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Implementing Project Managers in the Software Engineering Classroom

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Abstract

Project management is a discipline that spans many industries and has undeniable benefits in its application. Sometimes, however, it can be difficult to convey its importance and application in the classroom environment. Many process and project management classes cover the core concepts, but fail to provide students with the opportunity to experience both the dynamics and leadership elements so core to project management as both a leader and a team member.

This paper describes an innovative approach to using project managers (PMs) in the classroom that has had measured effects in several areas, including individual student participation, group project disposition, and in-class presentations. Results have been encouraging, with student feedback (from both PMs and group members) indicating positive effects on interest in the field and application of project management, improved group dynamics, and more individual participation in the outcome of group projects.

Specifically included in the paper are examples of PM inclusion in both the class curriculum and main project from beginning to end and how they have been applied to a process and project management course in the past. Areas explored include the PM selection process, class attendance improvement via the PM-led group dynamic, PM-specific activities and evaluation, and the inclusion of a final presentation as a product in a normally process and project heavy course. For context, a description of the class curriculum, some related work, and relevant quantitative and qualitative student feedback are included as well.

The concepts and examples have been successfully implemented as part of a software engineering curriculum, but they could easily be applied to any classroom that wishes to expand project management instruction beyond a simple explanation of process and project management to an immersive experience with both practical and pedagogical benefits.

1. Introduction

Process is a major focus of software engineering and its curriculum;[13, 18] because of this, project management has been included as a required topic of study in many of these programs.[24] While project management principles and practices are frequently a part of these classes,[6, 11, 14, 21] many do not include the opportunity to participate as a project manager (PM) or as a member of a PM-led team.[12] It is important to include the hands-on leadership and planning elements that make project management a discipline rather than simply conveying a collection of related methodologies.[8] In many cases, the disciplines involved in project management itself has fallen to the instructors; this is often carried out either through frequent direct intervention with student groups (i.e. leadership) or through heavily structured assignment descriptions (i.e. process). Unfortunately, this may serve to negate the need or desire of individual students to venture into

realistic project management within group work scenarios. As a result, these classes may be neglecting the lessons and skills that all computing students need in a realistic team environment.

At the Rochester Institute of Technology, we have offered an upper division Process and Project Management class within the Software Engineering major since 2003, with a focus including process methodologies, team development, and project management fundamentals. A project component has always been a significant part of this course, but until this point its primary focus has been delivery of project artifacts. In this paper, we describe an innovative approach for including a hands-on project management experience within the project component of the course. Under the supervision of the instructor, who serves as an advisor, students are given the opportunity to volunteer as PMs for the main group project. These PMs are given traditional expectations in managing their group's deliverables and dynamics, but are also expected to participate in a separate PM-only group that enhances their learning experience as well as that of their team members.

This updated project format has been included in at least eight class offerings and has experienced substantial success. Students have stated that it not only increased their knowledge and application of project management as a discipline, but that it has given them an opportunity to interact with project managers as a group member or vice versa. Results, in many cases, have far exceeded expectations, and student feedback has shown praise for both the interactive nature of the project and the resulting final presentation.

2. About the course

Although students are primarily Software Engineering majors, Process and Project Management is also offered to other majors, including Computer Science, Computer Engineering, and Game Design. The only prerequisite is the Introduction to Software Engineering course, a survey course which includes basic concepts core to the major, such as requirements gathering, design, patterns, the concept of quality, and the engineer's focus on identifying and solving the problem. In this prerequisite, students have also been introduced to some of the themes of Process and Project Management as well: teamwork and roles, an introduction to software development process methodologies, and basic scheduling and task management.

Three of the primary goals of this course are to introduce students to the core concepts and artifacts of project management, to continue to reinforce the software engineering process including process models, and to demonstrate the importance of process and project management in the students' chosen discipline. Lectures and texts enhance the concepts with case studies and real-world examples, striving for both present and future relevance. In addition to process, covered concepts include classic mistakes[15] (and anti-patterns[2]), team development, specific software engineering models (waterfall, agile, etc.), risk management, estimating and scheduling, quality and metrics, communication management, and process maturity models. Table 1 includes a schedule of topics covered in this 15 week course.

