AC 2012-4458: TECHNOLOGICAL LITERACY IN REQUIRED SCIENCE COURSES FOR NON-STEM STUDENTS IN A COMMUNITY COLLEGE WITH EXTENSION TO JUNIOR HIGH SCHOOL ENVIRONMENT

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Technological literacy in required science courses for non-STEM students in a community college with extension to junior high school environment

Abstract

Technological literacy is an important outcome for a non-STEM student taking a required science course to function effectively in our technology driven economy. We have found that the development of technological literacy in a non-STEM science course benefited from our experience in teaching engineering technology courses and practical field training with students. Social technological issues such as the pros and cons of various energy sources and genetically modified food are crucial elements for choices in a democratic society. The understanding of current personal technological devices, such as cell phones, and the pivotal science-based technology for the expected next generation of products could fundamentally shift understanding of technology with a positive effect on the economy. Such emphases have been taught in the two introductory science courses, Principles of Astronomy and Space, and Principles of Physics. Examples in imaging, remote sensing and control, wireless communication, fusion, radioactive dating, and others have been used to convey technological literacy in three cognitive dimensions: (1) knowledge, (2) capabilities, and (3) critical thinking and decision-making, consistent with the recommendation of the National Academy of Engineering (NAE). The astronomy course, which includes discussion of NASA priorities and operations, has been found to fulfill the five technological literacy expectations recommended by International Technology Education Association (ITEA); in addition to the usual science literacy requirement. Junior high school science sessions have been conducted with the inclusion of technological literacy as well, and our preliminary findings suggest that technological literacy would promote interests of parents and provide encouragement for STEM majors in families.

Introduction

Technological literacy is an important outcome for a non-STEM student taking a required science course to function effectively in our technology driven economy.[1] From the perspective of a student, job salary after graduation remains a priority.[2] The median starting salary for college graduates in 2009-2010 was $27,000, a 10% reduction for those who entered the work force in 2006 to 2008 . However engineering graduates usually have salary starting around $40,000.[3] Such a disparity should mean that non-STEM students would recognize the importance of technological literacy. Numeric skill deficiency has often been cited as a major reason for unemployable graduates by international companies such as HSBC and Procter & Gamble.[4] This employable issue certainly would belong to the "Abilities for a Technological World" category in an earlier International Technology Education Association (ITEA) publication.[5] (Note that ITEA has officially become the International Technology and Engineering Educators Association ITEEA in 2010.)

The development of technological literacy in some of our non-STEM science courses benefited from our experience in teaching engineering technology courses and practical field training with students. Beyond just job training, and our ABET accredited laser courses have taught us how to teach and provide a good education to our students. Fox example, physics is classified as general

education in the program. However, in this context, "How things work" becomes the goal of teaching physics. Writing intensive pedagogy, where students use short informal writing assignments to explore subject matter, serves as expression of literacy in technology and engineering and science. Technology innovation is usually driven by a needed product with sound engineering design supported by basic science.

Needs

Non-STEM students should know about the needs of our current society. Social technological issues such as the pros and cons of various energy sources, genetically modified food, etc. are crucial elements for choices in a democratic society.

Sound Engineering Design

Different students have different favorite devices/gadgets. The understanding of a current personal technological device/gadget and the pivotal science based technology for the expected next generation product are key ingredients for an understanding of how science and technology affect our lives. Such and understanding would drive the broad efficiency of society, resulting in a positive effect on the economy.

Basic Science

Such emphases have been taught in the two science courses, principles of astronomy and space, and principles of physics.

Implementation

Examples in imaging, remote sensing and control, wireless communication, fusion, radioactive dating, etc. have been used to deliver technological literacy in three cognitive dimensions of knowledge, capabilities, and critical thinking and decision-making; consistent with the recommendation of National Academy of Engineering (NAE). In this regard, a two-step approach has been concluded with some success. Requiring students to keep a continuous notebook or journal provides knowledge continuity and allows student capability to be assessed through their writing expressions. The selection of a pivotal word from each sentence in news release (according to each student's choice) and then linking the pivotal words together in a paragraph have been proven to be a valuable assessment tool for critical thinking and decision making. The linking of the selected pivotal words in a paragraph is almost like writing a précis. The selection of a news source actually make a difference since some news sources have more compact writing with more information. For example in teaching astronomy and physics principles to non-STEM students, we have found that the UK Dailymail science section usually provide more compact writing as compared to Space.com. Perhaps this is an indication of relative knowledge of English and/or reading skill among the respective readers of these two sources. Success in using news resource in teaching technological literacy has been reported as well.[6]

