

CS1 For an Early College Program

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Abstract – *This paper, describes the design of a CS1 course for an Early College High School program. The course, based on the C++ programming language, is given over two semesters and incorporates closed labs and science-based applications. It also utilizes an integrated development environment (IDE) and supplemental instruction to help students write and debug their programs. Programming assignments integrate topics taught in high school mathematics and science classes. This approach shows promise of helping an at-risk population of students succeed in college-level course work and inspiring these students to continue their studies in computer science or other technology-related areas.*

Keywords: Early College; P-16 Education; Introductory Programming; CS 1.

1 Introduction

Inner-city college freshmen typically under-achieve in STEM (Science, Technology, Engineering and Mathematics) related topics. This lack of achievement is often not related to the students' capabilities in STEM related fields but rather the result of a combination of factors including math and science stigmas, uninteresting course presentation, and lack of preparedness when transitioning from high school to university campuses. To many of these inner-city students, college level science work seems unapproachable. Often they are the first in their families even to attend college and frequently, English is a second language.

One general approach to increasing college admission and success of inner-city students is the "early college" strategy, aimed at addressing the needs of students in this at-risk population – students who currently are more likely to drop out of high school than to attend even one semester of college. The Early College High School (ECHS) model creates either a new high school or a program within an existing school and connects the high school to a nearby two- or four-year college. During high school, students have the opportunity to enroll in college courses and earn college credit towards an associate's or bachelor's degree.

The path to achieving high success rates for these students is still unclear, however. An evaluation study that looked at

five of these schools in different cities recommended that additional research be conducted to examine curricular strategies and their impact on student achievement [11].

In Fall 2004, Brooklyn College of the City University of New York (CUNY) entered into an Early College partnership with the Science, Technology and Research (STAR) Early College High School (ECHS) housed in the Erasmus Hall High School building, located near the Brooklyn College campus. This offered us a unique opportunity to design and implement a special version of an introductory computer science course targeted to twelfth-grade students in this program. The course, Introduction to Programming in C++, was offered for the first time to the ECHS students in Fall 2006, and subsequently in Fall 2007. In this paper, we describe our approach to the design and management of the course, which is traditionally known to be especially difficult for under-prepared students.

2 Background

There has been a national movement towards improving student achievement in core content areas at the college level. This task is exacerbated in public institutions whose mission is to educate a wide range of students including under-prepared students [18].

Nationwide, universities are faced with an increasingly academically under-prepared student body. In an effort to increase retention levels, many institutions have instituted programs targeted to under-prepared freshman. Most of these programs focus on academic advisement and personal counseling [7]. Some programs include academic interventions such as remediation and teaching of study skills [10]. Follow-up studies indicate that these programs have achieved varying levels of success [4], [13], [14], [21].

Over the past decade many states have begun to adopt a comprehensive approach known as P-16, which holistically examines the education process from Kindergarten through College [5], [9], [11], [16], [17], [19], [20]. Tech Prep programs have been developed to link high-school students with community colleges. However, this initiative seems to be more successful as a vocational program than as a strong

academic program. Although these programs have been successful at moving students to enroll in colleges [6], they have not integrated high school and college academics [2].

The Early College High School Initiative [8], sponsored by the Bill and Melinda Gates Foundation, supports the development of "Early College High Schools" - institutions designed to foster higher academic standards and prepare their graduates for the academic rigor of college courses, especially in the sciences. The primary targeted population is groups who are under-represented in the sciences. The Early College program currently funds 130 early college high schools nationwide, with a total student enrollment of 8,030. The program targets establishing 180 Early College High Schools in the USA by the end of year 2008, with a projected student enrollment of 68,000 by the year 2012.

The program has identified broad goals for this initiative, such as developing a seamless curriculum that will take students from high school to college in six to seven years rather than using the standard model where students attend high school and then college. However, there has been no research on the best approaches suited to introduce these students to a college curriculum [1].

