Effects of Communication, Leadership, and Team Performance on Successful IT Capstone Projects: A Case Study

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ABSTRACT

To provide students with the opportunity to synthesize the knowledge and skills acquired from their prior courses into one final project, IT capstone projects have become an essential part of the IT curriculum. This paper presents the successes and challenges from the student groups with post-project survey and student self reflection. Effective communication, strong leadership, and match-up of individual strengths and team roles emerged as the major factors contributing to the team success. The challenges include the size of the project team, the limited time to complete a comprehensive IT project, and the amount of effort on documentation. The intent of this paper is to have an in-depth understanding of the IT capstone projects to discover better approaches to enhancing student learning experience and improving teaching effectiveness in such capstone project courses in the future.

Categories and Subject Descriptors

K.3.2 [**Computer and Information Science Education**]: Information systems education

General Terms

Measurement, Performance

Keywords

IT Capstone Projects, Group Projects, Communication, Leadership, Success Factors, Challenges

1. INTRODUCTION

Information Technology (IT) is a popular and rapidly changing field of study. To keep pace with the field, gain industrial experience, and learn applied skills, students majored in Bachelor of Science in Information Technology at Southern Polytechnic State University are required to complete a capstone group project course in their senior year. The capstone project course was designed for students to apply their knowledge they have learned during their previous studies in the IT program in many IT areas, such as systems analysis and design, software engineering, programming, hardware, networks, infrastructure, information security, human-computer interaction, database design and implementation, web applications development and others. This project is typically the last step in the degree process, a systematic application of IT knowledge to practice.

Most of the capstone project topics come from real world IT problems, either suggested by our Industry Advisory Board members, or requested by a local IT company. Students work closely with industry professionals, faculty members and the government agencies in some cases throughout the entire semester. These projects involve practical user requirements solicitation, project planning, software design, implementation, testing and integration. During this process students learn to manage the project through all its development stages, communicate with project stakeholders, develop project documentation following professional standards, present their project work to faculty and industry professionals. In spring 2011, four groups of totally 21 students worked on four IT capstone projects: Community Watch (voice-to-text) project, Enterprise Vulnerability Management and Assessment Tool project, IT Maturity Measurement, and web-based IT Auditing Tool project.

This paper presents the successes and challenges from these groups with post-project survey and student self reflection. The study is guided by two questions: First, what makes a student capstone project successful? Second, what are the challenges that the student usually face during the course of the capstone project? The intention of this paper is to have an in-depth understanding of the IT capstone projects to discover better approaches to enhancing student learning experience and improving teaching effectiveness. We will focus on student team organization, motivation, team performance, and their active learning and collaborative learning through the capstone project setting, which will shed light on a better way of offering this course in the future.

The next section of the paper discusses the conceptual background. The third section presents the methodology and data analyses results, followed by suggestions for IT capstone project teaching and learning. The last section concludes the paper along with discussions of further research topics and their implications to the practice.

2. CONCEPTUAL BACKGROUND

Capstone projects provide a learning environment for students. However, learning occurs only when students have the right learning approaches. A spectrum with regard to the learning approaches can consist of (1) permissive, learner-driven, and practically-oriented, progressive and "free" education; (2) semi-structured education, e.g., the subjectivity of learning experience is recognized while learning experiences are guided via structured planning and reviewing processes, and (3) structured, knowledge-oriented, competency-driven, normative traditional education [9].

Experiential Learning [6] can be regarded as a semi-structured approach. Students have relative freedom to go ahead in activity and "experience," but the instructor also "commits to structuring other stages, usually involving some form of planning or reflection, so that "raw experience" is package with facilitated cognitive (usually) thinking about the experience" [9].

Team projects can be seen as providing an opportunity for students to learn practical skills obtained in semi-structured learning. The stages in the team projects include finding a real world IT problem, determining the requirements, building and testing the solution and implementing the completed product. Team projects, in particular IT capstone team projects, allow for leaning experiences that cannot be realized in an individual learning environment [7].

Moore [8] summarizes that a capstone course serves as "an instrument of evaluation in all three modalities of learning". Capstone courses are designed to assess cognitive, affective and psychomotor learning in a student-centered and student-directed manner which requires the command, analysis and synthesis of knowledge and skills [7, 8].

