An Experiential Education Approach to Teaching Software Project Management

Jeremy Straub and Scott Kerlin
Department of Computer Science
University of North Dakota
Grand Forks, ND 58202-9015
jeremy.straub@my.und.edu, skerlin@cs.und.edu

Abstract

A minimal-lecture approach to student education in software project management has been developed and implemented at the University of North Dakota. In CSCI 297-Experiential Learning, there are no lectures (aside from presenting logistical information and assignments). Instead, students participate in weekly in-class discussions about project management topics. During these discussions they are required to demonstrate their knowledge of the material covered through the topics that they respond to (or bring up) and also to provide critical feedback to their peers (in an appropriate professional manner). They also undertake a (or participate in an ongoing) software project and produce applicable artifacts for the project management activities for this project. The goal of the course is to provide the students with a theoretical understanding of project management concepts and practical experience in project management.

To date, four projects have been utilized including software development as part of a small spacecraft program, development of software for a 3D Scanner, development of software for institutional instruction support and supporting the department's charitable computer refurbishment program. The learning which has occurred in this course has been measured via a pre-/post-test protocol which asks questions about student preparation and their outcome expectations and validates these through a quantitative assessment of knowledge and application both prior-to and after the course. Students also demonstrate their knowledge via the creation of a poster about their work which is displayed at a local forum or symposium.

This paper presents an overview of the format used for CSCI 297 and the progression of topics and assignments used. Then, an overview of the educational outcomes attained by students, from both a quantitative (based on the surveys and pre-/post-tests) and qualitative perspective is provided. These outcomes have ranged from increased knowledge of and ability to apply project management techniques to experience and confidence with public speaking and time management skills.

1 Introduction

A minimal-lecture approach to student education in software project management has been developed and implemented at the University of North Dakota. In CSCI 297-Experiential Learning, there are no lectures (aside from presenting logistical information and assignments). This paper presents an overview of the format used for CSCI 297 and the progression of topics and assignments used. Then, an overview of the educational outcomes attained by students, from both a quantitative (based on the surveys and pre-/post-tests) and qualitative perspective is provided. These outcomes have ranged from increased knowledge of and ability to apply project management techniques to experience and confidence with public speaking and time management skills.

2 Background

With several studies [1, 2] presenting information technology and software development project failure rates as high as 50% and many of these failures being attributed to project management, the existence of a problem is clear. What is less clear is where the solution may lie. Problematically, as de Bakker, et al. [4] note, despite a growing knowledge base about the reasons for project failure it's not being used. They also stress the importance of project risk awareness in practitioners. Bannerman [5] contends that project risks may be created through the project management process, identifying inflexible management techniques and the mismatch of control and management techniques to the environment as key risk drivers.

2.1 Project-Based Learning

The utility of project-based learning (PBL) has been extensively demonstrated. It has been shown to be effective across the spectrum of educational levels [6, 7] and numerous fields of study (including electrical [8], mechanical [9], computer [10] and aerospace [11] engineering, computer science [12], entrepreneurship [13] and project management [14]). It has shown benefit in student retention in a program [15], knowledge retention [16], student understanding [17], preparation for the workforce [17], enhanced creativity [18], self-image and motivation [19] and even job placement [20].

The combination of PBL and small spacecraft has also been demonstrated [21, 22]. In fact the CubeSat form factor was developed to enable PBL projects in Aerospace Engineering [23]. The use of PBL in computer science, however, O'Grady [24] asserts is generally "shallow"; its prior use in teaching technical project management [14] has generally focused on small self-contained projects. This, however, limits the ability to provide students with hands-on experience in many advanced project management concepts.

2.1 OpenOrbiter Program

The OpenOrbiter program is a student-run effort to create a design for a CubeSat (10 cm x 10 cm x 10 cm, 1.33 kg) class [25] spacecraft that can be built with a parts cost of less than $5,000 [26], allowing the spacecraft to be constructed from institutional teaching funds. This reduces the level of risk to the responsible faculty member, as educational benefits are the focus and science and engineering development are ancillary benefits. The spacecraft utilizes a new design [27] which, in conjunction with the public availability of the designs, facilitates innovation and exploration [28]. It allows the disruptive style of research advocated by Swartwout [29, 30].

