The Impact of Providing Project Choices in CS1

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Abstract: CS educators are constantly faced with the challenge of engaging students who have neither the interest nor skill level necessary to succeed in an introductory course. One potential solution is to allow students to choose their projects from a set of comparable alternatives, each of which represents a different problem domain. This paper reports on the results of a two-year study designed to measure the impact of project choice on student outcomes in a CS1-style course for non-majors. The results suggest that the gender plays a major role in both the projects chosen and student outcomes.

1. INTRODUCTION

Computer Science (CS) educators face many challenges in teaching the basics of computer programming to introductory students. Increasingly those introductory students are non-majors who likely have a low interest level in the course content [9]. Research suggests that introductory course (CS1) failure rates climb for non-majors, many of whom are often overwhelmed by the complexity and time commitment of the course (e.g. [7]). As a result, CS faculty must find new and interesting ways to maintain student interest and to provide an equitable opportunity for all students to succeed.

Compounding the challenge facing CS faculty is the increasing heterogeneity of student experiences and backgrounds. This heterogeneity can potentially be served by providing students with a set of alternative project assignments designed to measure understanding of particular topics. The concept of choice implies empowerment; the ability to choose between alternatives implies a certain amount of control over the subsequent effect of that choice. Previous research by Becker ([2], [3]) has suggested that a greater amount of choices available for the student promotes a greater sense of ownership and, consequently, higher levels of motivation and commitment. For example, allowing students to demonstrate understanding of arrays by choosing a problem from a preferred domain can help to engage students and bolster their chances for success.

This ability to choose between projects from different domains may also effect students' perceptions of their ability to master concepts and solve basic word problems.

Providing an interesting or familiar problem domain for students is especially important for engagement at the introductory level, as the abstract concepts and thought processes required for success in CS1 are often missing in beginning students ([1], [6]). In order to help engage student interest in otherwise difficult material, the use of real-world projects can help students see the applicability between the course content and their majors or private interests [5]. Emergent fields like bioinformatics provide a rich set of real-world problems, but the diversity of student backgrounds requires a broader set of problem domains be made available to beginning students.

This paper will report on a two-year study designed to examine the impact of project choice on student outcomes in a CS1-style course for non-majors. The primary question of this study was: does the ability to choose between projects from different problem domains lead to positive student outcomes? For purposes of our study, "student outcomes" involves both perceptions of the course as well as the ability to pass the course. The results suggest that the ability to choose enhances student perceptions of the course and, thus, may increase the likelihood of success. The results also suggest that male and female students gravitate towards different problem domains.

2. STUDY DESIGN

Our project spanned the course of four semesters over two academic years (2005-2006 and 2006-2007). Our CS1-style course is taught in Java, though three weeks of Alice were included at the beginning of the course in 2006-2007. While OOP topics are necessarily discussed in the course,

Table 1: Specific Project Problem Domains

Project Problem Domains	
2005-2006	2006-2007
Biology	Biology
Business	Business
Education	Etymology
Library Science	Epidemiology
Math	Math
Physics	Meteorology
	Physics

the focus of the course is primarily on modular design, methods, and the built-in Java objects. Course topics include the traditional CS1 staples (I/O, math calculations, decisions, loops, arrays, strings) in addition to more advanced topics as time permits.

these students, 21 (53%) were science, engineering, or technology majors, 12 (30%) were social science, humanities, or education majors, and 7 (17%) were undecided. There were 34 males and 6 females.

3. RESULTS AND DISCUSSION

The students who participated in this study were predominately successful in passing the course. Table 2 shows the breakdown by semester and grade category (ABC = Students who received a course grade of A, B, or C; DWF = Students who received a D, F, or withdrew from the course). These results show that while approximately 68% of the participating students passed the course with a "C" or better, the percentage of students passing the course varied widely between semesters.

Because the grades for each project made up the class grade it was expected that they would be highly correlated.

Table 2: Grade Distribution for Participating Students

Semester	ABC	DWF	*N*	% Passing (ABC)
Fall 2005	8	5	13	61.54%
Spring 2006	3	4	7	42.86%
Fall 2006	9	0	9	100.00%
Spring 2007	7	4	11	63.64%
TOTAL	27	13	40	67.50%

The course grade is primarily composed of grades received for assigned projects. There are 6-8 projects each semester, corresponding to recent topics discussed in class. Each project is intended to not only build mastery of recent topics but to reinforce previous topics. For each semester of this study, four consecutive project assignments were used to measure the impact that project choice has on student outcomes. These assignments were intended to measure students' mastery of the aforementioned CS1 staples.

Each of the four assignments allowed students to choose from two alternative projects, resulting in 16 "pairs" of projects across the two years of the study. Each alternative project was from a different problem domain. The domains were primarily math- and science-based, though a few projects involving business and education were also provided. Each pair of projects was used for two consecutive semesters (one academic year). The problem domains for these projects are summarized in Table 1.

Approximately 73% of the eligible students consented to participate in the study (N = 40 from a pool of 55). Of

What is interesting is that the students who chose the math, business, or education projects had higher class grades (28.9% received a "C" or above) than those who chose the physics or biology projects (21%).

A logistic regression was performed to determine what factors would influence student grades on individual projects. There were no significant results. There were also no significant differences in the choice of problem domains based on the students' majors.

