The Images of Computing: Engaging Undergraduates in the Broad Issues of Computer Science

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ABSTRACT

In this paper we describe a new course designed to give undergraduate students, including those who will be tomorrow's computer science professionals, the opportunity to think beyond the classroom, to reach out and examine some of the broader issues surrounding computing. This "research and action" based course – "Understanding and Broadening the Images of Computing" – explores the images, the realities and the (mis)perceptions of computing that influence public understanding and participation in the field. Students have the opportunity to reflect on some issues often taken for granted e.g. *What do we mean by computer science and how does it differ from computing? How do cultural images, attitudes and access to resources impact participation in computing? Are our attitudes to computing generalizable or culturally specific?* By engaging students in cultural analysis the course aims to prepare them to be critical thinkers, and better informed professionals, in the fields they have chosen to enter.

Categories and Subject Descriptors

K.3.2. [**Computers and Education**]: Computer and Information Science Education – *computer science education.*

General Terms

Human Factors, Experimentation

Keywords

Images of computing, culture, perceptions, broadening participation, outreach, global perspective

1. INTRODUCTION

In 2000 an ItiCSE working group made the following observation: "Students in today's university programs will be the CIT professionals of tomorrow. Industry and workplace professionals realize that skills beyond the technical are vital to the success of the students ….. Cultural issues are becoming more important as the world moves towards increased communication and globalization." [7]

In this paper we describe the design and implementation of a new course, a 7 week elective hosted by the computer science (CS) department at Carnegie Mellon University (CMU) and first offered in spring 2008. The course is designed to give undergraduate students the opportunity to think beyond the classroom and examine the broader issues surrounding computing. This research and action based course – "Understanding and Broadening the Images of Computing" – explores the images, the realities and the (mis)perceptions of computing that influence public understanding and participation in the field. In this sense exploring the *images* of computing provides a vehicle for exploring the broader issues and the cultural context of the discipline. Though specifically cultural in focus, and much lighter in CS concepts, we might place this course among others which also require students to examine the broader issues of computing. Fisk University, for example, offers "Exploring Computer Science – A Freshman Orientation and Exploratory Course"[1] and Duke has "CompSci 82",[2] both of which have been around for some time. Also, we see and welcome the development of a new AP Computer Science Principles[3] course in which students "learn to analyze, critique, and discuss the ethical, legal and social implications of computing."

The CS curriculum at CMU provides a solid foundation in computer science and aims to prepare "students to be industry and academic leaders who can apply technology and computer science principles across a wide variety of fields"[4]. Students are also required to take arts and humanities classes and to complete a minor in a second subject to gain depth in another area. Thus the CS program recognizes that gaining other skills in addition to their technical expertise will help broaden and strengthen their contribution as future computer scientists and citizens. At the same time the department offers non-CS majors the opportunity to explore the field through such courses as "Principles of Computation"[5] in which students with no prior background in

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[1] See http://www.cs.duke.edu/csed/fyi/egarievwe.pdf
[2] See http://www.cs.duke.edu/courses/fall08/cps082
[3] See http://csprinciples.org/
[4] See Carnegie Mellon's School of Computer Science web site http://www.cs.cmu.edu/about/index.html
[5] This course provides an alternative to an introductory programming class and satisfies the computing requirement for non-CS majors at CMU.

computing study the key concepts of the discipline. It is within this rich educational framework that the course – "Understanding and Broadening the Images of Computing" – fits and meets the school's aims and philosophy. By engaging students in cultural analysis the course aims to prepare them to be critical thinkers, and better informed professionals, in the fields they have chosen to enter.

2. COURSE OBJECTIVES

"Understanding and Broadening the Images of Computing" asks students to challenge their own assumptions about computing and computer science and to examine public perceptions of the field in the USA and globally. Students learn that in an image-based culture knowledge is often shaped by the images that surround us. [8] At the same time, as future professionals, students can be actively involved in re-shaping and re-presenting the field.

The objectives of this course are for students:

- To self-reflect on their own attitudes towards, and understanding of, computing and computer science.
- To research images of computing in the public media to identify images which might have broad appeal and images which might not.
- To understand the role of images in determining and perpetuating public (mis)understanding of computing.
- To examine how computing and computer science are defined and envisioned by CMU, by students and by experts in the field, and how this plays out in representations of computing in popular media in the USA.
- To gain understanding from a global perspective of how access to computing resources, attitudes to computing, and participation in the field are subject to cultural factors including how the field is represented.
- To practice and experience teamwork, collaboration and teaching, and to engage in cross-disciplinary debate.
- To design and implement an outreach presentation aimed at broadening the images of computing.