The IT 2008 Model Curriculum [5] identifies a broad computing technology and social perspective, the development of ability for "the selection, creation, application, integration and administration of computing technologies" as the key outcome of IT education [5]. IT capstone projects provide an opportunity for students to put their IT knowledge and competencies into practice, bringing education closer to the real world, and therefore prepare students for the IT professional environment they will be in after they graduate.

However, IT capstone project course is challenging to teach for several reasons. First, the capstone project topic must be carefully chosen so that it could provide a summative evaluation for a variety of areas specified in the educational objectives and IT program outcomes. Second, the student team dynamics could affect team performance and influence student learning experiences. How should the student teams be formed? Should students form their own groups or should instructor assign students into a team randomly or based on the expertise required by the projects? We appreciate the quotation from Henry Ford:"Coming together is beginning. Keeping together is progress. Working together is success." The question is how do we form a capstone project team that will work better together?

Third, the duration of the capstone projects needs to be considered when we select project topics and form a team. Some universities require a whole academic year to complete a capstone or senior design project, whereas others have only one semester for a capstone project. Both approaches have pros and cons in terms of workload and team coherence. While the teaching side of the IT capstone project course needs to be studied, this paper focuses on the learning side by investigating team performance and learning experience from student's perspective.

3. DATA COLLECTION AND ANALYSES

In the spring semester of 2011, a total of 21 students registered for the IT capstone course. Four groups were formed on a voluntary basis to work on the following projects: Community Watch (voice-to-text) project, Enterprise Vulnerability Management and Assessment Tool (EVMAT) project, IT Maturity Measurement project, and web-based auditing tool (WebPRISMA) project. At the end of the semester, student teams presented their projects and results to all IT faculty and the Industry Advisory Board members, along with industry professionals who sponsored a project and had communicated with the student team during the semester.

3.1 Survey questions

A post survey and student reflection were conducted and collected right after the project presentation. All 21 students responded. Five questions were asked in the survey regarding student self-reported IT and communication skills (Table 1 – 5). Students were given five choices (beginner, advanced beginner, competent, proficient, expert) for each of the five questions:

1. My programming skills would be best described as:
2. My project management skills would be best described as:
3. My IT experiences would be best described as:
4. My communication skills would be best described as:
5. My Software Engineering knowledge level would be best described as:

Table 1. Survey question #1: Programming skills

Level	Response Percent	Response Count
Beginner	4.8%	1
Advanced Beginner	38.1%	8
Competent	23.8%	5
Proficient	28.6%	6
Expert	4.8%	1

Table 2. Survey question #2: Management skills

Level	Response Percent	Response Count
Beginner	0.0%	0
Advanced Beginner	14.3%	3
Competent	38.1%	8
Proficient	47.6%	10
Expert	0.0%	0

Table 3. Survey question #3: IT experience

Level	Response Percent	Response Count
Beginner	0.0%	0
Advanced Beginner	19.0%	4
Competent	28.6%	6
Proficient	42.9%	9
Expert	9.5%	2

Table 4. Survey question #4: Communication skills

Level	Response Percent	Response Count
Beginner	4.8%	1
Advanced Beginner	4.8%	1
Competent	23.8%	5
Proficient	52.4%	11
Expert	14.3%	3

Table 5. Survey question #5: Software Engineering knowledge

Level	Response Percent	Response Count
Beginner	4.8%	1
Advanced Beginner	33.3%	7
Competent	42.9%	9
Proficient	19.0%	4
Expert	0.0%	0

The responses indicate that more than half of the students (about 52%) considered themselves proficient with communication skills; and almost half of the students considered proficient with management skills (48%) and IT experience (43%). In the category of technical and applied skills, data scatter among "advanced beginner", "competent", and "proficient." Most of the responses (38%) are advanced beginners in programming and 43% are competent in Software Engineering knowledge.

Although respondents often over-estimate their abilities, the findings are consistent with the demographics of the students in the IT program at the University. Most of the students work full time in IT-related positions. They have substantial IT experience and communication skills and they tend to be interested more in applied skills than programming.

