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Quantitative Assessment of All-Class Project-based Undergraduate Course on Graduates Career

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Abstract

The process of creating innovative technology applications is shifting to smaller development teams of entrepreneurial minded individuals who use a dynamic landscape of tools and much creativity. This new work environment calls for novel methods to best prepare its work force. In this paper we describe an All-Class Project-based Undergraduate Course as one possible effective approach and present the results of a survey to quantitatively measure the effect of the course on preparing the students and graduates for this new work environment. We also describe the course design, the hypothesis of effect, the survey design, the data collection, and analysis. Based on the participants' responses and the quantitative analysis presented in this paper, we confirmed quantitatively that the course has achieved its goal of preparing our undergraduates for the ever changing and challenging environment for developing technology applications and services. Overall, they believe that the impact on their career is worth the "value of contribution" they have exercised and estimated.

1. Introduction

Due to continuing advances in technology, far more resources and tools are available to innovators and entrepreneurs than in the past. This results in countless opportunities for new applications and services to be created as well as for existing applications and processes to be revolutionized. Not only have the tools changed, but so has the route to innovation and, with it, society's ideal image of the value creators. In the early 1900s, large companies such as IBM, Xerox and AT&T leveraged their resources to form research laboratories that invested millions of dollars in infrastructure, facilities, and personnel. Out of these investments, they were able to create structured research groups who then brought about breakthrough-enabling technologies such as the transistor and personal computer. These breakthroughs took significant resources and time to be rolled out and become accessible to the masses. We are now in an era where these types of massive investments are not necessary to bring about something from scratch, such as, Facebook and Twitter. A single team of dedicated and passionate entrepreneurs and developers are now able to rapidly build technology, design applications, gain investment, and ship quickly their creations to the world. These small, nimble and entrepreneurial companies aggressively seek undergraduates who are well prepared to innovate and roll out creative applications and projects. A number of different models of entrepreneurship education in engineering have been proposed and discussed in [1], [2]. We now have an opportunity to apply a new model in preparing undergraduate students with the necessary skills to strive in this dynamic and rapidly changing work environment.

A key goal of the Integrated Science and Technology program at James Madison University [3] is to prepare undergraduates to be professionally well equipped with the essential skills (technical and non-technical) when entering the workplace or enrolling in graduate programs. This is accomplished by developing students' ability to become problem solvers who are able to investigate local, national, and global issues not only from a science perspective but also from technology, engineering and social context perspectives. During their junior and senior years, the program provides undergraduates with a number of unique hands-on research, design, and prototyping experiences including Senior Capstone Projects and specially designed semester projects for numerous courses. In addition, in the Networking and Security sector, we designed a course to mirror this type of rapid development by taking a group of *under-skilled sophomore, junior, and senior students*, assigning them to groups, and demanding a final product over just one semester. In that class (to be referred to as *all-class project-based*) just 11 to 14 students were challenged to work together to identify a single idea for a network-based end-to-end application or service and deliver a working prototype.

We conducted this all-class project-based course over the last four years in the spring semesters (2010 to 2013) and successfully delivered seven working prototypes. The course advisor embraced the "Expectancy-Value (EV)" model of motivation described in [4]-[7]. As described in [8] and will be briefly covered later, the students were motivated to the extent that they valued the outcome of the project and expected that their own action could help bring about that outcome. The successful application of the EV model as part of the execution of the all-class project-based course was only qualitatively assessed in [8]. Moreover, the cost element was not taken into account in the assessment of that success. In this paper, we will present in detail the results of a survey of the Integrated Science and Technology alumni and students (from this point on, we'll refer to them as participants) who passed through the all-class project-based course from 2010 to 2013. We will demonstrate quantitatively just how effective and valuable the course approach has been by using a number of metrics including the impact of this course on the participants' careers and current jobs. Some of the metrics include how important participants rated the course in getting a job, whether the course was referenced at all during the job interview process and how prepared the participants felt for these interviews. Also, adopted as a metric is the value of the students' contributions as a cost element in the EV model.

Based on the survey response and feedback from participants, we believe that the course has achieved its objective of preparing our undergraduates for the ever changing and challenging environment for developing technology applications and services. The responses to the survey also helped us to quantify the strengths and improvements needed for this course to provide the best springboard into the challenging post-graduation workplace.

This paper is organized as follows. In section 2, we describe the course design assumptions, objectives, and structure, and the weekly course assessment and grading methods. In section 3, we define our assessment hypothesis and describe in some detail the data collection design and process. The data are analyzed in section 4 with detailed observations. Finally section 5 summarizes key observations, conclusions, recommendations, and next steps

2. Course Design Assumptions, Objectives, and Structure

Course Design Assumptions

The basic premise of this all-class project-based course is to foster a highly motivational learning environment where *under-skilled students* exercise an effective and practical peer-learning, self-directed management approach with a keen entrepreneurial spirit to deliver an end-to-end working prototype of a network-based service or application. We define under-skilled students as those who had

- no more than two introductory 200 series courses, one in networking and another in basic programming;

- no hands-on experience in mobile, web or desktop application design, architecture and development;
- no experience in being part of a development project involving up to 15 members;
- limited working knowledge of the development process and implementation of an end-to-end solution that requires the integration of a number of modules developed by other sub-teams; and
- limited hands-on experience with setting up a development environment infrastructure including networking and server management and administration.

