

# Computer Science and Computer Information Technology Majors Together: Analyzing Factors Impacting Students' Success in Introductory Programming

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**Abstract** - In 2004 Northern Kentucky University began offering a Bachelor of Science degree in Computer Information Technology. As these new majors began to enroll alongside Computer Science majors in the required and standard Computer Science 1 (CS 1) course, the context of CS 1 shifted. Accordingly, we made curriculum changes to adapt the introductory programming sequence to this new context. These changes included: creating a "CS 0.5" preparatory programming course taught in a variety of languages; allowing the scheduled laboratory component of CS 1 to be optional; and lowering the mathematics prerequisite for CS 1 from Pre-Calculus to College Algebra. We have studied the impact of these changes on student success. Because many Computer Science Departments in the U.S. began offering Information Technology degrees since 2000, in part to offset the downturn in CS enrollment, our results may be of broader interest. We found that gender, major, the programming language used in CS 0.5 and student attitudes toward technology (as revealed by surveys) did not affect student success in CS 1. Factors that were positively correlated with CS 1 success included mathematics ACT score, completing CS 0.5, and enrolling in the optional CS 1 laboratory section.

*Index Terms* – computer information technology education, computer science education, retention

## INTRODUCTION

This paper presents predictors of student success in an introduction to object oriented programming class (CS 1) for a regional comprehensive university integrating new Computer Information Technology (CIT) majors with existing Computer Science (CS) majors. It also evaluates curriculum changes made to the beginning programming sequence to support both CS and CIT majors.

In 2004 a CIT Bachelor of Science degree was created at Northern Kentucky University (NKU) and course modifications to preexisting courses were implemented in fall, 2006. The Computer Science department offers the degree and some courses were modified to accommodate both CIT

and CS students in order to minimize duplication of content. This paper evaluates student success in one course, "Introduction to Object Oriented Programming" or CS 1, and discusses factors contributing to their success.

Similar to other programs nationwide [1-2], NKU's CS program saw a decline in enrollment starting in 2002, and NKU historically had low minority and female enrollment [3-6]. With the creation of the CIT major, there was an opportunity to try new approaches to the initial programming sequence. The short-term goal was to evaluate course modifications by examining student success, evaluate factors influencing student success and to use this information to influence future curriculum modifications. The long-term goal is to improve recruitment and to attract and retain a higher percentage of minority and female majors. The initial plan and preliminary results were presented and discussed in 2007 [7].

## BACKGROUND

Figure 1 defines the prerequisites for CS 1 and CS 0.5.

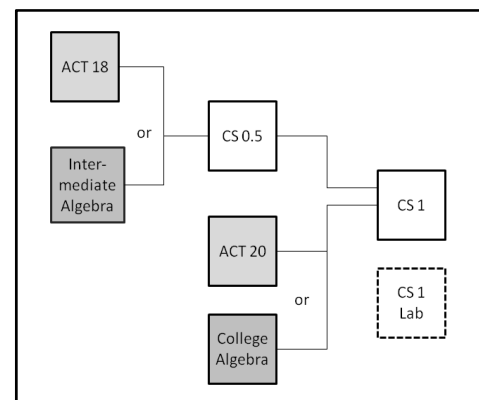


FIGURE 1  
CS 0.5 AND CS 1 PREREQUISITES

The CS 1 course uses Java and teaches objects late in the course. Prior to 2006, the course was taught lecture style with a separate and required one-credit lab. To accommodate CIT majors the following changes were made to the introductory sequence:

- The math prerequisite was lowered for CS 1 from an ACT of 23 to 20,
- A CS 0.5 course was created as a prerequisite to CS 1 to cover basic non-Object Oriented constructs,
- The co-requisite one-credit CS 1 lab was offered but no longer required, and
- The CS 1 content coverage was extended to cover inheritance and polymorphism

Research has correlated the number of math courses taken in high school with CS 1 success [3,8] and for this reason, prior to 2006, the prerequisite for CS 1 was either pre-calculus or a minimum of 23 on the math ACT. CIT majors have different math requirements than CS majors, yet still need to take programming early in their course sequence. In order to support CIT majors the math prerequisite was lowered to either passing college algebra or a math ACT of at least 20.