3.2 Student Self Reflection

The personal reflection and recommendations to the capstone projects were also collected from the students. The key factors that contributed to the success of the project and the major challenges that the students faced during the project emerged from the review of the reflection.

Success factors

Students reported the following success factors:

1. Effective communication

Communication is the most mentioned factor in the reflection. Students reported that they had started to email to invite team members even before the semester started. During the period of the project, they had used a variety of communication tools for collaboration and communication, such as Google groups, Google docs, phone, text, and face-to-face meetings. With different ways of communication, they were able to keep frequent contact with each other to update on the status of each person's task/part. Several team members in one group praised the way their group meetings were conducted. They usually took a few minutes at the beginning of each group meeting to loosen up by talking about their hobbies and news. With effective communication, students kept the team on the same page and they kept together to contribute to the project.

2. Effective leadership

Leadership is another equally most mentioned factor. The voluntary team leader coordinated project effort with each team member, called for group meetings, assigned tasks, set internal goals and deliverable deadlines, among others, on top of his/her own share of project tasks. The effective team leader is seen as a source for team motivation and commitment, which are two key elements in effective teamwork.

3. Know each team member's strengths and specialties

It is important to know team members before the group was formed through prior classes or recommendations. One student sent out an invitation email to those who she knew (and liked) from previous classes and friends' recommendations even before the capstone course started. They reported that it helped the team to share a common work ethics, better collaborate and communicate with each other, and be able to define jobs based on each member's strengths or specialties. It helped students work together as a team to deliver a quality product.

The following quotes from students illustrate these success factors:

"Throughout the semester, we kept the team on the same page. Communication is very important in a project, and keeping us students who are working part-time, full-time, and taking other classes, is not an easy task. Fortunately, with a combination of emails, phone calls, and text messages, we were able to update each other on tasks, meetings, and deadlines."

"I believe to form a successful team you have to have an excellent project leader. E(name omitted) was that project leader. He was able to find our specialties and use them efficiently as we worked on this project."

"Motivation, trust, and commitment was how our team kept together to contribute."

"We realized how big this project was for each of us. That being said, I believe we all put in extra effort to make sure this project came out the best it possibly could. If you let yourself down, you were probably letting down the other 6 people in the group and none of us wanted that!"

Students also reported that keeping positive throughout the project, taking quick action, and instructor's help and encouragement helped them succeed in the capstone course.

The student reflection echoes various researches that show that the effective teamwork is produced when these interconnected factors are present. These factors are vital for building a good team that works successfully in the categories of team structure, individual contribution, and team process: good leadership, effective communication, defined roles, strong motivation, commitment, and harmonized team climate, among others [For example, 1, 2, 3, 10, 11].

Challenges

It is noted that students faced some difficulties and challenges as well. Students reported the following major challenges they encountered during the capstone projects:

1. Size of the group

There were 2, 6, 6, and 7 members in each group respectively in the capstone course that was studied in this paper. Teams were formed the second week of the class. Students formed their own groups based on their personal preference. Two students were left out without a group at the end of the second week and the instructor had to put these two students into one group to work on an existing project for revising WebPRISMA, a web-based IT auditing tool. While a small size group could not handle a significant amount of work, the large size of the group makes it difficult to coordinate the team schedule.

2. Limited time

Most of the students work full time and took several other courses besides the capstone course. The tense deadlines and workload make them feel very challenging and difficult. One student wrote in his refection: *"Also it was worth a mention that this system was created and tested and presented in a period of three months."* Groups reported that they had to work on the projects at late nights at some points, especially toward the end of the project. Some usually sent text messages to other group members to update on the projects in the early mornings at 2 or 3AM.

3. Amount of documentation

The capstone projects involve the phases of project research and planning, understanding of the project requirements, and development of project documentation to a professional standard. Students reported that the amount of documentation to read and write and time spent on documentation were overwhelming. However, they reported that this experience was rewarding and worthwhile. One student reports:

"(With our documenting and framing the EVMAT structure,) I feel confident that the next group will have plenty of invaluable material to work with in furthering the implementation of the application."

