Innovating Introductory Computer Science Courses: Approaches and Comparisons

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ABSTRACT

In recent years much attention and effort have been devoted to the task of innovating computer science courses, especially the introductory ones. In this paper we describe an innovation in an introductory computer science course at South Carolina State University, a four-year minority-educating institution. Our approach is a combination of: a) *adoption* - we started by adopting the concept of studying jointly computer science concepts and digital media concepts, b) *adaptation* - we introduced the new course concept as extension and adaptation of a legacy computer literacy course, c) *innovation* - since we aim primarily at students majoring in Science, Mathematics, and Engineering Technology (STEM), we introduced specific modules and topics designed to enhance topics of interest to these students. We present some of the content of our course and its influence on students' knowlegde acqusition process. We also present students' survey data and compare them with data obtained at two other institutions: a major research university, and b) a two-year college.

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

ACMSE'07 March23-24, 2007, Winston-Salem, North Carolina, USA

In recent years a much attention and effort have been devoted to innovating computer science courses, especially the introductory ones. The motivation was primarily to improve enrollment and retention in computer science programs, which were perceived as rapidly losing their attractiveness. After years of growth, there appeared signs of lack of interest among the youth in the discipline of Computer Science as a whole, and and as a career choice. Consequently the enrollement of computer science prorams began to drop. This trend was first spotted at the top-tier research universities, and then was observed to spread among the rest.

Responding to this worrying development, computers science educators started to test a number of approaches to innovate and modernize computer science education, especially the introductory computer science courses ([3], [5], [1], [7], [4], [6], [10]).

A number of researchers have adopted the following approach to designing an introductory course: choosing an interesting and rich real-life domain, in the context of which to set and explain important computer science topics. The idea is that the students learn both new and interesting computer concepts, but also acquire interesting and useful knowledge of some important domain. Approaches that seemed to work particularly well involved: *digital media* - digial images, video, and audio - an approach that was pioneered by Guzdial and Ericson ([5]; *game design and multimedia animation* - ([9], [2]). Students do seem to prefer to work with digital media content than to delve into complexities of, say, sorting methods.

The complexity of designing an innovative introductory computer science course is underlined by the remnants of the "language wars": which to choose as a first programming language? Guided by the increasing popularity of Java, some have taken that approach, easing the complexity of Java by carefully choosing class libraries and methods that can be used simply and efficiently, thus leaving the student to grapple only with design choices and choices of simple control and data structures. Other researchers stand firmly on the opinion that a gentler introduction to computer science is needed, suggesting the use of a scripting language such as Python for CS1 ([6], [10]), followed by using Java for CS2 ([6]).

In this paper we describe an innovation in an introductory computer science courses developed at the South Carolina State University (*SCSU*). Our approach was a combination of: a) *adoption* - we tried to adopt the concept of studying jointly the computer science concepts and digital media con-

cepts, as in [5]; b) *adaptation* - for organizational and other reasons we had to introduce the new course concept as an extension and adaptaton of an existing computer literacy course; and c) *innovation* - since our vision is to target at first students in the Science, Mathematics, Engineering and Technology majors, we introduced *project modules* exploring topics which they will encounter in the further of their major. Project modules are designed to enhance, illustrate and extend the computer science related concepts and contents previously introduced in the course.

2. COURSE ADOPTION - ADAPTATION - INNOVATION

2.1 The Institution

South Carolina State University *SCSU* is a land-grant, Historically Black College and University (HBCU), founded in 1986 and located in Orangeburg, South Carolina. SCSU is regionally accredited by the Southern Association of Colleges and Schools, and is one of the 12 senior public post-secondary educational instutions in South Carolina. With a 92% black student bodu out of approximately 4500, SCSU currently ranks seventeenth in the nation in the number of undegraduate baccalaureate degrees (533) awarded to African-Americans per year. The College of Sciences, Mathematics, and Engineering Technology at SCSU currently produces 31% of the African-American STEM degrees in South Carolina ([8]). All programs within the College that have nationally recognized accreditation criteria are accredited - e.g., the Computer Science program, which was re-accredited in 2006 by the national body CAC/ABET.