This course is designed to prepare students for the diverse, fast-paced work environment that is commonly associated with the fields of networking, security and computing technologies. This classroom experience is unique because it is aimed at promoting rapid learning and overcoming difficult group situations. The class is typically conducted under the following set of assumptions:

- *Course***:** Networking & Security (NET, also known as Telecom) sector course;
- *Size of the class*: 10 - 15 students (Sophomores, Juniors, and Seniors);
- *Students' diversity and proficiency*: Under-skilled students who are enrolled in the Networking and Security (NET) sector and two of the following sectors: Information Knowledge Management (IKM), Energy (ENE), Environment (ENV), Applied Biotechnology (BIO), and Engineering & Manufacturing (E&M). The majority of the students have taken only one introductory course in programming and another in network computing;
- *Duration of the course*: one semester (15 working weeks);
- *Frequency and duration of class meeting:* once a week for 100 minutes;
- *Out of class time:* 3 to 4 hours a week;
- *Facilities*: 24x7 accessible Networking and Security Lab and Instrumentation and Measurement Lab;
- *Resources*: Official advisor (a faculty member), two TAs (consultants), and support (an electronics technician). Students are encouraged to seek help from other professors. $500 is dedicated for hardware components, (for example sensors, Arduino microcontroller, and smart mobile devices). The course relies heavily on open source software such as Linux, Python, Java, Android, cross-platform Mobile Development PhoneGap (Cordova), Web Development Technologies (HTML, JavaScript, CCS, php, for example), MySQL, and Apache Web Server

Course Design Objectives

The course goal is to prepare the students to create value, innovate, and roll out creative application prototypes in a small, nimble and entrepreneurial work environment. The course has been designed to meet the following objectives:

- to expose under-skilled students to basic networking, computing and software development technologies and tools and important trending;
- to form highly motivated and diverse team(s) that are effective and efficient;
- to have an organizational structure that would support the design of modular and integrated solutions;
- to create a classroom structure that mirrors the rapid software/application development environment;
- to foster project-based environment where the students are responsible for their own learning (self-learning and peer-learning [9]);

- to ensure adequate accessibility and availability of resources for the students (human resources, facilities, hardware, software, and budget);
- to adopt an assessment process that is effective in providing timely feedback to the students and enabling them to apply adjustments and corrections as appropriate (structurally and scope-wise); and
- to motivate the students to propose, design, implement and successfully deliver an end-to-end solution in the form of working network based application prototype.

Course Design Structure

In designing this project-based course for a class of 10-15 students engaged in one large integrated project, we had to enhance the students' motivation. There are two general sources of motivation: students' expectation of success (Can I do the task?) and the value that students place on a goal (Do I want to do the task?). Viewing motivation in this way is often called the Expectancy-Value (EV) model of motivation [4-7]. The Expectancy-Value (EV) theory offers one of the most influential models for understanding and managing motivation. In adopting the EV model, the two sources were mapped into (1) the successful identification of a topic, idea, opportunity, or problem the entire class would value, and (2) the successful design of an approach that consistently enables, enforces and supports their expectations that the expected deliverables can be achieved.

In implementing the EV model, the entire class was trusted to conduct a number of brainstorming sessions outside and during class time. Initially, the students recommended a number of projects they thought were practical and realistic. Note that the students shied away from most if not all ideas proposed by the advisor (regardless of the value or the merit of the idea); they wanted it to be their own idea! Eventually, the class chose a problem that was personal, that the students were struggling with themselves which made the whole class get behind each other. The entire class identified with this opportunity and rallied behind the high value of developing an end-to-end solution to a daily and personal problem.

In the first week of the semester, the students were introduced to the concept of an end-to-end integrated solution in the context of network-based applications and services. The course advisor, for simplicity's sake, explained that an end-to-end solution could be implemented by dividing the large team into sub-teams along the lines of the most basic and generic network based application architecture model, that is, back-end physical, central network and front-end user experience computing components as shown in Figure 1.

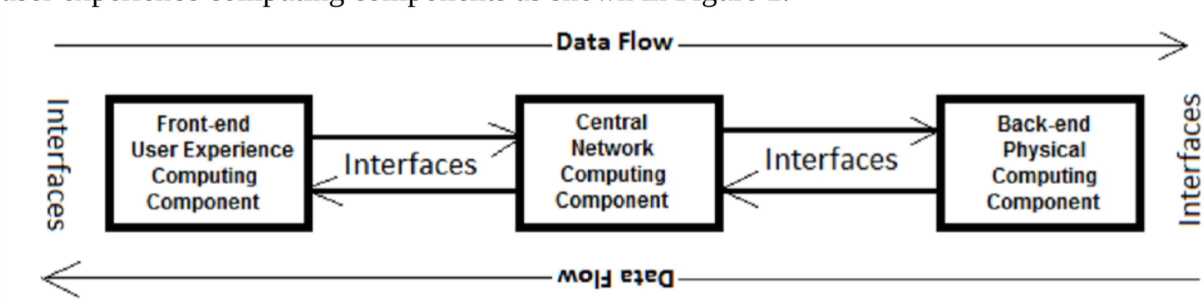


Figure 1 Simple Network-based Application Architecture Model

The front "end" must develop some form of user interface whether it be a mobile or web application. The back "end" must use some sort of physical computing hardware that can be used to collect data or perform a function. The central component, also known as the Database, must use some sort of database that can accept data from the back "end" and also be used by the front “end.” Students are then assigned into one of three sub-teams based on either their skills and knowledge and/or their interest and inclination. Finally, two students were assigned to a fourth sub-team known as the integration team. The integration team members acted as communication facilitators between the other three sub-teams and were responsible for the majority of the project documentation. A typical example of the class organization is provided in Figure 2. It should be noted at this point that the role of the course advisor was to be a coach, customer advocate, and an assessment and feedback provider, more like a group manager who does not have complete technical knowledge of all the components of the project, just like in the real-world!