Research also indicates that attrition in CS may be attributed to an initial course overwhelming a student who has no prior programming experience [3,9]. Combined with the lowering of the math requirements, NKU addressed this concern by creating a CS 0.5 course to provide a slower-paced, hands-on introduction to computer programming as a prerequisite to CS 1. All students are currently required to take CS 0.5; however students with prior programming experience can test out. CS 0.5 is taught in a computer lab half-time and the class is capped at twenty students. Instructors are allowed to choose the programming language, and past languages include C, C++, Java, Python and a combination of Java and Alice. The predominant language was Java in 2006 and Python in 2007. The course introduces students to problem solving, teaches imperative programming constructs, and concludes with arrays.

The lab was changed from a co-requisite of CS 1 to an elective in 2006. It was the opinion of the department that offering the lab as an elective provides weaker students with extra support and programming exercises without burdening stronger students. Similarly, since students understand basic constructs of programming languages when starting CS 1, the topics of inheritance and polymorphism were added. This provides instructors with the time to review material from CS 0.5 and provide students with a solid foundation in objects.

This study began in Fall 2006 in order to examine the impact of combining the CS and CIT majors as well as evaluate modifications to the curriculum. The study examines objective demographic data and survey results. In addition to evaluating current courses, it also was hoped that the study would provide information to refine and improve the introductory programming course offerings to improve retention in CS 1.

The remainder of this paper discusses the surveys in detail, and the analysis of attitude survey results, experience survey results and success in courses following CS 1.

### STUDY

The initial programming course in any computer science curriculum is one of the major hurdles in attracting and

retaining technology majors [4]. Characteristics of student success in introductory computer science courses include low anxiety (or high comfort level) and prior programming experience [5, 6]. Courses that can reduce anxiety or require no prior programming skills have lower failure rates.

A Computer Attitude Survey (CAS) was used to evaluate students' attitudes about technology and a Computer Experience Survey (CES) collected information about the technology experiences of students. Both surveys were shown to be valid and reliable [10]. The CAS evaluates students' attitudes regarding technology, computers and programming. The survey evaluates anxiety at its source by partitioning the 16 five-point Likert Scale questions into five possible causes of anxiety. The categories include: current and future interaction with computers, computer self-efficacy, beliefs about the impact of computers on social and personal life, attitude of the IT profession, and fears of long-lasting negative consequences of computer use. Anxiety changes over time and students are asked to take this survey at the beginning of the semester in CS 0.5 and CS 1.

The CES collects information on students' technology use and exposure to technology prior to their initial programming course at NKU. The CES combines question types and is slightly different from the reference survey used as a model [10]. Modifications were made to include technology more commonly used among NKU's student population. Experiences were examined in four categories: general environment of experience, computer use environment, content/quality or type of computer interaction, and current use including intensity of use. Students take the CES once.

### SURVEY RESPONSES

Surveys were implemented, along with the new curriculum changes, in fall 2006. During the first two weeks of each semester, the surveys were announced to all CS 0.5 and CS 1 instructors by email and instructors were asked to encourage students to take the surveys. Instructors were given links to the surveys to post on their class website and asked to announce the survey in class. Instructors were also asked to inform students that the survey was voluntary, yet to strongly encourage students to take the surveys.

Table I summarizes the percentage response rates for the two surveys. Both surveys were voluntary and response percentages were measured separately for the attitude and experience surveys and by course. The percentage responses for both surveys for CS 0.5 are in parenthesis and are computed as the percentage of students who participated in the survey and subsequently enrolled in CS 1. Surveys for students who took CS 0.5 but did not take CS 1 were not analyzed. For CS 1, the percentages are computed differently for each survey. CAS responses are the percentage of CS 1 students who took the survey in the relevant semester. CES response percentages were computed as the total CES surveys for students enrolled in CS 1 as a percentage of total CS 1 students who had not filled out CES when enrolled in CS 0.5.