3 Targeted CS1 Course

The standard introductory programming course is known to have a low student success rate [3], [12]. Retaining under-prepared students has proven particularly difficult as they tend to be intimidated by the technology.

Therefore, we decided that the students in the Early College High School program should not be enrolled in our standard CS1 course, but that we would rather develop a special section of the course tailored to these students and designed to maximize the opportunity for their success.

3.1 Split-Semester Course

In making a successful transition from high school to college, students must adjust to both the academic rigor of college courses as well as a more intense and faster-paced lecture format. The first decision we made, therefore, was to slow the pace of the course by distributing the course material and associated credits over two semesters. We felt that a split-semester course would ease the transition by introducing students to college-level coursework, albeit not at the standard pace of a college course. Thus, instead of a one-semester, four-credit course, which is offered to our standard undergraduate population, our course was delivered as a two-semester course, with two credits earned per semester. We retained the standard lecture time associated with the course, however, so that although the course earned just two credits per semester, it still met four hours a week each semester.

3.2 Closed Labs

An added benefit of the increased course time per semester was the ability to incorporate closed labs. The course was structured to meet once a week for a two-hour lecture and once a week for a two-hour lab session.

The laboratory sessions were used in two ways: for "live" demonstrations, and for students to work on assignments under the guidance and immediate supervision of the instructor. This approach played on a familiar saying, "A lab demonstration is worth a thousand lectures." The laboratory environment was particularly important when introducing students to the use of input and output files, infinite loops, and debugging techniques. Additional laboratory sessions were used for students to work on assignments. The assignments were carefully structured in staged parts, so that all students would be able to complete the first parts of the assignment during the two-hour laboratory session. The remainder of the assignment was to be completed at home. In this way, we never had a situation in which a student was faced with a homework assignment and "didn't know where to start". The introduction to writing programs and debugging them within the context of an integrated development environment (IDE) was also invaluable in helping students complete their assignments.

3.3 Science-based Applications

Since our Early College students come from a high school whose mission, and indeed name, is "science, technology and research", we structured our course to focus on programming applications that arise in the sciences. We integrated material from high school math and science courses into the programming assignments. These assignments show how programming constructs are applied in a "real world" setting, and provide a motivation for students to become more involved in the material.

The following is a sample of some of the applications that were used in the course:

- calorie needs when losing weight
- programming LEGO® robots
- projectile motion
- classifying chemical elements
- creating histograms
- manipulating DNA sequences
- cryptography
- creating and modifying a database for medical experiments

This interdisciplinary approach helped students consolidate their learning experiences while demonstrating the broader relevance of computer science to other disciplines.

3.4 Extra Credit Supplementary Assignments

As noted above, our course was specifically designed to proceed at a slower pace in order to ease the students' transition to the rigor of college-level academics. The slower pace was clearly beneficial to most of the students in the class. However, it was immediately obvious that one or two of the students in the class could easily accomplish more in that time. We were wary that if those students were not sufficiently challenged, they might get disillusioned by the course and conclude that computer science is boring. Our solution was to incorporate extra credit components into each assignment. The supplementary material required students to implement more complicated algorithms, learn programming details not covered in class, or further study the targeted science problem. This two tiered approach proved invaluable in motivating exceptional students.

3.5 Counseling

A key factor in the success of our course was counseling of the Early College students before they enrolled in the course. The students were carefully screened to ensure that they had completed the appropriate high school courses and were advised about the rigorous nature of the course before they were permitted to enroll.

Additionally, the students were monitored closely during the semester. Some students were required to attend additional study group sessions. In each of the two years, a small number (three the first year, two the second year) of students, whose performance did not improve despite the extra sessions, were advised to withdraw from the course early in the semester, so that they would incur no academic penalty and still have time to enroll in another college level course more suited to their interests and abilities.