Ultimately, the course also aims to engage students in the following questions: a) by understanding and broadening the images of computing can we help broaden participation? and b) why might this be beneficial to the field of computing and the nation as a whole?

3. COURSE PARTICIPANTS

This 6 unit elective[6] is open to undergraduates from all levels and all majors, although as one might expect most students are from the CS major. That said students from most schools across campus have participated including Humanities and Social Sciences, Engineering, Art, Science and Mathematics. We have found that the course works best with a mixture and balance of CS and non-CS majors. In this environment a range of perspectives and pre-conceived ideas about the field emerge to make discussions particularly interesting. The public perception of CS is often best articulated by non-CS majors, while CS majors do a good job of describing their field and of challenging and changing the perceptions of CS to non-CS students.

Each class runs for one hour and twenty minutes and meets twice a week over a 7 week period. The syllabus includes many in-class team/panel presentations and individual presentations. With this in mind it is not surprising that a small class size (16-18 students) appears to work best. As with any discussion-based course a small class size can also mean that all students get a chance to participate, to improve their public speaking skills and to feel included. This is particularly important if a student's class participation is included in their final grade.

The course has become increasingly popular and the waitlist has grown longer each year. Many students sign up out of strong interest and/or curiosity while some students are simply looking to fill course units for the second half of the semester. In 2009 the class size (even though still relatively small at 22 students) proved too unwieldy for the number of required presentations. At the same time class discussions were dominated by CS students who made up almost 70% of the class. By 2010 we limited the class size to 16 and, as in 2008, we were able to engineer a much better balance of CS and non-CS students. This situation meets the initial vision for the class structure and objectives.

The class has attracted students from all years but primarily sophomores through seniors. For the most part the class has had good gender balance with 29% women in the 2008 class, 36% women in the 2009 class and 44% women in the 2010 class. The class has also consistently attracted a good number of non-US born students from among the many international students that we have at CMU. Discussions in such a diverse atmosphere have proved favorable for developing students' understanding of what we mean by culture and different cultural values and expectations – concepts which are fundamental to the course.

4. COURSE DESCRIPTION

Figure 1. Image from "Take on Orbitz " T.V. Ad (2005)[7]

In this research and action based course we use the term "images" to refer to almost any text which carries meaning related to computing (however loosely or deliberately) and which can impact perceptions both of the field and those who work in it. Using images of computing as a focal point provides an ideal vehicle for examining the broader issues surrounding the field and for showing that images of computing can contribute to how the field is understood. CS is often crudely represented in the public domain and poorly understood outside of the CS community and even there CS professionals struggle to define this ubiquitous discipline. Limited understanding and exposure to the realities of CS leave the field open to the perpetuation of stereotypes and

[6] The majority of undergraduate full-semester courses at CMU are worth 12 units while most minis earn 6 units -- one unit being equivalent to one work hour, in class and homework.

[7] See http://pressroom.orbitz.com/index.php?s=43&item=236

misunderstanding. This is epitomized in an old "Take on Orbitz" commercial (see Figure 1.) which featured two male opponents, one a busy but clearly loving, friendly father complete with several happy, active kids, the other a single computer scientist. They were paired off in a "humorous" sketch to see who could get the best vacation package in the shortest time. The busy well-rounded father won. By using Orbitz.com, or so the message goes, using the computer becomes quick and simple for any user, regardless of distractions. On one hand the viewer sees a progressive/young image in the father-plus-happy-children representation. At the other extreme, we see the stereotypical image of the computer scientist as an isolated, nerdy looking, somewhat incompetent figure. At the same time the notion that the computer scientist should be set up as an expert at searching the web suggests a very odd and limited view of CS. All in all, the advertisement takes advantage of, and perpetuates, the negative stereotypes and lack of understanding that surround the field and the people in it. The irony, of course, is that Orbitz is a product of modern computer science.

So we see that misleading images of computing apply not only to the familiar geeky images but also to the field itself. One of the fundamental misconceptions is that CS equals programming and/or office applications. The content of many advanced CS courses in high school could easily suggest that CS *is* programming. Alternatively, many K-12 students in the USA are simply denied exposure to any CS courses – CS not being on the standardized national curriculum. This situation has become increasingly critical, indeed the ACM recently announced the introduction of the *Computer Science Education Act,* a new measure to address the crisis in K-12 computer science education.[8] Thus, many smart high school students are either missing out or may not be excited by a future in programming. [3]

Figure 2. Images of computers and computing have "evolved" into humorous graphics on t-shirts.[9]

We use academic papers, web sites, media texts, videos, personal testimony, group discussion and interviews to examine the above mentioned issues trying to understand how cultural images, attitudes and access to resources can impact participation in computing. We use our findings to build an action component in which student teams develop and implement a public presentation aimed at broadening understanding of computing. Students' own understanding of these issues is further enhanced by the section on computing in other cultures.