TABLE I  
RESPONSE RATE PERCENTAGES FOR SURVEYS IN CS 1 (CS 0.5)

Semester	CAS	CES
Fall 2006	58% (75)	58% (80)
Spring 2007	80 (0)	28 (0)
Fall 2007	52 (86)	54 (67)
Spring 2008	36 (0)	40 (0)

As can be seen from Table I, some response percentages are low and it is unlikely this is due to student indifference. There are four semesters with no responses from the CS 0.5 classes (spring 2007 and spring 2008). There are two semesters when no surveys were submitted (summer 2007 and summer 2008). The lack of responses, especially in CS 0.5 classes that are held in a lab, suggest that the survey is not being advertised to the class. Instructors are not required to advertise the survey and some have admitted to ignoring it. Fortunately, significant results were obtained from this data but efforts will be made to improve future response rates.

**DEMOGRAPHICS PRE/POST CIT MAJOR**

This section compares enrollment and success rates to determine if changing the prerequisites negatively impacts student success. Pass is defined as earning an A, B or C in the course. Withdrawals, D's and F's are considered failures. Data was collected from 2001 through 2007 for CS 1 students. The CS 1 course was taught in Java for all seven years. In 2005, a one-credit required lab was introduced. The lab was demoted to optional in 2006.

Figure 2 graphs the annual enrollment of students in CS 1 for 2001-2007. Graphs presenting annual data use light blue indicators for data collected post-curriculum change. The decline from 2002 through 2005 mirrors nationwide plummeting enrollments [1,2]. The number of students enrolled in CS 1 rose in 2005 and 2006, likely from the addition of the CIT degree. Both CS and CIT have approximately even numbers of students actively enrolled although individual classes are not typically divided 50-50. The 2007 enrollment numbers are likely more realistic than 2006, since 2006 was filling a backlog for CIT majors waiting for the degree program to be approved.

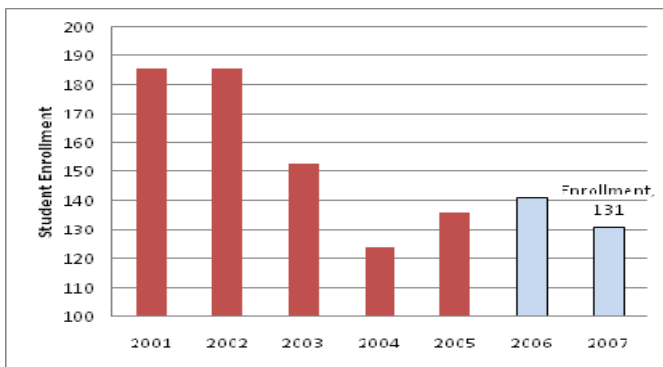


FIGURE 2  
CS 1 ENROLLMENT

Figure 3 shows the percentage of students who passed or failed CS 1 from 2001 through 2007. No conclusions about

this data resulted from statistical tests, although the success rates do not appear to be significantly different with the introduction of the CIT major in 2006.

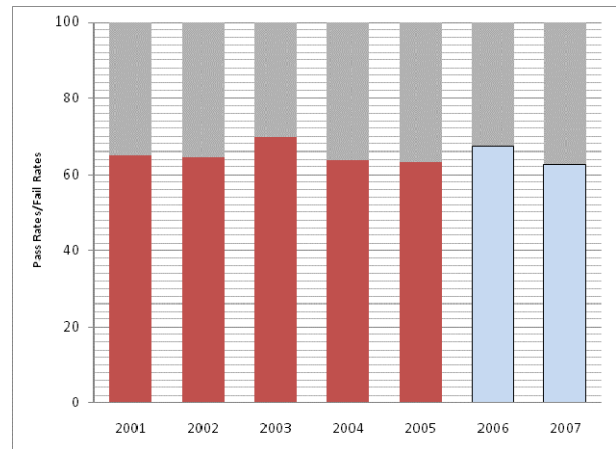


FIGURE 3  
CS 1 SUCCESS AND FAILURE PERCENTAGES

Studies show that student success in CS 1 depends on their (ACT) scores [11]. Figure 4 is the averaged combined ACT for students taking CS 1 who also took the ACT. Seventy two percent of all students taking CS 1 had ACT scores on file. Although there appears to be a trend of success with lower average combined ACT scores there is not yet enough annual data to analyze statistically.

