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Integration of Research Topics into Undergraduate Information Technology Courses and Projects

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Integration of Research Topics into Undergraduate Information Technology Courses and Projects

Introduction

Undergraduate information technology, computer science and software engineering courses often require that software projects be completed in courses that allow students to gain experience working on real-world-like problems. Senior technology projects (Capstone projects) require students to work on real-world projects that may require collaborating with companies. Research [1], [2], [3] has shown the advantages of using real-world-like projects in courses. Course projects, however, can also contribute to on-going research projects at universities, research projects with companies, or personal research projects. Even though undergraduate students may not be prepared to adequately perform research-related activities that directly support research projects, they can participate in some aspect of the research that does not require extensive experience or completion of an undergraduate degree. Introducing students to research-oriented projects where they are making some contribution to a project within the scope of their skill sets would expose students to a research problem, research techniques, new technologies, and the integration of technologies to solve problems in new innovative ways. In the information technology field this research may focus on new product development that incorporates emerging technologies or research on novel techniques. If the research project, course requirements and skill sets align, then incorporation of a research-oriented project into the course may be possible. Introducing research-oriented projects to students in information technology may encourage students to continue their education and consider graduate school after graduation. This paper describes how a computer information technology faculty research project was used as a basis for providing projects to students within information technology courses that were directly applicable or were a component of the research effort. A survey was conducted at the end of these courses to determine how well students liked these type of projects as compared to actual real-world projects, if these projects stimulated their interest into research, enhanced their undergraduate experience, increased their programming skills, and increased their motivation to attend graduate school.

Background

Healey and Jenkins [4] have suggested that a teaching-research link should be supported in higher education because it is one of the features that distinguishes higher education from vocational education and that it supports the “importance and fascination” of pursuing knowledge.

There are various techniques that are described on how to do this and what not to do. Elton [5] described teaching with research by undergraduates as one approach to bring research into a course. He indicated that it can be very successful in the final year of a course in the form of project work, but should not be the basis for whole courses. He described a program at a major research university that attempted to introduce undergraduate research at the beginning of undergraduate courses which proved to be a failure because students were not able to handle it.

Healy [6] described seven different methods for linking research and teaching. The fourth method suggested using assignments that involve elements of research and the fifth method suggested simulating research through project-based modules.

Hathaway, Nagda, and Gregerman [7] have investigated the relationship between undergraduate participation in research activities and further education at the graduate level in a program at a large research university. Their findings indicated that this relationship is supported. The program focused on faculty-student collaboration in research where students participated in a faculty research project for 10-12 hours per week.

Gates, Teller, Bernat, Delgado and Kubo Della-Piana [8] have investigated the use of the Systems and Software Engineering Affinity Research Group model at the University of Texas at El Paso to provide a socialization mechanism and infrastructure to help engage a larger pool of undergraduate students at various years in their undergraduate education that have a varying degree of skill levels into research projects. This model, based on a cooperative paradigm, integrated students into small research groups that supported a larger research project and used structured activities to develop student technical, research and group skills. The model has six components that include: 1) an orientation component to help assimilate new students into groups and help them understand the research skills needed and how the model works, 2) a framework that clearly defines the tasks to be done on the project, student use of project management to define timelines for goal completion, and student understanding of the relevance and importance of their assignments to the overall research project, 3) defined deliverables with each task that allow faculty to track research progress, 4) weekly meetings to report progress, refine goals, and discuss the research which helps to build interdependence on the team and increase student communication skills, 5) monthly meetings to integrate research results and build cooperation among the various small research groups, and 6) outreach involvement where students relate their personal experiences to pre-college students and participate in various outreach activities. Student feedback was obtained through surveys, interviews, and observation and was found that for the majority of students the Affinity model research experience helped them improve the research, technical, communication and leadership skills that they may have lacked prior to becoming involved and made them more confident to function as members of research groups.

This background suggests that care must be taken to pick research-related topics which can be handled by undergraduates and that the introduction of research into teaching should probably be done further on in the curriculum and not with freshman courses. Also, there is support for integrating research into courses through elements of research and project-based modules. Topics need to be carefully chosen to match student skill levels.