3 Learning Objectives

The objectives of this course met and exceeded the learning objectives stated relative to project management in the ACM / IEEE Computer Society model curriculum. Model topics include [3]:

- Team management
- Scheduling
- Measurement / Estimation
- Risk
- Quality Assurance
- Configuration management / version control / release management
- Project management tools
- Process models

The following learning objectives were also identified in the model [3]:

- Team project involvement (team building / management)
- Project plan creation (including estimation, scheduling, resource allocation, configuration and change management and risk identification / management)
- Determine a risk approach
- Compare / contrast quality assurance techniques

The foregoing is attributed a minimum core coverage time of three hours [3] (which means three contact hours devoted to the topic plus ancillary time devoted to related out-of-class work). In addition to providing additional depth in the foregoing areas (and allowing students to work on a larger than typical-classroom project to gain experience), other topics were included. These included:

- Project Initiation / Definition and Planning
- Work Breakdown Structures
- Budgeting
- Control (which is related to several of the model's points but not directly stated)
- Change Management
- Deliverable Management

- Issue Management
- Additional Risk Management areas
- Additional Quality Management areas
- Project Leadership
- Communications Management
- Expectations Management
- Performance Management
- Conflict Resolution
- Project Closeout

For each area students demonstrated knowledge acquisition via 'flipped classroom' discussions and use in managing the ongoing project or planning for it. Practical skills were also gained and demonstrated via use in the context of the project. The course approach is discussed in the subsequent section and experimental design for assessing student learning is described in Section V.

4 Course Overview

The work undertaken was performed in the context of the instruction of the University of North Dakota's CSCI 297 course. At UND, CSCI 297 is an open-format experiential learning opportunity. The project management implementation (which is planned to be offered again in future semesters) was a one-credit elective targeted at sophomore and junior-level students.

While a few initial lectures were given to provide an overview of the course and set expectations, the majority of the course was conducted via the PBL technique. A limited number of 'flipped classroom' style discussions were used to ensure students acquired, understood and could apply knowledge relating to areas that it was not possible for them to gain direct experience with.

During the course of the class, students selected one of the OpenOrbiter software teams and, for this team (based on information collected from other team members) they:

- Created a project definition document
- Created an overview of deliverables and their elements
- Created a work breakdown structure for the group
- Used the work breakdown structure for estimation
- Created a schedule for the group (including dealing with dependent tasks and fixed start/end date tasks, where applicable)
- Used Microsoft Project to build some of the foregoing
- Presented their work as a poster at a local event related to space robotics
- Broke in to two-person teams which each developed two operations-phase (risk / issue / change / etc. management plans)
- Adapted their plans based on supplied additional information that they were

required to consider
- Provided critical feedback to their classmates via verbal discussions and anonymous feedback cards
- Interacted with team members from the team that they were supporting to gather information and gain buy-in for their proposed plans

This one-credit course met once a week. Students were also expected to attend the weekly meeting of the group that they were supporting. Some got involved in the activities of their group beyond they requirements of the class, while others focused their involvement primarily on class activities.

4 Results

Students were given a knowledge pre- and post-test. This test consisted of questions from two common project management books, commonly used in higher-level courses. These were selected to prevent students from 'topping out' the scale if they fully mastered the material. Scores on the pre- and post-test, including the level of gain, are presented in Table 1. Notably, both the pre- and post-test were given unannounced, preventing students from having an opportunity to study or otherwise prepare and, thus, representing actual knowledge retained through experience (and de-confounding the impact of short term gains attained from cramming).

TABLE I
EVALUATION RESULTS.

	Pretest	Posttest	Difference
Form A - Form A			
Pre-testers Only	50%	67%	17%
Form A - Both		59%	9%
Form B - Form B			
Pre-testers Only	56%	67%	11%
Form B - Both		66%	10%

Students were also asked to identify areas of benefit that they received from participation in the course (and related participation in the larger project). They participated in a pre-survey (along with students in the program but not in the class) of expected benefits (the results of which were presented in [35]). Figure 1 presents the areas identified as the most important benefits received.

