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Footnotes

The Newsletter of FPRI's Wachman Center

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Engaging Students on Innovation

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January 2009
Vol. 14, No. 1

Trudy Kuehner is associate director of FPRI's **Wachman Center**. This essay summarizes the discussion on how to engage students in the history of innovation that took place at the Wachman Center's two-day history institute for teachers on this subject held October 18-19. The Institute was hosted by the Ewing Marion Kauffman Foundation in Kansas City, Missouri and webcast worldwide. See **www.fpri.org/education/innovation/** for videos and texts of lectures. The **History Institute for Teachers** is co-chaired by **David Eisenhower** and **Walter A. McDougall**.Core support is provided by the Annenberg Foundation and Mr. H.F. Lenfest; funding for the innovation program is provided by the Ewing Marion Kauffman Foundation. The next history weekends are Teaching the Nuclear Age, March 28-29, 2009, at the Atomic Testing Museum in Las Vegas, and America's Wars, Part II: 1920-present, May 2-3, at the Cantigny First Division Foundation, Wheaton, IL.

Lawrence Husick, co-director of the Wachman Center program on Teaching the History of Innovation, began the discussion by noting that our K-12 education system may separate out far too early students who display an aptitude for math/science from those more apt in the humanities. We seem to believe that people can do only one or the other, not both. In order to foster innovation, we need to maintain a more balanced and interdisciplinary curriculum for much longer than we do, Husick urged. That means asking all of our students to be rigorous in their reasoning, and in some ways, more "scientific" about what they do in all subject areas.

One negative result of our failure to demand careful and fact-based reasoning, he said, is that it is widely considered acceptable to hold beliefs about our environment, fuel use, waste processing, and many other issues with little or no factual basis. Another result of our academic separation between the sciences and humanities is reflected in the oft-heard statements that we're not producing enough graduates in science, math, and engineering. But that's the wrong focus. What we've failed to produce is *innovators*. Innovators are special people, but everyone has the innate capacity to innovate. It just requires understanding a few things about how the world works, about the process of innovation, and in particular, that in order to innovate, you must take risks.

How, then, to teach the process and benefits of innovation? First, Husick observed, innovations of all kinds engage young minds. Our students are, and want to be, innovative, but our educational system discourages them. We teach the accepted and conventional lessons, facts and methods, and disincentivize students from diverging from this narrow and efficient path.

Husick remarked that students have no fear of new technology. They don't worry about breaking an expensive computer — they know it can be fixed and that it's not hard to fix (unless you drop it hard, or drench it in your soft drink!). In the 1950s and 60s, young men played with souped-up cars. Now young people soup up their computers. (Husick noted that our kids run 20 or more programs at a time of their computers. It's not attention deficit disorder; they are gathering information, and interacting with each other in ways that are unfamiliar to their parents and teachers.) They view it as a game, and in so doing, they innovate by attempting to break the rules. Game designers now design games with rules that are intended to be broken. Video games have built-in "cheats." You try to discover what the cheats are by talking to other players. In so doing, students are discovering the inner workings of the machine, to "hack" the system because it feels good to know something the next person doesn't.

Innovators must fail, Husick emphasized. It is an essential way to learn. Almost all our hero innovators failed miserably multiple times. Being an overnight success as an innovator means you put in fifteen years when no one recognized you for what you were attempting to do. We must teach our children and almost as importantly, their parents, to accept failure. They must not only tolerate failure, but celebrate it. We must make it possible for a student's project to fail, without causing the student herself to fail.

So, can we give students environments in which failure is anticipated? A learning environment with the mental equivalent of athletes' mats on the floor? Contests like Olympiad of the Mind or Science Fair provide a safe environment and some safety constraints. Husick also recommended four more:

1. Problem-solving exercises. We can ask students to solve a problem we give them, but in an unconventional manner. The assignment should be interesting to students but with a highly constrained definition. The value of innovators' education is that it serves as a sieve that allows them to focus on a particular problem and get down deep to the truth of it. This process obviously takes too long to be done in a class setting, so we limit the scope of the problem and make it appropriate to the students.

Once the puzzle has been defined, brainstorming is a skill we can teach our students that has great value. The rules are simple. Just throw out ideas for solutions and approaches. The most difficult part for students is that they may not judge during this process—no negative comments! Put all the ideas on the board, no matter how silly they may sound.

Then comes the rank-and-select criticism. Ask each student to write down his or her top 3-5 solutions. Then go home and collate all of those, put the top ones on the board in order at the start of the next class, and identify the best two solutions. Then build, or if actual construction exceeds available time and physical resources, describe and draw, the solutions, and have students present the solutions in a slide format.

The final step is demonstration. Silicon Valley's culture is "demo or die," Husick noted. At Apple, every potential feature of a product is built two ways by two different teams, who play at the secrecy between them. Each one wants to get their version of the solution into the final product.

Teacher comments included that after the demo, there needs to be a reflective process so students may further refine what they've done, identify pitfalls, and streamline the process. Another teacher observed that solving one problem usually creates others. Accordingly, students should be asked to identify new problems that might be created by their solutions, to help them learn to anticipate unintended consequences.

