An HCI Approach to Computing in the Real World

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We describe the implementation of a six-week course to teach Human-Computer Interaction (HCI) to high school students. Our goal was to explore the potential of HCI in motivating students to pursue future studies in related computing fields. Participants in our course learned to make connections between the types of technology they use in their daily lives and the design processes that went into creating these technologies. We suggest that by portraying computing through the lens of HCI, as an innovative, creative, and challenging field with authentic, real-world applications, we may be able to motivate students to become more interested in computing.

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1. INTRODUCTION

> "You can actually make up a new technology or something or you can design stuff and improve it . . . I like that we can have ideas that we might some day see them as real." (Tim, 13)[1]

In the fall of 2006 and the spring of 2007 we interviewed 13 teenagers from local schools and observed over 40 teenagers in after-school technology programs, ranging in age from 11-19, to learn about their perceptions of computing [Yardi and Bruckman 2007]. They told us that they love to hang out online, stating that they "check Facebook and chat on IM on the computer all day long"

[1]Name changed to maintain anonymity.

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(Tanya, 15) yet they perceive computing careers to be boring, solitary, and lacking real-world context: "I wouldn't want to just stare at the computer all day" (Nathan, 14). Despite their enthusiasm for using computers and the Internet, they convey a significant lack of interest in computing as an academic field or career path. The goal of our research is to engage teens in computing by bridging the gap between what they love to do with computers in their daily lives and their perceptions of computing careers.

Our approach is to build from HCI, an area of computing that we know college students to be highly engaged in [Yardi and Bruckman 2007], and to explore the effectiveness of teaching these same concepts at the K-12 level. As a relatively young and evolving discipline, the role of HCI in higher education is frequently discussed among researchers and practitioners. What topics should be taught? What skills should students have when they go into industry? What is the role of HCI in related disciplines? In 1990, Terry Winograd challenged the field of HCI to "create a course in which students are challenged to develop competence in design through a process of guided learning" [Winograd 1990]. Soon after, the ACM SIGCHI Curriculum for Human-Computer Interaction was published as a resource for HCI educators [ACM 1992]. It was followed by wider community interest in developing a standard higher education HCI curriculum [Gasen 1993; Lowgren et al. 1994]. The field was in its nascence and the emphasis was on establishing credibility, standardization, competence, and awareness in the discipline [Gasen 1994; Winograd 1990]. More recently, discussions address the challenge of maintaining relevance in today's rapidly evolving technological culture [Carroll et al. 2006; Wing 2006]. What steps should the HCI community take to stay on the cusp of the changing face of computing?

As we near the end of the second decade of HCI education, we explore the role of HCI in a K-12 curriculum: how should we teach it and what impact can it have? The ACM K-12 Model Curriculum for Computer Science proposes that HCI is one of the "core subjects that all major programs should cover" to prepare students for college CS [Deek et al. 2003]. However, there is less certainty about what should be included in this curriculum and how to teach it. We designed a six-week introduction to HCI course for K-12 students (specifically targeted to ages 11-15) during the summer of 2007 in which participants designed touch-screen digital desktops to replace the physical desktops that they currently use in their classrooms. We modeled our course after a college-level introductory HCI curriculum while targeting a subset of the "core" subjects in the 13 areas in the K-12 Model Curriculum. Our research questions are:

1. Did participants enjoy learning HCI? What parts of the HCI process were exciting and engaging for them? What parts were not engaging?
2. Did our HCI course influence their perceptions of and interest in future careers in computing?

1.1 Broadening Participation in Computing

Computer science is the study of computers and algorithmic processes, including their principles, their hardware and software designs, their applications, and their impact on society [Deek et al. 2003]. *Computing* is a broadly defined discipline (of which computer science is one subfield) which we characterize as the study of computational processes, devices, and technologies. The broadening participation in computing agenda has been given significant attention recently in the computing research community (see Peckham et al. [2007] for a review). Educators have explored a variety of curricular and cultural approaches for engaging students and diversifying participation in the field of computing [Deek et al. 2003; Frieze et al. 2006; Margolis and Fisher 2002]. Others have called for a more innovative shift in the computing paradigm to make it more relevant and meaningful to students [Foley et al. 2005; Forte and Guzdial 2004; Guzdial and Soloway 2002; Kelleher et al. 2007]. The results of some of these early experimental courses suggest that students may become more interested in computing when it is grounded in more socially relevant, meaningful, or interesting domains. Similarly, Tenenberg and McCartney [2007] call for alternative models of computing education from that of the ACM and IEEE-CS, declaring that "in an increasing global and pluralistic world, having a number of thoughtful and coherent models for computing education will be vital to maintain the vitality of the discipline."

We build on this related work to offer further insights into some of the challenges in increasing participation and to suggest ways the computing education research community can help to address these challenges. The field of HCI has been described as motivating and progressive by its practitioners as well as external observers [Myers et al. 1996; Truitt 2000]. We suggest that by portraying computing through the lens of HCI, as an innovative, creative, and challenging field with authentic, real-world applications, we may be able to motivate students to become more interested in computing.

The goal of our study was not to convince all participants that they should become computer scientists nor did we anticipate that we would transform their career aspirations over a six-week period; however, we do believe there are basic computational methods, mechanisms, and ways of thinking that all K-12 students should have, regardless of their career interests [Wing 2006]. This study is an attempt to expose them at an earlier age to some of these new ways of computational thinking.

