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Self Directed Projects to Increase Engagement and Satisfaction in Basic Programming Course

Ms. Tonya Whitehead, Wayne State University

Ms. Whitehead is a Part-time Faculty in Basic Engineering and Doctoral Candidate in Biomedical Engineering at Wayne State University. She also holds a Graduate Student Assistantship in the Office for Teaching and Learning, where she focuses on course development for STEM and graduate student pedagogy training. The university honored her with the Garrett T. Heberlein Endowed Award for Excellence in Teaching for Graduate Students in 2017 for her work improving undergraduate engineering courses. Prior to Wayne State, she completed a Master of Science in Manufacturing and Engineering Management and a Bachelor of Science in Computer Engineering at Michigan State University.

Prof. Jeffrey Potoff, Wayne State University

Dr. Jeffrey Potoff is a Professor of Chemical Engineering and Materials Science, and the Associate Dean for Academic and Student Affairs for the College of Engineering at Wayne State University. Potoff received his PhD in Chemical Engineering from Cornell University in 1999, and his BS in Chemical Engineering in 1994 from Michigan State University. Prof. Potoff is interested on improving the engagement of engineering students in their coursework through the implementation of evidenced-based teaching practices.

Work in Progress: Self Directed Projects to Increase Engagement and Satisfaction in Basic Programming Course

Tonya J Whitehead and Jeffrey J Potoff
Wayne State University, tonya.whitehead@wayne.edu, jeffrey.potoff@wayne.edu

***Abstract* - Introductory programming courses can be very challenging, leading to students being disengaged and having difficulty relating the material to their specific area of study. We hypothesize that a student-centered project will lead to greater student motivation, satisfaction, and opportunity to excel. The newly designed final project uses the same programming and computation tools taught in the course and challenges students to analyze large sets of data. A pilot implementation occurred during Fall 2016 across three sections of the course, with different instructors involving, slightly different requirements and assignment structures. Based on instructor assessment and student feedback, revisions were made to the structure of the project and it was rolled out to both the sections in Winter 2017. To ensure consistency, both sections were team taught by the same two instructors. The new final project consists of multiple group and individual assignments. Assignments are staggered to not only ensure that groups are progressing successfully toward an effective final product, but also that all team members are making significant contributions. Due to the positive feedback received so far, for Fall 2017 we will be employing pre- and post- surveys to quantify if and how the project impacts students' motivation. One goal of this activity is to create a framework for group projects to engage and motivate students that can be easily implemented in other courses or at other universities.**

Index Terms – Group Project, Large Lecture, Programming, Student-centered Project

INTRODUCTION

Motivating and engaging students in required core courses can be challenging. This is very common in introductory computer programming courses due to the nature of the content, which can be completely foreign to many students. At Wayne State University (WSU), all engineering students are required to take such a course, except those in Electrical and Computer Engineering. Due to the number of students required to take the course, it is taught as a large lecture containing 70-100 students in six different majors. The course is required for transfer students as well, leading to students being anywhere from their first semester to last semester, however the majority are in their first or second year. Many students perceive the course to be unrelated to their chosen field, leading to a large spectrum of motivation and interest.

Several studies have shown that motivation can be critical for student success in programming. For example, Bergin and Reilly have looked at the role of intrinsic and extrinsic motivation and self-efficacy [1]. Shell et al. has looked at students initial motivation, goal orientation, and instrumentality [2]. While not directly tested on computer programming to date, grit has been shown to correlate with success in higher education as well [3]. The overall goal of this study is to develop and implement new course materials and pedagogies to increase student motivation in the course and lead to higher overall retention in engineering.

STUDY CONTEXT

As part of an internal grant from the NSF-funded Widening Implementation and Demonstration of Evidence-Based Reforms (WIDER) initiative at WSU, new pedagogies, activities, and assessments were added to the introductory programming course. A self-directed, student-centered final group coding project was the primary component directly intended to increase student motivation in the course. Prior to this change, projects in the course were highly scripted, where all groups and students did exactly the same very specific tasks.

Other pedagogical changes were also incorporated into the course to improve student motivation and outcomes. A flipped classroom model was implemented, where students watch videos prior to class focused on syntax and programming structure, then practice what they learned during class time [4]. Due to the large class size, Peer Mentors (PM) and Teaching Assistants (TA) were incorporated into the classroom to ensure that all student questions are answered [5]. A classroom response system was added to gather real-time data on student understanding of the underlying concepts in the course [5, 6]. All of these tools worked together to increase classroom engagement. Klingbeil has shown that a similar structure for teaching engineering math using Matlab improved student retention [7].

IMPLEMENTATION

The new final project was first introduced as a pilot in Fall 2016 (F16) in all three sections of the course. While the same broad project concept was introduced in each section, Table I summarizes differences in class size, instructor, support personnel, and implementation. Instructor A had the largest class at 95 students and provided minimal instruction to the students about what to include in the project, but had PMs that were experienced in using the data that the students could select from. The students in that section presented their projects as both posters, viewable by students and faculty in the College of Engineering, and as videos posted online. Instructor B had slightly fewer students at 68, but provided a more detailed framework for the project. The students in that section presented their project orally in class or via video due to classes being canceled the last day of the semester because of inclement weather (snow day). Finally, Instructor C's course met at a satellite campus and had 22 students. The same project framework was used in this section as in Instructor B's course and the students presented their work in videos as well due to the snow day.