The pass rate for CS 1 has not changed significantly with the introduction of CIT majors and modifications to the curriculum indicating CS 0.5 may be providing the support intended. Data will continue to be collected and monitored in case this trend changes.

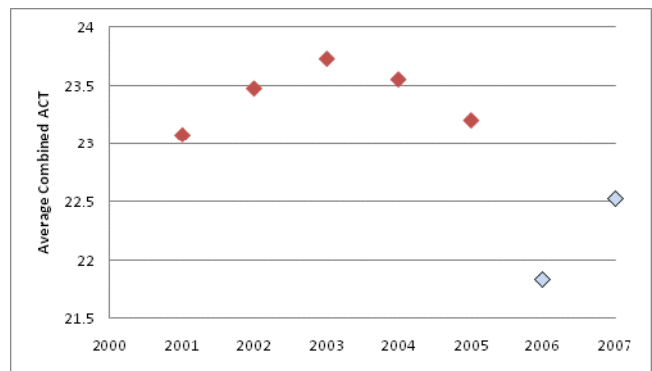


FIGURE 4  
AVERAGE COMBINED ACT

**2006-2007 RESULTS**

This section contains detailed analysis of both descriptive demographics of predictors of success as well as the student attitudes and experience surveys.

*I. Demographic Results*

Influence of many attributes on success in CS 1 was tested using Pearson’s Chi-square test. This section describes the tests done on demographic data and the attributes that did or did not influence student pass percentages. The attributes that effected higher success rates were passing CS 0.5 as taught by the CS department, ACT score, and taking the optional one-credit lab. Neither gender nor major (CS or CIT) had a significant impact on success rates.

Students who passed CS 0.5 had higher success rates in CS 1 than students who did not take CS 0.5 (success rates are 82% and 69% respectively, p-value = 0.03). Before making this conclusion, the distribution of ACT scores of students who took CS 0.5 prior to CS 1 and the distribution of ACT scores of students who did not take CS 0.5 was carefully studied. Surprisingly, there was no indication that students who took CS 0.5 were students with lower ACT scores.

The students’ ACT scores had significant impact on their success in CS 1 (p-value = 0.03). The success rate was greater for students with higher ACT scores. Students with ACT scores greater than or equal to 23 (prerequisite for pre-calculus) had the highest success rate at 84%, ACT scores between 20 to 22 had a success rate of 70% and students with ACT scores below 22 had the lowest success rate at 61%.

The highest success rate in CS 1 was observed among students who successfully completed CS 0.5 over students who successfully completed a CS 0.5 offered by a different department (77% to 24%, p-value = 0.00). The alternative CS 0.5 is a course offered by the Business Informatics department (formally Computer Information Systems). The course is taught using Visual Basic for Applications. Students had primarily defined macros for business applications in Microsoft Excel and Access. As a result of the low success rates of students taking CS 1, the alternative CS 0.5 course was restructured adding coverage of method structures and loops. Evaluation of the modified course is ongoing.

The effect of taking the elective CS 1 lab was significant on students’ success in CS 1. Students who were enrolled in the lab had higher success rates than students who did not (92% to 75%, p-value = 0.02) enroll. This result may be biased since respondents are not a random sample of students.

II. Attitude Results

The CAS was given at the beginning of each semester in both CS 0.5 and CS 1 to evaluate students’ anxieties and self-efficacy to guide us in future updates to the program.

Students’ attitudes about technology did not affect success in CS 1. Similarly, there is also no attribute that significantly decreases or increases between CS 0.5 and CS 1.

The results might be interpreted as positive, however at this time they are inconclusive. Too few students recorded feeling anxiety or fear with respect to technology, the class or programming to conclude that attitudes do not influence success in CS 1 at NKU. Although highly unlikely, one scenario that might explain this is that an online survey is self-selective, with students who were uncomfortable with technology avoiding the survey since it was online and required them to use technology just to take the survey.

