On the Efficacy of Interactive Preparatory Work in a Flipped Computing Course

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Abstract

In the College of Computing and Informatics several sections of ITSC 1213, which is a second semester programming course, are taught using the flipped classroom pedagogy. This pedagogy hinges on students doing the preparatory work, which includes reading the textbook and watching videos, before class. To encourage the students to do this work, they are also required to complete a short multiple-choice online quiz. Yet, many students do not spend enough time on the preparatory work despite the quiz incentive. To address this challenge, we will introduce a new approach that is designed to be more engaging. We will replace the regular textbook with an interactive textbook and replace the multiple-choice quizzes with small programming assignments, which will be graded automatically to give students immediate feedback. We hypothesize that this will improve student engagement with the material and will lead them to be more prepared for class. To test the efficacy of this approach, two sections of the course will be offered with the only difference being in the preparatory work; the experimental section will use an interactive textbook and small programming assignments and the control group will use the current textbook and multiple-choice quizzes. This study will address a noticeable gap in computing education literature by testing the effect of combining the flipped classroom pedagogy with an interactive textbook.

Budget Request for SOTL Grant
Year 2018

Joint Proposal? ____ Yes X No

Title of Project: On the Efficacy of Interactive Preparatory Work in a Flipped Computing Course

Duration of Project: 2018-2019

Primary Investigator(s): Lijuan Cao, Audrey Rorrer

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UNC Charlotte SOTL Grants Previously Received (please names of project, PIs, and dates): Celine Latulipe, Bruce Long, Mary Lou Maher, Audrey Rorrer, Karen Bean: Flipping Traditional CS Education Upside Down (2014)

Allocate operating budget to Department of: Software and Information Systems

		Year One
Account #	**Award**	**January to June**
Faculty Stipend	Transferred directly from Academic Affairs to Grantee on May 15	3,000
911250	Graduate Student Salaries	
911300	Special Pay (Faculty on UNCC payroll other than Grantee)	
915000	Student Temporary Wages	2,400
915900	Non-student Temporary Wages	
920000	Honorarium (Individual(s) not with UNCC)	
921150	Participant Stipends	
925000	Travel - Domestic	
926000	Travel - Foreign	
928000	Communication and/or Printing	
930000	Supplies	
942000	Computing Equipment	
944000	Educational Equipment	
951000	Other Current Services	
	Year One Total	$ 5,400

		Year Two
Account #	**Award**	**July to June**
Faculty Stipend	Transferred directly from Academic Affairs to Grantee on May 15	
911250	Graduate Student Salaries	
911300	Special Pay (Faculty on UNCC payroll other than Grantee)	
915000	Student Temporary Wages	
915900	Non-student Temporary Wages	
920000	Honorarium (Individual(s) not with UNCC)	
921150	Participant Stipends	
925000	Travel - Domestic	3,000
926000	Travel - Foreign	
928000	Communication and/or Printing	
930000	Supplies	
942000	Computing Equipment	
944000	Educational Equipment	
951000	Other Current Services	
	GRAND TOTAL	$ 3,000

Attachments:

1. Attach/provide a narrative that explains how the funds requested will be used.

Implementation of the experimental course will be conducted by course instructor, Lijuan Cao, as a part of her role as faculty. Assessment and evaluation analyses will primarily be undertaken by an undergraduate student in the CCI college, under the supervision of Audrey Rorrer and Lijuan Cao.

- Faculty stipend

Audrey holds a 12-month appointment and thus is not considered for a stipend. Lijuan holds a full time 9-month appointment and thus is not employed during the summer months. The stipend will allow Lijuan to work in the summer to complete the data analyses and work on writing and disseminating the results and findings of this project.

- Student temporary wages

An undergraduate assistant will be hired in Spring 2018 and Summer 2018. The salary total of $2,400 will support 10 hours a week during the spring and 20 hours a week during the summer at a rate of $10 per hour. The student will perform data collection and data analyses.

- Travel domestic

Dissemination of study outcomes will include travel for the two faculty members to a computer science education symposium or conference. In particular, we are targeting the Association of Computer Machinery's Special Interest Group on Computer Science Education (SIGCSE). Estimated travel costs are based upon 2018 conference registration [$425 each= $850] and host city hotel fees at the conference group rate [$160 for 3 nights, per person= $960]. The 2019 conference will be held in Minneapolis, for which a current round trip flight costs [$400 per person = $800]. This gives a travel subtotal of $2,620, for which we have rounded up to $3,000 to account for expected increases in hotel and airfare by 2019.