1.2 Why HCI?

Recent increases in computational processing power and expanding computational contexts suggest shifting paradigms in the role of computing in our lives. Today's teen could script a Flash stick figure animation, dub it over with customize digitally remixed music, post it to YouTube, and spread it virally across thousands of viewers in the same time that the Atanasoff-Berry computer in the 1950s could solve a Marchant equation [Campbell-Kelly and Aspray 1996]. While efficiency and cost-effectiveness drove the economics of early computing, the need for an emphasis on fun, in addition to functionality, drives an increasingly larger segment of today's computing culture.

Over 87% of youth in America use the Internet and usage spikes from 60% in the sixth grade to 82% by seventh grade [Lenhart et al. 2005]. Many teens are

Table I. 26-Item Computer Attitudes Survey (1 = Strongly Disagree, 5 = Strongly Agree)

1a. Enjoyment and Efficacy	**Mean**	**Std Dev**
I enjoy doing things on a computer	4.42	1.437
I know how to use the Internet as well as most students	4.350	0.689
I am always finding better ways to use the Internet	4.35	0.797
1b. Importance	**Mean**	**Std Dev**
I might someday make more money if I learned to use the computer	3.770	1.275
Most good jobs require Internet skills	3.150	1.405
My success in school is related to how well I can use the Internet	3.00	1.386

Table II. 10-Item Career Interests Presurvey (1 = Strongly Disagree, 5 = Strongly Agree)

Career Interests	**Mean**	**Std Dev**
Professional Athlete	3.52	1.503
Doctor	3.23	1.521
Technology Designer	3.16	1.369
Entertainer	3.10	1.423
Lawyer	3.03	1.449
Engineer	2.84	1.440
Computer Programmer	2.77	1.283
Law Enforcement	2.68	1.492
Artist	2.58	1.501

actively participating in creative and complex activities online—customizing their MySpace pages, creating Flash games, or scripting anime movies. Among the participants we surveyed (n = 26), the level of enjoyment and self-efficacy on the computer and Internet were rated high (see Table Ia). However, participants who responded to the career interests survey (n = 32) rated the importance of computing in their future school and career choices much lower (see Tables Ib and II). The difference in response rate was because the survey was administered in two parts, where 26 returned the attitudes part, and 32 returned the career interests part.

Their statements expressing enthusiasm for using computers and the Internet are not surprising, nor are their statements describing their lack of interest in computer science as a career choice [Lenhart et al. 2005; Vegso 2007]. Our survey was constructed to understand these preexisting attitudes, as a baseline from which we could measure in what ways teaching them HCI would affect their perceptions of computing.

Our goal in this study was to describe the process of teaching HCI to K-12 students, to learn about what parts of the course were motivating for them, and to understand in what ways their perceptions of computing were influenced. In the following section, we describe our participants, the course syllabus, and our research methods. We then discuss our results and suggest future directions for broadening participation in computing.

2. METHODS

We partnered with the local branch (hereafter referred to using the pseudonym "LMY") of a large, national organization whose mission is to prepare students to pursue college degrees. LMY is a six-week intensive summer program for 90

Table III. Data Collection Methods

Method	Purpose
Video	Capture informal interactions
Presurveys	Measure computer attitude, enjoyment, importance, creativity, self-efficacy, outcome expectancy, and career interests
Post-Surveys	Measure changes in career interest across control and experimental groups
Pre-Interviews	Understand informal daily activities and perceptions of computing
Post-Interviews	Understand changes in perceptions of computing after taking HCI course
Design Logs	View sketches and early design ideas, capture unused designs
Design Artifacts	Document iterative design process
Participant Observation	Capture subtleties and details of engagement, interest, and collaboration

middle-school students from local public schools who make a six-year commitment to the program. The majority of participants in the local LMY branch are African-American and from middle or lower socioeconomic status. Students are required to fill out applications to LMY, request teacher recommendations, and maintain a minimum GPA before being considered for acceptance. Thus, they tend to come from families who encourage their children to work hard. The program is organized and well-run with consistent attendance and a high retention rate. Our team of three researchers taught the HCI course as an elective within this program, with the help of an LMY teacher. There were five girls and five boys in our class ranging in age from 11-13. Participants expressed a general interest in technology but did not have more advanced skills and expertise or greater access to technology than their peers.

We advertised our research study during the program orientation to more than 90 student participants and their parents. We gave a brief presentation about our research, then handed out flyers, consent forms, and a presurvey. We used pre- and post-surveys, pre- and post-interviews, participant observation, design artifacts, and design logs to explore the effects our study (see Table III). We videotaped each class and audio-recorded the pre- and post-interviews. Participants knew we were researchers from the local university and not part of their formal LMY program, but appeared to be neither affected by nor interested in our presence in the classroom as outsiders. We reviewed videos after each session, transcribed the interviews verbatim, and each member of the research term took detailed field notes immediately after each session. Class time over the six weeks was evenly split between the classroom and the computer lab.

2.1 Survey Design

We designed our surveys based on two existing validated instruments that measure computer attitudes, self-efficacy, and outcome expectancy among middle-school students. We then created two additional instruments to measure career interests, Internet self-efficacy, and Internet outcome expectancy. The surveys used a 5-point Likert Scale (where 1 = Strongly Disagree, 3 = Not Sure, 5 = Strongly Agree). All items were compiled and administered as a single survey in the recruiting packet. Of the 90 LMY participants, 32 participants and parents returned consent forms and surveys, ten of whom participated in our HCI elective. In the last week of the program, six weeks later, we handed out the career section of the survey again to each of the same 32 students. All ten participants in our HCI course completed this post-survey and 13 of the noncourse participants returned the post-survey. Attrition was likely due to the surveys being given to these students indirectly through their homeroom teachers. We used existing validated instruments because the small sample size limits the extent to which we could validate a new instrument. The effectiveness of our intervention will vary across wider and more varied student demographics; however, we hope to reveal general patterns in ways of engaging students in computing.