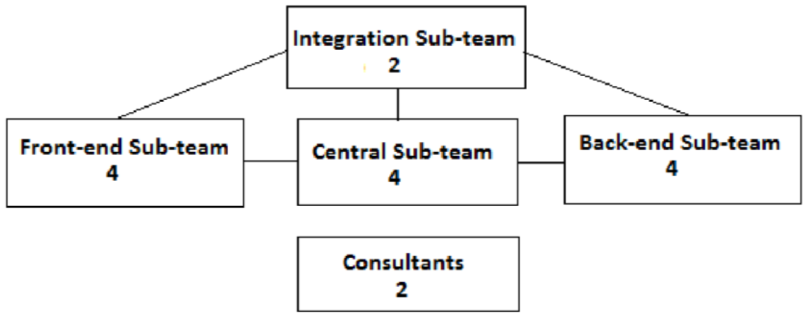


Figure 2 Typical Class Organizational Chart

In the literature review of the implementation of the EV model, we realized that one component of the model has been largely ignored in empirical research, that is, the cost element [10], [11]. The authors in [11] (a work in progress) attempted to address this shortcoming by proposing a new scale to measure the cost element using items such as effort-related (I have to put too much energy into this class) and psychological/emotional (This class is too stressful). In this paper, we have briefly addressed the issue of cost using the following item “Value of Contribution to the class project” as perceived and ranked by the participants as will be seen in section 4.

Course Weekly Assessment and Grading

Throughout the semester, each sub-team was required to present what they have done each week in a scrum-like [12] meeting style which is commonly embraced in a rapid software-development environment. These scrum-like meetings allowed the entire team to see what progress each sub-team was making and the challenges they faced. At the end of the semester, the entire class demos the end-to-end solution on three occasions: two “Dry Run” and one “Final” presentation. Just before the first “Dry Run” demo and presentation, a number of members were identified to develop and perform end-to-end test cases. These were considered invaluable to the ultimate success of the project.

The breakdown of the class grade was 20% on the weekly status, 10% on the project “Dry Runs” and 70% on the “Final project demo, presentation, and report. After our weekly status meeting, each student was provided with a brief written feedback and a letter grade taking into account the student’s individual contribution and the overall accomplishment of his/her sub-team. The weekly status grade was used to ensure that those who are typically accustomed to hiding behind the group contributions are identified and well informed of where they stand. The dry run demo and presentation were used to help the students hone their presentations skills and the logistics of how best to deliver an effective demo of their application. The grade for the dry runs was based on the contributions and performance of the individual sub-teams; each student in a sub-team received the same feedback and grade. The grade for the final presentation, demo and report was based on the quality, completeness and delivery of the integrated solution demo, the quality of the presentation and delivery, and the quality and completeness of the project report.

At the end, the students were placed by the instructor into one of three categories: (a) consistently demonstrated excellent contributions to the success of the project (19%), (b) consistently demonstrated strong contributions to the success of the project (54%) and (c) consistently demonstrated weak contributions to the success of the project (27%). The number between parentheses is the percentage of the students fell in that category. It is interesting to note that the above results are not far off from the prediction of the Pareto Principle or what is more commonly called "the 80:20 rule" [13]. The weak contribution by 27% of the class (roughly one student in each of the 4 sub-teams) was highlighted in the responses of some of the participants as a contributing factor to the high cost that they incurred.

The projects successfully delivered through this course from 2010 to 2013 are provided in Table 1. The number between parentheses represents the number of the students.

Semester	Section 1	Section 2
Spring 2010 (SP 10)	Email and SMS Network for Controlling Home Lighting (12)	Not Applicable
Spring 2011 (SP 11)	Smart Home Application- Wireless temperature Control & Energy Consumption Solution (11)	Parking Spot Web Application – A solution to availability across James Madison University Campus (13)
Spring 2012 (SP 12)	Classroom Count Mobile Application – IR Sensor Enabled Bi-Directional Turnstile (14)	E-JAC Mobile Application – Bluetooth enabled mobile application to gain Accessibility to certain rooms (12)
Spring 2013 (SP 13)	<mascot name>Serve – Providing convenience and increasing quality of service at James Madison University (14)	Party Playlist – Essential Tool for all DJs (14)

Table 1 working prototypes delivered in this course

3. Course Assessment – Hypothesis and Data Collection

The course introduced in the previous section was run for four (4) consecutive spring semesters (2010 to 2013) with a total number of 90 students enrolled and passed. The student course evaluations highlighted that the students were generally satisfied by what they gained from the course despite the course only being worth one credit. However, the success, the value and the scope of the impact of the course could realistically be measured by feedback from graduates in the workplace as well as students who already have recently gone through a job interview. To realistically assess the value of the course, and not rely on self-appraisal, the authors (including one senior student who completed the course in spring 2013) conducted a preliminary survey soliciting feedback from those who attended the class over the last four (4) years (see Table 1). We iteratively crafted the survey questions (Appendix A) and a hypothesis guided by the original goal of the course as stated earlier.