2. Has funding for the project been requested from other sources? ___ Yes __X__ No.
   If yes, list sources.

UNC CHARLOTTE
College of Computing and Informatics

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MEMORANDUM

TO: Scholarship of Teaching and Learning Grants Committee

FROM: Fatma Mili, Dean

DATE: Oct 17, 2017

RE: Support for Proposal: *On the Efficacy of Interactive Preparatory Work in a Flipped Computing Course*

I am pleased to offer my support for the SOTL proposal submitted by Dr. Lijuan Cao and Dr. Audrey Rorrer, College of Computing and Informatics (CCI). The proposal aims to investigate the efficacy of interactive preparatory work in the second semester introductory to programming course, several sections of which are taught using a flipped classroom pedagogy. The findings from this proposed study will inform our college of educational approaches that are grounded in research, as well as contribute to the knowledge of research based pedagogy at the national level. The college of Computing and Informatics is part of a national initiative to broaden the computing pipeline through multiple efforts that include pedagogy and research initiatives to support increased persistence and success in STEM areas like computer science and software information science. The proposed project and is closely aligned with the goals of our college, and I am pleased to support this effort.

Sincerely,

Fatma Mili, Ph.D.
Dean and Professor

Project Narrative

A. Specific Aims

It has become increasingly clear that the traditional teaching pedagogy, where the instructor spends the entire class time lecturing, is not the best approach for teaching computer science courses (Giannakos, Krogstie and Chrisochoides 2014). This is because, in this approach, the learning that takes place in-class is almost entirely passive. For this reason, the College of Computing and Informatics (CCI) has adopted the flipped classroom pedagogy in a number of courses at both the undergraduate and graduate levels. This pedagogy devotes the entire class time to problem solving sessions and other hands on activities. Here, content delivery occurs primarily through preparatory work, which includes watching online videos or reading the textbook. To motivate students to do this work, most instructors require them to complete short online quizzes. These are usually comprised of multiple-choice or true-false questions since such questions are easy for computers to automatically grade. While this active learning pedagogy is very engaging inside of the classroom, the preparatory work required outside of class time is still very passive and problematic. Studies show that many students do not spend enough time on preparatory work, even when the quizzes are taken into account (Nørmark 2015, Lacher and Lewis 2015, Gehringer and Barry W. Peddycord 2013). This is a major concern, since students who do not adequately complete the preparatory work are unprepared to engage with that day's in-class problem solving session effectively.

While the challenge of motivating students to complete preparatory work is a noted issue within the literature, very few studies have addressed how to deal with this challenge. One promising approach is the use of interactive textbooks, which are distinct from electronic books in that they contain built-in animations and practice activities required for progression. While it has

been suggested that such textbooks may be "well-suited" to serve as preparatory work in flipped classrooms, and should be studied (A.D. Edgcomb, et al., 2015), thus far we have seen no studies in this direction. Part of our aim is to fill this gap in the literature.

In this project, we will study a new approach, based on an interactive textbook, for making the preparatory work, both the content delivery and the quiz, more effective in ITSC 1213, several sections of which are already taught using the flipped classroom approach. This class is a second semester programming course, which is required for all CS majors and is particularly important, since it influences many students' decisions about continuing with the CS major. Specifically, we will replace the standard textbook with an interactive textbook and we will replace the multiple-choice quizzes with small programming assignments, which will be automatically graded. We hypothesize that this will improve student engagement with the material and will lead them to be better prepared for the in-class problem solving sessions. To test the efficacy of this approach, we will compare with a control group of students who are taught using the current approach. The only difference will be in the preparatory work, the rest of the course will be taught identically in both classes. The overarching research question that guides this study is: are there any significant differences between student performance, student preparedness, and student satisfaction in the control versus experimental groups? In particular, this study will investigate the following:

- Is the new approach more effective in preparing students for the class?
- Does the new approach improve students' performance in ITSC 1213?
- In self-report, how do students rate the effectiveness of the two approaches?
- How much time do students spend on the preparatory work?

The results of this project will serve two primary aims. The first is to contribute to the needed research on active learning strategies, and, in particular, to determine which strategies best engage

students and prepare them for in-class work. The second is to actually implement these strategies and to provide students with a more active and engaged learning experience.

