Retention in Computer Science Courses

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Abstract

Throughout its history, careers in fields related to Computer Science (CS) have expanded. However, there have been periods, like the year 2000 following the 'dot-com bust' when skilled people had to change employers, invoking negative publicity. The effect of this on enrollment in CS education was dramatic and lasted until 2007. According to Computing Research Association (CRA), there was an amazing increase in CS enrollment in 2008. Total enrollment per department by majors and pre-majors in U.S. CS programs is up 6.2% in 2008, and if only majors are considered, the increase is 8.1% [1]. CS student data are similar in Canadian schools [1]. There is a significant increase in number of enrollments in Computer Science education since 2008 [1]. The vital next step is to retain the enrolled students in Computer Science courses. Keeping that in mind, our research has combined the understanding of retention issues with some action strategies. This paper describes a first year CS course with this objective, initial finding and recommends some strategies to help students to successfully complete the course. In this research, we seek the clear indicators of withdrawal from or unsuccessful completion of a first year CS course. We suggest strategies to reduce the withdrawal rate and provide students with greater confidence in their ability to succeed. Our recommendations are for exam-

ple, adapting the curriculum to the learners expectations i.e., making early assignments easier and less intimidating. Overall, the number of female students in computer science is low [2] and becomes diminished when they withdraw from the courses. Our suggestion is designating support for female students through the course.

1 Introduction

According to survey of Computing Research Association (CRA), there is an amazing increase in CS enrollment in 2008. Total enrollment per department by majors and pre-majors in U.S. CS programs is up 6.2% in 2008, and if only majors are considered, the increase is 8.1% [1]. CS student data are similar in Canadian schools [1]. There is a significant increase in number of enrollments in Computer Science education since 2008 [1]. The enrollment in first year Computer Science courses (CS1 and CS2) at the University of Victoria has followed this trend. Table 1 shows the enrollment numbers in those courses. Our research focus is to analyze the teaching and learning activities and the surrounding institutional support to help students to maintain their interest in CS education.

Retention in Computer Science courses has an effect not only on the student numbers in Computer Science programs, but on many programs that require the courses. Throughout this research, we tried to focus on three main key

points:

- What identifies the students who might be at risk early in 1st year CS course?
- What are the exact reasons that cause a student to drop from the 1st year CS course?
- What are the strategies that should be adapted to retain the enrolled students in the program?

In this research, we have chosen a basic computer science programming course titled: Fundamentals of Programming (CS1) to study the enrollment and retention trend.

Organization: The rest of the paper is organized as follows. In Section 2, we give an overview of related work. In Section 3, we present an outline of the CS1 course. Sections 4 and 5 contain the description of our method, data and analysis and our observation. In Section 6 and 7, we have discussed our strategies and future work.

Table 1: Trends in fall enrollment for CS1 and CS2 in Computer Science Department of University of Victoria

Year	No. of students
2001	675
2002	580
2003	523
2004	499
2005	495
2006	462
2007	238
2008	317
2009	332

2 Related Work

Patricia Lasserre [2] proposed Team-based learning as an active learning tool to increase

the amount of students practice, interest and confidence and to decrease the drop out rate. She demonstrated that it is possible to successfully engage the students by Team-based learning and the number of students who drop the class decreases. J. McGrath Cohoon [3] focused on departmental characteristics and outcomes to identify effective methods for retaining women. They found that CS departments gendered attrition rates varied across institutions. In other words, attrition rate differed between male and female attrition rates. It appears that environmental characteristics may overcome or exaggerate gender differences. J. McGrath Cohoon also provided evidence that the college experience plays an important role in female underrepresentation in computer science.

3 The Course

CS1: Fundamentals of Programming: The main focus of the course is on developing specific programming skills, namely analyzing mathematical and informatics problems using a structured and methodical approach.

3.1 Course Content

Introduction to designing, implementing, and understanding computer programs using a programming language. Topics include overview of computers and software, introduction to computing and problem solving, fundamental elements of object-oriented programming, top-down design and incremental development.

4 Our Study Process

4.1 Goals

Our research seeks to answer the following student retention question:

- Why are students registering in, then not completing the CS1 course?