The importance of providing students opportunities to showcase their work to adults and the community was noted, if time is available for that. (Sometimes teachers might prefer having students solve a "toy" problem that can be looked at in one class period, in order to focus on process.) It was observed that this whole matter may really be about the teaching of creativity.

It was agreed that students should be asked to identify who the stakeholders are in their project. For instance, for large-scale projects, there must be buy-in from the parents, community, and administration. Students should learn how to "sell" whatever their solution is, in order to get buy-in from others – in the "real world" these are superiors, venture capitalists, consumers, and the market.

Concerning teaching creativity, we want to avoid people saying either, "I don't need to be taught that" or "I'm not creative, so don't bother." Rather, try to see innovation as scratching an itch. The difference between inventors and others is simple. We all invent things, but an inventor writes it down and pursues it to see if it's been done before, how it may be changed. Perhaps the idea goes nowhere, or maybe it results in a patent. The rest of us do nothing and then see same thing at Target or WalMart in six months.

Conference speaker **Peter Watson** noted that the psychological evidence suggests that groups are actually more conservative than individuals, and wondered if maybe group projects simply identify the leaders. Husick agreed that "group think"—the tendency not to say things outside the group's norm—does exist. The exercises can be done with individuals as efficiently as with the class as a whole. For groups, toy situations tend to work best because group members don't think that the stakes are very high.

One teacher noted that our educational system tends to group students so that the "gifted" get to do innovation projects, and it was agreed that really, these projects should be for all students. This mirrors the problem of our separating students by science/humanities too early.

2. Biographical narrative. Second, Husick noted that biography is a great way to teach innovation because students learn best through narrative. Biography allows students to explore what makes innovators different. What do they do? How do they view the world, approach problems, and choose problems?

Understanding a narrative thread about innovation is one way for students to learn this history. We tend to focus on a few heroes, and then only on the myths about them, having students study Thomas Edison as the "Wizard of Menlo Park." What we know about him is actually different from what most of the biographies say. The Wizard of Menlo Park is a fictional invention, given to the world by Edison, who was as innovative in creating his own image as in everything else he created. Edison built a factory for innovating, hired lots of people, and drove them hard. Edison always took credit for everything, and was ruthless about protecting his businesses once they got started, as with his motion picture cartel. But he also had the ability to choose important problems. He once remarked, "I never invent anything that people don't want to buy." (Though Henry Ford observed, "If I had asked people what they wanted before I brought out my product, they would have asked for a faster horse.")

You can use projects that focus on real stories of real innovators. Pick a known one or one who lives or works in your area (the patent office website is a good source for this, **www.uspto.gov**, which website includes an Inventors Hall of Fame.) Students can research, interview, and invite inventors to speak. They can learn the innovators' stories of problem-selection, alternative weighing, and failure, and ask about their processes and the obstacles they faced.

Conference speaker Prof. **Walter McDougall** added that students can be asked to think about kinds of innovation other than technology—e.g., in institutions and philosophical or psychological approaches to life.

Wachman Center Senior Fellow Prof. **Paul Dickler** encouraged teachers to teach disruptive vs. sustaining innovations. Disruptive innovation theory has been extensively written about by Prof. Clay Christenson of Harvard Business School, Husick noted. This theory classifies innovation into two categories: Disruptive, which seemingly comes out of nowhere, is given no credit by the people who know what the "right" things are, but overtakes the market leader to become new standard. By contrast, sustaining innovations make a product/service/system better incrementally. One clearly disruptive technology of our lifetime was the personal computer, which was derided as a useless toy by computer manufacturers but is now the standard.

3. The Rube Goldberg contest. Goldberg was a cartoonist, a "hypothetical inventor" who invented strange and different ways of doing common tasks that were illustrated in his drawings. E.g., to empty a bucket of water, one might mount a boot on a wagon wheel and have that boot turn with the wheel and kick the bucket over at the end of a long series of other events. A search for "Rube Goldberg" on sites like YouTube will produce videos of fantastically complicated machines doing simple things. Students, like Goldberg, don't have to build such devices (although that's lots of fun, too), they can just draw them and come up with new ways to do common tasks.

4. Consider and rank order important innovations (see e.g. **From Stone to Silicon: A Brief Survey of Innovation** (FPRI, Oct. 2008, at **www.fpri.org**). While "Stone to Silicon" takes the broad view (all innovations, over all time), students may do better with more constrained parameters. For instance, ask them to research and list: the top 10 innovations in transportation; the top 10 in the United States since 1945; the top 5 during their lifetimes; the top 5 in the industrial revolution; or the top 10 in military technology. The number, era and subject are not particularly important. What is important is that there are clear metrics for ranking the innovations, and that students develop reasoned arguments for their own versions of the lists. These projects are ideally suited for small group work, so having five students responsible for a list of 5 innovations gives each an investment in one candidate for the top spot, and naturally leads to discussion and competition. Give several groups different areas of innovation during the same era, and then have a competition to merge all of the lists into a larger list leads to lively disagreement and a great deal of learning.

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