Applying an Agile Approach in an Information Systems Capstone Course

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Abstract

This paper outlines the content of a Master of Science in Information System degree and the development and deployment of the first two iterations of the capstone course. Research shows that a capstone course can be valuable for both students and future employers. The steps taken to prepare for the course and set up the capstone course are included. Students utilized an agile methodology, Scrum, with regular meetings and five sprints. Students answered questions about their experience with the capstone course and the findings from two cohorts of students are shared. The paper concludes with considerations for future follow up and iterations.

Keywords: capstone, agile, Project-based Learning, Scrum, real world client, system analysis and design

1. INTRODUCTION

University graduates seeking career opportunities want to prove to employers that they are ready to contribute to companies or organizations. Employers want people who can work well on teams as well as be lifelong learners. Capstone courses are used in academic degree programs in different kinds of schools such as business, engineering, information technology, health care and education (Schwering, 2015). When students enroll in a capstone course, they often gain skills and insight that will help in their career. The central challenge for information systems graduates is to productively design, implement, and manage information systems, and to do so in a timely fashion (Carlsson, Hedman, & Steen, 2010). A graduate capstone course can provide proof of educational effectiveness of a program.

A regional public state university in the Midwest created a Master of Science degree in Information Systems (M.S. in I.S.) and included a one-semester capstone project course. Students in the program take courses in technical areas including object-oriented programming, networking, business intelligence, cybersecurity, and databases. They learn business and management knowledge through project management, information systems, and financial modeling. They acquire and practice UX design, requirements gathering, and systems diagrams with student projects. Students learn how to analyze and think through ethical and professional dilemmas they may face in a computing career. These courses all help students develop the knowledge and skills to complete the capstone project. They use the technical skills for the technology component, the management

skills to manage the project, and professional skills to interact appropriately with the client.

The capstone course uses the principles of Project-Based Learning (PBL) as an instructional strategy. Student teams using PBL research and devise solutions to projects while increasing communication and problem solving skills (Bell, 2010). Several studies have found PBL to add authentic learning experiences for students (Bell, 2010; Danford, 2006; Genc, 2015; Ozdamli & Turan, 2017).

Many instructors have incorporated agile methodologies into their class projects (Magana, Seah, & Thomas, 2018; Mahnic, 2012; Taipalus, Seppänen, & Pirhonen, 2018) with overall positive results. Our students learn about agile methodologies including Scrum in their coursework including a project management course with concepts, cases, and a project using Scrum. The project in the capstone course allows students to practice implementing a larger project using agile methodologies.

The rest of the paper is organized as follows. In the next section, a literature review covers the basics of capstone courses, PBL, and agile methodologies. Then the design of M.S. in I.S. capstone course is summarized and the implementation of this project-based course is explained. Results of the survey including significant findings are shared. The conclusion includes plans for future course iterations as well as lessons learned.

2. LITERATURE REVIEW

A capstone course is placed at the end of the curriculum and allows students to assess and share their achievement of the program's outcomes (Hobson, Johnston, & Spinelli, 2015; Schwering, 2015). Capstone courses review program goals, lead students through a structured reflection to become self-directed learners, and communicate students' academic accomplishment to professional peers (Cuseo, 1998). A study showed that employers preferentially valued a student's capabilities of using knowledge to solve real world problems (Schwering, 2015). Capstone courses also compel students to be self-directed learners (Wallace, 2015). The advancing and changing technical environment in today's companies require information systems graduates to be able to learn new technologies on their own.

Project-Based Learning (PBL) is one strategy that can be used to help students develop into independent thinkers and learners (Bell, 2010). Students engaged in PBL have more control over their learning and the tasks they complete; the projects have less structure and are more complex than typical assignments (Taipalus et al., 2018). These projects generally do not have one right answer (Martí, Gil, & Julià, 2006) which can be frustrating to students while providing a more authentic learning experience. Students can develop creative and research skills while also being more active in the project solution (Genc, 2015).

Students engaging in PBL are focused on an end project and it is often expected to be an excellent product (Danford, 2006). Genc (2015) used PBL in an environmental education class where students created projects on environmental problems. Students working on projects had a more positive attitude regarding the subject (Genc, 2015). Danford (2006) had corporate clients work with student teams to develop market research for corporations. Other classrooms have tried using PBL including a mobile application development course (Ozdamli & Turan, 2017) and a computer graphics course (Martí et al., 2006).