[8] For more on this see ACM's news release: http://www.acm.org/press-room/news-releases/2010/cs-ed-act

[9] Image at www.scs.sk.ca/cyber/blog/evolutio.jpg

4.1 Introduction and Overview, Issues and Definitions

Figure 3. Gamer as portrayed in TV's Southpark show[10]

We begin this 4 part course by exploring the meaning of culture, the role of images in determining the public understanding of computing, and definitions of computing and computer science. We look to cultural studies and Raymond Williams in particular, for useful definitions of culture. [18] For an understanding of how meaning is produced through the interplay of images and viewers we look to the work of philosopher Roland Barthes. [2] We also examine how the "same" image can produce different messages. Students describe their own definitions of computer science and also hear definitions from past CS seniors at CMU. We use both terms – computing and computer science – throughout the course and students are encouraged to think about their different and/or similar meanings and how they would explain them to various audiences. We turn to the Computing Curricular Reports for expert definitions of the 5 disciplines that make up the field of computing including computer science. [13] The ultimate aim of this discussion is *not* to define computer science but rather to expose students to the ongoing debate on *what is computer science?,* a debate which has engaged the SIGCSE community for several years. Discussions on broadening participation in CS in the USA are prompted after reading the perspectives of CS faculty Sanjeev Arora, Bernard Chazelle, Richard Ladner and Peter Lee. [1, 10, 11]

4.2 Participation in Computer Science and Images of the field (USA)

We examine and analyze images of computing throughout the entire course. Many researchers have concluded that stereotypical images, like the gamer from T.V.'s Southpark shown in Figure 3, frequently appear among the list of factors that deter some students from seeing themselves in the field[11]. Thus, in part two we pay close attention to the issue of participation in CS by asking if, and why, this matters and how this relates to images of the field.

We read and discuss arguments from different perspectives (the equity case, the academic case and the business case) that have been made to support broadening participation in CS. We look at data on participation in CS at the undergraduate level and at the

[10] http://blogs.courierpostonline.com/worldofwarcraft/files/2008/12/southpark_wow2.jpg

[11] Such researchers include (but are not limited to) Aspray, Blum, Borg, Camp, Cohoon, Cuny, Fisher, Frieze, Greening, Gurer, Keisler, Kuhn, Margolis, Schmidt, Spertus, Sproull, and Townsend.

K-12 level and compare projected CS Bachelors' production with projected jobs in the USA. [6, 14] And while the 2010 Taulbee survey notes a welcome upturn in applications to the CS major in the USA it is not yet clear if women and minorities are included in the good news. What the survey does tell us is that women represent only 11.3% of CS bachelor's recipients, African-Americans 3.4% and Hispanics 5.8% [6], at a time when they comprise 50.7%, 12.8% and 15.4% of the US population respectively. [17]

Data clearly indicate the low representation of women and minorities in CS and discussion centers around reasons why this might be. Students are encouraged to explore cultural factors and in particular to see factors *outside of gender* as contributing to participation in CS. While images are the primary focus throughout the course, we also discuss other cultural factors that would affect participation, such as different experiences, opportunities, mentors, expectations and levels of encouragement.

In this section we also look at myths and stereotypes and include readings and discussions of the work of Claude Steel and Margaret Shih on stereotype threat. [15, 16] We pay particular attention to how images of computing rely on myths and stereotypes – for better or worse – and how such images might work to include or exclude women and minorities and those men who might not see themselves as fitting the field.

4.3 Outreach and Broadening Understanding

Part three is the action component of the course. Students examine and discuss some current outreach efforts and assess their potential for providing new images of computing and for broadening understanding of CS. In particular students are exposed to the ideas presented in CSUnplugged [5] and cs4fn [4] which provide interesting material to ilustrate the concepts of computational thinking for young audiences. Discussions focus on creativity, on ideas and preparation for their own outreach efforts. Students are assigned to work in teams and are encouraged to choose a specific audience and venue for their outreach presentations.

Students are given the following guidelines:

- What is your goal?
- Who is your target audience?
- How will you make the presentation interactive?
- What materials/equipment will you use?
- How long should the presentation be?
- How will you measure impact?

Where time allows teams practice in class and receive feedback from their fellow classmates. They are all required to do at least one practice presentation with the course instructor.

