Beyond Competency: A Context-Driven CSO Course

Jeff Cramer
Computer Science and Engineering
Taylor University
Upland, IN 46989
765 998 4684
jcramer@cse.taylor.edu

Bill Toll
Computer Science and Engineering
Taylor University
Upland, IN 46989
765 998 4931
btoll@cse.taylor.edu

ABSTRACT
In the process of revising our general education course, which is required of a large fraction of students, we attempted to answer the question "What should a graduate of a liberal arts university understand about computational technology?" As computing technology has impacted and created drastic change in nearly all aspects of everyday life, university students may know more about narrow areas of technology but the true impact on their lives cannot be understood without an appreciation for the nature and limitations of the technology. This paper presents a set of assumptions about the impact of technology on individuals and society and describes elements of a computing context designed to enable students to critically evaluate the technology that has such an impact on their lives. Assessment of the approach indicates that students are more aware of the impact of technology and the importance of an understanding of the technology.

Categories and Subject Descriptors
K.3.2 [**Computer and Information Science Education**]: Computer science education, Curriculum, Information systems education

K.4.2 [**Social Issues**]: Abuse and crime involving computers

K.7.4 [**Professional Ethics**]: Ethical dilemmas

General Terms
Measurement, Design

Keywords
Computer Science education, Non-majors, Liberal arts

1. INTRODUCTION
The authors received an internal grant to continue a process of revising the general education computing course at Taylor University. This course is required of all majors except for those offered by Computer Science and Engineering and Elementary Education majors, who have their own required course. Many schools refer to these computer classes as technological "competency" or "literacy". Jane Turk recognized that these terms can be broadened [1], but there is still a need to replace these terms with something larger. For several years our course has increasingly focused on a broader picture than competency and literacy.

Various approaches have been investigated to design and deliver a computing course that promotes an understanding of computation and its role in society. Many papers available in the literature discuss application to majors, [2] as example. Others address courses designed for a more general audience such as ours [3], [4], [5], [6], [7], [8]. Some papers seem to fall into a category that is somewhere between a major specific course and a general education requirement [9]. A helpful view of the difference between such courses was presented in a discussion of computer science education in China through the distinction of professional computing from fundamental computing [10].

While there is much in common in the approaches discussed in the literature, a model was needed for our environment of a course for nearly all students at a selective liberal arts university. Several discussions and two brainstorming sessions were conducted with a variety of faculty and staff in an attempt to answer our key question "What should a graduate of a liberal arts university understand about computational technology?" The interactions reinforced the instructors' views of the direction the course should take and helped formulate a design for the course that could successfully match expectations. The input also clarified to the instructors that students in a liberal arts setting must learn more about computing than just tool using. They must learn to evaluate the effects of technology on self and society.

The word "context" captures the vision for what the course should be. We are convinced that the course can be successful only by careful, continuous attention to the idea of ***context*** presented throughout the course. The understanding of the importance of developing the proper context within which such courses are taught has been recognized [11], [12].

2. DEFINITION OF CONTEXT
A liberal arts education requires students to gain an understanding of the world around them. Technology is a major part of this world and therefore must be understood. Put another way, educated people cannot have a fully informed view of the world if they do not understand the way technology is integrated into so much of it. The twentieth century philosopher, Martin Heidegger [13] reminds us that to view technology as simply a tool is only partially correct. There is something else going on with technology when we use it. He referred to this as the essence of technology. Thus, part of the context of technology is

SIGCSE'12, February 29–March 3, 2012, Raleigh, North Carolina, USA.

understanding how it effects our view of the world when we use it.

For the purpose of course development the word "context" was defined as the set of fundamental concepts

- within which computing technology exists
- that must be considered to understand and evaluate the interaction of technology with society and individuals
- that allow an educated person to function in the contemporary world

Assumptions were developed so that specific elements of context could be defined and described. The list was derived through conversations between the course instructors as they tried to understand the areas of context that our students are lacking. These assumptions are:

1. As computing technology becomes more complex and hidden

- students understand less about how the world functions
- the student's worldview is impacted by technology in ways that are not recognized and, therefore, not critically evaluated

2. Computing technology creates an alternate view of the world where societal structure and human relationships have different meanings than in previous generations.

