Teaching History of Science and Technology at a Polytechnic University

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Abstract

I teach a survey-level course on History of Science and Technology, which is designed to suit a greatest possible range of student backgrounds and interests. The course aims to maximize student choice, especially with respect to what course elements might most interest each student. Students are encouraged to focus each of their individual attention and learning efforts on whatever subjects they like the most, and this is also how the instructor assesses student effort and learning. One major category of assignments requires each student to prepare his or her own, uniquely-packaged take-home exams with respect to what might have worked well and not so well, within each unit of the course. My overriding intention is for students at a polytechnic university – and especially those students interested in STEM fields – to gain useful historical background to any field of personal interest, as ideally these will be backgrounds capable of helping students in their chosen professional field. My chief desired outcome is to inspire students to consider STEM careers in part by exploring STEM history. My project fits within the research focus area of Higher Education STEM.

Keywords: STEM, Conference Proceedings, Teaching Quality, Student Retention

Introduction

The University of Wisconsin-Stout is the state's polytechnic campus. UW-Stout emphasizes career training, collaboration with business and industry, and applied or hands-on learning. History courses on a polytechnic campus introduce several exciting challenges, especially when the specific field is a professor's research specialty.

At UW-Stout, I teach History of Science and Technology. Beyond the title, in its actual delivery this course is a history of science, technology, engineering, and mathematics (STEM). As well as including interactions between science and technology, the course recognizes significant accomplishments in the history of engineering. When it comes to any mathematical content in the course, this is kept to a minimum, at least in a technical sense, owing to the fact that no specific mathematical knowledge is designated as a course prerequisite. Mathematical breakthroughs are noted on occasion throughout the course, particularly when new mathematical approaches enabled major breakthroughs in science and technology. Subject matter in the course covers from about the year 1500 to today, and is taught as a global survey.

Background and Literature Review

History of Science and Technology is, at its core, a course in the liberal arts. Such courses are part of a tradition of broad-based and philosophical approaches to learning. Liberal arts coursework traditionally provides an essential component of a student's education for all major programs, and provides foundations for some; this can be as true for a polytechnic institution as for any other college or university. Students who select to pursue degrees at a polytechnic school pursue higher learning with a practical bent, in that they pursue knowledge to help them advance and excel in an anticipated specialty or profession.

Teaching within a polytechnic campus culture provides valuable opportunities for incorporating into the "General Education" curriculum my own research in history of science and technology. I have done this by developing a survey course on History of Science and Technology, as well as two specialized courses, on History of Mad Science (used by students to attain three credits in "Ethics and Social Responsibilities") and History of Social Science (which helps fulfill credits in "Racial and Ethnic Studies.")

The curricular nature of a polytechnic institution strongly benefits especially the survey approach to History of Science and Technology. Most students take one or perhaps two history courses while at UW-Stout. Their knowledge base is thus limited to roughly what they acquired during their K-12 years. Yet they also bring into a history course various useful skills from their pre-professional university course work. For example, polytechnic students tend to enjoy hands-on learning. Often times such learning involves computer applications. Students at UW-Stout all are provided with a wireless-ready laptop computer. My class makes use of this by creating web-based assignments; especially they do so via in-class employment of a largely image-based approach to the subject matter.

Polytechnic students enrolled in pre-professional programs have honed specific skills and insights that enable them to make unique contributions to historical study. An example is our school's art programs, which range from traditional studio work to printing and graphic design. Students in these programs naturally do an excellent job of visual interpretation. Their attention is drawn to images, be these drawings, photographs, cartoons, or paintings. An area of recent great interest to historians of science and technology is the roles that images have played for scientists and technicians. Historians explore various meanings in these images, and many students are drawn into the course when we explore these images ourselves (Robin, 1992).

Historians of science and technology have developed no extensive literature to date for how they teach and improve their teaching of survey courses in history of science and technology. On occasion, the journal *Isis* offers discussion sections on how to explore a particular topic in more of a special-topics course. Discussion about using scientific images and illustrations may represent the most interesting general-level discussion in recent years that can be drawn upon by teachers of survey courses in the field (Gingerich, 1989; Murdoch, 1984; Cohen, 1980; Williams, 1978).

METHODOLOGY

I structure History of Science and Technology to suit wide-ranging student backgrounds and interests. I intend the course to potentially maximize student choice for what topics each student will explore, especially with respect to the elements of the course that might interest any particular student for his or her graded work. I hope to enable pursuit and realization of each student's uniquely discovered interests when focusing his or her personal attention and effort; what this means is that I build into the course a great level of flexibility for assessing a student's contributions and learning.