Hypothesis

If students take this course then they will have gained skills and experience to innovate and roll out creative products and projects, making the students more valuable to potential employers and their work teams, especially considering the current trend of work moving to mobile, technology and web projects in the hands of small, nimble and entrepreneurial startups or startups-like groups within large companies.

By setting strict project guidelines and deadlines, students in the course are pushed to new limits of intellectual learning, effort, and time-management. Creating a classroom structure that mirrors the rapid software/product development environment helps at least expose students to important trends in programming languages, libraries, hardware, and development platforms as well as end-to-end work in a relatively small group. The class size ranging between 10 and 15 students with sub-teams of 3 to 5 members resembles a traditional size for a technology startup company or project team in a larger corporation. Having this exposure will greatly prepare students that have completed the class to successfully work in a creative and team environment.

Given access to these same tools and tasked with the production of an end-to-end application or service, the all-class project-based teams have demonstrated, through experience, that the ability to create value and innovate is realistically attainable in as short a time as one semester. These classes were able to successfully apply the new generation of tools at hand to a specific field, without limited knowledge of how to operate them, and not only re-imagined the world of disk jockeying (one project example) but also added value to all involved parties. We believe that this unique classroom setting provides students with an unparalleled level of preparation for producing results in a challenging and dynamically changing work environment.

Data Collection

Two Google Form surveys [14] were created that allow respondents/participants to answer a series of questions based on their college experiences, preparedness for interviews and jobs, and their current working situations. One survey was sent to the students that completed the class in question (most of whom have graduated or are graduating this year) while the other survey was sent to a group of students that had not completed the course. These surveys' responses were sent directly into a Google spreadsheet for analysis and interpretation. A total of 90 students completed the course from spring 2010 to 2013. In this paper, we will focus on the analysis of the responses to the first survey for which we received 24 responses (26%). The analysis of the responses to the second survey is out of the scope of this paper and we hope to provide it in a future paper.

4. Course Assessment - Data Analysis

Classification and Categorization of Responses

Table 2 shows the breakdown of the 24 participants in terms of the following categories: Course Semester, ISAT Program Concentration, Employment, Gender, Sub-Team and the size of team involved in the participants' current jobs. In this paper, we will focus our detailed analysis on the first three categories: Course Semester, ISAT Program Concentration and Employment. The survey showed that 50% of the participants now work in a team of 2 to 5 members and 21% from 6 to 10 members. All employed participants, with the exception of one, are working for private sector companies with more than 200 employees such as IBM, Capital One, SAIC, Accenture, CSC, CACI and Sunapsys. In addition, the majority of the employed graduates identified their current jobs as being software engineering or IT consulting.

In this study, the lag time between course completion and survey varies. It is 1 to 3 years for the employed graduates and 6 months for the current seniors (to graduate in SP 2014). In the data analysis given below, we have not taken into consideration the lag time.

Category	Sub Category	Count	Category	Sub Category	Count

Course Semester[1]	SP 10-12	13	Sub-Team	Front End	8
	SP 2013	11		Central	7
Program Concentration	NET+IKM	18		Back End	7
	Others[2]	6		Integration	2
Employment	Employed	12	Size of Team on the Job	1	5
	Students	12[3]		>1-5	12
Gender	Female	6		>5-10	5
	Male	18		20+	2

1 SP 10 – 12 and SP 13 mean Spring Semesters 2010 to 2012 and Spring Semester 2013, respectively.
2 "Others" means Energy, Environment, Engineering & Manufacturing, and Bio-System. 3 one took the class in 2012 but still a student.

Table 2 Classification of Participants

Value of Contribution and Impact on Career

Recall our earlier discussion regarding the cost dimension of the Expectancy-Value (EV) model; the strategy we adopted in this class to boost the motivation of the students. In here, we have opted to summarize cost in terms of one item, that is, Value of Contribution to the class project as perceived and ranked by the participants. The contribution is a quantitative value, in the range of 1 (I didn't contribute anything) to 10 (I did a majority of the project), provided by the participants' in response to Q8 (see Appendix A). In contrast to the Value of Contribution, the participants were asked in Q22 to rank the impact of the class on their career on a scale from 1 (Very negatively) to 10 (Very positively).