Statement of the Problem

Getting students in computer information technology, computer science, and software engineering to continue their education beyond the undergraduate level can be a challenge since jobs are plentiful and have reasonably high starting salaries. Baum and Steele [9] have shown that 28% of students in computer and information sciences enrolled in graduate school within

four years of graduation as compared to 39% of all graduates. To increase computer information technology student interest in research and motivate them to continue their education beyond the undergraduate level, techniques need to be explored that increase student interest.

Significance of the Research

This study explores the effectiveness of using research-oriented projects in computer information technology that directly contribute to on-going faculty research projects in order to help meet the following goals: 1) increase student interest in research, 2) enhance the student undergraduate experience, 3) increase student programming skills and 4) motivate students to continue their education beyond the undergraduate level.

Overarching Research Questions

There are a number of research questions that are asked in the study survey to answer the above goals:

1) Did the research-oriented project topic increase their level of programming skills specific to the course?
2) Did the research-oriented project topic increase their level of programming skills more than other types of programming projects?
3) Do students prefer a research-oriented project topic to other topics?
4) Do students prefer to have projects that contribute to a professor's on-going research?
5) Would students like to have other research-oriented topics in other courses?
6) As a result of doing a research-oriented topic in the course, would students like the opportunity to collaborate on an undergraduate information technology research project with a professor?
7) As a result of having exposure to a research-oriented topic in the course project, would students be motivated to go to graduate school?
8) As a result of having exposure to a research-oriented course topic, would students like the opportunity to do more undergraduate research through independent study courses?
9) Do students perceive that having some undergraduate research-oriented experience have a positive impact on getting a job after graduation?
10) Did doing a research-oriented project in the course enhance your undergraduate experience?

Specifically, the questions that correlated to the above goals 1 through 4 (hypotheses) are as follows:

- Goal 1: Survey Questions 3, 4, 5, 6, 8
- Goal 2: Survey Questions 9, 10
- Goal 3: Survey Questions 1, 2
- Goal 4: Survey Questions 7,

Study Methods and Data Collection

Participants

In order to explore the perceived effectiveness of using research-oriented course projects as an approach for increasing student interest in research, increasing student motivation and continuing their education beyond the undergraduate level, a small pilot study was conducted where students were evaluated using this approach.

The small pilot study was conducted in two courses with roughly the same course content in the Computer Information Technology department over the course of one year. There were a total of 28 students that participated in the pilot study over the course of one year. Course details are shown in Table 1.

Table 1: Pilot Study Course Descriptions

Course	Session	Year	Department[1]	Major[2]	Number of Students / Survey Respondents
CNIT 350 Object Oriented Programming	Spring	2017	CITG[3]	CIT[4]	17 / 14
ITS 245 Integrative Programming	Fall	2017	CITG	CIT	11 / 7

1: This refers to the department within the College of Technology that offered the concerned course
2: This refers to the major of the students that participated in the study by enrolling in the offered course
3: CITG = Computer Information Technology and Graphics
4: CIT = Computer Information Technology

Limitations

Survey questions 1 and 2 ask whether student programming skill levels were increased due to their participation in the research project. The answers to these questions are from the student perspective and not on some metric that measured skill sets. Also, question 10 in the survey asks if participation in the research project enhanced their undergraduate experience. Again, this is from the general student perspective and not upon a measure of specifically stated experiences. Finally, question 7 asked if students would be motivated to go to graduate school as a result of doing the research project. This questions is again from the student perspective and is rated quantitatively using a scale. It does not capture any qualitative, narrative comments from students which could reveal more information.

Data Collection Methods

The data that was collected included: 1) survey-based feedback from the students that participated in the pilot study, and 2) end-of-semester project grades from classes that used research-oriented projects and those that did not use research-oriented projects. The survey was used to gauge student interest in research, whether the research-oriented project enhanced the student's undergraduate experience, whether it increased their programming skills and whether it motivated them to possibly continue their education beyond the undergraduate level. The end-of-semester grades were used to determine if doing research-oriented projects increased their motivation during the project to work harder, learn more and achieve a higher grade or whether it had a negative impact on project grades. The survey is presented in Appendix A, the survey results in Table 2, the scores for research-oriented projects in Table 3 and scores for non-research-oriented projects in Table 4.