Other challenges such as switch to another solution halfway of the projects brought difficulties to student groups too. They had to work in late nights to catch up on the deadlines in this case. Despite the immense challenges, students were excited by the projects and they thoroughly enjoyed the experience, as indicated by comments in their reflection:

"I will not be able to look back on this project with any regrets. I put in every ounce of effort and energy that I could towards making us successful and spent more time on this course than my other two courses this semester, combined. My team members did a massive quantity of work on their own and I cannot explain in words how amazing it was to work with such people throughout the semester."

"This was the most challenging and time-consuming project I've worked on during my time at Southern Polytechnic State University." However, it's also been the most fun, most engaging, and most rewarding. It's something I'll be able to look back on and be happy about the effort I expended, the things I learned, and the people I met and worked with. I am very thankful to have had such an experience."*

4. SOLUTION AND RECOMMENDATION

The team capstone project managed by students and facilitated by instructor provides enriching personal development opportunities for students. The team projects let students expose to real world development, project management, and tight deadlines. This exposure broadens students' horizon, stimulate critical thinking and experiential learning and promote excellence.

Two questions that guide this research are answered. The key factors that make the student capstone projects succeed are effective communication, strong leadership, and match-up of student strengths and team roles. The challenges that the students faced during the course of the project include size of the group, limited time for the project, and the amount of documentation and time spent on it.

We propose the following solutions and recommendations for similar IT capstone projects or capstone courses:

1. Faculty involvement

The successful team project is a challenge to students and to faculty as well. It requires involvement, commitment and dedication from faculty. A general perception among educators appears to be coordinating a capstone design course involves a significantly greater amount of time than that required for a regular course [3]. As Dewey puts [9]: "It is the teacher's responsibility to structure and organize a series of experiences which positively influence each individual's potential future experiences." In other words, instructor needs to carefully plan beforehand, for example, obtain suitable projects and find an effective way to evaluate the scope of the projects. Meanwhile the instructor needs to be alert to team dynamics and individual strengths and specialties in student teams. Instructor also needs to closely assess and guide individual and team performance throughout the projects to motivate, encourage and enable students to have more valuable learning experience with "good experiences" in the team projects.

2. Time management

Effective time management is one of the most challenging issues in team projects. Meeting deadlines in team projects can become very demanding. Careful guidance on periodical deliverables, internal deadlines, and mechanisms such as Gantt charts help teams to balance their time and project deliverables. Instructor plays a role in team time management too by alerting the team not to underestimate the extent of the project and the amount spent on documentation, especially in the starting phase of the project.

3. Group management

Each student submits a weekly project progress report focusing on their individual contributions to the project. Students report their work by answering the following questions: (1) What action items

had been assigned to you for the period of last week? (2) What have you accomplished during this period? (3) Have you completed the action items assigned to you in your Project Control File? (4) Are there any suggestions or comment for your group in the coming week? (5) If you are a project leader, please upload your Project Control File reflecting your previous and current tasks and progress for the time period of evaluation. Initiated by the project leader and discussed during project meeting, each team created a Project Control File containing the following content:

- A list of tasks for the current week.
- For each task, assign person(s) in charge of this task.
- For each task, list its start time and completion time.

4. Student peer evaluation

Peer assessment is one way to motivate students. Assessment takes into account the individual contribution. On a scale of 1-5, each student evaluates her/his peer students working within one team for the following performance: quality of work, timeliness of work, task support, interaction, attendance, responsibility, involvement, leadership, and overall performance rating. As studies indicated [7], the peer assessment instrument does not always provide the perfect solution to team problems. In case teams are divided into two camps their assessments can counteract one another. Other mechanisms need to be used to resolve the issues.

5. Team equality and diversity

There were no conflicts reported in our case study. However, a diversity of technical skills, communication skills and cultural background may cause conflict in team if not properly monitored and controlled.

In summary, there are many benefits and challenges of team capstone projects. Instructor and teams need to work closely to make team function effectively to accomplish a common a goal as IT2008 model curriculum suggests [5].