While studies generally report positive findings, some challenges are regularly noted when using PBL. Unhealthy group dynamics, poor time management, stress of big projects, and communication problems are often noted (Danford, 2006; Ozdamli & Turan, 2017). Another challenge for any instructor seeking to use real world clients is convincing the corporate world of the value of becoming involved in the experience (Danford, 2006).

Increasingly companies are using agile methodologies in their development and planning activities. Most systems analysis and design and software engineering courses introduce both traditional and agile software development methodologies. The four core values of the Manifesto for Agile Software Development is "individuals and interactions over processes and tools, working software over comprehensive documentation, customer collaboration over contract negotiation, and responding to change over following a plan" (Agile Alliance, 2018, p. 1). Given the prevalence of agile, practicing these concepts in student projects is important.

Over half of today's companies use Scrum (Magana et al., 2018) with the overall success rate of projects using Scrum at 62 percent (Denning, 2015). Scrum is an agile software development process for small teams (Rising &

Janoff, 2000). Scrum is made up of sprints, which are short durations of time, usually about 2 to 4 weeks. Teams must complete a set of product functions during every sprint (Baird & Riggins, 2012).

Generally, there are three roles in a project using Scrum. In a class project, the students are part of the project team. The instructor becomes the Scrum Master, and the client is the product owner (May, Yoir, & Lending, 2016). When the teacher is in the role of Scrum Master, he or she is serving as a facilitator; the teacher as a facilitator is also a key idea in PBL (Danford, 2006; Guthrie, 2010). In some class projects, the instructor may also be the product owner or may do some of the tasks a product owner typically completes.

Faculty are increasingly using the Scrum framework in student projects (May et al., 2016). The integration of an agile methodology in a capstone project is a natural fit (Sharp & Lang, 2018). Practitioners say "in many ways Scrum is a study in the learning process itself" so exposure while in college seems appropriate (Echols, 2016, p. 10).

3. COURSE DEVELOPMENT & DELIVERY

The purpose of this course is to help students integrate the knowledge gained during the M.S. program in IS by facilitating a student-executed Information Systems project, including requirements, design, documentation, and a fully functional prototype. This course is designed as a team project where teams work for a real industry client to address a real business problem. The project typically covers the conceptualization, analysis, design, and production of a working, functional prototype of the system that serves as a proof of concept on which a final system may be built. It may also involve a pilot and/or implementation. Students are expected to bring knowledge from the rest of the program as well as their own unique experience. Students in this course will apply this knowledge to information systems practice using different tools and techniques while respecting others' views, in an effort to learn how to be effective IS professionals.

The topics that are addressed in the capstone course include: information systems development methods and techniques, agile methods and techniques, prototyping, participative design, project management methods and techniques, database design and management, information systems (IS) security, systems architecture, usability theory and methods for presentation, and reporting. Thus, the course covers the full spectrum of information systems development from conceptualization and analysis to design, prototyping, and development, depending on the project assigned to the student groups. The student groups need to synthesize knowledge on complex topics to complete the capstone projects.

Since the course focuses on a real-world information technology problem that the students have to solve as a team, this is not a lecture course but rather a series of project meetings. The project is managed through on-going consultation with the professor, teaching assistant and other advisors invited by the professor. In addition, advisory and Socratic educational practices are incorporated as a key pedagogical component in the course. The project problem is typically offered and owned by an organizational representative. The organization can be a local business or organization or a campus office or organization. The client is involved in the entire project life cycle.

There are two student group meetings every week. Each group must develop a meeting agenda. The professor plays primarily a mentoring and facilitating role in this course. In consultation with the professor, the students define the scope of their work and define the structure of the project meetings. Each meeting agenda and process is student-prepared and has to be approved by the professor. During the rest of the week, student groups work on specific assignments that are defined during the project meeting. Groups present their results during each weekly meeting. A summary of each weekly meeting is sent to the problem owner (the client) at the end of the meeting. To successfully complete this capstone course, students need to submit the following assignment and deliverables associated with planning and completing their team projects.

Project prototype: The expectation is that the project team will deliver a working (functional) prototype that meets the client's requirements.

