Georgia Institute of Technology

Multimedia Support for Introductory and Advanced Computer Science Education

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1. Overview of Goals and Objectives

We have two goals:
(1) To address the needs of intermediate-to-advanced level computer science students. While there is research and products to support introductory-level students, as well as computer experts, there is relatively little support for intermediate-to-advanced level students. These sophomores, juniors, and seniors are past the stage where they are learning to program, but they are still struggling with issues of:

- Content (e.g., what is z-buffering in a graphics class?)
- Design (e.g., what does an object-oriented program in Smalltalk or C++ look like, as compared to a program in Pascal?)
- Integration (i.e., how do all these pieces fit together?)

(2) Apply the expertise in the Graphics, Visualization, and Usability (GVU) Center at Georgia Tech to create multimedia resources that address these needs. In an earlier Educational Infrastructure grant, we built a multimedia authoring tool to use in creating these resources. The Web has quickly become the platform of choice for multimedia, so we are developing materials for the Web.

Our research is strongly informed by research in education and cognitive science. Much of our approach is attempting to create a cognitive apprenticeship (Collins & Brown) for students in computer science.

2. Current Status and Accomplishments

We have three major accomplishments:

- Graphica: Graphica is a Web-based collection of tools and resources for learning computer graphics structured around providing a cognitive apprenticeship. These tools include visualization tools for active exploration of concepts (e.g., drawing Nurbs vs. Bezier curves over the same set of points), case libraries of expert activities in graphics, and peer review to encourage critical thinking about computer graphics Exercises are designed to be authentic (i.e., have a real-world context), and they are scaffolded (a kind of support provided in apprenticeships) through a variety of mechanisms such as communicating the process and coaching. A year ago, we conducted an analysis of student errors in computer graphics assignments and exams, which informed our design of Graphica in terms of defining students' needs. Graphica has been in use in several computer graphics courses in the last year. Work on Graphica has been primarily carried out by a post-doc on our project, Amnon Shabo.
- STABLE (SmallTalk Apprenticeship-Based Learning Environment): STABLE is a case library of projects in Smalltalk. STABLE leads students through the object-oriented analysis, design, and programming phases of a project, with particular reference to significant concepts, reuse issues, and general/abstract processes. STABLE has been used in a sophomore-level class on object-oriented design
- CaMILE (Collaborative and Multimedia Interactive Learning Environment): CaMILE is a Web-based collaborative forum designed for educational applications. CaMILE has been used in an object-oriented design class, a software engineering classes, and upper-level special-topics courses.

3. Plans for Remainder of Project

Our main focus is evaluation and dissemination at this time. In addition, we are:

- Enhancing Graphica, to cover more topics of concern to computer graphics students and teachers;
- Developing authoring tools for Graphica so that we can create new versions for other domains;
- Developing new versions of STABLE for other subjects;
- Developing visualization tools to be used in a range of classes.

4. Materials That Have Been Developed

- Graphica: A collection of Web materials, primarily composed of HTML pages (700+) with embedded JavaScript, and Java applets.
- STABLE and the ABLE Generator: STABLE is a collection of Web pages (800+). STABLE was created by generating the pages from a database of Smalltalk cases. Versions of STABLE for other domains should be relatively simple to create.
- CaMILE: A collection of Perl scripts.

5. Dissemination Activities

- Graphica is available partially on the Web (http://www.cc.gatech.edu/gvu/multimedia/nsfmmedia/graphics/edulib/CSA.html-- sign on as guest). The recording of students' answers (e.g., through "Submit Your Answer" actions) must be localized. We are exploring options for disseminating and localizing Graphica.
- STABLE is freely available on the Web (http://www.cc.gatech.edu/computing/classes/cs2390_96_fall/stable/stable.html). We are talking with publishers about creating and distributing a version of STABLE for Java.
- CaMILE has just been released to the Web (http://www.cc.gatech.edu/gvu/edtech/CaMILE.html) and can be freely licensed to educational institutions.

6. Evaluation Activities

We are currently evaluating Graphica in computer graphics courses. Our findings so far suggest that the interface is usable and that the tools are perceived as useful. The current focus in our evaluation is on the paths that students take through Graphica to determine the educationaleffectiveness of that process and to encourage a useful process.

Two evaluations of STABLE have occurred. The first compared STABLE to non-hypertext Web pages and to paper-based case library. STABLE-using students were more satisfied, performed better at a task, and had better post-test scores than the other two groups. The second evaluation was on learning measures compared to the same course without STABLE. Students using STABLE did the same as other students on domain knowledge (e.g., Smalltalk syntax, discrete vs. continuous simulations), but better on design tasks (e.g., repairing a faulty class hierarchy).

CaMILE use in one class has been contrasted with use of newsgroups in the same course in the previous quarter. The newsgroup class had an average discussion thread length of 1.8 notes, while the CaMILE-using class had an average discussion thread length of 7.2. Only 2% of the newsgroup notes (119 for 49 students) were on class topics, while 44% of the CaMILE notes (493 for 75 students) were on class topics. CaMILE-based discussions seem to be more in-depth and focus on the learning issues more than traditionalcomputer-based collaborative learning.

7. Benefits Seen and Expected

Our evaluations are suggesting that our approach is producing learning benefits for students. Other faculty in the College of Computing (and elsewhere) are becoming more interested in use of these tools and are asking us to help them with access and with applying these tools in their classes.