Table 1: Process and Project Management topics by week

	Topic	**Details**
1	Course Introduction	Course overview, what a project is and why it's important, basic project terms
	Classic Mistakes	Steve McConnell's list of classic mistakes[15]
2	Core Concepts	The project triangle, process and productive work, the cone of uncertainty, etc.
	Teams	Basic concepts (trust, conflict, accountability, etc.), leadership types, Tuckman's model[22]
3	Risk Management	What/when/why, assessment and control, quantification, risk registries
	Lifecycle Planning	Explanations of 10 basic models: waterfall, spiral, evolutionary delivery, etc.
4	Methodology Concepts	Cockburn's methodology structure,[5] plan-driven methodologies (PSP, TSP, RUP)
5	PM Anti-Patterns	What an anti-pattern is and some major examples[2] such as analysis paralysis
6	Agile Methodologies	Agile concepts, comparisons to plan-driven, specific methodologies (Scrum)
7	Estimation	Basic process, challenges, methods, LOC vs. function points, risk reserves, expectation management
	CoCoMo	Constructive Cost Model[4] use cases, calculation, benefit, limitations, use with function points
8	Scheduling	Scheduling concepts, work breakdown structures, sequencing, scheduling tools, tracking, extrapolation and reporting
9	Quality	Definition, relationship with testing, verification and validation, quality assurance, relation to other concepts covered in class
10	Measurement/Metrics	Defined, project/product/process metrics, collection, analysis, examples of metrics and their use
11	Testing	Testing concepts, sweet spot, pooling/seeding/etc., the Testing V Model[7]
12	Change Control	Types of change, maintenance (types, concepts), metrics, software distribution
13	Communications Management	Channels, planning, stakeholders and team communication, professional responsibility
14	Process Quality	Maturity models (CMMI[1]), process frameworks, application of changes to processes

The Software Engineering department considers this 3-credit course the core class in the process track (one of two major tracks) taken by all students in the major. This class is a prerequisite for other classes, such as Software Process & Product Quality and Trends in Software Development Process. Methodologies and processes taught in this class are also a required implementation in the Senior Project capstone which immediately precedes graduation. The department understands that a strong foundation in this area is a vital part of students' future success and the reputation of the college.

Software Engineering majors typically take this course in their third year, and it often directly proceeds or follows students' required one-year cooperative internship (co-op). For many students, this time period is a watershed moment, as upper level courses and co-ops often have the effect of encouraging the student to realize their area of focus and concentration. Though not always an explicit minor, students naturally begin to specialize in areas such as testing, design, enterprise or web systems, process and project management, or other related disciplines.

While most students are not likely to become PMs directly upon graduation, we do expend effort to allow students to see the value of the discipline and its individual practices, which will inevitably come into play in the modern team-based computing environment. Half of class time is devoted to lectures, and the remainder is reserved for reinforcing activities, discussion, and group work time. Students are graded in several criteria including short quizzes, three exams, individual and group activities, and a large group project (detailed below). Class sizes have typically ranged from 20 to 35 students.

3. About the project

This course has always had a major project component, as exposure to both the expectations and the artifacts within a typical project has been an objective since its inception. This project has been in many ways similar to those in other classes: groups are assigned, each group is required to complete a paper, and all are required to present findings to the class at the end of the term.

While the problem statement has varied, the artifact deliverables have remained consistent with a typical project plan: an overview and scope, list of functional and nonfunctional requirements, methodologies overview, schedules and their justifications, risks, metrics, and lessons learned. Deliverables are turned in three times, with each building on the previous version. Groups participate in cross-team feedback with other groups, and a 10-15 minute final presentation takes place during the last week of the semester. Opportunities for group members to provide feedback on each other's performance are in week 12 and 15 (the end of the semester). Table 2 contains the main activities and their typical timetable.

Table 2: Project Activity by Week

	Activity	**Details**
1-5	Pre-Project	Students are encouraged to review the project outline
6	Project Begins	Required deliverables and due dates set
9	Draft 1 Due	Outline, risks, scope, requirements
10	Cross-Group Feedback 2	Feedback effort is graded
12	Draft 2 Due	Update draft 1, methodology, estimating, and scheduling
12	Peer Evaluation 1	
13	Cross-Group Feedback 2	Groups are encouraged to refer to previous feedback
14	Final Version Due	Updates to draft 2, lessons learned
15	Group Presentations	10-15 minutes in length
15	Peer Evaluation 2	Completed after final presentation

Because of its similarity to other paper-based group projects, students have been familiar with the format and competent at completing the assignment, but many have felt that it was merely an extension of individual assignments and have treated it as such. It had become evident that student groups have been dividing work ineffectively and inconsistencies in both the content and flow of their papers and the final presentation have demonstrated this ineffectiveness. These symptoms and the desire to allow students to have a PM-led experience (see the Related Work section) have prompted us to make some changes to both the project and its disposition.

