amount of sand on the beach is changing at time i.

Our method of teaching is not going to alter the manner of setting up this story line into mathematical language. We are not going to suggest changes in the mathematical way to solve this problem. We are going to alter the story line itself so that it is exciting and so that there is a reward for success. For example, sand goes out of the beach, sand is pumped into the beach. But your partner in adventure is buried in the beach by brutal pirates and has only her/his head sticking. Are you going to watch your loved one die or are you going to solve this problem and how much time do you have. And there are consequences: If you succeed you advance in this game; if you fail you lose this avatar.

Our existing courses build upon the mindset, cognitive processing, and environmental comfort level of the majority of American college students, all of whom have grown up in the internet age and who obtain much of their information, learning, and satisfaction from the internet. There is a splendid coordination between these interactive courses and the experiences and expectations of students. In addition, numerous fields, including calculus of course, truly lend themselves to web-based visualizations, animation, interactivity, self-pacing, learning during time periods that are the most personally conducive, self-testing and immediate test results over the internet, and educational instruction and feedback based on expert systems.

With respect to the math course content and the evaluation of that content, we use the national AP Program has two key features: (1) course curriculum that measures consensually developed mathematical concepts; and (2) the actual AP tests themselves which measure student achievement on those consensually-developed standards. *APWorlds* marries AP to the creative advanced technology and the drama of role playing with virtual reality..

Achievement is highly rewarded in various ways, some of them extraordinary and unique which bring figures of national, regional, or local prominence from many walks of life into the project effort. *APWorlds* permits the nation to rally around education. The project will solicit the student-motivating participation of public servants, corporate leaders, prominent individuals in sports, mathematics, science, research, and philanthropy, and many others to help students do well in learning for the fields that are vital to the national security and the economic performance of the United States. One of the ways that this can be achieved is by having premier student achievement rewarded by having the recognized student travel to various sites such as the National Science Foundation, NASA, NIH, Exxon Mobil, various state and city units of government, and so on, and spend a day simulating the job of the CEO or other high officials. In turn, prominent individuals and organizations can enthusiastically become part of *APWorlds* itself, the people who produce “the stuff that dreams are made of.”

From the beginning, we will create courses that can instantly change the language of instruction from English to other languages such as Spanish, Haitian creole, or Portuguese. *APWorlds*’ language of instruction will be in English, but support will be instantly available by pressing a key on the keyboard in such languages as Spanish, Mandarin, Cantonese, Navajo, Haitian vernacular forms of French, and other languages, beginning in its pilot phase, with Spanish.

III. Begin Where it Counts

The targeted student population for advanced mathematics in the United States is disgracefully small. Ours is large.

APWorlds' target is the top 66% of the student population. There are about 5 million 11th graders in United States education, public and private schools combined. Assume that 80% of that total, or 4 million students already take mathematics of some kind in the 11th grade. Recent statistics from the AP 2007 Report indicates that out of the pool of approximately 4 million students, only 148,684 students took the AP Calculus AB examination (in 2006). That is about 3.5% of the total population of 11th grade students taking some course in mathematics. A successful *APWorlds*, after a number of years of appropriate ramping in the earlier grades that meaningfully reached 66% of a population of 4 million students, would bring its program of education to 2,640,000 students. *APWorlds* has as its goal for this population of 11th grade students to take high school honors/AP level Calculus. If we had a success rate of only 50%, the current 148,684 would increase to 1,320,000 students, a nine-fold increase.

APWorlds will focus especially on underrepresented minorities and women, and this focus will increase the mathematical education of that population by between a twenty-fold to fifty-fold increase, depending on the group (the number of Native Americans, for example, currently taking Calculus AB is extraordinarily tiny). Targeting the non-traditional, inner city and marginalized rural populations of America are highly desirable for additional reasons.

The secondary schools servicing these students mostly do not offer honors calculus at this time. This educational sector is an open environment where the need is enormous and urgent and where we will find a warm welcome through online distance education.

The majority of teachers in the various fields of mathematics working in these schools are not trained in or credentialed as teachers of mathematics. These schools need expert instruction and *APWorlds* can immediately begin to provide it over the internet and support our online education through the teacher-training component of our program.

IV. The Partners: Arizona State University: A Model for Success

Arizona State University and its partnering organizations such as the Los Alamos National Laboratory will take the lead in developing the virtual reality, game-like scripts and tying them to the mathematical concepts and problem sets. ASU has been successful in mathematics education for over 20 years, and is currently the flagship in such education in the view of numerous program officers at the National Science Foundation, the Alfred P. Sloan Foundation, the Ford Foundation, the Carnegie Corporation, the Pew Charitable Trust and elsewhere.

The College Board will bring to *APWorlds* its existing AP Calculus program including the identification of curriculum to meet national mathematics education standards and the use of the Advanced Placement AB and BC examinations to certify competency by high school and college students in first-year college-level calculus. The College Board will take the lead in extending the identification of course curriculum for each course to as early as the 7th grade in and it will provide final evaluation of the student's competencies in a manner analogous to its existing AP Calculus tests.

Google, Inc., will extend its existing collaboration with ASU to *APWorlds* in the development of the game platform and it will provide the technological means for an unlimited number of learners and their teachers to participate throughout the nation and internationally. Google is already an active partner with Arizona State University especially on Google Mars and ASU has provided Google with 17,000 photographs of the Red Planet. Google's involvement as a full partner in this project makes scalability and world-wide distribution a certainty.

V. A Note on Money and Scalability

According to PricewaterhouseCoopers, 2008 game revenues are projected at $37.5 billion with profit margins, such as for *Halo 3* in the 90% bracket. By contrast films often lose money and even a huge blockbuster such as *Spider-Man 3* can expect a profit margin of around 46%. *Spider-Man 3* cost about $400 million to make and release in 107 countries. Producing and marketing the DVDs cost an additional $100 million, and Sony spent tens of millions on such expenses as overhead, profit participation and residual payments. In addition, stars Tobey Maguire and Kirsten Dunst and filmmaker Sam Raimi are believed to receive portions of the top line in the form of box-office receipts. The total cost to Microsoft for *Halo 3* is a little more than $60 million.

With $60 million *APWorlds* could possibly meet the math, science, and computer science needs for every grade level beginning in the 7th grade through the high school honors/ college level. For $60 million we could provide *APWorlds* in every STEM (science, technology, engineering, mathematics) subject area in which the AP operates including calculus, biology, chemistry, computer science, physics, etc. With Google as a partner, our advantage in scalability and access to the world population of 9th grade through first-year college students is without peer or parallel to any actual or envisioned educational project anywhere on earth.