Procedure

This section focuses on the methodology used to conduct the research-oriented projects. The intention of this section is to provide the reader with a step-by-step, description of the process used in this approach. The process involved the following steps:

1. Select a research-oriented topic for the class project. A research-oriented topic is selected from an on-going faculty research project. If a sub-topic can be chosen from the research project that matches the skill sets of the students doing a project in the course, and the topic is within the scope of the course content, then it can be used as a course project topic.

   The on-going faculty research project used for this pilot study was "A Natural Language Driven Intelligent Home Health Status Monitor and Advisor". This research project included data on a patient's general medical history collected through an automated interview with the patient. The data from the interview was stored in a back-end relational database system. There was a need to create a user-friendly, graphical user interface to the database's general medical history tables that would allow a user to view, modify, add and delete the collected data. The students in the pilot study courses were learning either C# or Java programming and had taken at least one course in database systems. Therefore, the topic that was chosen matched the student skill sets and the course content.

2. A Statement of Work (SOW) is written by the professor with the research project in conjunction with the class instructor to identify the topic, project scope for the course project, and to make sure that the topic correlates to the course content and student skill sets as discussed in step 1.

   An excerpt from the SOW for this research topic is a task summarized from various parts of the original SOW as follows:

Create a form for patient medications using Java Swing that displays all of a patient's medications both current and discontinued in a list. The list must display the medication name, amount, dosage, frequency, route, and start and end dates. Upon selection of a medication from the list, all medication data must be displayed in a medication entry area (see the Medication table database fields specification for all data to be displayed). To edit a selected medication include an "Edit" button which must be clicked in order to enable the medication entry area. To add a new medication, include a "New" button that clears any data displayed in the medication entry area and enables data to be entered. Turn the data entry text boxes to a white background upon clicking Edit or New. To save any edited or new medication data, include a "Save" button that saves the data to the database. Once data is saved the data entry area text boxes should turn a light grey color and be locked. Include an "Undo" button that restores data to the previous value before any edits or additions. Include a "Show Current Medications" button that displays only current medications in the medications list, and a "Show All Medications" button that displays both current and discontinued medications. Include a "Close" button that closes the form. Include a "Delete" button to delete a record. Also, include buttons to navigate to the reports form, prescription form, and a button for printing a prescription.

3. The class project is done in teams of 2-3 students.

4. The student teams clarify any questions in the SOW prior to starting the project.

5. At the completion of the course projects, each team demonstrates their project application to the class.

6. The student team project is scored by the instructor in the class according to a rubric designed by the course instructor that correlates to the SOW. All the requirements specified in the statement of work are scored on whether they were implemented by the student team and how well they worked. A score between 0 and 100 is assigned to the project.

   An excerpt from the rubric for specifically scoring the patient medications form includes:

   Medications Form (10 points)

Form list box including selection functionality (1 pt):	_____
Medication entry area (1 pt):	_____
Save button with database insert or update and view mode functionality (2 pt):	_____
Edit button with functionality (1 pt):	_____
New button with functionality (1 pt):	_____
Delete button with database delete record functionality (2 pt):	_____
Medication list display content buttons (1 pt):	_____
Navigation buttons (1 pt):	_____

7. At the completion of the projects by all the student groups in the course, the professor with the research project (in the pilot study the professor with the research and the class instructor

were the same) would evaluate whether any of the student projects were of a high enough quality to be integrated into the research project.

It was found that in both courses that used the research-oriented topic, there was at least one student team's project code that could be used with relatively little modification and be integrated into the research project.

Results

A total of 28 students participated in the study over the course of one year. There were a total of 21 students that completed the anonymous, hard-copy survey that was distributed to all the students in the study. The survey used a Likert scale of 1-5 where 5 was "Strongly Agree", 4 was "Agree', 3 was "Neutral", 2 was "Disagree" and 1 was "Strongly Disagree". Table 2 presents the participant's responses to each question in the survey. It quantifies the survey results by displaying both the number of students that provided answers to each of the scoring categories as well as the percentage of the total number of participating students that responded in each of the aforementioned ways.

Scores for the team project were assigned to all 28 students. Table 3 presents the grade scores for each of the projects in the courses and Table 4 presents grade scores for team projects that did not use a research-oriented topic from previous classes. Additionally, a grade analysis was performed that compared student project scores of research-oriented projects to scores of projects that were not research-oriented.