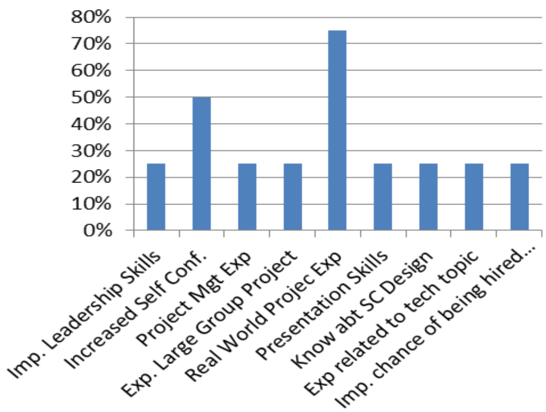

Figure 1. Top Areas of Benefit Identified by Participants.

5 Conclusion

This paper has presented an overview of the CSCI 297-Software Project Management Through Experiential Learning course offered at the University of North Dakota. It has demonstrated student learning has occurred in the courses. However, due to the lack of an objective standard for comparison to, it is impossible to say (with any certainty) how the performance of the approach taken compares to other approaches taken at other institutions that may offer courses with similar content. Thus, the extrapolation of this work, in the absence of comparative data is not practical.

Future work will include additional assessment of the performance of students in this course over multiple offerings and analysis of the differences in projects and other factors on student learning outcomes.

6 Acknowledgements

Small satellite development work at the University of North Dakota is or has been supported by the North Dakota Space Grant Consortium, North Dakota NASA EPSCoR, the University of North Dakota Faculty Research Seed Money Committee, North Dakota EPSCoR (NSF Grant # EPS-814442), the Department of Computer Science, the John D. Odegard School of Aerospace Sciences and the National Aeronautics and Space Administration.

The involvement of the numerous students from multiple disciplines in UND small satellite development is gratefully acknowledged. Also, thanks are given to the numerous faculty mentors who have helped make this possible.

References

[1] M. Keil, A. Rai, J. Cheney Mann and G. P. Zhang. Why software projects escalate: The importance of project management constructs. *Engineering Management, IEEE Transactions On 50(3),* pp. 251-261. 2003.

[2] B. Wysocki Jr. Some firms, let down by costly computers, opt to 'De-engineer,'. *Wall Street Journal 150(84),* 1998.
[3] K. De Bakker, A. Boonstra and H. Wortmann. Does risk management contribute to IT project success? A meta-analysis of empirical evidence. *Int. J. Project Manage. 28(5),* pp. 493-503. 2010.
[4] P. L. Bannerman. Risk and risk management in software projects: A reassessment. *J. Syst. Software 81(12),* pp. 2118-2133. 2008.
[5] J. Straub, J. Berk, A. Nervold and D. Whalen, "OpenOrbiter: An Interdisciplinary, Student Run Space Program," *Advances in Education,* vol. 2, pp. 4-10, 2013.
[6] N. Mathers, A. Goktogen, J. Rankin and M. Anderson. Robotic mission to mars: Hands-on, minds-on, web-based learning. *Acta Astronaut. 80*pp. 124-131. 2012.
[7] E. Bütün. Teaching genetic algorithms in electrical engineering education: A problem-based learning approach. *Int J Electr Eng Educ 42(3),* pp. 223-233. 2005.
[8] N. Robson, I. S. Dalmis and V. Trenev. Discovery learning in mechanical engineering design: Case-based learning or learning by exploring? Presented at 2012 ASEE Annual Conference. 2012, .
[9] U. Qidwai. Fun to learn: Project-based learning in robotics for computer engineers. *ACM Inroads 2(1),* pp. 42-45. 2011.
[10] G. N. Saunders-Smits, P. Roling, V. Brügemann, N. Timmer and J. Melkert. Using the engineering design cycle to develop integrated project based learning in aerospace engineering. Presented at International Conference on Innovation, Practice and Research in Engineering Education. 2012, .
[11] N. Correll, R. Wing and D. Coleman. A one-year introductory robotics curriculum for computer science upperclassmen. *Education, IEEE Transactions On 56(1),* pp. 54-60. 2013. . DOI: 10.1109/TE.2012.2220774.
[12] G. E. Okudan and S. E. Rzasa. A project-based approach to entrepreneurial leadership education. *Technovation 26(2),* pp. 195-210. 2006.
[13] C. E. Pollard. Lessons learned from client projects in an undergraduate project management course. *Journal of Information Systems Education 23(3),* pp. 271-282. 2012.
[14] A. Edwards, S. M. Jones, E. Wapstra and A. M. Richardson. Engaging students through authentic research experiences. Presented at Proceedings of the Australian Conference on Science and Mathematics Education (Formerly UniServe Science Conference). 2012, .
[15] T. L. Bauerle and T. D. Park. Experiential learning enhances student knowledge retention in the plant sciences. *HortTechnology 22(5),* pp. 715-718. 2012.
[16] L. Simons, L. Fehr, N. Blank, H. Connell, D. Georganas, D. Fernandez and V. Peterson. Lessons learned from experiential learning: What do students learn from a practicum/internship?. *International Journal of Teaching and Learning in Higher Education 24(3),* pp. 325-334. 2012.
[17] A. Ayob, R. A. Majid, A. Hussain and M. M. Mustaffa. Creativity enhancement through experiential learning. *Advances in Natural and Applied Science 6(2),* pp. 94-99. 2012.
[18] Y. Doppelt. Implementation and assessment of project-based learning in a flexible environment. *International Journal of Technology and Design Education 13(3),* pp. 255-272. 2003.