4 Obstacles

One issue we faced during the first year was motivating students to complete homework assignments outside of class. It seemed to us that the students were simply unaccustomed to the idea that college courses require a substantial amount of work to be done outside of class time. In the current year we are addressing this issue by scheduling additional required study periods, during which the students work on homework assignments in the computer lab under the supervision of a student teaching assistant. This approach has already proven beneficial. In the Fall 2007 semester, 92% of the assignments were submitted; most students had perfect submission records, and only one student missing more than two of the twelve assignments.

In 2006-2007, we found a noticeable shift in the students' attendance and work habits between the fall and spring semesters. During the spring semester, attendance became sporadic and some students stopped completing assignments. At first, we thought that the "slacking-off" was due to the

increased complexity of the assignments. After talking to the students and the high school faculty, it became clear that the performance in our class was symptomatic of general "senioritis" evident across the entire twelfth grade class. These high school seniors, who at this point in the year had finalized their plans for the following year, did not feel the need to apply themselves any longer. This issue is not unique to this particular high school; some colleges have resorted to revoking acceptances of students who do not maintain their academic record [15]. We have learned from this experience that the administrators and instructors at both the high school and the college components of the program have to communicate to the students the importance of staying focused during their last semester of high school. During the Spring 2008 semester we are currently putting more emphasis on attendance and timely submission of assignments by instituting regular in-class quizzes and enforcing grade penalties on late homework submissions. These measures serve to reinforce the connection between good work habits and academic success.

5 Successes

Overall, we were pleased with the results of the course. In Fall 2006 we began with a small group of eleven students. Three students were advised to withdraw early; the remaining students performed very well, all achieving A's and B's, with an average GPA of 3.3 (B+). At the end of the Spring 2007 semester, the students took the same uniform final exam given to all sections of our introductory course. Although they did not do as well as they had in the first semester (average GPA of 2.8, B-), all of the students completed and passed the second semester of the course. In Fall 2007, out of a cohort of sixteen students, two students were advised to withdraw; the remaining fourteen completed the course with an average GPA of 2.8 (B-). We expect that the students will continue to do well throughout the Spring 2008 semester.

The results of an end-of-year assessment administered at the end of the 2006-2007 academic year indicated that the students felt that they had benefited from taking the course and that, with one exception, they had enjoyed the course. The comments indicated that they found the course challenging and, as one student put it, "It helped me flex some creative muscle."

A more detailed preliminary assessment of the course was done at the end of Fall 2007 by the Institute for Learning Technologies (ILT) of Columbia University (Susan Lowes) through a sequence of questionnaires that were given to the students, which were approved by the Institutional Review Board (IRB) at the City University of New York (Brooklyn College). Although most of the students reported that the course was not what they expected, many wrote that this was because it was harder or more challenging; while others wrote that they had been expecting to learn about computers and software, not about programming. In both cases, the students did not consider this a bad thing—they liked the challenge or

they liked learning how to program. The students who responded that the course was what they had expected had liked it because of the challenge. As one student commented, "I expected this class to be boring and not useful but I was very wrong. It was interesting to me and most definitely is a useful class." Additionally, there was a question designed to assess whether their thinking about computer science went beyond knowledge about programming to include a sense of the uses of that knowledge. For all but two it had, with many writing about the uses of computer programs to better the world.

6 Conclusions

Minorities are under-represented in the sciences and mathematics, especially at the upper ranks of these disciplines. Urban institutions such as Brooklyn College have a student body that is ethnically diverse and is primarily comprised of minorities (52% at Brooklyn College). The Early College program presents a unique opportunity to explore and develop a curriculum for this population with the goal of inspiring more of these students to stay with the STEM pipeline through college graduation and beyond.

The CS1 course that we developed for this program was planned around several principles: structuring the course as a split-semester course, incorporating closed laboratories and providing individual counseling and tutoring. We also used an interdisciplinary science-based context for teaching programming and its applications and provided supplementary challenging assignments. We anticipate that our experience will have application to other Early College High School programs nationwide.

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