Table 2: Survey Results (Total Number of Respondents N = 21)

Q[1]	Strongly Agree[2]	Agree[3]	Neutral[4]	Disagree[5]	Strongly Disagree[6]	% (+)[7]	% (-)[8]	% (neutral)[9]
1	7	11	3	0	0	85.7	0	14.3
2	7	7	7	0	0	66.7	0	33.3
3	3	5	6	6	1	38.1	33.3	28.6
4	4	13	3	1	0	81.0	4.8	14.3
5	8	5	4	4	0	61.9	19.1	19.1
6	5	8	6	2	0	61.9	9.5	28.6
7	1	3	11	2	4	19.1	28.6	52.4
8	3	8	8	1	1	52.4	9.5	38.1
9	5	13	3	0	0	85.7	0	14.3
10	6	11	3	1	0	81.0	4.8	14.3
Avg[10]	4.9	8.4	5.4	1.7	0.6	63.4	11.0	25.7

1: Q: Question from survey (see Appendix A)
2: Total number of students that provided feedback of "Strongly Agree"
3: Total number of students that provided feedback of "Agree"
4: Total number of students that provided feedback of "Neutral"
5: Total number of students that provided feedback of "Disagree"
6: Total number of students that provided feedback of "Strongly Disagree"

7: % (+): Positive feedback expressed as a percentage (rounded up) of the total number of students that responded to the survey as either "Strongly Agree" or "Agree"
8: % (-): Negative feedback expressed as a percentage (rounded up) of the total number of students that responded to the survey as either "Strongly Disagree" or "Disagree"
9: % (neutral): Neutral feedback expressed as a percentage (rounded up) of the total number of students that responded to the survey as "Neutral"
10: Avg: Average of all 10 questions.

Table 3: Project Scores for Research-Oriented Projects

Student	Course	Session/Year	Total Score (%)
1	CNIT 350	Spring / 2017	90
2	CNIT 350	Spring / 2017	85
3	CNIT 350	Spring / 2017	90
4	CNIT 350	Spring / 2017	85
5	CNIT 350	Spring / 2017	50
6	CNIT 350	Spring / 2017	89
7	CNIT 350	Spring / 2017	50
8	CNIT 350	Spring / 2017	101
9	CNIT 350	Spring / 2017	89
10	CNIT 350	Spring / 2017	50
11	CNIT 350	Spring / 2017	80
12	CNIT 350	Spring / 2017	90
13	CNIT 350	Spring / 2017	101
14	CNIT 350	Spring / 2017	101
15	CNIT 350	Spring / 2017	80
16	CNIT 350	Spring / 2017	80
17	CNIT 350	Spring / 2017	89
18	ITS 245	Fall / 2017	80
19	ITS 245	Fall / 2017	50
20	ITS 245	Fall / 2017	80
21	ITS 245	Fall / 2017	80
22	ITS 245	Fall / 2017	95
23	ITS 245	Fall / 2017	95
24	ITS 245	Fall / 2017	95
25	ITS 245	Fall / 2017	50
26	ITS 245	Fall / 2017	80
27	ITS 245	Fall / 2017	0
28	ITS 245	Fall / 2017	50
Average			74.3

Table 4: Project Scores for Non-Research-Oriented Projects

Student	Course[1]	Session / Year[2]	Total Score (%)