TABLE I
PILOT IMPLEMENTATION COURSE ENVIRONMENT

	Instructor A	Instructor B	Instructor C
Students	95	68	22
Groups Size	3-4	3-4	2-3
Support Personnel	2 TAs 4 PMs	1 TA 2 Graders	1 Grader
Project Introduced	Week 10	Week 7	Week 5
Formal Due Dates	1	4	4
Final Presentation	Poster Video	Oral Video (Snow Day)	Video (Snow Day)

Student feedback after the pilot indicated that students preferred the open-ended structure of the project. They felt that multiple due dates helped keep them on schedule and that being able to select the topic increased their motivation to complete the project. Based on instructor assessment and student feedback, revisions were made to the structure of the final project and it was used in both sections in Winter 2017 (W17). To ensure consistency across the sections, both were team taught by the same two instructors. The two sections, one with 74 students, the other with 42, shared 3 TAs and 4 PMs.

A description of the project as implemented for W17, including the improvements made following the pilot is provided in the following section. The same structure is being used for Summer 2017 (S17).

PROJECT STRUCTURE

The newly developed final project is group based. Groups are formed from 3-4 students at the beginning of the semester using catme.org based on information provided by the students [8]. Groups are created in a way that avoids the isolation of women and underrepresented minorities, which has been shown to improve outcomes for these groups [9]. In class, student groups work on practice exercises and polling questions with the guidance of PMs and TAs for several weeks prior to starting the project. This allows the students to have moved past the "forming" and "norming" steps of group development, so that they can immediately begin "performing" on the final project [10].

The project statement provides a scaffolding for the students to design their project around. Each group must select a freely available large data set from the internet. Repositories for these data sets include kaggle.com and hadoopilluminated.com. Some examples include crime statistics for Philadelphia, a bike sharing system in Boston, and air quality data from Italy. Once they select the data, the groups must define their own questions to answer. To ensure that the project demonstrates student's mastery of the course material, a core set of programming concepts from the course are defined that must be included in the final code. There are multiple deliverables that build toward the final submission, described below, to ensure that the groups are creating a high-quality product, and to allow instructors to intervene if a group has embarked on a project that does not meet the requirements.

The first deliverable is a project proposal. Groups must identify their chosen data set, explain why they selected it, and what answers they would like to obtain from the data. Next, they must outline and/or flow chart how they expect the program to work at a high level. Third, the groups participate in peer review. They present their work to at least two other groups and the other groups provide them with both positive feedback and suggestions for improvements. Peer reviewers also complete the final submission rubric so that the team being reviewed can gauge where they stand regarding the final requirements. Each team member submits a short, written report of what they learned from the peer review. Finally, the complete project code and brief report are turned in by the group collectively and each individual creates a video describing the project and demonstrating the results. The individual videos are used to help identify if the work was not evenly distributed among the team members. Students that do not make a significant contribution to the project often struggle explaining the project and code, or occasionally are unable to run it.

Having students produce completely unique projects creates a challenge for consistent grading. To overcome this, rubrics were created for each deliverable of the project. The rubrics are focused on the underlying structure of the code and logic, rather than getting a specific answer. For instance, each project must include function calls, points are awarded for using correct syntax and for selecting appropriate pieces of code to be put into functions.

RESULTS

To date, student projects have exceeded expectations. As designed, the data sets and thus results varied widely. Some examples of the data set selected and questions addressed are listed in Table II.

TABLE II
STUDENT PROJECT PROPOSALS

Detroit Crime Statistics:
1) What areas of the city have the most crime?
2) Is the amount of crime changing over time?
3) Does the type of crime vary by season?

Oil Pipeline Accidents:
1) Which company has the most spills?
2) Which State had the most spills?
3) What company's spills cost the most?

Lake Erie Tributary Nutrient Levels:
1) Does flow rate or suspension of solids change by season?
2) Which tributaries pose the most risk to Lake Erie water quality?
3) Which nutrients are increasing and decreasing?

US Homicide Statistics:
1) What city has the highest number of homicides
2) What is the relationship between victim and assailant?
3) Is murder rate dependent on season?

Air Quality in Italy:
1) How does air quality change by season?
2) Is there a time of day when air quality is worst?
3) Is there a significant difference in air quality between day and night?

Anecdotal feedback from instructors in higher level courses indicates that students are performing better following the changes in the introductory course.

FUTURE DEVELOPMENT

This study will continue to make incremental changes to the final project based on student feedback and instructor reflection. Additionally, the effect the final project structure has on student motivation, not only for this particular introductory programming course, but also for programming and engineering overall will be quantified. Surveys to be given to all students at the beginning (pre) and end (post) of the course are under IRB review for implementation in F17. The pre-survey includes questions from Intrinsic Motivation Inventory [11] and GRIT-S [12] questionnaires that have been repeatedly used in other studies. This allows work to be compared to other research related to motivation. The pre-survey also includes questions relating to student's interest in the subject matter, previous satisfaction with working in groups, and prior experience with programming. These factors can all potentially impact student outcomes for the course. This will help delineate if the pedological tools and final project or other factors are more strongly impacting student outcomes in the course. Finally, the pre-survey includes student self-assessment on engineering skills to be compared to the end of the semester.

The post-survey will include the same self-assessment on engineering skills and impressions of group work, allowing changes in these attitudes and skills to be quantified. The post-survey will also allow students to indicate which pedagogical tools they felt were most and least beneficial to their learning in the course. This will help direct course development. Finally, the post-survey will ask students about their impressions of several aspects of the project and whether those aspects changed their motivation toward the project.

The one goal of this activity is to create a frame work for group projects to engage and motivate students that can be easily implemented in other courses or at other universities. To support this a similar project is being developed for an introductory materials science course at WSU. The generalized structure and rubrics will be posted to a website for open access. Overall retention rates in engineering will also be examined to compare students that received the new project to those prior to the implementation.

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