Table II details the results from this survey. The first and second column defines the question ID and question from the survey. The third column contains the percentage of respondents with positive responses. Responses were defined respondent when either the respondent selected strongly agree or agree for questions in bold font in Table II (3, 9-14) or selected strongly disagree or disagree for normal font questions (1, 2, 4-8, 15, 16). The last column is the percentage of respondents who gave different answers in CS 1 than they gave in CS 0.5. The first number is percentage with improved answers and second is percentage whose answers were worse.

TABLE II  
CAS RESPONSES

ID	Question	%Positive	Change
1	I feel discomfort when I have to use the keyboard	93	4/-4
2	I feel uneasy about the prospect of connecting computer's cables	92	10/-4
3	<b>I feel at ease using complicated electronic devices</b>	75	13/-15
4	The thought that I may make a mistake that will cause computer malfunction really scares me	80	14/-7
5	When I use or am about to use a computer, I feel anxious	90	6/-7
6	I feel uneasy when I am present at discussions that concern computers' technical characteristics	83	9/-7
7	I feel I don't have adequate knowledge to meet the course's needs regarding computer use	93	9/-7
8	I feel uncomfortable when I sit next to experienced computer users	81	12/-14
9	<b>I believe that computers are essential tools in work and education</b>	94	6/-10
10	<b>Computers make our life better</b>	88	8/-10
11	<b>Computers improve people's communication</b>	88	7/-7
12	<b>I always look forward to using a computer</b>	85	9/-7
13	<b>I enjoy programming</b>	74	12/-6
14	<b>I eagerly anticipate working as a computer specialist</b>	80	10/-6
15	I feel uncomfortable with the prospect of spending long hours in front of a computer	76	5/-8
16	I am afraid that continuous work with the computer will harm me physically	69	5/12

These results do not support modifications to the course sequence at this time. The survey will continue and monitor future attitude changes.

III. Experience Results

Research has shown that experience with technology or prior software development improves students’ success in early programming courses [11-13]. Experience also helps students develop self-efficacy and minimize anxiety [13,14]. In the CES, students were asked to report on their backgrounds using technology and current modes of usage. The experience indicators were examined to determine if they were indicators of student success. The experience indicators were also analyzed by gender to determine if the combination of gender and experience influenced student success.

The initial finding, that 95% of NKU students who participated in the survey had a computer in their home (85% of all females) and they could use it as much as they wished prior to entering college, sets the tone for the results of this

survey. There was no difference between the success rates of students who had access to computers at home and students who did not have access to computers at home. Table III summarizes a subset of experiences that had no relationship to student success. The percent of yes responses refers to the percentage of all students answering true to the question, the first number in parenthesis is percentage of males and the second is the percentage of females who answered true.

TABLE III  
CES EXPERIENCES

Experience	% Yes Responses
Used computer in their home	95% (96/86)
Used a computer that they owned	90 (90/90)
Responsibility of computer maintenance	83 (87/65)
Used computer without supervision	92 (93/91)
Use computer at least once a day	99 (99/99)
Know the speed of internet connection	86 (94/43)

As the results in Table III summarize, most NKU students have significant experience with technology and an understanding of computers. There is also no significant difference when evaluating only men or women. It appears that, for the most part, lack of technology experience is not a hindrance for most of our students.

However, there are three factors that require examination. Two factors are indicators of student success: using a computer without supervision and knowledge of computer hardware. There is slight indication of differences between the success rates of students who used a computer without supervision prior to their first college programming course and the students who did not (82% (CS 0.5 respondents), 56% (CS 1 respondents),  $p$ -value = 0.051). This result supports prior research on the influence of self-efficacy on student success [13].

Surprisingly, there is a slight indication that students who did not know the specifications of their computer had higher success rates than students who did (93%, 77%,  $p$ -value = 0.074). This is also more significant when considering only males ( $p$ -value = 0.005). There is no difference in performance between CIT and CS students; this result may indicate that students planning on focusing on computer components or hardware may not be as successful in CS 1. Future analysis will examine this further.

The third factor that influenced success was students' computer usage intensity. This attribute had no significance when genders were combined, however considering only males did result in a significant difference ( $p$ -value of 0.06) at both end of the usage spectrum. Males in two time use ranges, between 1 and 4 hours or more than eight hours logged onto a computer for one session, negatively influenced CS 1 success. Males' computer intensity when spending between four and eight hours did not influence success.