History of Science and Technology uses a survey approach for all topics covered in the course. This approach is a bit uncommon to find in a course on the history of science and technology. Often these fields of history are taught in more specialized courses, with such courses tending to be found at colleges and universities where students can major in history, or even in a more specialized field such as history of science, history of science and technology, history and philosophy of science, or science and technology studies. UW-Stout offers no such majors, meaning that history courses are traditionally "service" courses here. History courses are offered within a social science department which offers a B.S. degree in applied social science. Yet more than any other role at our school, history courses provide General Education credits for the great majority of our students.

Students who enroll in History of Science and Technology are all non-history majors by definition. They come from all over campus. History of Science and Technology has been a permanent course since spring 2011. Students use it to earn three credits in two areas that are required for graduation: “General Education” (GE) and “Global Perspective” (GP). Some students use it to fulfill all their needed credits in GE-Technology, and for any student who has already met these credits, he or she can opt to take the course for three credits in GE-Humanities. Nearly every student in the course uses it to earn three GP credits, for which they need a total of six.

Enrollment numbers run strong in the course. The first offering was an experimental offering in spring 2010. Since then, single sections have been taught during spring 2011 and spring 2012, drawing a total of 53 students. These latter two offerings each involved the course design that I now introduce to you. It is a design that potentially maximizes student choice.

The course consists of three kinds of assignments. One area of assignments encourages the development of uniquely-packaged take-home exam. This is done by asking each student to reflect on two topics within a course subunit that worked best for them, as well as two topics that might not have worked so well. The course offers thirty-five daily topics, divided into three subunits. A second category of assignments requires each student to explore problem-based learning by focusing on problems that involve ethical dilemmas in the use of technologies. The final category of assignment is an open-ended research paper, fairly short in nature at six to eight pages.

My overriding intention is for each student to gain useful historical background relating to just about any STEM field in which he or she might be interested; ideally these historical backgrounds will become information bases that can help each student improve their understanding of a present-day field of interest, and for many students this is indeed a STEM field. I hope, as well, to inspire students to consider STEM careers by exploring something of the history of these careers.

FINDINGS

With respect to how students execute their take-home exams, I shall share the last two years of results concerning how students responded when asked to select two “relatively liked” and two “relatively disliked” topics in each subunit of the course. I require each student to defend their basis for selecting the four daily topics that they identify for critique. I look for a student to present lines of reasoning for why they declare a relative like or dislike for any particular topic. I hope for each student to discover a wider range of such reasons exists than what they might have recognized before joining the class. When I hand back and go over exams for the benefit of the class, I use this occasion to create a bit of higher level critical exploration of what they learn about any given topic. I find, indeed with satisfaction, that the same topic can be highly preferred by one student, while being received as disappointing to another.

Let us consider two years of results for unit one of the course (for 53 total students), in which there are eleven daily topics:

Table 1. Student Preferences for Topics in Course Unit One

	Like	Dislike
Indigenous Technical Knowledge	13	9
Medieval Scientific Thought	5	14
Beginnings of a Scientific Revolution	14	5
New Astronomy and New Physics	15	5
New Methods and New Communities	7	9
Atomistic and Mechanical Sciences	6	17
Natural History and Species & Races	12	7
Encounters between Civilizations	7	8
Agricultural and Industrial Revolutions	13	5
Newton and Tests of "Newtonianism"	20	2
Natural History and Geology	8	11

I have discovered that students tend to employ a few main categories of evidence and logical support for why any given day's topic is preferred or not preferred. Potentially there are five categories of such support, each effectively with two possibilities within it: (1) It is a topic that already interested them (or already did not interest them). (2) It is a topic they knew little about and the chance to learn more about it pleased them (or did not please them). (3) The topic is so different from the way science and technology work today that they were pleased (or not so pleased) to learn how people once did such science and technology. (4) When considered from a point of view of how a day's topic was executed and presented, the material came across clear, organized, and manageably sized (or unclear, unorganized, and unmanageably sized). (5) Students sometimes also consider the way in which serious and challenging material was made accessible (or how simple ideas got muddled beyond recognition). If there are any patterns with clustering such approaches as these, I do sometimes find differences between students who are a bit more interested in substance and content, in contrast to students who think more about how the material was taught.

I believe these categories of response cover just about all the lines of explanation that students have given. From about 26 or 27 students in a semester, with their great range of abilities and interests, I sometimes discover that all these basic options can come forth when enough students opine on the very same topic. Since I ask each student to briefly explore four daily topics on each exam, it is rare indeed that any two exams much resemble each other.