B. Literature Review

- Limitations of the Flipped Classroom Approach

A great deal of research has been devoted to understanding and optimizing the flipped classroom pedagogy for Computer Science courses. While many positive outcomes have been reported, see e.g. the survey paper (Giannakos, Krogstie and Chrisochoides 2014) and the references therein, researchers have recently raised some concerns related to this approach. A number of studies have found that many students do not complete the preparatory work in an adequate manner that is necessary for the approach to be successful. For instance, in one study (Gehringer and Barry W. Peddycord 2013), students self-reported that, on average, they completed only 18.7 out of 26 reading assignments, and watched only 11.6 out of 25 videos. Similarly, another study (Nørmark 2015) reports that only 15.5% of students' self-report watching all of the videos, while almost 30% report watching just a few of the videos. In both of these studies, there are no quizzes to motivate the students to complete the preparatory work. However, one study (Lacher and Lewis 2015) used multiple-choice quizzes to check students' preparedness. They found no significant difference in learning outcomes between groups of students who were required to complete the quizzes and those who were not. Taken together, these results suggest the need to further optimize student engagement with preparatory work and to better understand what approaches motivate students to complete preparatory work.

- Interactive Online Course Materials

With the emergence of MOOCs (Massive Open Online Courses), a lot of interactive online course materials have become available for Computer Science education. Two widely used platforms are zyBooks (zyBooks) and OpenDSA (OpenDSA).

zyBooks is a well-known interactive learning platform. Specifically, zyBooks are interactive textbooks, which integrate an online textbook with many interactive activities. These include animations, learning questions, and automated exercises. These exercises provide immediate feedback and allow unlimited attempts. Further, the platform automatically records students' progress on reading and completion of all activities. A study across 4 courses at 3 different universities shows improved student performance using zyBooks as compared to traditional textbooks (A. D. Edgcomb, et al. 2015). Another study suggests that, by assigning zyBook activities as low stakes assignments, on average, there is a 90% completion rate as compared to 50% when there are no points awarded (Edgcomb and Vahid 2015).

OpenDSA is a similar platform, but developed specifically for courses in data structures and algorithms. A pilot study compared a course taught on this platform with one taught using traditional course materials (Färnqvist, et al. 2016). They found a statistically significant increase in the proportion of students getting an A or a B in the class.

It is encouraging to see studies showing that the use of these platforms increases learning outcomes. However, there has been recognition that the use of these platforms in conjunction with the flipped classroom pedagogy requires further study (A. D. Edgcomb, et al. 2015)

C. Methods

Currently, one- third of the sections of ITSC 1213 are taught using the flipped classroom approach. Within these sections, each week's study is divided into three main components that occur in the following order:

- Preparatory Work: The students are asked to read several sections from the textbook and to watch several videos. To motivate them to complete the preparatory work properly, they are required to complete an online multiple-choice quiz. This quiz is low-stakes and the questions are meant to be simple to answer if the students have completed the preparatory work.
- Lab Session: Students are asked to work in pairs to complete a series of programming tasks, which are designed to allow them to apply the knowledge from their preparatory work.
- Workshop: At the end of the week, the students and the instructor meet during the workshop, where they have group discussions, an interactive clicker quiz, and additional hands-on activities.

The preparatory work is a critical component since it is the first time that the students encounter the main terminology and concepts related to the topic covered that week. However, despite the required quiz, we have observed that quite a number of students do not do the preparatory work and are not well prepared for the lab and the workshop. To better engage the students and to help them to prepare, we will change the preparatory work in two ways:

1. Adopt the interactive online textbook *Programming in Java: Early Objects*, which is created by zyBooks. This book is different from traditional textbooks in several ways, which include:
    - The material is presented in small "bite-sized" pieces. Instead of relatively long sections with several topics, the sections are very short and focus on just one very specific topic. This way students can clearly understand what the main concepts are and focus directly on them.
    - The readings are punctuated by short, interactive animations and videos, which help students to visualize the concepts and make reading the book more active.

- The book includes many interactive exercises throughout each section. Students work on these as they read the book, and are thus allowed to practice newly learned concepts at their own pace. The exercises provide immediate feedback and allow unlimited attempts.
- The book automatically records a student's progress on reading and completion of activities. This allows the instructor to keep track of the students' performance and to give grades on the work.