Interim Deliverable Documents: The team will submit interim deliverable documentation that includes both system analysis and design specifications and project management documents. Documents may include, but are not limited to, requirements and design documentation, test plans, test reports, burndown charts, Gantt charts, and other documented artifacts. Students could choose the

technologies; most groups used Moqups, Justinmind, and Wix.

Final report: Each team will submit a final report that includes the documents prepared during the development process. This report will include the memorandum of understanding, the statement of work, the technology plan, the feasibility study, use diagrams and use cases, the test plan and results of the testing, and the agendas and minutes from each meeting.

Final presentation: Each project team will make a formal presentation that showcases the prototype to the client, members of the University faculty, and other interested individuals. The presentation should include a demonstration of the prototype as well as a presentation of the project process, including a post-mortem.

This capstone course is a 3-credit graduate course offered in the fourth semester of the M.S. in I.S. program. It has been taught for two semesters now. Students are assigned to project teams according to their varied knowledge levels, learning abilities, and work experience. The professor used specific criteria to balance the teams to avoid one team having an advantage over another team and to ensure that all teams could be effective. Each team consists of five or six members. Each team should finish one independent project within 15 weeks to meet the course requirements and objectives.

As suggested by literature, IS practitioners should regularly work cross-functionally with business users when implementing systems (Maloni, Dembla, & Swaim, 2012). In our previous IS courses, students typically relied on professors, other faculty members or even themselves to collect user requirements. This is not truly cross-functional in nature. To address this gap, we sought outside clients for these projects. The city manager and the new conference center manager from the local community agreed to serve as clients for the first semester. A new conference center was set to open at a local lake, and four information systems projects were needed. The four systems were: employee management system, beverage management system, room management system, and supply management system. The students were able to tour the new conference center to understand the facility better, and then the client came to campus for the remainder of the project meetings and presentations.

The professors were not able to secure an outside client for the second semester so two on-campus clients served as clients for the projects. The projects were a professional inventory system for the Learning and Teaching Center and a student success center reporting system for the campus Student Success Center.

After the professor introduced the syllabus and course structure, the client representative came to class for a kick-off meeting to provide basic information about their organization and their need for an information system. The clients remained involved throughout the project, providing requirement details, responding to information requests, and offering feedbacks to each team's interim prototypes. The client representatives periodically attended project teams' review meetings, and frequently communicated with project teams via email. An active, involved client is essential for success in these projects.

Students applied Scrum methodology to manage their projects. The system prototype development was divided into five sprints with different sprint backlogs, which were the prioritized lists of tasks to be completed. Besides daily Scrum meetings, students attended two 75-minute classes per week for team meetings and consultation with the professor. At the end of each sprint, the potentially deployable prototypes were demonstrated to the client. The clients were able to see and understand what the system looked like and were able to give direct feedback. This was effective and allowed students to practice using an agile methodology.

Students completed peer/self-evaluations after every sprint. They provided quantitative and qualitative feedback to every team member, grading each team member's effort and quality of work during the sprint. The peer review results were reviewed by the professor and summarized for students. After giving feedback to students, the professor met with individual team members regarding the existing issues and discussed how to improve their performance. Peer review provides an opportunity for "correction" of performance and quality issues with individual team members.

The projects in both semesters were deemed successful by the course professor and the clients. All capstone projects were completed by the end of the semester. The teams presented their system prototypes to the client in final presentation session. Final reports for each system were submitted to the client together with the prototypes.

4. DATA ANALYSIS

The students completed a survey to gain insight on their experience in the program and the capstone course. The survey is included in Appendix A.

Students answered 18 questions about their capstone experience including questions about the client, team, communication, project management principles, and Scrum. Thirty-four students participated in the study as the first cohort had 22 students while the second cohort had 12 students. The questions used a 5-point scale with 5 being strongly agree and 1 being strongly disagree.

Table 1 shows the mean scores for each question. Overall, the mean scores were high, indicating a positive learning experience for the student.