3. If the way in which computing technology impacts every aspect of life is not understood, it is impossible to have a full concept of what it means to be human.

4. Technology is so intertwined with contemporary life that ethical issues are more easily hidden. A person who does not have some understanding of technology cannot understand ethical issues.

5. Education now includes reading, writing, arithmetic, and computation. Less emphasis is placed on the traditional three pillars due to the supposed power of computation.

6. The availability of google, wikipedia, and similar resources provides quick surface-level answers to almost any question, especially technical how-to questions. While this approach offers solutions to immediate problems, it forms an inadequate knowledge base for a liberally educated person.

7. General education computing courses aimed at competency and literacy foster the above paradigms rather than critically analyzing them.

8. Although the above assumptions emphasize a broad view of computing, students need to learn what tools are available and how to use them.

3. COURSE MODIFICATIONS

The course has undergone a series of modifications. For several years the course has stressed the examination of technology's impact on society to include negative aspects and unintended consequences. These concepts fit well with the revised course and are continued in a somewhat modified manner. It is important to state that discussion emphasizes such issues but that we do not judge that computing technology is "bad", but rather to counteract common assumptions that all aspects of technology are "good". As Neil Postman [14] said, the benefits of technology are obvious; therefore we should look more closely at the negative effects. The course has included, and continues to include, material from Neil Postman as well as Nicholas Carr [15] as required readings.

Some material is presented with strong statements in order to gain the attention of the students. For example, the course web page begins with the following quote from Jacques Ellul [16]:

> "Prepare them to live in technology and at the same time against technology . . . to develop a critical awareness of the modern world"

The course has also emphasized ethics applied to computing and technology, including an introduction to ethical theory.

3.1 FALL 2008 – SPRING 2009

The first change made to the course was between fall 2008 and spring 2009 when the class sections and sizes were modified to allow for a team-teaching approach. In fall 2008 the course was taught in 5 sections of 45 students each on a Tuesday/Thursday schedule. Beginning in the spring 2009 semester the course was changed to meet in two large groups of 120 each on Tuesday and then broken into four smaller groups of 60 each on Thursday. Lab times remained the same for both semesters. This format change allowed for more lecture style and lab demo material to be covered on Tuesdays, and for discussion and interaction on Thursday. An interesting effect was that even though the class sizes were larger, because the students moved from a large lecture hall on Tuesday to a smaller classroom on Thursday, the 60 student sections seemed small in comparison and facilitated an acceptable amount of interaction and discussion.

3.2 FALL 2009

Major modifications were incorporated beginning in the fall semester, 2009. Students were introduced to our concept of a context driven course. Lectures, labs, and course readings were designed to emphasize the context of computing in the students' world.

The idea of computing context and its relation to a liberal arts education is mentioned and acknowledged in nearly ever class session. Each lab includes an introduction section placing the tool and/or the topic of the lab in the broad context presented in the course. Students are provided with an explanation of why the particular topic is valuable to learn.

Labs are designed as much as possible to convey more than one idea. For example, three labs are devoted to the use of different tools (spreadsheet, database, and web forms) but also illustrate concepts of data structures and their impact. The first lab of this set requires manipulating data and answering certain questions about student registration information. The second lab explores the use of a database with the same data while discussing additional questions that can be easily answered due to increased structure in the data. The third lab utilizes a provided database and web server software to generate responses to queries from a student created web form.

Guest lectures are utilized to stress context and provide relevance to topics. The University Director of Technology Services discusses bandwidth and related issues that are important to students.

The Department offers an "add-on" curriculum in Systems (analysis, design, etc.). The Director of the Systems program

presents material on "what is a system?" and "what does it mean to approach a problem from a systems perspective?"

