Tracking an Innovation in Introductory CS Education from a Research University to a Two-Year College

Allison Elliott Tew
College of Computing, Georgia Tech
801 Atlantic Drive
Atlanta, GA 30332-0280
404-385-1105
allison@cc.gatech.edu

Charles Fowler
Gainesville College
PO Box 1358
Gainesville, GA 30503
770-718-3803
cfowler@gc.peachnet.edu

Mark Guzdial
College of Computing, Georgia Tech
801 Atlantic Drive
Atlanta, GA 30332-0280
404-894-5618
guzdial@cc.gatech.edu

ABSTRACT
Innovations in teaching and learning computer science education can easily be overly-specific to a given institution, or type of institution. For example, an innovation may require special hardware, or may make assumptions about the background of the students. This paper tracks one such innovation, a multimedia-focused introductory computing course, as it moved from a research-focused university to a public two-year college. At both institutions, the new course resulted in dramatically improved retention. Students at the two-year college were even more motivated and more positive about computing after the course than students at the research university. The results suggest ways of approaching innovation that is easily adaptable to other institutions.

Categories and Subject Descriptors
K.4 [**Computers and Education**]: Computer and Information Sciences Education; H.5.1 [**Information Interfaces and Presentation**]: Multimedia Information Systems

General Terms
Design.

Keywords
Adoption/adaptation, multimedia, CS1, programming.

1. INTRODUCTION
While we hope that our teaching and learning innovations are usable in any computer science classroom, the reality doesn't always match our expectations. An innovation may require hardware that isn't available at all institutions. For example, a particular approach may be too slow on older processors to maintain student motivation at institutions that can't afford new, faster processors. Or an innovation may not be successful if students don't have adequate mathematics background.

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Therefore, we cannot assume that an innovation that is successful at a research-focused university would be as successful at a smaller institution, such as a public two-year college. This paper describes an exploration of exactly that kind of a transition. We hope that our experience might inform others developing teaching and learning innovations that are portable between institutions. We describe in this paper the innovation that we developed and the result of its use at Georgia Institute of Technology (Georgia Tech). We then describe the use of the same innovation at Gainesville College. Based on demographic data, grade distributions, and surveys used at both institutions, we describe how the innovations worked similarly and differently at each institution. We end with our explanation of what happened and why.

1.1 Media Computation as an Introductory CS Course
In Spring 2003, Georgia Tech first offered a new introductory computing course whose goal was to motivate non-Engineering and non-CS majors [5,7]. Georgia Tech has had a requirement for all students to take a course in computing, but only had one version of CS1 until Spring 2003. The new course had an explicit focus on *media computation*. Students were introduced to programming and computing concepts by creating Photoshop-like filters, splicing and reversing sounds, writing programs to mine Web pages, and generating animations.

Table 1. Success rates at Georgia Tech before and with Media Computation class.

	Enrollment	Success Rate
Georgia Tech's CS1		
Average 2000 – 2002	930	71.2%
Media Computation		
Spring 2003	120	90.0%
Fall 2003	303	86.5%
Spring 2004	395	89.9%

The new course met with improved success rates (the percent of the course earning an A, B, or C in the course—that percentage of the course that did not withdraw or earn a D or F) over the general course (Table 1). Students enrolled in the media computation class were generally more motivated to study computer science—they told us that they understood better why computing was relevant to them and their careers [7].

The Media Computation course approach was explicitly designed to attract students who were not succeeding at a traditional computer science class [1,6]. The students in the Media Computation class were not majoring in technical fields and were mostly women. We explicitly designed the course to address the issues that research had found were barriers to students' success in computer science. In particular, we aimed at:

- *Relevance*: We explicitly made the argument that understanding media computation was useful and important to students in Management, Architecture, and Liberal Arts, with examples drawn from those domains.
- *Creative*: We created opportunities to explore computing as a creative medium. Where possible, assignments were open-ended. For example, one assignment required the creation of a collage where the same image had to appear four times, three with modifications. Students could choose their images and their manipulations, and add whatever other images they wanted.
- *Social*: We encouraged collaboration at several points in the class, and made on-line forums so that the results of students' programs could be shared in a gallery of student created images, sounds, and animations.

2. ADAPTING THE COURSE

The Media Computation class was used at Gainesville College in the CSCI 1100 – Introduction to Computing and Computer Programming course. This was the course taken by students who did not feel that they had adequate background in computing to take the traditional CS1 course (CSCI 1301). The Gainesville College version of the course used the same text [4], lecture slides, assignments, and overall structure.