Table 1: Enrollment in STEM Programs at SCSU

	Fall 2004	Fall 2005
Biology	292	289
Chemistry	55	53
Civil Eng. Tech.	57	46
Computer Science	208	190
Electr. Eng. Tech.	152	128
Mathematics	56	57
Mech. Eng. Tech.	74	92
Nuclear Eng.	13	12

(Source: University's Fact Book 2005-2006, p. 60)

2.2 The Course

For organizational reasons we decided to start innovations into introductory computing courses by innovating an existing introductory computing literary course named "Computer Technology". This course is offered by the Computer Science program of the Department of Mathematics and Computer Science under the designation CS 150, and is a required course for all majors, except Computer Science. The course currently consists of lectures and labs: the lectures cover basic concepts of computer technology: basics of computer architecture, basic concepts of computer software, Internet and the World Wide Web. The lab part covers the basics of Windows/OS and Microsoft Office: Word, PowerPoint, Excell etc. We decided to devote one special section of the course to introducing the innovations. For that reason, we had to shorten the exposition of the old material to about half, and use the remaining time for introducing the basics of Java programming and digital media (using roughly the Chapters 1-5 of ([5])).

Another innovation to this course regards the *Project Modules*. The Project Modules are intended to clarify and expand the knowledge gained by the students on particular topics of the material. We introduced two such modules in the Fall of 2006, while the third is also completely prepared and will be presented in Spring 2007. The first project module is designed to test and augment the students' grasp of Java programming (to the extent it was presented in the course), and digital media concepts: the theory of color, and the encoding and filtering of digital images. It is described in more detail in the following section. The second module is about using Excel to solve simple electrical circuits, and it will be described elsewhere.

2.3 The Media Project Module

The unit on how digital pictures are represented and manipulated by computers exposed the stuidents to: a) basic theory of colors, b) encoding of digital pictures, c) the data structures used to represent and store digital pictures: one- and two-dimensional arrays, d) the classes and methods used to manipulate digital pictures. The students learned in class how to write simple methods to implement various filtering operations on images.

The project module following this unit posed to the student a task to write a method doing something similar it should read a digital picture from a file, display it, "dye" it in sort of a "purple" color, and display it again to see the difference. The coloring should be implemented using a method called *colorPurple( )*. The students were advised that before writing the method, they should do a little research in how to describe a purple color, and in fact any color.

Specifically, the students were required to structure their project reports according to the following format:

1. Problem Statement
2. Problem breakdown, or analysis
3. Brief sketch of the theory of colors (1/21 page); this requires WEb searching, using, say, the keywords Color Theory and Introduction; students will find a number of web pages. One of them contains a neat summary of color theory in 8 pages: page number 7 describes the RGB color model and contains the numbers needed to describe this particular purple color.
4. An step-by-step description of the algorithm to realize this operation
5. The Java program that implements the algorithm.
6. Experiments with several images: the originals, and the colorations.
7. Conclusion: what did the student learn from this project?
8. References: a list of what the student needed to read and use to realize the project

In the preliminary exposition and explanation of this project assignment, the instructor demonstrated the assignment using a photograph of two celebrities, highly recognzable by the students: the hip-hop artist and actrees Erykah Badu and the comedian Dave Chapelle. Also, the title of the assignment ("Color Purple") is a clear allusion to the movie of the same name, also known to all the students.

3. COMPARING APPROACHES, STUDENT EXPECTATIONS AND OUTCOMES

3.1 A Survey at the Beginning of the Course

At the beginning of the course the students were asked to evaluate their previous knowledge of several aspects of computers (e.g., knowledge of operating system, experience in programming), as well as their usage of the Internet and the World Wide Web. Our goal was to use this data to guide and adapt our teaching strategy. The results of this initial survey are summarized in Tables 2 and 3. There is a strange discrepancy/contradiction in the answers from Table 2 (Previous Computer Experience). Approximately 22 % stated they had none previous experience with Operating System/Windows, and 37% stated no previous programming experience. Yet they all (100%) stated in another survey question that they had a computing course in high school. A computing course in which nothing is taught about operating systems/Windows or programming?

Table 2: Previous computer experience

	OS/Windows	Programming Experience
Extensive	0.0%	0.0%
Moderate	68.0%	21.0%
Some	11.0%	42.0%
None	21.0%	37.0%

Table 3 confirms the fact that the use of the Internet and WWW is widespread among the students: 80% use it daily or often for serching for information, while 58% use it daily or often for downloading digital multimedia: images, video, and audio.