Question	Mean 1-5 scale N = 32
Team worked well with client	4.12
Open dialogue with client	4.50
Client effectively involved	4.21
Easy to communicate w/ team	3.82
Use of correct communication media	4.15
Team communication timely	3.91
Use of formal project mgt processes	4.06
Team followed project plan	4.21
Tasks clearly assigned	4.00
Had knowledge/skills to be successful	4.06
Could get help with technical	4.24
Prototype is successful	4.32
I will get a good grade	4.29
I learned a lot	4.29
Project expanded thinking & skills	4.21
Project was realistic	3.74
Scrum was appropriate	4.26

Table 1: Mean scores from survey

Since each capstone course is different due to the projects and clients, further analysis was done on the two groups to see if there were any differences in their answers. An independent-samples t-test was conducted to compare ratings between Cohort 1 and Cohort 2. The results are shown in Table 2.

There was a significant difference in the scores for Cohort 1 (M=4.32, SD=.72) and Cohort 2 (M=4.83, SD=0.39) on the question about open dialogue with clients; t(32)=-2.72, p=0.011.

	Cohort 1 (n = 22)		Cohort 2 (n = 12)		df = 32	
	M	*SD*	*M*	*SD*	*t*	*p*
Work with client	4.14	.71	4.08	.79	.20	.849
Open dial. w/ client*	4.32	.72	4.83	.39	-2.7	.011
Client involve	4.18	.73	4.25	1.1	-.22	.826
Team comm.	3.68	.95	4.08	.90	-1.2	.238
Team media	3.95	.95	4.5	.52	-1.8	.078
Team timely comm.	3.91	.92	3.92	1.0	-.02	.982
Formal PM	4.05	.58	4.08	.90	-.15	.882
Team project plan*	3.95	.79	4.67	.49	-2.8	.008
Task assign.	3.86	1.1	4.25	.86	-1.0	.310
Know/ Skills*	3.77	1.0	4.58	.67	-2.4	.019
Tech. help	4.09	.68	4.50	.52	-1.8	.081
Proto. succ.	4.32	.65	4.33	.78	-.06	.952
Good grade	4.18	.80	4.50	.67	-1.2	.249
Learn a lot	4.27	.70	4.33	.99	-.21	.836
Expand skills	4.14	.71	4.33	.89	-.71	.484
Project real.	3.77	.92	3.67	.89	.33	.748
Scrum appro*	4.05	.72	4.67	.49	-2.7	.012

*Significant

Table 2: Results of t-test

These results show Cohort 2 who worked with on-campus clients reported significantly higher ratings on having an open dialogue with the client. The second cohort had higher scores for each of the other questions where significant differences were found. There was a significant difference in the scores for Cohort 1 (M=3.95, SD=1.02) and Cohort 2 (M=4.58, SD=.67) on the question about the team following a documented project plan; t(32)=-2.84, p=0.008. A significant difference was found in the scores for Cohort 1 (M=3.77, SD=.79) and Cohort 2 (M=4.67, SD=0.49) on the question regarding if the team had the knowledge and skills necessary to

successfully complete the project; t(32)=-2.47, p=0.019. Also a significant difference in the scores for Cohort 1 (M=4.05, SD=.72) and Cohort 2 (M=4.67, SD=0.49) regarding whether Scrum was an appropriate project management method for the capstone project was discovered; t(32)=-2.65, p=0.012.

Qualitative comments from the cohorts were also analyzed. Positive comments from cohort 1 centered around the value of working with a real world client while several students in cohort 2 mentioned the lack of an external client as a weakness of their experience. Some students in both cohorts mentioned that they wanted to do more than just create a prototype in the capstone project. Positive remarks from cohort 2 included an overall good experience with professor support, Scrum, and the project management processes.

5. DISCUSSION OF FINDINGS

Students participating in the capstone course experience several advantages. First, the capstone projects provided students with systems analysis experience in the professional world. Students learned effective team collaboration skills necessary for their future careers. Second, students needed to integrate the knowledge gained from a variety of discipline-based courses they have studied in the curriculum. They had to draw together learning from all graduate courses and apply these concepts to a real-world business problem setting. This capstone course could deepen students' appreciation of the discipline as an approach to specific problems (Carlson & Peterson, 1993). Third, the project may have increased student engagement. Another study of students who worked on industry projects found that students were more committed to spending time on the projects and executed greater effort as they were more motivated to deliver quality results (Marcketti & Karpova, 2014).