The first survey we used was the Computer Attitude Questionnaire (CAQ) which was designed to measure attitudes and disposition towards computers among middle-school students and was shown to have "very good" internal consistency reliability values based on results from two preliminary studies and in a full study with 588 middle-school students [Christensen and Knezek 2000, 2001]. We used three of the eight possible subscales of the CAQ, which measured Computer Importance, Computer Enjoyment, and Creative Tendencies (Cronbach's Alpha $r = 0.80$, 0.80, 0.87, respectively).

The second survey instrument we used was the Microcomputer Beliefs Inventory (MBI) which was developed to assess the self-efficacy and outcome expectancy beliefs of middle-school students toward computers [Enochs and Ellis 1993, Riggs and Enochs 1993]. Item analysis, scale reliability assessment, and factor analysis of scale integrity were previously conducted with a sample of 269 sixth-, seventh-, and eighth-grade students and both scales performed with "good" reliability (Cronbach's Alpha $r = 0.80$, 0.85, respectively) [Riggs and Enochs 1993]. We selected the self-efficacy scales to measure participants' interest in HCI, and computing more broadly, and how it correlated to their sense of self-efficacy in these environments. Students will be more inclined to take on a computing task if they believe they can succeed, avoiding tasks where their self-efficacy is low [Bandura 1997]. Their decision to take a course in HCI, and their attitude towards computing in general, are influenced by their sense of self-efficacy. Their capabilities and outcome expectancy in HCI may therefore be strongly correlated with this sense of self-efficacy.

Because we were teaching HCI to students who were not familiar with the terminology of the field, such as "Human-Computer Interaction," we designed our data collection instruments to use closely related concepts that we would triangulate to help paint a more accurate picture of their perceptions of HCI. For example, the attitudes instrument used the terms "computer" and "Internet" and the career choices instrument asked about being a "Technology Designer"' (as well as related fields like "Computer Programmer," "Artist," and "Engineer"). When developing our syllabus, we adjusted the vocabulary to use age-appropriate terminology: "Needs Assessment" and "Requirements Gathering" became "Talking to the users" and "What features should the design have?" We wanted our methods to capture the process of learning HCI and the level of comprehension of related computing concepts that the students came away with, while minimizing internal validity threats that might arise from unfamiliar terminology.

Table IV. HCI Curriculum

Modules	Topics and Sample Activities
Introduction to HCI	Why is it important? Team time trials with iPods and cell phones
User Studies, Part 1	Brainstorming, requirements Gathering, take photographs of similar technologies around the school
Design Principles, Part 1	Aesthetics, usability; sketch design on paper, compare designs
User Studies, Part 2	User-centered design; interview peers, in-class heuristic analyses
Design Principles, Part 2	Incorporate feedback; design computer-based prototypes
Presentation	Marketing; give sales pitch of design to a room of CEOs

3. INTRO TO HCI CURRICULUM

Each of the 10 participants designed their own digital desktop over the six-week period. Our curriculum consisted of six modules with one to three lesson plans within each module (see Table IV). We structured our lesson plans using the LMY model, which included an introductory activity, the new material lesson, the main class activity, and the homework assignment[2]. We taught our 90-minute course twice a week over the six-week period. We developed the course curriculum based on our own experiences in higher education HCI courses, the ACM SIGCHI Curricula for Human-Computer Interaction [ACM 1992], and the Model Curriculum for K-12 Computer Science [Deek et al. 2003]. The curriculum was structured around five key concepts in HCI: *Requirements Gathering, Brainstorming, User Needs, Design, and Iteration.* We introduced this 5-step model in the second class and revisited it in each subsequent stage of the course. In the next section, we describe the lessons and activities and present the results of their design artifacts. In the following section, we discuss the implications of these results.

3.1 The Touch-Screen Digital Desktop Project

While conducting our interviews with teens in the spring of 2007, we also interviewed 22 students in HCI graduate programs to learn about their experiences and attitudes towards computing. We found that there was a disconnect between teens' perceptions of computing fields and graduate students' actual experiences in HCI [Yardi and Bruckman 2007]. Teens perceived computing to be boring, solitary, and lacking real-world context, yet graduate students described their research as exciting, challenging, and having a direct and meaningful impact in the world. Many graduate students expressed an interest in programming and CS, and chose HCI because they were looking for a more interdisciplinary experience [Yardi and Bruckman 2007]:

> I realized I was different in how I was thinking. A lot of people think things are cool just for existing. For me, the issue was "who would use it?" In CS classes, something new was presented and most people's question was "how does it work?" Mine was "what is it useful for?" (Jake, 23)

[2]Guide is available for reuse at http://www.cc.gatech.edu/gacomputes/Members/yardi/HCI_Guide.pdf.

> I was always into the visual aesthetics of things. I found myself doing more development and more programming. HCI was a cool way to help me balance my design skills and programming. It was a cool merging of art and technology. I started to see the art behind computing and I definitely saw art behind visual functionality. (Sarah, 21)

We developed the digital desktop project to draw from the two most common themes describing graduate students' interest in studying HCI: real-world relevance and interdisciplinarity [Yardi and Bruckman 2007]. Middle-school students spend the majority of their school day sitting in desks; designing a touch-screen digital desktop for their own use in a classroom was an interaction design challenge that they could closely relate to and could recognize an immediate use and purpose for in their own lives. Furthermore, the timely release of Microsoft's Surface Computer and Apple's iPhone gave us opportune examples for teaching them about what touch-screen technology was, how users would interact with it, why real companies were incorporating it into their own products, and the design processes that these companies went through to do so.