5. CONCLUSION AND DISCUSSION

This paper makes a step toward understanding the team dynamics and the factors that affect student team performance in an IT capstone project course. There are unique issues that arise in IT capstone projects that would not occur in a traditional non-IT group project setting, such as the impact of development methodology used in the project. The challenges faced by student groups also include they may have to switch to another solution halfway of the projects due to lack of functionality or compatibility that was not anticipated until the implementation and testing phase. As in any traditional student group projects, the smooth running of capstone team projects is a challenge to both faculty and students. Team projects are usually demanding in terms of group management and time management. This paper also provides implications for practice to guide instructors who design and deliver the similar capstone projects or capstone courses in IT field. The intent of this paper is to motivate educators into engaging in careful observations as to what dynamics occur in their IT capstone classes and how to enhance student learning experience and improve teaching effectiveness.

There is still a great deal of future work to be done and considered in pedagogical and organizational approaches for a successful IT capstone project course. First, an inter-departmental student team

could be organized to gain more benefits from multidisciplinary interaction during the project process. For the situation of our university, we have three degree programs in our School of Computing and Software Engineering, namely, Information Technology, Computer Science, and Software Engineering. Rather than offering a separate capstone project course for each degree program, we could offer a Computing Capstone Project with student teams of mixed computing majors. An even more open thought is to organize a larger student team consisting of computing and non-computing majors.

Second, it is important to use capstone project as a summative tool to evaluate program outcomes and connect this assessment data to ABET accreditation and continuous improvement effort.

Third, the intellectual property (IP) issue has popped up after one student team developed a prototype with potentially commercial value. If a project proposal comes from an IT company, there is a need to clearly define the IP ownership at the beginning of the course, possibly with a non-disclosure agreement signed as well.

Finally, it is worthwhile to consider the relationship between IT capstone project and career portfolio for IT students.

6. REFERENCES

[1] Costa, A. C. "Work team trust and effectiveness", *Personnel Review*, Vol. 32 Iss: 5, pp.605 – 622, 2003

[2] Cragan, J.F., Wright, D. F., Kasch, C. R., *Communication in Small Groups: Theory, Process, Skills,* Cengage Learning, 2008.

[3] Dutson, A.J., Todd, R. H., Magleby, S. P., and Sorensen, C. D., A Review of Literature on Teaching Engineering Design Through Project-Oriented Capstone Courses, *Journal of Engineering Education*, 17, January 1997.

[4] *Effective teamwork: http://www.buzzle.com/articles/effective-teamwork.html*, accessed May 30, 2011.

[5] Ekstrom, J. and Lunt, B. IT2008: Information Technology Model Curriculum, *Seventh LACCEI Latin American and Caribbean Conference for Engineering and Technology (LACCEI'2009)*, June 2-5, 2009, San Cristóbal, Venezuela, http://www.laccei.org/LACCEI2009-Venezuela/Papers/CSI044_Ekstrom.pdf, accessed May 30, 2011.

[6] Kolb, D.A., Boyatzis, R.E., and Mainemelis, C., *Experiential Learning Theories: Previous Research and New Directions*, in Perspectives on cognitive, learning, and thinking styles. R. J. Sternberg and L. F. Zhang (Eds.), NJ: Lawrence Erlbaum, 2000.

[7] Lynch, K., Heinze, A, and Scott, El. Information Technology Team Projects in Higher Education: An International Viewpoint, *Journal of Information Technology Education*, Volume 6, 181-198, 2007,

http://jite.org/documents/Vol6/JITEv6p181-198Lynch354.pdf, accessed May 30, 2011.

[8] Moore, R. C. *The capstone course*. In W. G. Christ (Ed.), Assessing media education: A resource for educators and administrators. Hillsdale, NJ: Erlbaum. 2005, http://users.etown.edu/m/moorerc/capstone.html, accessed May 30, 2011.

[9] Neill, J, *Experiential Learning Cycles*, Overview of 9 Experiential Learning Cycle Models,

http://wilderdom.com/experiential/elc/ExperientialLearningCycle.htm, accessed May 30, 2011.

[10] Sharon Michan and Sylvia Rodger, Characteristics of effective teams: a literature review, *Australian Health Review* 23 (3), pp. 201 – 208, 2000

[11] *Teamwork in the classroom*, http://www.ndt-ed.org/TeachingResources/ClassroomTips/Teamwork.htm, accessed May 30, 2011.