Figure 3 represents the averages of the Value of Contribution and the Impact on Career side by side. Overall, they believe that the impact on their career is worth the "value of contribution"

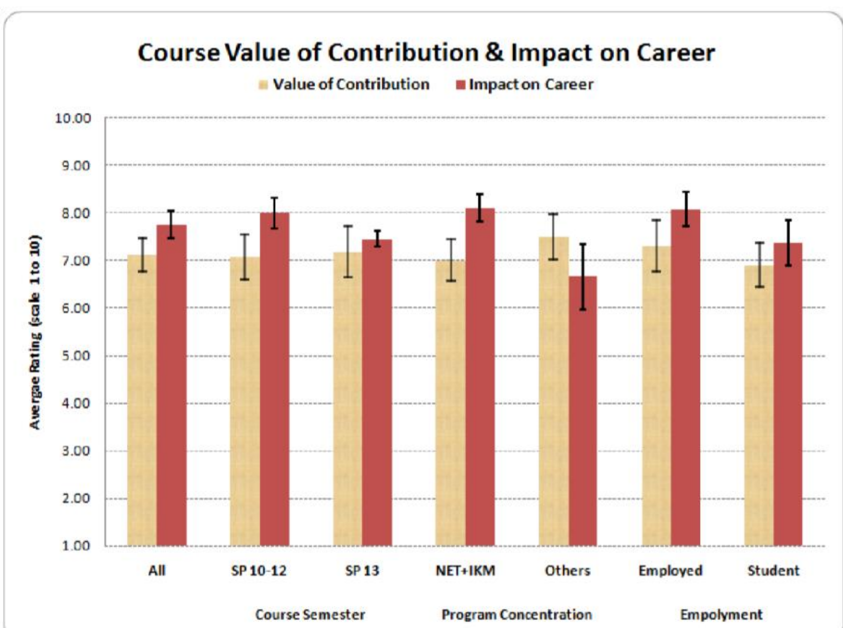


Figure 3 Average Ratings of "Value of Contribution" and "Impact on Career"

they have exercised and estimated. This can be seen by comparing the average rating under "All of 7.75±0.29 (Impact on Career) with 7.13±0.34 (Value of Contribution.) Note that 7.75±0.29 means the following: 7.75 is the average of the rating selected by the 24 participants for the Impact on their Careers and 0.29 represents the standard deviation of the mean (also known as standard error of the mean) based on the small sample's t-distribution [15]. In Figure 3, the vertical "error" bars represent the ± standard deviation of the mean.

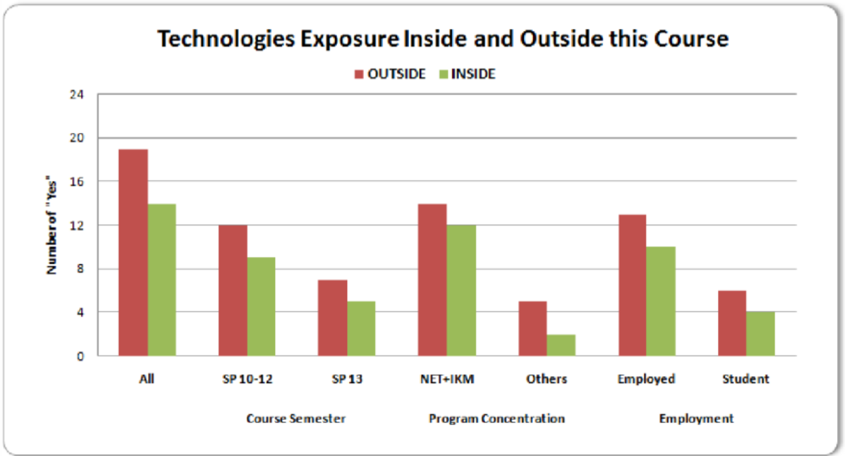
It should be noted that the participants who adopted an Integrated Science and Technology (ISAT) concentration other than IKM or NET, felt that the impact on their career was less than the value of their contribution, as can be learned from the Impact on Career average of 6.67±0.68 and Value of Contribution average of 7.50±0.47. The other interesting observation is that the employed participants' view of the impact of the course on their career is higher than those of the students (seniors), as can be seen from the average of responses of 8.08±0.36 versus 7.36±0.47, respectively.

Note that we have found no obvious and direct correlation between the number of hours the participants claim to have spent weekly on the course (in response to Q7) and their value of contribution rating (in response to Q8). This highlights again that the quantification of the cost dimension of the EV model is far from being directly correlated with the perception of the value of the participants' contribution.

Technology Exposure

One of the main objectives of the course is for the students to be exposed to skills that are essential to the realization of an end-to-end network-based service or application including both the technical and non-technical elements. The students acquire such an exposure through self-learning, peer-learning and advisor guidance, but not through traditional classroom methods, such as, lecturing, assignment and homework. In addition, the course is designed so that the students gain an appreciation of the major elements and tasks that go into making an end-to-end application a reality, from teaming within a small sub-team (3 to 5 students), to interfacing and interacting with other sub-teams, to self-learning and peer-learning of new software and hardware frameworks and technologies. Here is a short list of the specific technologies to which the students were exposed: HTML, JavaScript, CSS, jQUERY Mobile, PhoneGap/Cordova, PHP, MYSQL, JSON, Python, Arduino and variety of sensors including RFID and Wireless Sensor Network motes.

Figure 4 summarizes the responses to questions Q26 and Q27 (See Appendix A) where the participants were asked to answer with either "Yes" or "No." Note that the second question is specific to the course under study in this paper, whereas the first is about other courses the participants took. The IKM and NET concentrators rank the highest in terms of the technology exposure in this course relative to other courses at a level of 86%. This is explainable by the fact that they are motivated to apply themselves both in self-learning and peer-learning practices more so than other concentrators. Also, it indicates that the design and structure of the course expose the students to a wide scope of technologies and skills that are directly relevant to the current networking, computing and software development work environment. Note that the responses of those concentrated in "Others" (ENE, ENV, E&M and BIO) stands at 40%; this is understandable as their main *technology tools'* focus is outside the scope of this course; they enrolled for breadth and not for depth. The overall result shows that the course has provided the students with a high level of exposure to technologies that the participants currently use in their employment (jobs and internships) at 74%. However, what is most important to appreciate is that the students' technology exposure "inside" this course, as high as it has been rated, was realized via non-traditional college methods, that is, via self-learning and peer-learning.