We had originally anticipated that there would be rich opportunities for conducting user studies given the availability of the 80 other LMY middle-school participants, each of whom would be potential users of a digital desktop. In an ideal world, we would like to teach the students the entire HCI design cycle, beginning with the importance of early field work in order to shape initial design requirements, moving to prototyping and iterative design, and continuing on to summative evaluation. In the short six-week time frame we had available, it was necessary to choose just one slice of that cycle: brainstorming, prototyping, and one round of iteration on the prototype based on feedback from the target audience. This decision was technocentric and left out important lessons around user-centered design; however, a longer slice of the design cycle was not possible. Nevertheless, this middle slice of the HCI process introduced students to powerful ideas like feedback from users and iteration. More fundamentally, it introduced students to the basic idea that the artifacts all around them are designed by people and those designs may be more or less successful in supporting human needs.

We developed our methodological approach by drawing from related research in the areas of HCI for kids and interaction design for children [Bruckman et al. 2007; Druin 1998; Guha et al. 2005]. We drew especially closely from the literature on working with children as design partners, which closely aligned to our goals of developing a project that would empower children to "have a voice" in the way the computing technologies they used in their daily lives were designed [Druin 1999]. Our primary emphasis throughout the course was that the digital desktop was a type of project that people working at real companies like Microsoft, Google, Apple, or Yahoo! did at their jobs. We wanted to show participants that they were designers designing computing devices, similar to what computing professionals did in the real world.

3.2 Teaching the Introduction to HCI Course

In the first class, we asked participants to reflect on different computing technologies: “Ten years ago, many of the technologies that people use every day weren’t around or were very different. Cell phones, mp3 players, Web sites, and computers all looked very different. What do you think will be different about these technologies five years from now?” We followed with a series of Technology Time Trials in which we formed teams and participants raced to turn on iPods and figure out how to play a song or to turn on cell phones and call one of the researchers. Participants were particularly well-attuned to the technological constraints that slowed them down in the races, such as the time lapse between when they turned it on and when the first screen appeared. They also reflected on the intuitiveness of the graphical interface and how many buttons they had to push before they could figure out how to perform the desired task.

3.2.1 *Requirements Gathering.* In the next lesson, we introduced the digital desktop project: “Think about how you have used your desktops in the classroom since you have been in school. Write down three things that describe what you use the desk for. Then, write 3-5 suggestions you have for a digital desktop that would help you in some way.” One participants’ suggestion, for example, was a digital chip containing electronic books, notes, and homework that could be plugged into any digital desktop so students would not have to carry their classroom supplies. Participants were given digital cameras and instructed to explore the school to document the ways desktops are currently used throughout the school day. Their pictures ranged from serious, innovative, or insightful to silly and playful. Most took pictures of common school supplies such as books, computers, and the desktops themselves and some took pictures of printers, projectors, and televisions or other multimedia devices. A few considered more innovative ideas, such as incorporating the cafeteria card swipe system into the desktop as a personal identification system.

3.2.2 *Brainstorming Ideas.* In the next class we printed out their photographs on large poster paper and taped them to the walls. Participants individually and collaboratively brainstormed ideas on the posters for tasks and features that their designs might require and what types of technologies could be used in implementing these designs. Although they added their ideas individually, they frequently extended existing ideas that their classmates had already written on the posters. We found that they struggled to think outside of the box when generating these initial design ideas; however they embraced the process of innovative design as soon as they recognized that there were no right or wrong answers, which we emphasized to them repeatedly during the beginning design stages.

3.2.3 *User Studies.* We taught them about how to conduct user studies, explaining the goals of understanding the user, how it fit into the overall design process, and the relevance of user-centered design in our project. While they quickly understood the importance of doing user studies, they did not intuitively grasp the difficulties and methodological challenges of

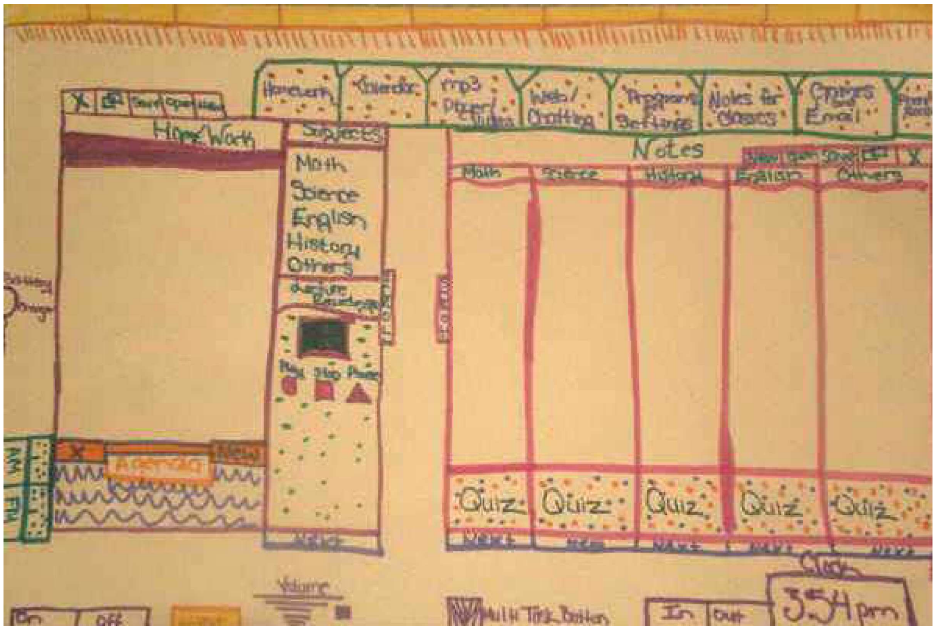

Fig. 1. Digital desktop paper sketch.