Students in a web application development course (from our department) speak to the class on the topic, "What every graduate of a liberal arts university should understand about the Internet."

Throughout the semester, students are able to move from seeing only the benefits of computational technology and the usefulness of computer applications, to critically analyzing the effects on self and society. They are given a chance to put computational technology in a proper context with their world.

3.3 FALL 2011

As with most computer science courses, the modifications are ongoing. This fall the labs have moved to a cloud computing environment. Instead of using PhotoShop, we are using pixlr.com. Instead of traditional web design with Adobe Dreamweaver, we are using WordPress. Instead of Microsoft Office, we are using Google Docs. The goal is to meet the students where they actually live—online. Like the rest of the course, students will be asked to evaluate both benefits and problems with cloud computing.

4. CONTEXT DRIVEN CONTENT

As course modifications continue, context remains the driving force. There is sometimes conflict between what students think they need to know, and what the instructors want them to learn. By placing course topics in context, students are better able to see why they are doing what's asked of them. For example, the context for students while working through the section on programming and algorithmic thinking is not that every student will become a programmer. They are asked to understand that this is what a computer scientist does, how a computer scientist thinks, and what is possible in software development. Part of the context of computational computing is knowing what is possible and what is not—removing the "magic" from what a computer is doing.

The instructors believe that course modifications, past and future, serve the purpose of the course if they are designed and taught with context in mind.

4.1 ELEMENTS

In order to map "context" to course structure and material, elements of the context that can be related to course activity were identified.

Beyond the aspects of ethics and the relationship of technology and society discussed above, the elements in very broad terms are:

- nature of computation – algorithm processes, concepts of complexity, practical and theoretical limits on what is reasonable to compute
- systems mindset
- data can be organized – the method of organization impacts what can be accomplished easily and efficiently
- ethical theories to support application
- history of computing and technology – the way in which technology has developed has had its own impact on
- tools – an educated person knows what tools are available and should not be intimidated by new hardware and software
- technological literacy – basic ideas of hardware and software, including speed issues, cloud computing, and virtual machines

4.2 TOPICS

A list of topics was developed from the context elements. The approach used is that topics are organized into "context ingredients". As in a recipe prepared by a master chef, it is possible to taste the individual ingredients but the true flavor of the course is determined by the combination of the ingredients.

Topic categories are:

- Ethics and society
  - ethics – theory and application
  - intellectual property
  - societal impact
  - appropriate technology
  - computing to support non-profit endeavors
- Data organization
  - structuring of data
  - spreadsheets
  - database
- Information
  - web pages – construction, design
  - information context
  - interaction with data through web interfaces
- Computation
  - limits on power
  - algorithmic thinking – including concepts of complexity
  - systems thinking – what is a system?
  - programming – to provide understanding of process, not practical skills

4.3 EXAMPLES

To further explain the course design, we provide the following examples of topics that are taught to develop an understanding of context with students.

A. Ethics

Computers (especially when networked) allow people and organizations to do things that couldn't be done in the past. They also allow for the same things to be done in different ways. Students are taught to think about the ethical issues arising from such change.

Graduates of a liberal arts university should be able to analyze computer ethics issues as they arise and be able to respond to them in an informed way. Students are taught a basic overview of

ethical theory and asked to respond to case studies and other readings of ethical issues in computing.

Students are introduced to the ideas of employee monitoring, privacy, intellectual property, theft, and even human relations in a social networking environment.

This section of the course concludes with a book discussion related to computational technology and society. Neil Postman's *Technopoly*, and Nicholas Carr's *The Shallows: What the Internet is Doing to Our Brains*, are two books that have been used. Because the students meet twice a week, once in a large group, and another time in a smaller section, we are able to facilitate an open atmosphere of discussion.

B. Data

Graduates of a liberal arts university should know that the manner in which data is organized affects what can be done with the data. Students are given some realistic student enrollment data in spreadsheet form and directed to answer some questions about the data that require spreadsheet manipulation.