Other studies have surveyed students to get their perspective on capstone projects using Scrum. Baird and Riggins (2012) and Mahnic (2012) found the students were satisfied with the hybrid project management methodologies that included Scrum principles. While both cohorts reported positive ratings, some differences in scores and comments require further review.

One common theme was the role of the client. Clearly both cohorts prefer to work with an outside client, likely due to the idea that the experience is more beneficial when interacting with an industry client (Marcketti & Karpova, 2014). The fact that the first group had a very public outside client with news coverage on their project may have made Cohort 2 doubt the value of their projects with on-campus clients. However, the on-campus clients were more available to the student groups, leading to the statistically significant higher rating on open dialogue with client from Cohort 2. Given that the scores on several questions were lower for the first group, the degree of client involvement appears to be vital. Other studies have also found that lower client involvement can lead to overall lower satisfaction (Baird & Riggins, 2012). We thought there was value to an outside client, and this finding validates it and leads the professors to identify more outside clients and make sure they can be available for students to ask questions.

We try to identify clients by reaching out to members of our professional advisory team and community organizations. The advisory team members may have a project at their company or be involved with a group that has an information systems need. Often our clients are non-profit or small companies who lack the resources to pay for similar services. Our graduate applied computer science program has worked with outside clients for several years. We are attempting to develop a system where the prototype the IS students develop is handed off to the computer science students for development.

A second finding centers on the other three areas where Cohort 1 ratings were statistically significantly lower than Cohort 2. These items were documented project plan, knowledge and skills, and whether Scrum was an appropriate project management method. There could be various explanations for this including higher expectations of Cohort 1 since this group also gain lower course evaluations or perhaps a learning curve and processes were refined in the second iteration of the course.

Over thirty percent of the students indicated that they did not think developing a proof-of-concept prototype was enough for the capstone project. Professors realize the challenge of creating working applications in a short time period and want to keep client expectations reasonable (Schwering, 2015). Baird and Riggins (2012) also believed that a proof-of-concept project was most appropriate but allowed students to try new packages and cloud-based solutions. In future iterations, we plan to allow students to experiment with this. We are planning to use Mendix, a platform that would allow development

without too much time coding. We still want the emphasis to be on systems analysis, design, and project management.

As with all student projects, there were some issues with groups. Schwering (2015, p. 100) used "a diagnostic survey that evaluates 30 attributes of team and leadership performance." He found that having students complete the survey twice during the project allowed them to enhance their strengths and address weaknesses. Students reported the survey required them to think about their leadership skills in ways they had not before (Schwering, 2015). We could use this survey or an instrument like it to help students develop their skills and work better in teams.

6. CONCLUSION

There are some limitations in the results from our study. The small sample size of 32 is enough to do some analysis but more data from more cohorts would make the findings more relevant. It is difficult to find appropriate real-world projects and clients for a short-term development. Our university is in a small town, which limits the potential clients. Clients for these projects need to be committed to communicating with the students in a timely manner while also realizing there are no guarantees of the project outcome. We have found this to be the most challenging part of organizing and delivering the class.

The project-based course generated heavy workload on professors, and student work and stress levels were high which is typical in a project-based course (Marcketti & Karpova, 2014). Since teaching Scrum in the classroom and using it in industry appears to be standard, not a fad (May et al., 2016), the effort to create the capstone experience with a good client and using Scrum principles is worthwhile.

7. REFERENCES

Agile Alliance. (2018). The Agile manifesto. Retrieved from https://www.agilealliance.org/agile101/the-agile-manifesto/

Baird, A., & Riggins, F. J. (2012). Planning and sprinting: Use of a hybrid project management methodology within a CIS capstone course. Journal of Information Systems Education, 23(3), 243-257.

Bell, S. (2010). Project-Based Learning for the 21st Century: Skills for the Future. Clearing House, 83(2), 39-43. doi:10.1080/00098650903505415

Carlson, C. D., & Peterson, R. J. (1993). Social problems and policy: A capstone course. Teaching Sociology, 21(3), 239-241.

Carlsson, S. A., Hedman, J., & Steen, O. (2010). Integrated curriculum for a bachelor of science in business information systems design (BISD 2010). Communications of the Association for Information Systems, 26(24), 525-546.