The difference of these results to prior research [11-14] may exist because most of our students have prior experience with technology and it is necessary to collect additional data to achieve statistically significant results. Additionally, future studies should include an analysis that factors out grade point average (GPA) and/or ACT to determine if these are

influencing the results. Based on the initial results, the survey will continue in initial programming courses.

SUCCESS IN PROGRAMMING SEQUENCE

With the addition of CS 0.5, the CS 1 course has more or less expanded to two semesters. CS 0.5 was added to help more students succeed, however there was a concern that this 'gentle' introduction might instead defer student failure as a CS student. Success rates for the next two programming courses required in the CS curriculum were evaluated to address this concern.

The two courses following CS 1 are CS 2 and Data Structures, respectively. The prerequisite for CS 2 is CS 1. The prerequisite for Data Structures is CS 2. Neither course is required for CIT students, although CIT majors with a CS minor must take CS 2 and may take Data Structures. Since these courses must be taken sequentially, the results contained only three semesters of data for CS 2, post CS 0.5 and two semesters of data for Data Structures, post CS 0.5.

A t-test of unequal variances was performed for fall and spring semester success rates for academic year 2000 through fall, 2008. No significant differences in success between students who took the new course sequence from earlier students was found for CS 2 ( $p$ -value = 0.16) or Data Structures ( $p$ -value = 0.43). The following figure shows the pass rates for CS 2 with the last two columns reporting on post- CS 0.5 student successes.

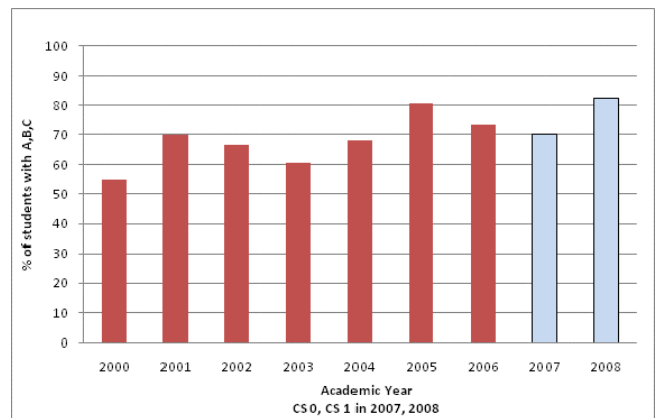


FIGURE 5  
CS 2 SUCCESS PERCENTAGES

THREATS TO VALIDITY

There are two threats to the internal validity of this survey due to the low response rates. First, formal statistical tests could not be carried out and reported because so few students reported negative attitudes in the attitude survey. As a result, care must be taken when generalizing the results. Second, this is a voluntary survey and therefore there is a risk that the results may be biased. Students who responded to the survey may not represent the population of interest.

An external threat to validity is that this study was done at one regional, comprehensive university in the Midwest and the results may not apply to all institutions.

#### CONCLUSIONS AND FUTURE WORK

The results of this study show that success in CS 1 has not decreased with the lowered mathematics requirements, not requiring a co-requisite lab and adding a prerequisite course, CS 0.5. Neither gender nor major (CIT or CS) have an influence on success in CS 1. High ACT scores, passing of CS 0.5, and participating in the optional lab, indicate student success. At this time, the authors recommend requiring the lab for all CS 1 students.

Student attitudes about technology are quite positive among NKU CS 0.5 and 1.0 students, however since the surveys are optional, there is a chance the results are biased. For example, students with poor attitudes about technology may avoid taking the survey. Future work will include improving the response rates of this survey to see if it impacts students' reported attitudes.

Students at NKU responded that they arrive with extensive technology experience and there are only a few indicators of success and experience. Students who know a lot about hardware seem to perform worse in CS 1, which is a programming course. This prompts analysis exploring students' attitudes about programming and their hardware knowledge to determine if there is a relationship and how it might be addressed. Future work also includes exploring characteristics of success in CS 0.5.

The attitude and experience analysis is planned to expand in Fall 2009 to also include students at Thomas More College. Thomas More College is a small, liberal arts college in Northern Kentucky.

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