In a later lab, the rows of the spreadsheet are divided into database tables. Students are asked to answer questions that would be difficult in spreadsheet format but are easy with database organization.

In the next lab, students have designed a web form using Dreamweaver to query a provided data base and server application. Although writing SQL is not stressed, students are shown the SQL statement generated by their query along with the results.

C. Computational efficiency

Graduates of a liberal arts university should be aware that some problems are "harder" to solve, in an algorithmic complexity way, than others. To illustrate this point, an interactive lecture is presented where the professor guesses a number between 1 and 1000 with no more than 10 guesses using binary search. The next problem considered is one where students schedule a time to meet for lunch in groups of 2, then in groups of 3, etc. Students are convinced that adding one more person to the discussion doubles the amount of work. These types of problems are described as logarithmic $O(\lg N)$ and exponential $O(2^N)$ although most of the students do not grasp the mathematics involved.

D. Algorithmic thinking

Graduates of a liberal arts university should have some understanding of algorithmic approaches to problem solving. Students complete a "programming" lab where a game is played to move a character to light a lightbulb. Students choose and order operations such as turn right, move forward, jump in order to accomplish the task. The selected steps are not executed until after all are selected.

There are a limited number of locations to store the steps. Therefore, functions in the form of a group of icons representing steps are needed. The concept of procedural abstraction to simplify problem solving is discussed in this context.

5. ASSESSMENT

In order to assess the impact of the newly redesigned course on students, a survey was given at the end of each semester from fall 2008 to spring 2010. The same 17 questions were asked using a five-point Likert scale of Strongly Disagree, Disagree, Undecided, Agree, Strongly Agree.

The goal of this survey was to discover whether students had an increased understanding of the purpose of the course and whether they were satisfied with what they had learned. Our reasoning for this measurement of student perceptions was based on two ideas; 1) students will learn more if they believe they have a clear understanding of the purpose of the course, and 2) increased student satisfaction represents a positive improvement in the learning that takes place, especially in a campus-wide, general education course, where motivation is an important factor. The data gathered represents 100% participation among the 220+ students each semester.

The seven questions most pertinent to this paper are listed in Table 1 below. They were used to measure, across five semesters, student perceptions of the value of the course.

Table 1. Survey Questions

1.	I have a better understanding of the relationship between technology and society.
2.	This class is about understanding the role of computation in today's society.
3.	This course caused me to rethink my personal use of technology.
4.	This course is necessary at Taylor University.
5.	I am better prepared to interact with computers and technology in the future because of this course.
6.	*My attitude towards this course at the beginning of the semester was that it would be valuable.
7.	*My attitude towards this course at the end of the semester was that it was valuable.

* No data for fall 2008

5.1 Results

It is important to note that this course was redesigned over the course of several semesters. The fall 2008 semester represents the last time the course was taught as-is without any modifications.

During the next three semesters, new ideas were implemented into the course. In the second semester, spring 2009, besides changing class sizes and format, the idea of context was becoming a part of the course. But it wasn't until fall 2009 and spring 2010 that the emphasis of context was intentionally introduced as the overarching idea. The survey results continued to show an increase in the students' perceptions that they understood the purpose of the course and were increasing their satisfaction. Some highlights across all five semesters follow:

An indicator that students are satisfied with the course can be found in the results from survey item 4. From fall 2008 to spring 2010 students increased their perception that this course is useful for students at Taylor University. The 19% increase moved from 41% to 60% of the students responding with Agree or Strongly Agree. A side benefit of this response could be that students will

speak positively of the course to their peers and help change the perspective that this is a competency course.

Students also showed an increase in the perception that learning about ethical issues with technology and society was valuable. Survey item 3 measured this positive result.