4.4 A Global Perspective

In this final section students read and discuss a selection of research papers focusing on computing around the globe. Papers range from a study of women's participation in CS in Armenia, to CS education in China, to the representation of computing in Indian cinema. [9, 19, 12] In particular, by looking internationally at the different levels of participation of women in the field we can establish that the image of computing in some cultures is not as gendered as it is in the USA. We explore the different perceptions of CS in different cultures and countries. For example we can see how in some cultures CS is perceived as being closely related to math while in other cultures CS is perceived as being closely related to engineering. We discuss the implications of such different cultural perceptions. We also examine the relationship between computing, technology and developing nations where the images of computing can range from positive and aspirational to paternalistic and damaging.

5. ASSIGNMENTS AND GRADING

Students are graded primarily on the quality of their performance in 3 assignments – 2 individual assignments and one team assignment. The assignments constitute 80% (25%, 25%, and 30% each) of the final grade. Students are also expected to do a considerable amount of reading and to lead the discussions of particular research papers. In most cases this takes the form of a panel in which student teams initiate a debate on the paper. This component along with attendance and participation accounts for the rest of the grade, i.e. 20%.

Assignment 1: This assignment has taken two formats: a) interviews and b) researching images. In the former a) (given in 2008 and 2009) students were required to interview a CS faculty, or industry researcher/engineer, to find out firsthand about their self-image, their day-to day work, and general computing company/department culture. Each interview transcript was accompanied by a report comparing expectations with interview findings along with comments on ways in which findings challenge and/or support popular images of computing professionals. In 2010 this first assignment was changed to researching images of computing in the USA in popular media: e.g. online sites, television, games, books, journals and magazines, etc. The goal is to identify an image which could have broad appeal and one which might not. The assignment also includes a short paper and a "show and tell" presentation on the chosen images.

Figure 4. Students Present at Take Your Child To Work Day

Assignment 2: For this assignment students work in small (mixed gender) teams on an outreach component in which each team prepares and implements a presentation at a local venue, or on campus, with the goal of showing the breadth of computing and the potential for diversity. For example, students use introductions of themselves to show that computer science students have a range of backgrounds and interests. Where team members are not all CS majors they reach the same goal by asking audiences to guess their majors. Other outreach activities include robotics, cryptography, "magic" tricks, and algorithmic style problems and puzzles to encourage interaction and audience participation.

Assignment 3: For the final assignment students are required to write a 3-5 page research paper exploring attitudes to, and

participation in, computing in a specific country, culture, or micro-culture. This assignment carries most weight because there is such a paucity of international data. Students are also given tips on writing a good research paper.

6. OUTCOME AND STUDENT FEEDBACK

Students have responded well to this course. Anonymous feedback from *informal* end-of-course surveys and the school's *formal* anonymous faculty course evaluations (FCEs) have been very positive. Many students have said how much they value the opportunities for teamwork and for improving their presentation and public speaking skills. FCE's ranged from "Interesting course, but it does squeeze a lot into a mini which can get a little confusing at times as the class structure jumps around a lot from writing papers, reading articles, presenting, etc." to "great experience with outreach. Excellent practice for presentations and stimulating class discussions" and "a lot of hands-on work made it very enjoyable and informative".

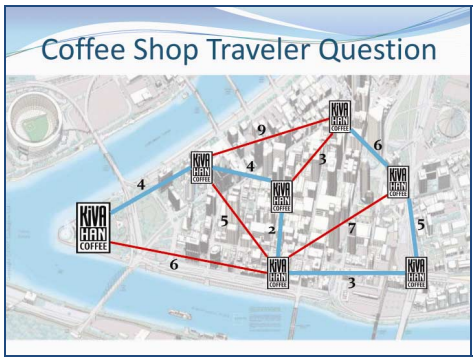

Figure 5. Slide from Student Outreach Presentation

Early in the course, during a class which focused on definitions, two CS seniors mentioned that this was the first time in the CS major that they had actually thought about what computer science means. This was echoed in this student's feedback response to the question *what new ideas did you learn in this class?:* "This was the first class after 3 years as a CS major that tried to define CS! THANK YOU!"

Students had very little idea about the ups and downs of CS enrollments. Most appeared to have a good sense of how CS and computing professionals were narrowly perceived by the general public but it was often left to the non-CS students to describe just how poorly understood the field is generally.