The adaptation of the course occurred to allow for additional topics usually found in a computer literacy course and to allow generous amounts of time for students to complete programming assignments. The Gainesville course covered slightly more than half of the material in the textbook. Pair programming was encouraged but not required. Some class time was reserved for students to work on programming assignments or in-class exercises. The instructor was available in the classroom to help students who were stuck and/or frustrated. Some assignments, such as the picture collage, became great fun for some of the students.

Table 2. Success rates at Gainesville College before and with Media Computation class.

	Enrollment	Success Rate
Gainesville's CSCI 1100		
Average 2000 – 2003	28	70.2%
Media Computation		
Summer 2003	9	77.8%
Fall 2003	39	84.6%
Spring 2004	22	77.3%
Summer 2004	11	90.9%

In the three year period before CSCI 1100 became a media computation class, the average success rate was 70.2%. Gainesville College has enjoyed similar increases in success rate as previously demonstrated at Georgia Tech (Table 2)[1]. These results at a very different institution indicate that this innovation is adaptable to new environments.

3. COMPARING THE STUDENTS

The most relevant comparison for these courses at these institutions is probably the students. We would expect that the students who choose Gainesville College and those who choose Georgia Tech would differ in terms of their interests, their academic goals, and perhaps their demographics.

3.1 Coming in to the class

The majority of the students surveyed at both institutions were female (averaging 53.8% female at Georgia Tech and 69.2% female at Gainesville College) and Caucasian, although Georgia Tech did have students representing a more diverse set of ethnic backgrounds.

Table 3. Gender of Survey Participants

	Georgia Tech		Gainesville	
	Male	Female	Male	Female
Sp03	32.9%	67.1%	--	--
Su03	--	--	20.0%	80.0%
Fall03	51.1%	48.9%	37.5%	62.5%

Table 4. Ethnicity of Survey Participants

	Georgia Tech	Gainesville
African-American	6.4%	0.0%
Asian	7.0%	0.0%
Caucasian	80.8%	96.2%
Hispanic	0.3%	0.0%
Other	5.4%	3.8%

During Spring 2003 and Summer 2003 semesters at Georgia Tech and Gainesville respectively, students were surveyed at the beginning of the course to gather information about their academic background and experience with and attitudes about Computer Science. All students at both institutions intended to complete a traditional 4-year bachelor's degree and were majoring in areas such as Business, Liberal Arts, Nursing & Architecture (Table 5). While not enrolled in traditionally math or science focused programs, these students did not consider themselves to be technophobes. Only 32.9% and 31.2% of the students at Georgia Tech and Gainesville agreed

[1] We considered using statistical comparative techniques on the entire data set, but the dramatic variation in sample size across institutions precluded meaningful statistical analysis.

with the statement "I do *not* think of myself as being good with technology."

Table 5. Survey Participation by Degree Program

	Georgia Tech	Gainesville
Architecture	12.8%	--
Business	45.3%	22.2%
Liberal Arts	38.4%	33.3%
Nursing	--	11.1%
Sciences	3.5%	11.1%
Undecided	--	22.2%

Gainesville and Georgia Tech students did have different priorities or goals for the class. The top 5 goals of at each institution listed in Table 6. Gainesville students were much more focused on learning how to programming (60.0% of the students listed this as one of their goals for the course) and gaining general computing knowledge and skills (30.0%). Georgia Tech students included both of those goals, (22.1% & 27.9% respectively) but also listed getting a good/passing grade (24.4%) and learning skills that would be practical/relevant for their major (22.1%) equally as frequently.

Table 6. Student Goals for Media Computation class.

	Georgia Tech	Gainesville
1	General Computer Knowledge	Programming Knowledge & Skills
2	Good or Passing Grade	General Computer Knowledge
3	Programming Knowledge & Skills	Good or Passing Grade
4	Practical/Relevant Skills for Major	Fulfill CS Requirement
5	Media Skills	Computer Science Knowledge & Skills

3.2 During the Class

In addition to the initial surveys during Spring & Summer 2003 semesters, a mid-term survey was also collected asking for students' opinions about the course in progress.

From the initial survey, we found that a majority of students at both institutions had been looking forward to the class (Figure 1), while many more students at Gainesville reported they were satisfied with the course while enrolled. After the course, 68.8% of students at both institutions reported they had enjoyed the class.