1	CNIT 350	Spring / 2016	90
2	CNIT 350	Spring / 2016	91
3	CNIT 350	Spring / 2016	74
4	CNIT 350	Spring / 2016	74
5	CNIT 350	Spring / 2016	0
6	CNIT 350	Spring / 2016	82
7	CNIT 350	Spring / 2016	86
8	CNIT 350	Spring / 2016	88
9	CNIT 350	Spring / 2016	82
10	CNIT 350	Spring / 2016	82
11	CNIT 350	Spring / 2016	92
12	CNIT 350	Spring / 2016	99
13	CNIT 350	Spring / 2016	91
14	CNIT 350	Spring / 2016	99
15	CNIT 350	Spring / 2016	91
16	CNIT 350	Spring / 2016	77
17	CNIT 350	Spring / 2016	86
18	CNIT 350	Spring / 2016	90
19	CNIT 350	Spring / 2016	99
20	CNIT 350	Spring / 2016	92
21	CNIT 350	Spring / 2016	88
22	CNIT 350	Spring / 2016	88
23	CNIT 350	Spring / 2016	74
24	CNIT 350	Spring / 2016	92
25	CNIT 350	Spring / 2016	86
26	CNIT 350	Spring / 2016	77
27	CNIT 350	Spring / 2016	77
28	CNIT 350	Spring / 2016	92
29	CNIT 350	Spring / 2016	92
30	CNIT 350	Spring / 2015	92
31	CNIT 350	Spring / 2015	85
32	CNIT 350	Spring / 2015	93
33	CNIT 350	Spring / 2015	107
34	CNIT 350	Spring / 2015	96
35	CNIT 350	Spring / 2015	95
36	CNIT 350	Spring / 2015	95
37	CNIT 350	Spring / 2015	96
38	CNIT 350	Spring / 2015	100
39	CNIT 350	Spring / 2015	85
40	CNIT 350	Spring / 2015	95
41	CNIT 350	Spring / 2015	93
42	CNIT 350	Spring / 2015	93
43	CNIT 350	Spring / 2015	107
44	CNIT 350	Sprint / 2015	107
Average			88.0

1: ITS 245 is a new course in a new curriculum and was not offered before Fall 2016.
2: The course project for Spring 2016 was a personal "Customer Relationship Management System" and for Spring 2015 was a "Personal Electronic Health Record".

Interpretation Of Data

Given, the small number of students involved in the pilot study a statistical analysis was not performed. The survey feedback showed that generally, over 50% of the students participating in the survey responded favorably to 8 of the 10 questions (see column 7 in Table 2). Eighty percent of the students responded favorably to 4 of 10 questions. In one question 52.4% of the respondents responded neutrally (see column 9 in Table 2).

Based on the above discussion, it can be seen that a majority of the students in the pilot study responded positively to the use of research-oriented projects in their courses. In particular, a significant majority of the students that participated (over 80%; see column 5 in Table 2) responded positively to questions 1, 4, 9, and 10. Question 1 supported goal 3, question 4 supported goal 1, and questions 9 and 10 supported goal 2. Goal 4 was considered neutral by the majority of students (52.4%, see column 9 in Table 2). Thereby, three of the four goals of this pilot research project were supported by these results. The remaining goal was neutral, but not negative.

It should be pointed out that having students participate in a research-oriented project did not motivate them to consider continuing their education beyond the undergraduate level. Also, students were fairly neutral on preferring research-oriented topics over other topics such as real-world problems with 38.1% in favor, 33.3% opposed, and 28.6% neutral (see Question 3, columns 7, 8 and 9 in Table 2). Finally, it was also found that scores for non-research-oriented projects averaged considerably higher 88% versus 74.3% for research-oriented projects (see Tables 3 and 4).

Specifically, the analysis for each research question is as follows:

Q1: Did the research-oriented project topic increase their level of programming skills specific to the course?

It can be seen from the tabulated survey results that 85.7% of the total number of students surveyed (see column 7 corresponding to question 1 in Table 2) responded positively ("Strongly Agree" or "Agree"). This supports using research-oriented topics in future class team projects since an overwhelming number of students thought that there was obvious value to them by the increase of their programming skills specific to the course content.

Q2: Did the research-oriented project topic increase their level of programming skills more than other types of programming projects?

It was found that 66.7% of the total number of students surveyed (see column 7 corresponding to question 2 in Table 2) responded positively ("Strongly Agree" or "Agree"). Students have

typically had courses where they already had other team-based course projects in other classes. Yet, the majority believed that using a "research-oriented" topic in a course project increased their level of programming skills more than other project topics with which they may have had experience. The use of a research-oriented topic required a more rigorous adhesion to the requirements in the statement of work and more extensive input validation and testing since the project code could potentially be integrated into the research project. This may have contributed to student belief that this type of topic increased their level of programming skills more than other project topics.

Q3: Do students prefer a research-oriented project topic to other topics?

In this question, there was a more balanced distribution of answers. 38.1% of students preferred a research-oriented project topic, 33.3% were neutral, and 28.1% did not prefer this type of topic.

In the previous questions, the majority believed that a research-oriented topic increased their programming skills more than other types of topics. Yet in this question only 38.1% preferred this type of topic. This could be linked to the fact that the research-oriented topic was more rigorous and difficult to complete satisfactorily because of the strict adherence to requirements and quality of software. Some of the students that found it increased their programming skills more than other approaches may have felt neutral to whether they actually prefer it over other topics.