conducting interviews. We looked to encourage critical reflection on the interview process by conducting mock interviews in which we broke all the rules of interviewing—interrupting the interviewees, not listening to them, criticizing their responses, and asking leading questions. Participants easily related our blatant violations of social communication norms; when the interviewer made fun of the interviewee for liking math, our participants commented that the interviewee might be too embarrassed to suggest that the digital desktop could have something like a calculator built into it for fear of being chastised by their peers.

We then gave them an interview protocol for the digital desktop and conducted an in-class activity in which students were grouped into pairs and conducted interviews of one another. We walked around and audiotaped sections of the interviews, and replayed the recording to them. They were then given a homework assignment to interview a potential user and to write up their findings.

3.2.4 *Design Process.* We gave them poster paper and encouraged them to sketch their ideas freely, embracing the early design stage as a creative design challenge rather than a scientific methodological process (see Figure 1). We reminded them that they would have multiple opportunities to refine their designs. We then had them create their desktop interfaces on the computer. We used PowerPoint because we wanted an environment that all the participants were already familiar with and that would have a minimal learning curve. Given the short amount of time we had with them in the computer lab over

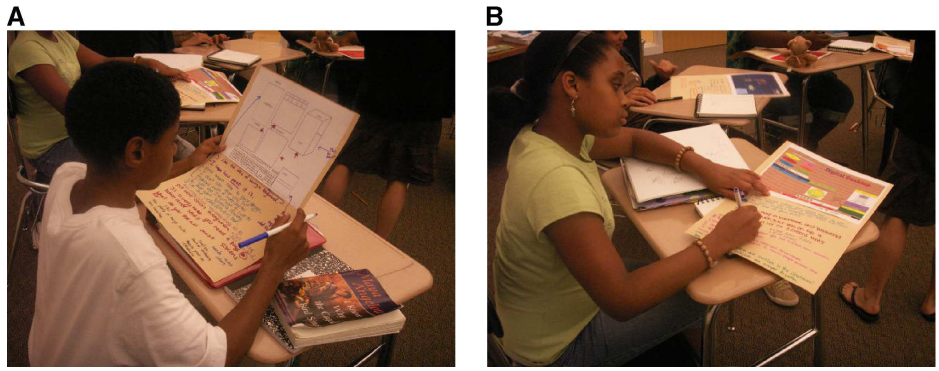

Fig. 2. Conducting heuristic evaluations.

the six weeks, we wanted to maximize their focus on the design process rather than on learning how to use the tool. Furthermore, most of the participants were not familiar with using Macintosh computers and had to spend some time adjusting to its affordances, such as dragging an image from Safari into PowerPoint, rather than right-clicking on the image to cut and paste it.

After designing the first prototype on the computer, participants conducted heuristic evaluations to assess interface usability. We characterize this activity as an introductory lens into a highly skilled and rigorous methodological practice, intended to help create a sense of authentic participation in a professional practice. We conducted the heuristic evaluations in class, describing the process to the participants as one of "identifying design problems for the user." We printed their designs and taped them to poster paper and they provided written feedback directly on their classmates' designs using the heuristics that we taught them: usefulness, ease of use, efficiency, flexibility, ease of learning, consistency, aesthetic appeal, and error prevention (see Figure 2).

We coded the heuristic evaluations to understand the rubrics they employed in their assessment of one another's designs. We found that over 90% of the feedback fell into two categories: features and layout. Negative feature feedback usually involved a request for an explanation of functionality ("There's a tennis ball for no reason," "Why do you have two Internets?") while positive feedback was in the form of a compliment on a unique idea ("I like that you need a password so that no one would look at your files," "I like how you can choose between stylus and a keyboard"). Feedback about layout referred to the visual and aesthetic appeal of the design ("Make the search box a different color so it's more obvious," "Maybe you could move [*volume box*] to the side").

Some of them took their peer feedback seriously and walked us through the various changes they made in their designs. For example, the researcher asked Tony about the changes he had made after receiving his feedback. Tony replied "Well, I changed some of the colors from before, see it looked like this" [*points to screen*] (see Figure 3). The researcher looked to clarify what he meant: "so you made them other colors instead of the wooden?" Tony responded "Yes, so it's more clear."