	Category	INSIDE/OUTSIDE
	All	74%
Course Semester	SP 10-12	75%
	SP 13	71%
Program Concentration	NET+IKM	86%
	Others	40%
Employment	Employed	77%
	Student	67%

Figure 4 Technologies Exposure "Inside" and "Outside" this course

Preparation and Enhancement of the Interview Process

Now we turn our attention to the value of the class experience in enhancing the participants' job interview process. The participants were asked to answer the following questions Q14, Q17, Q18, Q19, and Q25 with "Yes" or "No." Note that Q25 is not specific to this course. It is introduced as a reference to the other four questions which are specific to this course.

Figure 5A (responses to Q14 versus Q25) represents the contribution of the class to the preparation of the participants for job interviews where the contribution of the class is measured by whether a participant referenced the class or not. Overall, it is clear that the class contributed in a strong and positive way to the enhancement of the participants' job interview experience. They ranked the contribution of the class at a level of 68% relative to the overall preparation of the participants in general. The value jumped to 81% for the participants with concentration in IKM and NET and went way down to 33% for others as expected. Again note how comparable the results are for the Course Semester and the Employment categories.

Figure 5B summarizes the participants' responses to Q17, Q18, Q19 and Q25. The responses to the first three questions are compared again with the general "preparation" question Q25. It should be noted that those who were members of the Central sub-teams view the contribution of

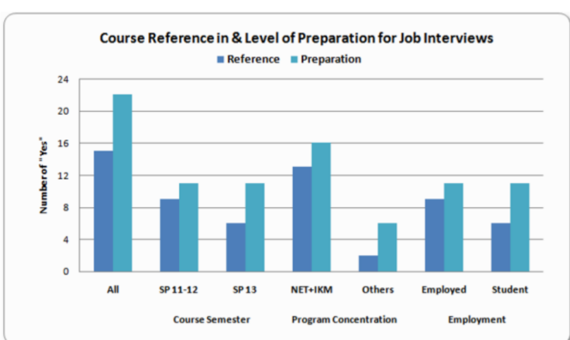


Figure 5A

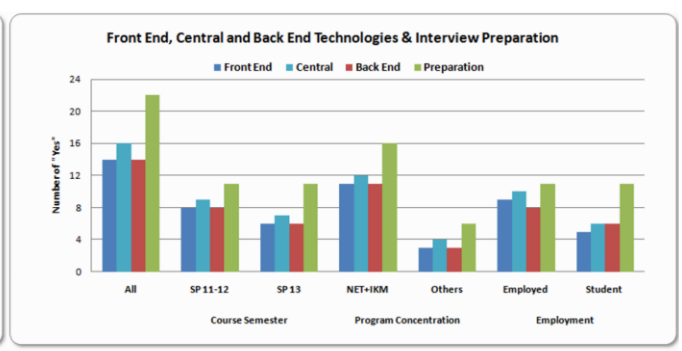


Figure 5B

Figure 5 Impact of this course on enhancing the participants' job interviews process

the class to their preparation a bit higher by about 15% compared with the Front or the Back End sub-team members. This can be attributed to the fact the Central sub-teams' members have acquired a better overall appreciation of the various technologies and processes involved in the realization of the end-to-end service or application in spite of the fact that they may not have acquired in-depth knowledge of either the front-end or the back-end specific technologies.

Skills Developed in Class and Used on the Job

Here, we focus on the ultimate value of the course in terms of its applicability to the current jobs of the participants. Figure 6 summarizes the participants' responses to questions Q15 and Q21. These were answered with "Yes" or "No." Note in the case of Students under Employment, the responses are based on the internship experience.

The results in Figure 6 highlight an interesting fact about the course, that is, the graduates appear to apply a great deal of the project management and teaming skills they developed in the course in their current job or internship as evident by 83% (total "yes"/total number of responses) of the participants answering "Yes" for the first question (including all program concentrations) as compared to 63% for the technical skills. It is worth noting that in the case of Employed (mainly SP 2010 -2012), the two values are closer at 83% (total "yes" in the NET+IKM/total number of NET+IKM participants) and 77%, respectively. Also, it is clear that the students' internships are not making best use of what they have learned technically as evident in the low score of 45%. Put it in a different way, not all internships are expecting the level of productivity and the know-how that highly paying employers are typically expecting of their employees. Another interesting observation is that although the "Others" under the Program Concentration are using much less of their acquired technical skills in this than NET+IKM concentrator, their responses show clearly that they have gained and currently apply their developed project management and teaming skills in their jobs as evident by the high score of 83%. This demonstrates that the course's objectives of exposing the students to the processes of how projects are selected, designed, created and managed on an end-to-end basis have instilled in them a set of universal skills that are of high value to all students regardless of their area of concentration.