The gender gap in CS enrollments was also a new issue for most students. However, students raised in countries where women are well represented in CS were quick to bring this fact to the attention of the class promoting the point that the level of women's participation in CS is largely a cultural issue. Arguments for gender differences (in characteristics, attitudes and abilities) as a cause for the low participation of women in CS in the USA have generally been argued as *untenable* since from their experiences at CMU students have seen both men and women fitting the field.

Students were quick to recognize a possible connection between participation in CS and how the field is represented in the popular media. They soon discovered that images of computing were for the most part either absent or negative. Some students had difficulty in discerning whether or not an image had broad appeal, thus recognizing that many images are not easily categorized. By the time they were reading about the global situation students seemed comfortable in doing basic cultural analysis. However, each year this final section has been the weakest section of the course largely due to poor time management. Not surprisingly writing the final papers was noted as the *least* favorite part of the course and students have often ended up using online blogs and news sites as sources rather than research papers.

In 2010 time management was still an issue even though attempts were made to find more space for the global studies section. The first assignment, for example, was changed from having students conduct interviews to researching images of computing. While the interviews turned out to be very interesting the time spent on them, along with having to meet IRB requirements, proved too demanding for a mini course, although this assignment would work well in a full 12 unit course. Researching images proved to be a very successful change and it was surprising to see few duplications in the images chosen and discussed by individual students. Most images came from TV advertising of computing related products. Figure 6, for example, is from a series of Intel television commercials – these provoked disagreement among students in terms of whether or not the images had broad appeal. Other images came from movies featuring gamers or geeky characters. Students overwhelmingly agreed that it was much harder to find images with broad appeal than to find images which presented a narrow view of computing. This research activity showed a very real need for changing the images of computing to encourage broader representations of the field.

Figure 6. 'Our Jokes Aren't Like Your Jokes' Intel Commercial[12]

The outreach assignments were particularly well done and clearly the students enjoyed presenting the field in a fun and exciting way to their audiences. It seemed clear, however, that they could use more guidance in how to work in teams. The most popular strategy involved each student individually contributing several slides which were then put into one final presentation. But even students who were fairly reticent in class showed a flair for presenting CS to young audiences. Most presentations were designed and implemented for K-12 audiences taking advantage of Take Your Child to Work Day on campus and an after school technology program for middle school girls. Other audiences consisted of high school students who had been accepted in CS at

[12] 'Our Jokes Aren't Like Your Jokes' – 2010 Intel Sponsors of Tomorrow
http://www.youtube.com/watch?v=e0FULHGwPkw

CMU, undergraduates from a variety of CMU majors, and even the random clientele of a local coffee shop.

All students said they would recommend the class to other students. Almost all said they would recommend the course to CS majors and about half said they would recommend the course to non-CS majors noting that "Other students would understand CS better after taking this course". Almost all students said that they felt comfortable expressing their views in class. For the majority of students the outreach presentation was their favorite part of the course even though it was time intensive. Several students said they thought the class should be a full length course. Most students indicated that the course had met its goals i.e. it challenged them to re-think their ideas about the images of computer science, what we mean by computer science, the reasons for participation in the field, and what we mean by culture and cultural assumptions. One student summed up the course in this way: "How to think about how other people think about CS".

7. SUMMARY

The predictions of the ItiCSE working group have played out over the past ten years as the fields of computing have been immersed in issues of national and international concern, ranging from the fear of jobs being outsourced and declining enrollments (especially among women and minorities), to the future and safety of the internet. The course described in this paper, "Understanding and Broadening the Images of Computing", uses the images of computing as a thought provoking vehicle for engaging students in the broader issues that surround the field. The course has been well received by undergraduates and the numbers of students interested in taking the class has increased quite dramatically. Revisions of the course will be ongoing as new material comes to light and time management improves.

For both CS and non-CS majors the opportunity to explore what we mean by computing and computer science and how the discipline is perceived and represented helps develop their critical thinking skills and broadens their own understanding. This computer science major noted: "I felt that this course helped me understand a lot about my major from an entirely new angle – how computer science is perceived from a cultural perspective". By coupling this new understanding with the task of designing and implementing an outreach presentation reinforces what they have learned and helps them imagine the field outside of the classroom. One student said the course helped her "to break down the complex language of CS and present it to a non-CS related audience". This is a challenge for us all; indeed, ongoing discussions on the SIGCSE d-list indicate the need to pay attention to what we mean by computer science and computing and to how the field is understood within and beyond the CS community. If computer science is to be a highly valued discipline contributing to the future of the nation we need to pay attention to how the field is represented and perceived. In an image based culture understanding and broadening the images of computing is no trivial matter.

More information about this course can be found at http://www.cs.cmu.edu/~cfrieze/courses/index.html

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