We have conducted focus groups with students who failed or dropped the course and the stu-

dents who successfully completed the course. The goal was to increase our understanding of why students did not successfully complete the course. In addition, we have done analysis of instructors attendance and grade sheets in the hopes of determining early course activities that missed or poorly completed indicate the student will not complete. We have surveyed the students to determine learning characteristics.

4.2 Methods

We actively spent more than three years engaged in learning more about retention issues as well as collecting and analyzing data that was accessible to us. We learned that one of the most important issues of student retention is student engagement. This entails:

1. knowing who the students in the class are,
2. knowing their expectations of the class
3. building a relationship with the students.

During the Fall 2007 term the instructor made an email contact with every student who did not complete Problem Solving Session 5 (PSS5, which occurred a little past the midpoint of the term), asking about the students' progress in the course and inquiring if there was anything the team could do to support the students. Nearly all of those students replied to the instructor and half of those were directed to other campus resources, for example, to the Resource Centre for Students with Disabilities and to Counseling Services. In the spring 2008 term the instructor chose to move this contact earlier, after PSS2 (about three weeks after the start date of the term) and broadened the group of students receiving the email messages. In this case, anyone who failed to complete PSS2, Labs 2 or 3, or Assignment 1 or anyone whom the lab instructor (i.e., the people who saw the students in the smallest groups) received a message. This time very few students replied;

maybe the contact was too early in the term, when the students were not ready to communicate with the instructor, or the email communication was not as inviting. However, it is possible that the students are unable to see the relation between this lack of completion and their possible success in the course.

4.2.1 Data

To build such a foundation, we conducted a Getting to Know You (entry) Survey in the beginning of the spring semester. This survey provided the instructor with some information about students program, their previous programming experience, their expectations of the course and the difficulties they might anticipate. Although it was not possible to adapt the course material to on the fly, the exit survey conducted at the end of the course followed up on several questions of the entry survey. Additional data sources that were accessible were the instructors class records. These provided detailed information about students gender, year of study & faculty, their pass and not pass status, as well as their participation and attendance of Problem Solving Sessions, Labs, Assignment Submissions and Grades. Much of our work this semester included an analysis of this data in order to identify themes or patterns that would help us:

1. to identify early on (first three weeks) who may be at risk of withdrawing, receiving an N Grade (Incomplete) or failing the course and/or
2. to initiate actions with which to support students in completing the course successfully. The data from the entry and exit surveys needs to be treated carefully as it represents only about a third of students in the class.

4.2.2 Analysis

The students in the study were separated into two groups, those that passed the course and

those that did not pass the course. In fact, there are finer divisions, the passing students receive various grades ranging from D to A+ and the not passing students receive one of three grades, W which indicates that they withdrew from the course, N which indicates that they did not withdraw from the course but they did not write the final exam and F which indicates that they failed the course. In this study we do not distinguish between the various levels of passing the course, but do consider the various not passing grades.

5 Our Observation

The following is a compilation of the most interesting results of our research.

5.1

Gender. Approximately two thirds of the class was male, one third was female.

Year of Study. Approximately 65% of students were in their 1st year of study, approx. 20% were in their 2nd year of study, approx. 15% were in their 3rd year of study and only very few 4th year students.

Faculty. We encountered students from seven faculties within this course. Approximately 40% of students were from a Science faculty (SCIE), approx. 30% were from the Social Sciences (SOSC), approx. 15% were from the Engineering faculty and the remaining 15% consisted of students from the faculties of Human and Social Development (HSD), Humanities (HUMN), Fine Arts (FA) and Education (EDUC). The data suggests that there are a larger number of females from the social sciences than males.

5.2

5.2.1 Lack of attendance or poor performance

A lack of attendance or poor performance in PSS or Labs as well as missing an assignment may indicate a lack of interest in the

course. Persistence is correlated with achievement; low grades in the first few weeks may predict the persistence in the course. We also noticed that although a specific number of students appear on the class records as registered, several students do not attend a single class.

5.2.2 University calendar

University calendar withdraw dates, e.g. specifying tuition refund, are important markers for withdrawal times. By the second month of a four-month course (time of the '50% tuition refund date'), students in CS1 have completed the first two assignments and a midterm. If students have not done well in these assignments and midterm they may consider dropping the course. However, we also noticed that some students who dropped the course did complete the first assignments with good grades.