3.1 Gender Impacts

A secondary phase of analysis examined the role that gender played in both the choice of projects by the students as well as the overall course grades. There were a total 145 projects that were completed during the study, 122 by the male students and 23 by the female students. Female students proved to be more diligent about submissions than males, missing only one possible assignment (4.1%) versus 14 (10.2%) for the males. Table 3 shows the distribution of project domain choices by gender.

Table 3: Problem Domain Distribution by Gender

Project Problem Domain	Male	Female	% of Total	% of Male	% of Female
Biology	22	6	19.31%	18.03%	26.09%
Physics	16	3	13.10%	13.11%	13.04%
Math	24	3	18.62%	19.67%	13.04%
Business	28	2	20.69%	22.95%	8.70%
Meteorology	6	4	6.90%	4.92%	17.39%
Etymology	9	1	6.90%	7.38%	4.35%
Epidemiology	3	3	4.14%	2.46%	13.04%
Education	13	1	9.66%	10.66%	4.35%
Library Science	1	0	0.69%	0.82%	0.00%

The distribution shows that female students were most likely to choose projects in math and science, with biology being the most popular problem domain for females. Male students were most likely to choose projects in business, math, science, and education. Proportionately speaking, the distribution suggests that female students are more likely than their male counterparts to select projects in the life and earth sciences (e.g. biology, meteorology, and epidemiology) and males are more likely to select projects in business and math than their female counterparts.

Female students were found to have a higher proportion of overall passing grades than their male counterparts. Five of the six female participants (83%) passed the class with a "C" or better, as opposed to only 22 of 34 (65%) male participants.

ability to choose between different projects enhanced their learning. This contrast between the perception of the projects and their ability to choose may be at odds; by being able to choose the projects they preferred, students were given a better perception of how the individual projects added value to their experience in the course.

Chi-square analysis was used to determine correlations between responses. A positive correlation was found between how students felt about the course and how they felt the ability to choose projects enhanced their learning ($x = 20.73$, $p < 0.05$). While the ability to choose projects was likely not the only contributing factor, these results suggest that the empowerment of "choice" contributed to the overall positive course perception. A positive correlation was also found between how students felt about the course and how they felt about the projects themselves ($x = 40.45$,

Table 4: Post-Test Survey Results

	Strongly Disagree/ Disagree	Neutral	Agree/ Strongly Agree
Ability to Choose Enhanced Learning	3 (13.04%)	8 (34.78%)	12 (52.17%)
Individual Projects Enhanced Learning	1 (4.35%)	5 (21.74%)	17 (73.91%)
Course Was Interesting	1 (4.35%)	3 (13.04%)	19 (82.61%)
Projects Were Interesting	2 (8.70%)	7 (30.43%)	14 (60.87%)

3.2 Student Perceptions

The final phase of the project involved a survey of students and their perceptions about the course content. Despite efforts to the contrary, only 23 of the study participants (58%) completed the survey. All survey responses were anonymous and no distinction between genders was made. Students were first asked to report on their attitudes about the course and their ability to choose between alternative projects. The results are summarized in Table 4. The data between the two years was combined due to the small number of respondents.

Approximately 83% of respondents thought the course was "interesting", though only 61% thought the projects were "interesting". In terms of the projects themselves, 74% reported that the individual projects enhanced their learning of the material but only 52% reported that their

$p < 0.01$), again suggesting that the ability to choose between different problem domains ultimately enhanced their perception of the course.

4. LIMITATIONS AND FUTURE DIRECTIONS

The biggest limitation involved with this study has been minimal student enrollment in the course. A larger number of student participants may have made the effects of both the choices and gender more evident. A classic experimental study, complete with a control group, was not possible due to low enrollment. The wide disparity of enrollment and grades between the semesters also speaks to the diversity of students and majors who enroll in the course. For those non-CS majors requiring this course, there is no defined sequence in which the course is to be completed. Another variable was the introduction of Alice

in the second year of the study. While the effects of Alice on student outcomes have been well-documented [4], the effects are unclear in this case.

The project choices themselves represent another potential limitation. The number of choices available to students during any one assignment was minimized for this study, but a wider diversity of projects may have resulted in more positive results. The diversity of projects and the subsequent testing and grading requirements may make this approach prohibitive to those faculty teaching large sections, especially without the aid of teaching assistants.

Another limitation involves efforts to construct projects of comparable difficulty. Measuring the comparative difficulty of project assignments requires trial-and-error, and is largely subjective. Projects for this study were chosen based on the instructor's prior experience as well as student feedback from prior years. However, a more rigorous test of the comparative difficulty of the project course would be a basis for future research.

5. CONCLUSIONS

The results of the study suggest that providing students with a choice of projects from different domains can increase success rates in CS1-style courses. Rather than the projects per se, the actual choice can allow the student to choose those problems with which he or she feels more comfortable, thus enhancing their perception of the material and the course as well as fueling their chances for passing the course. The results also suggest that gender plays an important role in the projects chosen, with females gravitating towards the life sciences and males gravitating towards traditional math and business projects.

The variation exhibited in the passage rates for the course suggest that the diversity of students enrolled in any one semester may play a more important role in student outcomes that simply the act of providing choices. Further study may prove useful in establishing a broader set of problem domains and projects, one that appeals to a more mass audience while being manageable from an administrative perspective.

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