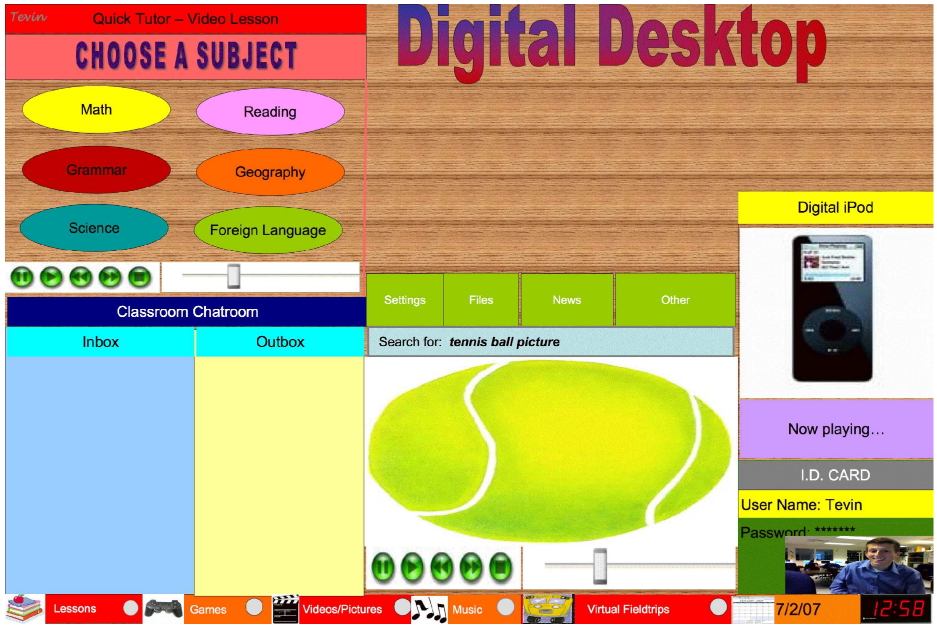

Fig. 3. Tony's updated design.

We draw from these heuristic evaluations, the design logs, final designs, post-surveys, interviews, videos, and in-class observations to describe their levels of engagement and interest. In the following section, we discuss our results using the two metrics we presented above: enjoyment in the course and interest in HCI.

4. DISCUSSION

4.1 Did They Enjoy Learning HCI?

Giving participants time on the computer was an essential aspect of their experience. Although we could have focused on teaching HCI concepts more rigorously and in more depth by removing the computer lab component from the curriculum, we would have also removed the important element of fun that was essential to our underlying goals. During the post-interviews, participants unanimously affirmed that realizing their designs on the computer was the most engaging and motivating part of the class for them. Designing on the computer helped them to make a connection between the familiar activities that they do for fun on the computer—drawing, sketching, manipulating images, and cutting and pasting, to the computing concepts we were looking to teach them—design, layout, aesthetics, and usability. It also introduced an element of professionalism to their designs that helped to portray the activity as a real-world process.

The extent to which they were pleased with their final design correlated with their ability to translate design ideas and feedback into design specifications. Recommendations about layout, color, and functionality were more intuitive to them than recommendations about ease of use, error detection, recovery, and consistency. Most teens are consumers of popular mainstream technologies and the experience of using products that are nonintuitive or difficult to use may be less familiar to them. Similarly, error prediction is challenging because it requires anticipating events before they have occurred. With fewer developed critical thinking skills at their disposal than college students have, their design approaches were more likely to be grounded in their personal experiences than in the design principles we had taught them. For example, Tony had previously told a researcher that his friends at other schools got to go on cooler field trips than he did and we later saw this specific experience directly inform a major feature in his design:

> RESEARCHER: What kinds of things have you been thinking about?
> TONY: I like my virtual fieldtrip idea ... 'cause in our class we never really went on that many fieldtrips so you could get an updated map connected to a satellite or something and it's like we could go to China and see how it looks present day and just ... learn about facts from there instead of ... it'll be like going there, but not exactly.
> RESEARCHER: What gave you the idea to do that?
> TONY: School ... and our no field trips.

Their levels of enjoyment of our course also correlated with their individual learning styles and how well our course enabled them to approach the design process in personally meaningful ways. We encouraged them early in the design process to think freely and creatively—there would be no wrong answers and no bad ideas, especially during the brainstorming and sketching stages. As they progressed in their designs, we pushed them to continue thinking innovatively, while also justifying each decision they made.

We characterized some participants as "artists" and "inventors"—they developed novel and innovative ideas then translated these ideas into specific design features. The artists and inventors incorporated unusual colors, layouts, and technologies. They also sketched, scribbled, and doodled more often in their design logs even when it was not part of the assignment:

> RESEARCHER: What other kinds of stuff would you like to design?
> JAMAL: Gaming systems.
> RESEARCHER: What would you want your gaming system to do?
> JAMAL: All you have to do it hold it and these little pixels or something will flow up your nose and ears ... and, like it would go in your brain and you're actually in the game.
> RACHEL: You have to be creative and you have to know how to use the computer and you have to be writing to make new designs, to think.
> PAT: Math.
> RESEARCHER: Anything else?
> PAT: Creativity.

We characterized other participants, such as John and Brandon, as the "architects." They explored more structured approaches to the design process, using rulers and simple color schemes. Both groups' approaches were often closely aligned with their academic and personal interests and also with their career goals. John and Brandon want to be an Engineer and an Architect whereas Jamal and Rachel want to be a Video Game Designer and an Artist, respectively.

Regardless of individual style, there were some commonalities across groups in learning styles. In the Creativity section of the presurvey, almost all participants gave a high rating to "When I think of a new thing, I apply what I have learned before" ($M = 3.85$, $SD = 0.732$) and gave a relatively low rating to "I choose my own way without imitating methods of others" ($M = 3.12$, $SD = 1.137$), suggesting that they do in fact perceive their learning process to include the reuse and imitation of what they experience in the world around them. In prior work we described how teens actively remix and appropriate ideas and artifacts from pop culture and other forms of media when they are engaged in the production process [Yardi and Perkel 2007]. Their methods for incorporating multimedia-based artifacts in their designs in creative ways suggests that they might be most engaged in an HCI curriculum that emphasizes multiple approaches in the design process. Our emphasis on innovation may have encouraged them to reflect on design as a creative learning process instead of focusing on rote memorization and regurgitation.