The astronomy course with an emphasis on discussion of NASA priorities and has been found to be suitable in fulfilling the five technological literacy expectations recommended by International Technology Education Association (ITEA), in addition to the usual science literacy requirement. The first category of "Understanding the Nature of Technology" has been

implemented as the teaching of the "Basic Science" as discussed above. The second category of "Understanding of Technology and Society" has been implemented as explaining NASA priorities, which could be taught in a historical approach. The third category of "Understanding of Design" has been implemented as "Sound engineering design" as discussed above. The fourth category of "Abilities for a Technological World" has been implemented as reading-writing skill as discussed above and numeric skill. The numeric skill in a community college science course for non-STEM is kept at the level of Excel spreadsheet level with the plotting and linear trend capability, in contrast to other approaches.[7] The biggest hurdle has been identified as taking ratio, as applied in such areas as image scaling and Hubble law expansion. Similar questions such as the estimation of the angular size of a host star from an exoplanet surface are hurdles to non-STEM students. This ratio deficiency could be traced back to deficiencies in elementary school level applications of multiplication and division and the concept of inverse functions. The reverse operation of division in conjunction with multiplication in image scaling is not easy for non-STEM students in our community college. It seems that non-STEM students have difficulty in handling three or four numeric items in an exercise, and the working memory issue may be a factor.[8] But this category has direct effect on employability from the perspective of a company as discussed before. Finally the fifth category of "Understanding of the Designed World" has been implemented by studying NASAs operation budget allocation and the "Needs" as discussed above.

Junior high school science sessions have been conducted with the inclusion of technological literacy as well, and our preliminary findings suggest that technological literacy would promote parents' interests and encouragement for STEM majors in their families. Health related topics such as microbes on Earth and perhaps elsewhere are most receptive to parents, but the teenaged learners have more diverse interests such as pulleys, prism, and optics.

What Is Literacy?

What is literacy? In general being illiterate would suggest a person who lacks the ability in reading and writing, but has no trouble in listening and speaking in daily life. The ability to read and write is essential to fulfill the NAE criterion on critical thinking and decision making, the third cognitive dimension on technological literacy. Recollection, being a fundamental element in the critical thinking process, would be easier when reading and writing skills are available. In fact recollection belongs to the second cognitive dimension of capabilities in the NAE perspective on technological literacy. Of course, all students from junior high school to college are expected to know how to read and write. However the important part would be how to 1) do reading with some perspective from the pre-requisite (the first cognitive dimension of knowledge in the NAE perspective on technological literacy) and 2) do writing demonstrating critical thinking in the discussion and informed judgment in the conclusion (the final cognitive dimension). A laboratory report component should include discussion and conclusion writings, and lecture session essays can also be designed accordingly to improve general literacy. Technological illiteracy suggests a person who lacks the ability to read technological news, device instructions, etc., together with the lack of critical thinking based judgment in writing as expression. The call from Google CEO Dr. Eric Schmidt in the UK last summer that students should study arts and engineering together so as to avoid falling behind the current digital age could be an extreme example.[9] Perhaps Google was responding to questions in the media such

as "Is Google Making Us Stupid?".[10-12] In any event, the literacy element that helps engineers should not be underestimated. By extension, the benefits for non-STEM majors to use the literacy built into their programs (humanities, arts, business, etc) can be inferred readily. Therefore it is crucial that homework assignments be designed accordingly for achieving the NAE final cognitive dimension of critical thinking and decision making.

Conclusions

The implementation of technological literacy in teaching non-STEM students in required science courses has provided a clear pedagogy to improve teaching. Using examples from currently evolving technology or items of current interest in the media have been found to encourage students' learning and technological literacy. The guidelines of the NAE and ITEA offer a useful development tool. The hurdle of understanding numeric skill at the ratio level among the community college non-STEM students needs further attention.

Acknowledgements

A grant from JP Morgan-Chase (PI-Tremberger, Jr) is gratefully acknowledged. The support of Mr. Alexei Kisselev is gratefully acknowledged.

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