5.2.3 Difficulty level of initial assignments

Difficulty level of initial assignments and first midterm is very important. Several students in the spring 2008 exit survey stated that Assignment 1 and 2 of CS1 were very difficult. Most of the CS1 students in spring 2010 also stated that early assignments were difficult. Although all of these respondents wrote the final exam, this may have also been experienced by students who then decided to not complete the course.

5.2.4 Programming with a partner

Programming with a partner may be an effective and enjoyable way of learning. In our survey with CS1 students in spring 2010, we found that 59% of students think that programming with a partner (*Pair programming*) is beneficial. Only 14% students think that Pair programming is not beneficial.

These facts increased our awareness of student support and retention issues in CS1 and enabled us to consider more tailored strategies

to address the student drop out rate.

6 Strategies

Throughout the research process we have combined our growing understanding of retention issues with action strategies. Here are some of the ideas that will be put out for discussion:

6.1 Know your students

Continue to gather data from incoming students in the second week of class to understand who is in the class and what they are expecting from the course. With a data base it can be easily to pull out gender, year of study and faculty, previous programming experience, etc, and a more tailored course outline to student participants.

6.2 Expectations of the course

Set clear expectations of the course for students.

6.3 Curriculum adaptations

Adapt the curriculum, as much as possible, to learner expectations. If the course makeup remains fairly consistent, then it may be possible to design the course differently to address the makeup.

6.4 Assignment difficulty level

Consider assignment difficulty levels in the beginning of the course. Perhaps the first few assignments can be designed to clearly indicate a series of simple stepping stones to be accomplished by the new student.

Extend the existing Computer Science support for the first few challenging weeks in the course. This might include pre-planned tutorials sessions or specialized CS1 help sessions, ensuring the confidence as they begin to learn to program.

6.5 Pair programming

Pair programming is an effective way of active learning. It increases students' interest and

confidence in the course.

6.6 Gender difference

Consider research on gender differences in Computing Science and whether and how CS1 takes this into account. The number of female students in computer science is low [3] and becomes diminished when they withdraw from the courses. Appoint a Womens Advocate in the department who will regularly meet with female students to discuss the course related issues and set up different technical workshops, tutorials etc. Ensure this person is visibly located near the work/study area of the first year students.

6.7 Advertise support for student

Ensure that students know where to get support. Build Instructor and teaching team as Support Resource and Advisors, and designate a Womens Advocate. This means informing, educating and delegating certain relationship building tasks or performance monitoring to other sources than the course instructor. Establish who takes on what role. Regularly display a slide in the classroom and on the course web site to remind students about support places academic and personal.

6.8 Relationship with students

Some researchers reported that there are two main reasons; a loss of confidence that led to a loss of interest in the program, and a direct loss of interest in the program that is, unmediated by a loss of confidence[4]. Building relationship with students improves this situation. If the class is too large for personal contact by the instructor, ensure that each member of the teaching team (including lab instructors and consultants) are personal contacts as an integral part of their teaching. A welcome email and further emails about how its going are appropriate for all students and for those especially that seem to not be attending or are not doing too well in the first few weeks.

6.9 Consider course structure and content

One of the recurring questions is whether one course can adapt to the variety of students and expectations within the course.

Our study (from Fall 2007 to Spring 2010) shows that the factors contributing to successful completion of the first year computer science courses are strongly dependant on the previous programming experience, the students' motivation and dedication to learning the material as well as a strong work-ethic.

7 Future Research

Our future research plans are

- Conduct individual interviews with students who have dropped, not completed or failed the course.
- Conduct individual interviews with students who have passed the course.
- Collect and analyze class records, Getting to Know You and Exit surveys of the upcoming fall and spring semester to get a longer term view.
- Conduct a review of retention programs of other universities to gain further ideas.
- Extend the Teaching Team / Learner communication to include personalized communication and continue to search for an appropriate time for this communication.

8 Conclusion

This valuable study showed the composition of the learners in the course and revealed that the early part of the course is a critical time for learners. There are still many unknown factors that affect decisions to withdraw from this course. This study gave increased insights into class dynamics, and additional research would allow further exploration. Since the researchers are an integral part of the teaching

team, the research results did effect the instruction in the courses through the terms.

References

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