We had originally placed participants in groups of two or three and told them they would be working on their projects in these groups throughout the semester. We found that they had trouble negotiating boundaries in team activities and that teaching them how to collaborate effectively would be an additional challenge in itself. Even in the undergraduate level, students from multiple disciplines express concerns about how to create common ground from which they can develop new design ideas [Adamczyk and Twidale 2007]. Although middle-school students are far from disciplinary experts in any particular field, we found that they nonetheless had strong disciplinary interests that led them to individual approaches in the design process. Participants enjoyed working in groups or as a class during the early brainstorming and idea generation processes; however, as they developed their designs, they became more focused on their individual interests and goals. We therefore adjusted our curriculum to allow them to work individually, especially as they began to sketch out their designs and create them on the computer.

4.2 Were They Interested in HCI?

Did they perceive themselves to be engaged in authentic computing practice and did they perceive it to have relevance in the real world? In the presurveys, there was a strong correlation between both the importance of the computer and their sense of self-efficacy on the Internet in terms of their future careers. An analysis using Pearson's correlation coefficient indicated a statistically significant linear relationship between Computer Importance and Computer Outcome Expectancy ($r[26] = 0.708$, $p < 0.01$) as well as Internet Self-Efficacy and Internet Outcome Expectancy, ($r[26] = 0.516$, $p < 0.01$). However, there

Table V. Interest in HCI ($n = 10$)

	Yes	**No**	**Not Sure**
Would you take more computing classes?	9	0	1
Would you want a career in HCI?	2	3	5

was no significant correlation between Computer Self-Efficacy and Computer Outcome Expectancy. In other words, they did not perceive their sense of efficacy in using computers to correlate with the role of computers in their futures. This latter finding, which contrasts with the 1980s and 1990s when there was shown to be a strong correlation [Compeau and Higgins 1995] is likely due to teens' high confidence in their ability to use computers, but that they place little explicit value in these skills. During their pre-interviews, participants had told us they were excited about our class because it related to their existing interests:

> CHAD: I knew it would help me in the long run and with what I'm trying to do now like drawing, electronics, stuff like that.
> BRANDON: I like dealing with technology and different types of computers.
> JOHN: I want to be an engineer when I grow up.
> TONY: I like designing and inventing and I want to make video games and stuff like that for fun.
> KATIE: I liked the idea of future technologies and drawing what they might look like in the future.
> KEVIN: 'Cause I like video games. I like to create them and play 'em and be proud that I made them.

Today's teens have been raised in an environment of ubiquitous computing and therefore may perceive core computing skills to be as fundamental as reading, writing, and arithmetic. In other words, they do not expect a significant career outcome from their computing skills, given that they perceive *everyone* to have these same computing skills. In our post interviews, all of the participants confirmed that the course was fun for them because it was closely related to activities they were already interested in. Of the ten participants, nine said they would be excited to take more computing classes in high school or college (see Table V). Only Chanice was not interested in taking more courses because she was determined to become a doctor, a goal that she had emphasized to us in her pre- and post-interviews.

4.3 Would They Want a Career in HCI?

Of the ten participants, two said they would definitely like to have careers in computing while three said they would not and five were unsure (see Table V). In contrast to their almost unanimous reasons for wanting to take more courses in HCI, John was the only participant who wanted a career in HCI because he saw it as being related to his existing interests: "Yeah, 'cause it's like, I like all sorts of stuff and games and things like that. And I'm determined to be an engineer." No significant correlation was found between pre- and post-interest across the control and experimental groups in our

Table VI. Reasons for Lack of Interest in HCI Careers (n = 8)

	n
Interested in other career choices	5
Tedious (reference to the iterative design process)	3
Just for fun (hobby, not directly related to school)	2
Expectations (thought they would be doing other activities related to computers)	3

surveys in terms of career interests so we coded the post-interviews to try to understand the underlying reasons for their lack of interest in computing careers (see Table VI). Why were they so excited to take more computing classes, but not so excited about having a career in computing? Many of them explained that they had conflicting interests with other career choices or that they perceived the things they were doing in our course to be just a hobby:

RESEARCHER: Could you see yourself having a career in HCI?
CHANICE: No. I'm going to be a doctor.
STEPHANIE: I like being on the computer a lot and designing stuff but after a while, I'm not sure.
KATIE: Maybe, I'm not sure, because I want to do a lot of other things, like be a vet or a lawyer.
RESEARCHER: Could you see yourself having a career in HCI?
JAMAL: Probably not. It's just something I like to do in my free time.
RESEARCHER: What's been your favorite part of this class so far?
JAMAL: [Pause] Ummm . . . the very beginning of the class I guess, where we were told to do a digital desktop, like the brainstorming and stuff.
RESEARCHER: What did you like about that?
JAMAL: It wasn't as hard work, we were just thinking of ideas and stuff.

Jamal's comment revealed another possibility for their lack of interest in HCI careers, primarily, that HCI is a challenging subject to learn. Even undergraduate and graduate students have difficulties synthesizing multiple concepts and putting them into practice in a team project. Our participants struggled in similar ways. In particular, the process of iteration was somewhat tedious for them. They were excited about their initial sketch and the initial design process on the computer but the process of revising and fine-tuning their designs required long-term discipline and focus which they struggled with. As such, they frequently had trouble translating their initial ideas into a final design.