Q4: Do students prefer to have projects that contribute to a professor's on-going research?

An overwhelming number of students 81.0% (see column 7, question 4, Table 2) prefer to have projects that contribute to a professor's on-going research. This somewhat contradicts the previous question which is more generic but acknowledges that if the project they are working on may be an actual contribution to an on-going research project then that increases their preference for such a research-oriented project in the course.

Q5: Would students like to have other research-oriented topics in other courses?

There were 61.9% of the students that agreed and 19.1% that were neutral (see columns 7 and 9, question 5, Table 2). This further supports the previous two questions, in that generally students view it favorably to have research-oriented topics in course projects, but would also like to have more research-oriented topics in other courses rather than a single research-oriented experience in one course.

Q6: As a result of doing a research-oriented topic in the course, would students like the opportunity to collaborate on an undergraduate information technology research project with a professor?

Again, 61.9% (column 7, question 6, Table 2) of students seemed to like doing something that appears to have a more tangible impact rather than a project which will never be used outside the course. The research-oriented project supported that a majority of students would like to work

on a research project with a professor. This is an encouraging statistic that could possibly motivate some students to go on to graduate school in order to participate more fully in research projects.

Q7: As a result of having exposure to a research-oriented topic in the course project, would students be motivated to go to graduate school?

Only 19.7% of students agreed or strongly agreed that exposure to research-oriented topics would motivate them to go to graduate school. There were 28.6% neutral and 52.4% indicated that it would not motivate them (see columns 7, 8, and 9, question 7, Table 2). Baum and Steele [9] have found that 28% of computer and information sciences students in their study enrolled in graduate school within four years after graduation. The feedback to this question is lower than the study number and suggests that there may be other issues that could affect student near-term decisions. A general issue could be the level of student debt which may necessitate this cohort of students to immediately start earning money. Other issues may include students taking longer than the traditional four years to complete a degree, family obligations for older students, and immediate job opportunities in their discipline. The reasons for the answer to this question need to be studied further to determine why this number is so low and which other variables may be significantly affecting this number.

Q8: *As a result of having exposure to a research-oriented course topic, would students like the opportunity to do more undergraduate research through independent study courses?*

52.4% (see column 7, question 8, Table 2) of students either "Strongly Agree" or "Agree" that they would like to do more undergraduate research through independent study which supports goals 1 and 2 that having exposure to a research-oriented course topic increased student interest in research and enhanced their undergraduate experience.

Q9: Do students perceive that having some undergraduate research-oriented experience have a positive impact on getting a job after graduation?

A large percentage of students 85.7% (see column 7, question 9, Table 2) perceived that having some research-oriented experience may have a positive impact on getting a job after graduation. This again supports having research-oriented projects within courses that perform team or individual projects.

Q10: Did doing a research-oriented project in the course enhance your undergraduate experience?

Again, a high percentage of students 81% (see column 7, question 10, Table 2) believed that having a research-oriented project in their undergraduate curriculum enhanced their undergraduate experience which additionally supports the integration of research-oriented projects into courses.

Grade Analysis

The percentage scores for each student's course project that used a research-oriented topic in the spring 2017 CNIT 350 Object-Oriented Programming course and fall 2017 ITS 245 Integrative Programming course are shown in Table 3. The percentage scores for each student's course project that did not use a research-oriented topic in the spring 2015 and spring 2016 CNIT 350 Object-Oriented Programming courses are shown in Table 4. The ITS 245 Integrative Programming course was not available prior to fall of 2017.

The same research-oriented topic was used in both spring 2017 in the CNIT 350 Object-Oriented Programming course and the fall 2017 ITS Integrative Programming course. There were a total of 28 students in these two courses. The average project score for all student in these two courses was 74.3% as shown in Table 3. To compare the scores from non-research-oriented topics in the two previous CNIT 350 Object-Oriented Programming courses in spring of 2015 and 2016, 44 student scores were averaged for the projects done in those two courses and were calculated to be 88% as shown in Table 4. The non-research-oriented score was considerably higher 88% versus 74.3% for the research-oriented projects.