The opportunity for students to learn how to offer critical feedback is something that benefits them potentially in myriad ways. Some will gain the experience of discovering how to offer criticisms that they can support and that make sense. Some will certainly appreciate learning new techniques – or refining existing skills – for showing courtesy and diplomacy. Many students will learn more than they previously knew about all the many ways in which they can critically reflect upon what they learn.

Let us explore another way in which we might attain greater understanding of how students come to understand their interests by considering unit three of the course. This time we focus on capturing some sense of student commentaries as they offer feedback on twelve daily topics in unit three: (1) Darwin and Darwinism; (2) Tissues, Cells, and Genes; (3) Technology "Systems"; (4) Human Evolution, Genetics, and Eugenics; (5) Atoms, Rays, and Particles; (6) From Media to War Technologies; (7) Astronomy, Relativity, and the Expanding Universe; (8) Totalitarian Sciences: Nazism to Stalinism; (9) Systems Sciences: Geology, Meteorology, and Ecology; (10) Technologies of Consumerism – to the 1990s; (11)

Technologies of the Cold War: Bombs & Computers – to the 1990s; (12) Rocketry and Space Flight – to the 1990s.[1]

Here are some received examples, as they correspond with each of the twelve topics in unit three: (1) "The lecture did a good job of going into what I didn't know about Darwin's life such as the fact that he was married to his cousin and one of his children died." (2) "The thing that I found overwhelming was the twenty different scientists that we discussed…The good thing that you did for this lecture was break down the lecture into the four sections, which made it a little more digestible." (3) "Although the lecture was kind of long (99 slides) I still felt like it went by quickly because the information presented was in my interests." (4) "This lecture was one of the lectures I didn't care for. This lecture was all about human evolution. The reason I didn't care for this one too much is because I think of that as an opinion. There aren't really proven facts for how humans came about." (5) "I wonder if being able to see through solid objects shocked the first people who discovered X-rays." (6) "The radio section was really intriguing to me because for me it's hard to imagine a time where that's all there was for entertainment." (7) "I wish we could of talked more in-depth about Einstein's theories as they are quite interesting and difficult to understand…I was also interested in Einstein's 4-dimensional equations that were discussed in class, and plan to learn more about them outside of class." (8) "Thank you for being willing to handle this toughest of subjects on Nazi medical experiments. I get the dilemma about what to do with data obtained from such horrible means if the same data might actually help save lives tod[a]y." (9) "I think this presentation needs to be redone and that the overlying concept should be re-thought." (10) "Did Europe have the same kind of appliance boom that America had?" (11) "I might actually understand the difference between an analogue and a digital computer now – or perhaps still not." (12) "But why did the Russians never land on the moon, or did they…? And how do we even know for sure that Americans landed in the moon?"

SUMMARY AND CONCLUSIONS

With this course design, I am able to draw upon quite a variety of student strengths and interests on any given topic. At the outset of the course, I let the students know that there can often be any one amongst them who will already know a great deal about any particular subject. I believe that such a pedagogical strategy aims to let students know that an instructor cannot have mastered knowledge about how every single thing was discovered and built in the last 500 years of history of science and technology.

In addition to the many possible kinds of benefits that I hope students may gain from my course, I believe I also benefit. I use feedback from students on their exams to continually improve the course – a process that I see as a kind of continual quality improvement. Such continual improvement is important, and because students provide feedback for each and every topic in the course, I am always in a position to consider incorporating such feedback. I believe I do better semester by semester, especially at assisting the potential academic success of students in the course, many of them STEM students, and all of them students at a Polytechnic institution, where all majors are "applied" majors.

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[1] For anyone interested in the daily topics in unit two of the course, they are: Beginnings of Social Science; Industrial Policy; Production: From Factory System to American System; Making Technology 'Scientific'; Transportation, Communication, and Imperialism; Science & Technology in India, China, and Japan; Electricity, Magnetism, and Light; Revolutions in Chemistry; Professionalized Science, including a Brief World Tour; Heat, Energy, and Sound; Technology "Sets," with Examples from Frontier Histories.

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AUTHOR'S INFORMATION

David Seim teaches history of science & technology and also various courses in world history, at the University of Wisconsin-Stout. He has also taught history of science & technology at Iowa State University, Texas A&M University-College Station, and Texas A&M University-Corpus Christi. The course described herein has been under development at each of these institutions, an opportunity for which the author is grateful. Contact: seimd@uwstout.edu.