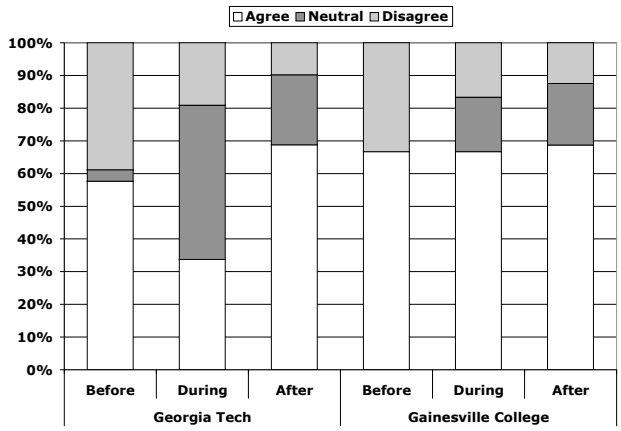

Figure 1. Perception of Class Enjoyment

Students at both institutions responded very favorably to the instructor and social atmosphere of the class. 96.8% of the students at Georgia Tech found the instructor to be enthusiastic about the material while 93.8% of Gainesville students did so.

Since one of our goals in the course was to make the study of computing a more social endeavor, we asked students about some of the social aspects of the classroom. Students at both institutions found the class atmosphere to be conducive to asking questions (Table 7), with more students at Georgia Tech feeling positive (strongly agree or agree) about that aspect.

Table 7. Class Atmosphere was Conducive to Questions

	Georgia Tech	Gainesville
Strongly Agree	26.6%	6.2%
Agree	53.2%	56.2%
Neutral	14.0%	37.5%
Disagree	4.0%	0.0%
Strongly Disagree	2.2%	0.0%

And students at both institutions were very supportive of allowing students to collaborate on homework assignments (Table 8), again with Georgia Tech students being more positive about this opportunity.

Table 8. Liked Collaboration on Assignments

	Georgia Tech	Gainesville
Strongly Agree	50.4%	37.5%
Agree	35.3%	31.2%
Neutral	12.0%	25.0%
Disagree	1.8%	6.2%
Strongly Disagree	0.5%	0.0%

In addition to their positive attitudes regarding course operations, an overwhelming majority of students at both institutions reported at midterm that they believed they were

learning to program, 96.6% at Georgia Tech and 83.3% at Gainesville.

3.3 Upon leaving the class

During Fall 2003, students at both institutions were given surveys at the end of the term asking them to reflect on their experiences during the semester. They reported on their programming ability, their experience in the class, and their attitudes about computing.

Almost all students reported that they had improved their programming skills during the term: 91.6% at Georgia Tech and 87.5% at Gainesville College. Georgia Tech students had slightly higher levels of confidence in their programming abilities 75.8% strong or very strong vs. 68.8% at Gainesville (Table 9).

Table 9. Programming Skills – Fall 2003

	Georgia Tech		Gainesville	
	Before	After	Before	After
Very Strong	1.4%	5.5%	0.0%	0.0%
Strong	8.1%	70.3%	12.5%	68.8%
Not Much	16.6%	17.8%	25.0%	25.0%
Very Little	18.4%	6.4%	6.2%	6.2%
No Skills	55.6%	0.0%	56.2%	0.0%

While one of the goals of the course design was to increase relevance of the computing materials for our students, our findings on that aspect are decidedly mixed (Table 10). Only 39.2% of Georgia Tech students found the homework assignments to be personally relevant and even fewer (31.2%) of Gainesville College students did so.

Table 10. Homework Assignments were Relevant to Me

	Georgia Tech	Gainesville
Strongly Agree	6.2%	6.2%
Agree	33.0%	25.0%
Neutral	31.7%	50.0%
Disagree	25.0%	18.8%
Strongly Disagree	4.0%	0.0%

However, when students were asked about the relevance of the skills they learned in the class, their responses were much more positive (Table 11). 59.9% of Georgia Tech students agreed that the skills learned from this class will be useful in other areas of their life. 56.2% of Gainesville students agreed. Georgia Tech students reported greater relevance to their professional career, with 45.5% students agreeing; 37.5% of the students agreed at Gainesville College.

Table 11. Skills from this Class will be Useful in

	Georgia Tech		Gainesville	
	Life	Career	Life	Career
Strongly Agree	12.6%	6.8%	6.2%	0.0%
Agree	47.3%	38.7%	50.0%	37.5%
Neutral	23.9%	31.5%	12.5%	25.0%
Disagree	13.1%	16.2%	25.0%	37.5%
Strongly Disagree	3.2%	6.8%	6.2%	0.0%

Another goal of the course was to grow students' appreciation for and understanding of computing. After completing the course, a majority of students at both institutions did recognize that programming can have a creative component. 61.5% of survey respondents at Georgia Tech agreed with the statement "Programming can be a creative outlet," while 56.2% of Gainesville students agreed with the statement. And an overwhelming majority of both students (89.0% at Georgia Tech and 87.5% at Gainesville) reported they felt more knowledgeable about computers as a result of this class.