Table 3: Usage of Internet and WWW

	Search for Information	Download Media
Daily	58.0%	21.0%
Often	32.0%	37.0%
Sometimes	16.0%	32.0%
Never	0.0%	10.0%

Table 4: Gender of Survey Participants

	SCSU	Ga TECH	GAINSVILLE
Male	55.0%	51.1%	37.5%
Female	45.0%	48.9%	62.5%

The next two tables (Table 4 and table 5) summarize the demographics data (gender and ethnicity) for the students enrolled in this course at SCSU, comparing them with the data gathered at Ceorgia Tech and Gainsville College, the use of which was kindly granted by the authors of ([1]). Note that Georgia Tech, being a large University, reflects in their enrollment the ethnic mix present in society at large. On the other hand, it is interesting that the ethnic breakdowns at SCSU and Gainsville seem to be "inverse" of each other: roughly inverse percentages of Caucasians/African-Americans and "Others" - and no others! (This statement is valid only for this course enrollment at SCSU, and not in general)

Table 5: Ethnicity of Survey Participants

	GA TECH	GAINSVILLE	SCSU
African-American	6.4%	0.0%	92.0%
Asian	7.0%	0.0%	0.0%
Caucasian	80.8%	96.0%	0.0%
Hispanic	0.3%	0.0%	0.0%
Other	5.4%	3.8%	8.0%

3.2 Mid-Course Survey

In mid-course we asked our students to do another another survey in order to examine whether their perceptions and goals regarding the course have changed, and how. Some of the survey questions were chosen the same as in ([1]) in order to enable comparisons.

Table 6 shows the answers of the students at SCSU and Gainsville College, respectively as to their goals for the class. The results seem to indicate that the students at SCSU are a little more pragmatic than their counterparts at Gainsville: No.1 goal for the first was "Good or Passing Grade", while "Practical/Relevant Skills for the Major" is No.3.

Table 7: Class Atmosphere was Conducive to Questions and Discussions

	SCSU	GA TECH	GAINSVILLE
Strongly Agree	8.0%	26.6%	6.2 %
Agree	69.9%	53.2%	56.2%
Neutral	23.0%	14.0%	37.5%
Disagree	0.0%	4.0%	0.0%
Strongly Disagree	0.0%	2.2%	0.0 %

The students at SCSU were a little more positive on the questions whether the class atmosphere was conducive to questions and discussions. Almost 78 % answers at SCSU were "Strongly Agree" or "Agree"; this should be compared to 89.8 % at Georgia Tech and 62.4 % at Gainsville. On the other hand, there were no answers "Disagree" or "Strongly Disagree" at *XYZW*.

3.3 Survey at the End of Course

At the end of the course we administered a third and final survey, asking students to express their views on various aspects of the course they just finished, and to reflect on the knowledge they gained and its usefulness. Before discussing the results, let us mention the success rate achieved in the course - defined as the percentage of A, B, abd C grades: it was 62.5%.

Table 8: Liked Collaborations on Assignments

SCSU	Before	After	GA TECH	GAINS.
Strongly Agree	15.0%	31.25%	50.4%	37.5%
Agree	31.0%	31.25%	35.3%	31.2%
Neutral	23.0%	25.0%	12.0%	25.0%
Disagree	23.0%	6.25%	1.8%	6.2%
Strongly Disagree	8.0%	6.25%	0.5%	0.0%

Table 8 reveals an interesting fact. The first two columns show *SCSU* students' views on teamwork and collaboration. The first column shows the attitudes expressed in the

Figure 1: Erykah Badu and Dave Chapelle. The picture was taken at *Dave Chapelle's Block Party*. Erykah Badu, an hip-hop artist and actress, is remembered for her poignant interpretation of Ms. Rose Rose in the Academy Award winning motion picture "Cider House Rules". On the left is the original image, and on the right is the "colored purple" image

midterm survey. we were quite surprised by the largely negative attitude of the students at *SCSU*: thus, the numbers of answers "Strongly Agree" and "Agree" is a cumulative 46 % at SCSU, much smaller compared to 83.4 % at Georgia Tech and 68.7 % at Gainsville. The answers of "Disagree" and "Strongly Disagree" are a cumulative 31 % at *SCSU*, and 2.3 % at Georgia Tech, and 6.2 % at Gainsville College. This negative view seems to have changed quite considerably after the experience of working in assigned teams on their project modules, which came in the second half of the course, and which the students found quite challenging. This experience seems to have largely convinced most of the students of the value and benefits of team work and collaboration when tackling challenging projects. However, the roots and causes of the initial negative views may point to further interesting research.