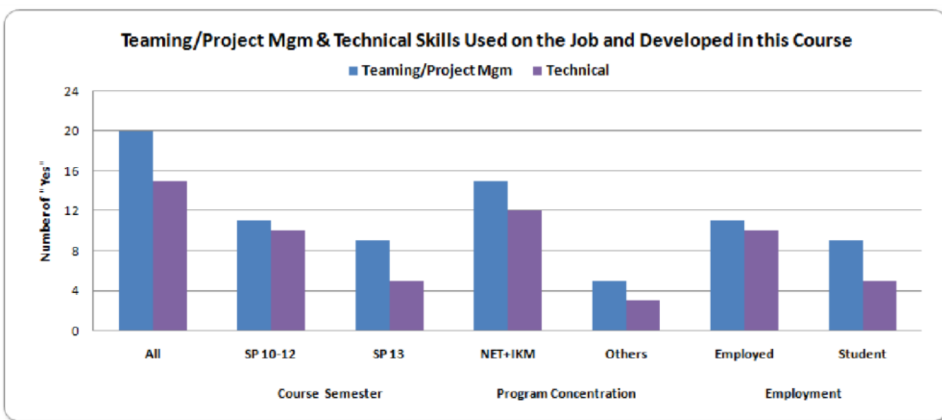


Figure 6 Skills Developed in this Course and Used on the Job

5. Summary, Conclusion, Recommendations and Next Steps

Summary of Key Observations

To affirm the effectiveness of this course we collected data by surveying past course participants. One of the indicators of effectiveness is whether the students felt that the course had a positive impact on their career and whether the amount of effort put into the course can be correlated to the amount of impact the course had on their career. In our data analysis we presented that the average rating of a student's contribution to the course in all cases strongly correlated with the impact that the course had on their career. Also, it is shown that students who concentrated in Networking and Security and/or Information Knowledge Management (NET/IKM) underwent the highest impact on their careers and those who concentrated in "Others" (other concentrations) realized the lowest impact. However, in general responses from all participants confirmed that the value they realized is as much as the effort put in and more.

The current work environment is increasingly dominated by mobile, computing technology and web projects along with a pressure to be able to develop rapidly [16]. New technologies are constantly being created that require new knowledge and skills to effectively apply them in the development of new applications. To remain valuable and able to contribute, students must be capable of teaching themselves to use these new technologies. Our data indicates that the strategy adopted by the advisor to primarily serve as a coach and not as a traditional teacher has encouraged the students to be responsible for their own learning. This has clearly been shown in the participant's report of being exposed in this class to a wide scope of technologies and skills that are directly relevant to their current work environment. This leads us to the conclusion that the design and structure of the course develops graduates who are able to effectively prepare themselves to become aware of and skilled in relevant and essential technologies in the ever changing work environment.

Another set of responses from the survey affirms the course's effectiveness in preparing students in ways beyond exposure to the latest technologies. Eighty three percent (83%) of the course participants responded that they are currently applying project management and teaming skills that they developed while in the course. Fifty percent (50%) work in teams of 2 to 5 and 21% in teams of 6 to 10. The small team skills and project management skills were acquired through this class in a group size similar to the size of the groups that the majority of those participants are working in now. This further highlights that the course is providing students with an experience realistically relevant to that of which they can expect in their work after graduation. It should be noted that project management techniques and team skills is not an area that was entirely self-taught as it was mandated by the class advisor as part of the weekly scrum-like status meetings.

Conclusion

We started our assessment journey with the following hypothesis:

> "*If under-skilled students take this course then they will have gained skills and experience, to innovate and roll out creative products and projects, making them more valuable to potential employers and their work teams, especially considering the current trend of work moving to mobile, network and web technology projects in the hands of small, nimble and entrepreneurial startups or startups-like within large size companies.*"

Our conclusion based on the participants' responses and the quantitative analysis presented in this paper is that the hypothesis is true and that the course has achieved its goal of preparing our undergraduates for the ever changing and challenging technology application and service development environment. The responses of the survey have also helped us to quantify the strength and areas of improvement of this course in providing the best springboard into a challenging post-graduation workplace. We are pleasantly surprised with the participants' rating that the impact of the course on their career, on the average, was higher than their rating of their value of their contribution.

Recommendations

The following are some of the recommendations provided by the participants in response to questions Q23 & Q24 (Appendix A). The participants encouraged us (1) to conduct the course with the involvement of a real client with a specific need or problem, (2) to publish the projects completed on the university web site for the benefits of potential employers, (3) to exercise methods that ensure more accountability for each individual, (4) to foster and encourage competition between sections; just like in the real world, (5) to encourage the use of centrally accessible repositories such as Google Drive and GitHub, (6) to introduce end-to-end testing much earlier in the semester including strong involvement of the TAs and the Integration Sub-Team, (7) to reconsider how much weight should be allocated to the back-end component due to the steep learning curve of the hardware programming, and (8) to increase the emphasis on the integration processes and resources.

In addition to the participants' recommendations, we believe that the survey has missed a few important questions, such as, (1) how much peer-learning was going on in this course, (2) how effective the course was in exposing the students to the latest technologies and tools, (3) how to compare the impact of this non-traditional course relative to other courses that are delivered and conducted using traditional lecture-based knowledge transfer, and (4) what best practices the participants may suggest for us to adopt based on their experience in the real world.