BRIAN: I don't really like mine all that much.
RESEARCHER: What don't you like about it?
BRIAN: I don't know, it doesn't look right, it doesn't feel right . . .
RESEARCHER: What do you think doesn't feel right about it?
BRIAN: Like the color and the texture and stuff.
RESEARCHER: If you had more time, how would you change it?
BRIAN: It's like, if there's a machine that can just go in my brain and do it exactly what I want it to . . . [long pause] Like, I wish there

> was a machine that could go in my head and put something on paper to be exactly how I want.

HCI instructors have emphasized the importance of "leaving the design early enough in its construction to allow for growth and meaningful critique" [Adamczyk and Twidale 2007]. Our curriculum may have moved into a high-fidelity design too early in the course such that participants had little opportunity to significantly adjust their designs during later stages. It is possible that adjusting the curriculum to allow more time for early sketching might help engage them throughout the design process or that providing them with more robust design tools could facilitate this process. However, it is also possible that the long-term perseverance that is required in the iterative design cycle may be difficult for this age group. This would be a fundamental difference between teaching an HCI course to precollege students versus college students. In future courses, we would like to find a similar program with high school students where we could teach more advanced HCI concepts.

4.4 HCI is Not Computer Science

Above we described the distinction between "computing" and "computer science." There is an ongoing debate among K-12 educators about what body of knowledge can be taught to prepare students for higher education and careers in either of these disciplines [Deek et al. 2003]. What is the role of HCI within this debate? Two ongoing questions drive our research. First, what HCI-related topics will motivate students to consider taking further computing courses? Second, what precursor skills will help prepare students for the rigor of these later courses? The broadening participation in computing agenda is about both increasing motivation to learn computing and about learning computing skills. We explore whether an HCI course will engage students and motivate them to pursue courses and degrees in computing as well as a wider range of related disciplines like computer science, software engineering, design, or new media.

Our target audience for our course is those students who could have an interest in or potential for a computing career, but, due to socioeconomic status, gender, or other cultural and economic constraints, are unlikely to pursue this path. We believe it is important to improve the state of computing education in K-12 to help prepare students for careers not just in computer science, but in a broad array of computing fields. This is the goal of our Georgia Computes research group, an NSF Broadening Participation in Computing project led by Professor Mark Guzdial. For example Jill Dimond, a PhD student at Georgia Tech, is building off our study by conducting HCI workshops with Girl Scouts to teach them programming skills on the XO laptop. Other members of our group are teaching programming using Alice, Lego Mindstorms, and Crickets. More information about our research is available online at http://www.gacomputes.org.

5. CONCLUSION

Computer science educators cite the importance of courses like "computing in the real world" for high school students and have highlighted HCI as one of the "most important priorities for future research and teaching by industry experts in computer science" [Canny 2006; Deek et al. 2003]. The implications of our research suggest that there is an important story to be told about the role of HCI in teens' lives. Our emphasis on teaching HCI in the real world is not new. What is new is teens' active engagement in today's computing-centered culture. An HCI project that is grounded in their world can be designed around their technology-rich culture—social networking sites, video games, and media. Our course did not directly change their career goals but it did influence their interest in taking more related courses in high school and college, and, more fundamentally, it raised their awareness of the important role that computers and technology play in their lives.

Assessing the value of our course in terms of attitude and learning is an ongoing challenge. Members of our research team are actively involved in improving CS education at the K-12 and higher education levels, and are working to better align measurement and assessment with learning goals. Assessment in HCI is particularly challenging, where much of the work is done in groups collaboratively and encourages creative thinking, which is not easily measured by a standardized test. However, we observed in our classroom that one of the most important underlying factors that influenced our participants' interest in learning HCI was their belief that they were learning real-world skills with real-world value: "Is this really what the people who designed the iPod do?" "Is this what people who work at Microsoft do in their real jobs?" Unlike some of their required courses in school, in which they often have trouble connecting the material to something that is important to them in the world, they could relate to the process of designing technology on a personal level. They use technology in their daily lives, they are a target marketing demographic, and they can easily grasp how the skills they learned in our HCI course might help them to become designers of the types of technology that they use in their everyday lives.

Throughout our course, we saw participants begin to recognize and reflect on the design process and its influence on the technologies that they used in their daily lives in interesting ways. We observed informal instances of critical reflection, such as when two students brought in their Nintendo PSPs to show us and described their features in the same manner that we had demonstrated the iPods to them in the first class. More formally, we saw that they began to develop an understanding of how certain features of a technology affected the way it would be used by people in the world around them.

5.1 Future Directions

The role of computers and the Internet in teens' lives offers a different lens into a possible computing paradigm shift. There is a need for students in today's modern computing world to develop broader computational literacy skills across multiple domains. We should look to support embedding a "humanistic spirit giving primacy to critical reason, rigorous methods, and student engagement in the research process as a fundamental aspect of learning" [Tenenberg and McCartney 2007]. We suggest that in a computing-centered culture, computing skills are becoming arguably as fundamental as traditional reading, writing, and arithmetic skills. Our results suggest that HCI provides a framework in which to teach precollege students computing skills and the ability to reflect on the design process and its role in today's rapidly evolving computer and technology-driven society.

Computing is not for everyone—not all students will want to have careers in computing and not all students need to have computing careers. However, we argue that all students should develop computational literacy skills to become competitive workers in today's technology-rich workforce. Through an HCI curriculum, we hope to encourage some students to pursue careers in computing and we look to guide all students toward developing the technological fluencies that they need to become successful members in our modern computing society.

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