2. To encourage students to more actively engage with the material introduced in the preparatory work, we will go beyond multiple-choice questions, and include several programming problems in each quiz in the experimental course section. These will be open ended and require the students to either write several lines of code or modify code, which they are given. We will use the assignment submission and auto-grading system zyLab, which is part of the zyBooks platform. With this system students can edit and test their code before final submission. Once an assignment is submitted, the system will provide immediate feedback and grade to the student. Further, for each assignment, the platform allows the instructors to give students multiple submission opportunities. This way, the students can improve their code according to the feedback.

D. Evaluation

The study design is a quasi-experimental design, using mixed methods of student performance and learning outcomes, evaluation of student preparatory work, and student perceptions, to test our hypotheses. The control group will be from the current semester (Fall 2017 upon IRB approval), where the traditional textbook and multiple-choice quizzes are being used, and the experimental group will be from the Spring 2018 semester, where we will implement the new approach. The following data will be collected to address the research questions. Student Performance: Course

performance indicators will be tracked, including lab assignment scores, exam grades, final grades, and student learning outcomes. The student learning outcome for programming knowledge is assessed in all sections of ITSC 1213 for the undergraduate computer science degree program. Student Preparatory Work: The amount of time that students spend completing preparatory work for the classes will be assessed in several ways. The multiple-choice quiz completions will be tracked and scored in the control course. The programming quiz completions and grades will be tracked in the experimental course via the interactive text platform log data. However, because these two measures are not comparable, we will derive metrics from the lab completions, lab assignment scores, and student self-report of how much time they spent on preparatory course work. Student Attitudes: An end of course survey will be developed and deployed at the end of each course, which will be introduced by Dr. Rorrer, who is not the course instructor. The survey will capture student views of their learning, the approaches used in the class, and the amount of time spent preparing for the course. These indicators will be analyzed for statistical differences between the control and experimental groups. The evaluation table below presents the research questions and data by course.

Table 1. Research Questions, Data by Course Group, Metrics and Analyses

Research Questions	Control Course: Group A Data	Experimental Course: Group B Data	Metrics & Analyses
Does the new approach improve students' performance in ITSC 1213?	Lab assignment scores, exam scores (5 per course), final grades, student learning outcomes (5 point rubric scale with 4 criterion)		Student Performance: Lab assignment scores, exam scores, and student learning outcome rubric scores will each be compared by Mann-Whitney U test between Group A and Group B; final grades will be compared via chi square
Is the new approach (interactive textbook) more effective in preparing students for the class? How much time do students spend on the preparatory work?	Lab Work: number and percentage of students completing lab assignments each week; lab assignment scores and grades Multiple Choice Quizzes: Canvas log data on time to complete, scores on preparatory quizzes	Lab Work: number and percentage of students completing lab assignments each week; lab assignment scores and grades Interactive Textbook Platform Log: actual time spent on preparatory work, scores on preparatory assignments	Student Preparatory Work: Lab completion rates compared by chi square; lab assignment scores compared by Mann-Whitney U test between Group A and Group B; lab grades by chi square End-of-Course Survey- independent t-test or Wilcoxon on self-report items of amount of time spent on preparatory work Descriptive statistics on quizzes and interactive text assignments
How do students rate the effectiveness of the two approaches?	End-of-Course Survey administered during the last week of the course, measuring opinion of the preparatory work overall, perception of learning from the preparatory work and course, average amount of time spent doing preparatory work, barriers to engaging in preparatory work, perception of lab and course engagement		Student Opinions: End-of-Course Survey- independent t-test or Wilcoxon between Group A and Group B

E. Knowledge Dissemination

The findings and results of this study will be disseminated in several ways. Locally, we will present the results to the CCI faculty through CEI luncheon presentations. Further, we will present the results in a poster at UNCC's annual SOTL Showcase. Nationally, we will submit a paper to a computer science education symposium or conference, such as Association of Computer Machinery's Special Interest Group on Computer Science Education (SIGCSE) or the Annual Conference on Innovation and Technology in Computer Science Education (ITiCSE).

F. Human Subjects

To protect the human subjects in this study, an Institutional Review Board approval will be obtained prior to the study.

G. Extramural Funding

We do not plan to apply for extramural funding for this study.

H. Timeline

Activity	Tentative Date
Design the student surveys and submit the IRB	Fall 2017
Develop the preparatory work materials	Fall 2017, Winter 2017
Deploy the developed materials	Spring 2018
Data collection	Fall 2017, Spring 2018
Data analyses	Spring 2018, Summer 2018
Prepare papers and presentations on the results	Summer 2018, Fall 2018
Disseminate results	Fall 2018, Spring 2019

References

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