The rest of the tables summarize survey answers to questions asked of students to:

- evaluate whether they thought the project modules were relavant to them,
- rate their programming skills after this course,
- whether the skills gained in this course would be useful in their careers,
- whether they understand how to use programming to communicate with others,
- whether they would like to take more courses in computer science (CS) and/or media computing.

While the results are comparable and somwehat similar across all three institutions, it is evident that the results of *SCSU* and Gainsville match much more closely. It was to be expected, since they are both similar as to size (both are comparatively small schools, with smaller size classes), educational beckground of their students, and probably teaching methods and techniques used. These similarities seem to outweigh the differences between the two schools on the ground of the race/ethnicity composition of their student populations.

Table 9: Project Modules Were Relevant to Me

	SCSU	GA TECH	GAINSVILLE
Strongly Agree	6.25%	6.2%	6.2%
Agree	37.25%	33.0%	25.0%
Neutral	50.0%	31.7%	50.0%
Disagree	0.0%	25.0%	18.8%
Strongly Disagree	0.0%	4.0%	0.0%

Table 10: My Programming Skills after this Course

	SCSU	GA TECH	GAINSVILLE
Very Strong	6.25%	5.5%	0.0%
Strong	37.25%	70.3%	68.8%
Moderate	56.25%	17.8%	25.0%
Little	0.0%	6.4%	6.2%
None	0.0%	0.0%	0.0%

4. CONCLUSION

In this paper we have described our approach at innovating introductory computer technology and programming courses at South Carolina State University. We decided to adopt a media-based approach to teaching computing and programming concepts, augmented with a number of specific Project Modules tuned toward particular majors disciplines. A number of results from students' responses to the course were presented, as well as their comparisons with results

from similar courses taught at other universities. One of the conclusions from this work is that situating the teaching of introductory computing and programming courses in the media-rich millieu, and more generally, in wider cultural millieu is beneficial. Examination of these new contents and teaching modes will be the focus of our future work in this area.

5. ACKNOWLEDGMENTS

This work was partly supported by the NSF Grant HRD-0506062 "Research Infused STEM Curriculum at South Carolina State University". Many thanks to Mark Guzdial and Charles Fowler for the generous permission to use their data for comparison among the three educational institutions. Discussions with Drs. James Anderson, Daniel Smith, and Kuzman Adzievski, which helped shape the approach and course design presented here.

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Table 6: Student Goals for the Class

	SCSU	GAINSVILLE
1	Good or Passing Grade	Programming Knowledge and Skills
2	General Computer Knowledge	General Computing Knowledge
3	Practical/Relevance Skill for Majors	Good or Passing Grade
4	Programming Knowledge and Skills	Filfill CS Requirement
5	Media Skills	Computer Science Knowledge and Skills

Table 11: Skills from this Course will be Useful in my Career

	SCSU	GA TECH	GAINSVILLE
Strongly Agree	6.0 %	6.8%	0.0%
Agree	64.0%	38.7%	37.5%
Neutral	30.0%	31.5%	25.0%
Disagree	15.8%	16.2%	37.5%
Strongly Disagree	0.0 %	6.8%	0.0%

Table 12: Now I Understand how to Use Programming to Communicate with Others

	SCSU	GA TECH	GAINSVILLE
Strongly Agree	6.25%	8.0%	0.0%
Agree	37.25%	50.9%	56.2%
Neutral	50.0%	23.7%	31.25%
Disagree	0.0%	14.8%	12.5%
Strongly Disagree	0.0%	0.9%	0.0%

Table 13: Would Like to Take More Courses in

	SCSU		GA TECH		GAINESVILLE	
	CS	Media Comp.	CS	Media Comp.	CS	Media Comp.
Strongly Agree	6.25%	12.5%	12.6%	6.8%	0.0%	0.0%
Agree	24.5%	25.0%	12.25%%	70.5%	12.5%	68.8%
Neutral	31.2%	50.0%	16.6%	17.8%	25.0%	25.0%
Disagree	19.0%	19.0%	18.4%	6.4%	6.2%	6.2%
Strongly Disagree	19.0%	6.0%	35.0%	0.0%	56.2%	0.0%