As society's definition of literacy grows to include digital technologies the use of computers as a communication tool, particularly for non-science and engineering majors, becomes a vital professional skill [2]. We asked our students not only whether they recognized the need to use the computer as a communication tool, but whether they could actually use it at as such. The results are shown in Table 12. A majority of students at both institutions reported that they did know how to use this new communication tool and even more so reported that the skills learned in this class will enable them to be able to better communicate with programmers in the future.

Table 12. Know How to Use Programming to Communicate

	Georgia Tech		Gainesville	
	with Others	with Programmers	with Others	with Programmers
Strongly Agree	8.0%	10.8%	0.0%	6.2%
Agree	50.9%	49.3%	56.2%	50.0%
Neutral	23.7%	24.2%	31.25%	31.2%
Disagree	14.3%	14.8%	12.5%	12.5%
Strongly Disagree	3.1%	0.9%	0.0%	0.0%

After completing the course a significant population of students at both institutions would like to take additional courses in Media Computation: 50.0% of the students at Gainesville College indicated such an interest; 42.6% of Georgia Tech students indicated so (Table 13). However, students were much less inclined to take additional CS courses, with only 31.2% of Gainesville students and 23.4% of Georgia Tech expressing interest. While these results do not indicate a majority of students with either of these opinions, at Georgia Tech this is a significant improvement over the only

3.5% who reported planning on taking additional CS courses in the pre-course survey.

Table 13. Would Like to Take More Courses in

	Georgia Tech		Gainesville	
	CS	Media Comp	CS	Media Comp
Strongly Agree	4.1%	16.1%	6.2%	12.5%
Agree	19.3%	26.5%	25.0%	37.5%
Neutral	23.8%	23.3%	43.8%	18.8%
Disagree	37.7%	22.9%	25.0%	25.0%
Strongly Disagree	15.2%	11.2%	0.0%	6.2%

These results demonstrate that students at both institutions, even after completing the course, perceive media computation and CS quite differently. When asked "Media Computation teaches a different set of skills than other intro CS courses", 66.2% of the Georgia Tech students and 56.2% of the Gainesville College students agreed with this statement. We believe these finding are consistent with our goal of reaching out to students who currently are under-served by traditional introductory CS courses.

4. EXPLAINING THE RESULTS

In general, we found that we had similar improvements in success rates at both Georgia Tech and at Gainesville College. We hesitate to use the word *significant*, since it's difficult to imagine applying a statistical model to these results, but it's clearly a *notable* and even *dramatic* improvement. What's perhaps more striking is that the Gainesville College students were even *more* enthusiastic about the class than the Georgia Tech students: They were more positive about the class upon coming in, and were even more positive about being interested in future computing courses than the Georgia Tech students.

There are several possible explanations for this difference. The Gainesville College classes were much smaller than the Georgia Tech classes at the same time, by more than an order of magnitude. A smaller class may lead to better teaching and better opportunities to learn. The Gainesville College students also had hands-on experience in the classroom and the class proceeded at a slower pace, covering approximately half of the material in the textbook. The Gainesville College students may have been enthusiastic about trying a new course developed at Georgia Tech.

An explanation that we find compelling is that the course was explicitly designed to attract students most at-risk at failing computer science, based on research results [1, 6]. The course was successful in meeting those students' needs at Georgia Tech. It's not surprising, then, that the course was even more successful at Gainesville College where *more* of the students look like at-risk students according to the research, e.g., there were more female students, and the students in the Gainesville College class were the ones self-selecting as having inadequate background for CS1. In a real sense, the goals for the course made it an even better fit for Gainesville students than Georgia Tech students.

The lesson for developers of learning and teaching innovations might be to know one's (student) audience and to build on existing research. The Media Computation class worked [2,5] because we carefully followed recommendations of research studies. The students who were most likely to succeed when following these recommendations were the kinds of students whom we invited into the class at both Georgia Tech and Gainesville College. The innovation was portable because those kinds of students were at both institutions. We could imagine innovations with a particular focus (e.g., drawing upon work in high performance computing or computational science) that might attract a student audience that is not common in all institutions. Because we aimed at a common group of students that were available at both institutions, the innovation was adaptable, and we might imagine that it would be adaptable at other institutions with similar audiences.

The results presented here do not include any qualitative data analysis. Such analyses have been done on the Media Computation course at Georgia Tech [3,6], but we have not yet been able to conduct similar studies at Gainesville College. In the future, we hope to be able to do so to gain further insight into the adaptation of this innovation at other institutions.

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