Cuseo, J. B. (1998). Objectives and benefits of senior year programs. In The Senior Year Experience: Facilitating Reflection, Integration, Closure and Transition. San Francisco, CA: Jossey-Bass.

Danford, G. L. (2006). Project-based Learning and International Business Education. Journal of Teaching in International Business, 18(1), 7-25. doi:10.1300/J066v18n01_02

Denning, S. (2015, Jul 23). Agile: The world's most popular innovation engine. Forbes.

Echols, M. E. (2016). What agile/scrum Can Teach Learning. Chief Learning Officer, 15(8), 10-10.

Genc, M. (2015). The project-based learning approach in environmental education. International Research in Geographical & Environmental Education, 24(2), 105-117. doi:10.1080/10382046.2014.993169

Guthrie, C. (2010). Towards greater learner control: Web supported project-based learning. Journal of Information Systems Education, 21(1), 121-130.

Hobson, E. H., Johnston, P. E., & Spinelli, A. J. (2015). Staging a reflective capstone course to transition pharmD graduates to professional life. American Journal of Pharmaceutical Education, 79(1), 1-10.

Magana, A. J., Seah, Y. Y., & Thomas, P. (2018). Fostering cooperative learning with scrum in a semi- capstone systems analysis and design course. Journal of Information Systems Education, 29(2), 75-91.

Mahnic, V. (2012). A capstone course on agile software development using scrum. IEEE Transactions on Education, 55(1), 99-106.

Maloni, M., Dembla, P., & Swaim, J. A. (2012). A cross-functional systems project in an IS capstone course. Journal of Information Systems Education, 23(3), 283-296.

Marcketti, S. B., & Karpova, E. (2014). Getting ready for the real world: Student perspectives on bringing industry collaboration into the classroom. Journal of Family & Consumer Sciences, 106(1), 27-31.

Martí, E., Gil, D., & Julià, C. (2006). A PBL experience in the teaching of computer graphics. Computer Graphics Forum, 25(1), 95-103. doi:10.1111/j.1467-8659.2006.00920.x

May, J., Yoir, J., & Lending, D. (2016). Play ball: Bringing scrum into the classroom. Journal of Information Systems Education, 27(2), 87-92.

Ozdamli, F., & Turan, B. (2017). Effects of a technology supported project based learning (TS-PBL) approach on the success of a mobile application development course and the students' opinions. TEM Journal, 6(2), 258-264. doi:10.18421/TEM62-10

Rising, L., & Janoff, N. S. (2000). The scrum software development process for small teams. IEEE Software, 17(4), 26-32.

Schwering, R. E. (2015). Optimizing learning in project-based capstone courses. Academy of Educational Leadership Journal, 19(1), 90-104.

Sharp, J. H., & Lang, G. (2018). Agile in teaching and learning: Conceptual framework and research agenda. Journal of Information Systems Education, 29(2), 45-51.

Taipalus, T., Seppänen, V., & Pirhonen, M. (2018). Coping with uncertainty in an agile systems development course. Journal of Information Systems Education, 29(2), 117-126.

Wallace, S. E. (2015). Team-based learning in a capstone course in speech-language pathology: Learning outcomes and student perceptions. Communication Disorders Quarterly, 37(1), 44-52. doi:10.1177/1525740114558462

Appendix A: Capstone Course Experience Survey

Directions: Indicate the choice that best fits your response using the following scale:

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

1. Our team worked well together with our client.
2. We had an open dialogue with our client during the project.
3. The client was effectively involved in our project.
4. It was easy to communicate within the entire project team.
5. Team members used the right communication media (e.g., discussion boards, e-mail, face-to-face meetings, etc.).
6. Our team communicated in a timely manner.
7. Our team used formal project management processes.
8. Our team followed a documented project plan to guide our work.
9. Specific project tasks were clearly assigned to team members.
10. We had knowledge and skills necessary to successfully complete this project.
11. We could always successfully obtain answers to technical questions from available resources (e.g., class, Internet, etc.).
12. Our final project submission and prototype is successful.
13. We will receive a good grade on this project.
14. I learned a lot from this Capstone project.
15. This Capstone project expanded my thinking and skills.
16. This Capstone project was realistic.
17. Scrum is appropriate project management method for this Capstone project.

Please share any comments you have regarding the Capstone course and project.