Next Steps

The assessment conducted and described in this paper has been an excellent first step toward the establishment of quantitative metrics that should guide us towards significant improvement in the future. The next step is to evaluate the responses we received from the second survey, that is, the survey sent out to alumni of the Integrated Science and Technology program who did not take the course. Comparing the results of the second survey with those described in this paper should provide insight into what other means by which students may be exposed to the latest information System, Mobile and Web Network & Security technologies and to what extent. Also, it would be of great value in substantiating our conclusion to entice those who did not respond to the first survey (66 graduates) to do so and extend our analysis to take into account the lag time between the course completion, and the assessment survey administration.

We will start developing assessment tools (including surveys) and metrics that will enable us to quantitatively track, determine, and predict the successful repeatability of such a course from one semester to the next. Also, we would like to be able to quantify, with a reasonable level of confidence, the value of the contribution of the students as a function of their effort expressed in terms of one or more cost items. Arming ourselves with quantitative metrics will enable us to pin point and track specific aspects of the class that could have the greatest effect on creating post-graduation value for students and potential employers.

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Appendix A - Survey: Network and Security (Telecom) (* Required)

Note that "306" represents the number of the course under assessment

Q1. Please enter your first and last name. *

Q2. Please enter your preferred email address. *

Q3. What is your gender?
- ☐ Male
- ☐ Female

Q4. Please enter the year and semester you took 306. *

Q5. Please enter your program concentration. *

Q6. What was your assigned role in 306 class? *
- ☐ Integrator
- ☐ Front End
- ☐ Central (Database Management)
- ☐ Back End ☐ Other:

Q7. What amount of time did you put into 306 outside of class? *
- ☐ < 1 Hours per week
- ☐ 1 - 3 Hours per week
- ☐ 3 - 6 Hours per week
- ☐ 6 + Hours per week

Q8. What amount of value did you contribute to your class project? *

1 2 3 4 5 6 7 8 9 10

Select a value from a range of 1 (I didn't contribute anything) to 10 (I did a majority of the project)

Q9. Describe your current employment? *
- ☐ Unemployed
- ☐ Large Private Sector (500+ employees)
- ☐ Middle Private Sector (200 - 500 employees)
- ☐ Small Private Sector (> 200 employees)
- ☐ Start-Up
- ☐ Self Employed
- ☐ Student

Q10. What is the size of the team that you currently work with? *
- ☐ 2 - 5
- ☐ 6 - 10
- ☐ 11 - 15
- ☐ 16 - 20
- ☐ 20 +
- ☐ I produce work alone

Q11. Please list your first employer or graduate school after graduating from JMU? * If still student name your first internship or job post 306

Q12. Please list your current employer or graduate school. *
If still student name your most recent internship or job post 306

Q13. Please list your current position title. *
If student choose most recent internship or job title

Q14. Did you reference work done in your 306 project during your job or graduate school interview process? *
- ☐ Yes ☐
- No

Q15. Do you currently use technical skills developed in 306 in your job? *
- ☐ Yes
- ☐ No

Q16. What field does your current position or graduated program most closely fall under? * If still at JMU choose your most recent internship position.
- ☐ IT
- ☐ Software Engineer
- ☐ Project Management
- ☐ HR
- ☐ Communications
- ☐ Education
- ☐ Data Analyst
- ☐ Network Design
- ☐ Engineering
- ☐ Information Systems
- ☐ Finance
- ☐ Marketing
- ☐ Accounting
- ☐ Other:

Q17. Did 306 class provide you with experiences that enhanced your interview process with relation to web based programming? *
- ☐ Yes
- ☐ No

Q18. Did 306 class provide you with experiences that enhanced your interview process with relation to database programming and structure? *
- ☐ Yes
- ☐ No

Q19. Did 306 class provide you with experiences that enhanced your interview process with relation to hardware programming and structure? *
- ☐ Yes
- ☐ No

Q20. Check any of the following that you became familiar with while taking 306.
- ☐ HTML
- ☐ MYSQL
- ☐ Python
- ☐ PHP
- ☐ JavaScript
- ☐ CSS
- ☐ Arduino
- ☐ jQUERY
- ☐ PhoneGap
- ☐ Java Mobile Dev
- ☐ C ++ Mobile Dev
- ☐ Other:

Q21. Did the required inter-team and cross-team communication in 306 better prepare you for post-graduate work? * If still at JMU refer to your job or internship experience.
- ☐ Yes
- ☐ No

Q22. On a scale of 1 to 10 how do you feel the 306 class project has impacted your career? *

1 2 3 4 5 6 7 8 9 10

Select a value from a range of 1 (Very negatively) to 10 (Very positively)

Q23. If you could add something to 306 class that would make it more beneficial to you in your post-graduate work what would it be? * Fill in the blank

Q24. Was there anything unnecessary in 306 class that did not positively impact your career?* Fill in the blank

Q25. Do you feel you were adequately prepared for interviews post-graduation? *
- ☐ Yes
- ☐ No

Q26. Were you exposed to technologies that you currently work with prior to graduation? *
- ☐ Yes
- ☐ No

Q27. Did the exposure to that technology occur in the 306 class?

Only respond if you answered yes to the above question.
- ☐ Yes
- ☐ No