Most notably there was a positive increase in the two questions, items 6 and 7, which asked about the students perceptions of the course at the beginning of the semester and then at the end. (Note: we have data for this response for only four semesters.) In the response to, "My attitude towards this course at the beginning of the semester was that it would be valuable," 31% chose Agree or Strongly Agree in spring 2009 compared to 39% in fall 2010. Likewise, for the response about their attitude at the end of the semester the responses were 53% and 64% respectively. This shows that students are moving in the right direction in a two-fold way. First, students are increasing each semester in their perceptions that this course will be valuable, as well as increasing in the final outcome that it was indeed valuable. Secondly, Agree/Strongly Agree responses increased from the beginning of the semester to the end from 39% to 64%--a 25% increase.

5.2 Assessment Conclusion

The responses to the survey indicate that as the idea of context was introduced into the course, students increased their perception that the course was valuable. When the course was revised to be centered around context, students shared the perception of being more satisfied and having a better understanding of its purpose. Improving student satisfaction is a good beginning towards increasing the learning outcomes for this course. It is our belief that students are increasing in their understanding that this course is relevant and fitting in a liberal arts education.

6. REFERENCES

[1] Turk, J. 2010. Computer Literacy as Life Skills for a eb 2.0 World. In *Proceedings of the 41st SIGCSE Technical Symposium on Computer Science Education*, 417-422.

[2] Purewal, T. S., Bennett, C., Maier, F. 2007. Embracing the Social Relevance: Computing, Ethics and the Community. In *Proceedings of the 38th SIGCSE Technical Symposium on Computer Science Education*, 556-560.

[3] Barr, J., Cooper, S., Goldweber, M., Walker, H. 2010. What Everyone Needs to Know About Computation (panel). In *Proceedings of the 41st SIGCSE Technical Symposium on Computer Science Education*, 127-128.

[4] Burns, B. 2005. A New Approach to Computer Science in the Liberal Arts. *Journal of Computing in Small Colleges,* 20, 68-77.

[5] Cliburn, D. C. 2006. A CS0 Course for the Liberal Arts. In *Proceedings of the 37th SIGCSE Technical Symposium on Computer Science Education*, 77-81.

[6] Giangrande, E. 2008. Computing for the 21st Century. *Journal of Computing Sciences in Colleges*, 23, 31-36.

[7] Turk, J., Wiley, S. 1997. Teaching Social and Ethical Issues in the Literacy Course. In *Proceedings of the 28th SIGCSE Technical Symposium on Computer Science Education*, 10-14.

[8] Zimmerman, B. 2004. Content and Laboratories of a Computing Science Course for Non-Majors in the 21st Century. *Journal of Computing in Small Colleges*, 19, 68-77.

[9] Guzdial, M., Forte, A. 2005. Design Process for a Non-majors Computing Course. *Proceedings of the 36th SIGCSE Technical Symposium on Computer Science Education*, 361-365.

[10] Zhang, M., Lo, V. M. 2010. Undergraduate Computer Science Education in China. In *Proceedings of the 41st SIGCSE Technical Symposium on Computer Science Education*, 396-400.

[11] Martin, F. G., Kuhn, S. 2006. Computing in Context: Integrating an Embedded Computing Project into a Course on Ethical and Societal Issues. In *Proceedings of the 37th SIGCSE Technical Symposium on Computer Science Education*, 525-529.

[12] Pasternak, A., Vahrenhold, J. 2010. Braided Teaching in Secondary CS Education: Contexts, Continuity, and the Role of Programming. In *Proceedings of the 41st SIGCSE Technical Symposium on Computer Science Education*, 204-208.

[13] Heidegger, M. (1977). *The question concerning technology, and other essays*. New York: Harper & Row.

[14] Postman, N., *Technopoly: The Surrender of Culture to Technology*, New York, Vintage Books, 1993.

[15] Carr, N., *The shallows: What the Internet is Doing to our Brains*, W W Norton & Co Inc. 2011.

[16] Ellul, J., & Vanderburg, W. H. (2004). *Perspectives on our age: Jacques Ellul speaks on his life and work*. Toronto: House of Anansi Press.