[19] D. Breiter, C. Cargill and S. Fried-Kline. An industry view of experiential learning. *Hospitality Review 13(1),* pp. 8. 2013.
[20] J. F. D. Nielsen, X. Du and A. Kolmos. Innovative application of a new PBL model to interdisciplinary and intercultural projects. *Int J Electr Eng Educ 47(2),* pp. 174-188. 2010.
[21] J. Straub and D. Whalen. An assessment of educational benefits from the OpenOrbiter space program. *Education Sciences 3(3),* pp. 259-278. 2013.
[22] R. A. Deepak and R. J. Twiggs. Thinking out of the box: Space science beyond the CubeSat. *Journal of Small Satellites 1(1),* pp. 3-7. 2012.
[23] M. J. O'Grady. Practical problem-based learning in computing education. *ACM Transactions on Computing Education (TOCE) 12(3),* pp. 10. 2012.
[24] California Polytechnic State University, "CubeSat design specification, revision 13," California Polytechnic State University, San Luis Obispo, California, August 19, 2013. 2013.
[25] J. Berk, J. Straub and D. Whalen, "Open prototype for educational NanoSats: Fixing the other side of the small satellite cost equation," in *Proceedings of the 2013 IEEE Aerospace Conference,* Big Sky, MT, 2013, .
[26] J. Straub, C. Korvald, A. Nervold, A. Mohammad, N. Root, N. Long and D. Torgerson, "OpenOrbiter: A Low-Cost, Educational Prototype CubeSat Mission Architecture," *Machines,* vol. 1, pp. 1-32, 2013.
[27] J. Straub, "Increasing National Space Engineering Productivity and Educational Opportunities via Intrepreneurship, Entrepreneurship and Innovation," *Technology and Innovation,* vol. 15, pp. 211-226, 2013, 2013.
[28] M. Swartwout. AC 2011-1151: Significance of student-built spacecraft design programs it's impact on spacecraft engineering education over the last ten years. Presented at Proceedings of the American Society for Engineering Education Annual Conference. 2011, Available: http://www.asee.org/file_server/papers/attachment/file/0001/1307/paper-final.pdf.
[29] M. Swartwout. University-class satellites: From marginal utility to 'disruptive' research platforms. Presented at Proceedings of the 18th Annual AIAA/USU Conference on Small Satellites. 2004, .
[30] L. Cassel, A. Clements, G. Davies, M. Guzdial, R. McCauley, A. McGettrick, B. Sloan, L. Snyder, P. Tymann and B. Weide. Computer science curriculum 2008: An interim revision of CS 2001. *Report from the Interim Review Task Force* 2008.
[31] R. J. Beichner, J. M. Saul, R. J. Allain, D. L. Deardorff and D. S. Abbott. *Introduction to SCALE-UP: Student-Centered Activities for Large Enrollment University Physics* 2000.
[32] S. D. Kerlin. Designing a SCALE-UP style instructional computer lab. Presented at Proceedings of the Midwest Instruction and Computing Symposium. 2013, .
[33] B. Tucker. The flipped classroom. *Education Next 12(1),* pp. 82-83. 2012.
[34] M. Horn, "The Transformational Potential of Flipped Classrooms," *Education Next,* vol. 13, pp. 78-79, Summer 2013, 2013.
[35] J. Straub and D. Whalen. Student expectations from participating in a small spacecraft development program. *Aerospace 1(1),* pp. 18-30. 2013.