It is not explicitly clear why the scores decreased in the research-oriented topic projects. However, the research-oriented topic required students to strictly adhere to a set of requirements in the statement of work whereas the other non-research-oriented topics were more flexible on how students could comply and implement a more broad set of requirements. Nevertheless, the survey found that 66.7% of students thought that the research-oriented topic increased their level of programming skills more than other types of programming projects, and student feedback to question 4 found that 81% of students found that they would prefer to have projects that contribute to a professor's on-going research.

The grade analysis was also done to see if grades improved if students were more motivated when working on a research-oriented topic that had the potential to be integrated into an existing research project. The grade analysis does not support this, but it is unclear if there were other variables that affected the scores as discussed above.

Conclusions and Future Work

Based on the aforementioned discussion, it can be concluded that:

- The incorporation of research-oriented topics into course projects was generally found to *increase student interest in research* (Goal 1) as supported by positive answers to questions 4, 5, 6, and 8 which ranged from 52.4% to 81%. Responses to Question 3 "Do students prefer a research-oriented project topic to other topics?" were spread relatively close between positive, neutral and negative (38.1% positive, 28.6% neutral and 33.3% negative). Therefore, there were no questions with a largely negative response.
- It was found that the incorporation of research-oriented topics into course projects *enhanced their undergraduate experience* (Goal 2) as supported strongly by questions 9

and 10 in the survey with the agreement of 85.7% of the students to question 9 and 81% of the students to question 10.

- The incorporation of research-oriented topics into course projects *increased their programming skills* (Goal 3) as supported by questions 1 and 2 in the survey with agreement of 85.7% of students to question 1 and 66.7% of students to question 2. The perceived increase of student programming skills was from the student perspective.
- It was found that the incorporation of research-oriented topics into course projects did not *motivate them to continue their education beyond the undergraduate level* (Goal 4) with only 19.1% agreeing. However, it was found that the majority of students were neutral on this question 52.4%.

Traditional topics that bring in real-world-like problems into course projects are typically used in information technology programs. Introducing research-oriented topics as shown in this small pilot study may be another approach to course project topics which can further expand the student undergraduate experience. Early feedback through this study is encouraging in that this may be a complimentary approach. It may be more difficult to formulate a research-topic that undergraduate students can successfully accomplish and that could potentially be integrated into a researcher's project, but it can be done on some research projects as shown in this pilot study. However, the use of these topics may not help increase enrollment in graduate school. Other factors that may influence this decision would need to be studied to determine how to increase this number.

Future work to determine if this approach is more broadly feasible across other computer information technology and engineering courses would be the next step along with the study of other variables that may affect student decisions for enrollment in graduate school in computer information technology, computer science, and software engineering disciplines.

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Appendix

1. The research-oriented topic in the course project increased your programming skills.

Strongly Agree Agree Neutral Disagree Strongly Disagree

2. The research-oriented project topic helped increase your programming skills more than other typical, conventional programming projects and assignments in other courses.

Strongly Agree Agree Neutral Disagree Strongly Disagree

3. You would generally prefer a research-oriented topic for the course project to a real-world-like topic.

Strongly Agree Agree Neutral Disagree Strongly Disagree

4. You would prefer to have projects where the code you develop may potentially be used within a professor's research project.

Strongly Agree Agree Neutral Disagree Strongly Disagree

5. You would like to do other applied research projects in other courses.

Strongly Agree Agree Neutral Disagree Strongly Disagree

6. As a result of having exposure to a research-oriented topic in the course project, you would like the opportunity to collaborate on an undergraduate information technology research project with a professor.

Strongly Agree Agree Neutral Disagree Strongly Disagree

7. As a result of having exposure to a research-oriented topic in the course project, you are motivated to go to graduate school.

Strongly Agree Agree Neutral Disagree Strongly Disagree

8. As a result of having exposure to a research-oriented topic in the course project, you would like the opportunity to do more undergraduate research through independent study courses.

Strongly Agree Agree Neutral Disagree Strongly Disagree

9. Having some undergraduate research-oriented experience may have a positive impact on getting a job after graduation.

Strongly Agree Agree Neutral Disagree Strongly Disagree

10. The introduction of a research-oriented topic into the course project enhanced your undergraduate experience.

Strongly Agree Agree Neutral Disagree Strongly Disagree