The first significant change is the inclusion of a formal PM role within the group project. Students are notified on several occasions prior to beginning the project that the final project teams are to be led by a voluntary PM. At the same time, students are told that the PM will have the opportunity to earn a higher grade, as peer evaluations are a significant part of the grade and positive leadership as a PM is a good way to earn higher evaluations. Those who are considering volunteering are asked to review the PM Activity Guide, a document that specifies their responsibilities as a PM (included as Appendix 1). Additionally, they are asked to note preferred team members for an opportunity to be afforded to them in group assignment efforts later in the semester. Group assignments early in the semester, in-class activities, and previous interactions with other students are useful in assisting with evaluation of potential team members.

Table 3: Project Manager Activity by Week

	Activity	**Details**
1-5	Consideration	Potential PMs consider volunteering
6	Project Begins	Volunteer as PM, final roster selection
7-11	Weekly Check-Ins	Cross-team problem solving
9-14	Deliverables Due	Manage group schedule, division of work, accountability
12-14	Presentation Differentiation	PMs meet at least 2x, provide summary to the instructor
15	Group Presentations	Report order of presentations to the instructor
15	PM Peer Evaluation	Completed after final presentation

Selection of the PMs takes place at the start of the project directly after the first midterm, roughly one third of the way through the semester. The process is public, by show of hands, and is continued until the appropriate number of PMs have volunteered. Students and instructors are rarely surprised at who has chosen to volunteer, as many have worked together in previous classes or even in the early part of the current class. So far there have always been an appropriate number of volunteers, and rarely have any volunteered who did not receive the opportunity to participate as a PM. Previous efforts have yielded between 1/4 and 1/5 of the class — an appropriate number, as 4 or 5 students per group is desirable. An evaluation of Midterm 1 grades (which occurs before PM selection takes place) has shown — motivation and leadership drive notwithstanding — that PM volunteers have only a slightly elevated average grade when compared to their group members. Further data concerning grade averages, group size, and grade distribution is available as Appendix 2.

The second change has been to treat the PMs as a separate group, requiring them to cooperate in several separate activities. The first activity exclusive to this group is the formation of the teams that they will each lead. This takes place immediately after selection of PMs and is a private negotiation process between PMs, as not to embarrass team members who are chosen near the end. As the semester progresses, PMs are called together weekly to check progress, answer questions about upcoming deliverables, and to mutually benefit each other in these exchanges. Checking attendance is integrated as well; PMs are asked if any of their group members are missing and, if so, whether they had indicated to the group their expected absence. At the end of the semester, PMs are required to evaluate each other in the areas of teamwork, knowledge and

skills, dependability, initiative and creativity, adaptability and flexibility, and delivery of results. Table 3 contains the main activities and their typical timetable, and Appendix 1 includes a description of PM activities and expectations.

The final and possibly the most unique change to the project relates directly to the separate PM-only group. As a group, the PMs are expected to initiate a way of differentiating the final presentation. Because each group is completing a project with the same guidelines, case study, and deliverable, the final presentations can be both repetitive and rather difficult to grade, with later-presenting groups unfairly benefiting from the insights or mistakes of their predecessors. Relating to their task of differentiation, some guidelines and previous examples are given, but the task is intentionally left up to the PMs. They are required to meet twice near the end of the semester and to provide a meeting summary to the instructor.

Benefits to this differentiation are seen in both the presentation itself and the reported engagement of the students both before and after the presentation. Because of the requirement to differentiate, group members are forced to prepare something other than a rehash of their paper. During the presentation itself students are more likely to listen, participate, and learn because the other groups' presentations are each significantly different (see survey results in the Student Feedback section). Although the project deliverables do not extend beyond project documentation, we feel that the opportunity to create something unique in the final presentation can act as a de facto product for the team, giving them the satisfaction of creating something besides an unimplemented project plan.

4. Project results

Class dynamics have generally been positive since the implementation of the project changes. The grouping of students has allowed them to participate in class activities as larger units as application and combining of concepts becomes a more prominent part of the course. The instructor has been able to call on groups rather than individuals to answer a question, seeming to result in less individual embarrassment or awkward class flow and in a more positive cooperative effort.

Because of the group selection technique, instances of a "super group" or a "left-over" group formed after others have banded together has become less common. Although there are still instances of groups that perform significantly better or worse than their peers, final grade distribution typically indicates that groups have a good mixture of students. In many instances, the PMs apply the team-building principles learned in the first part of the course not only to group management, but also in consideration and selection of the team members themselves. Overall, this has resulted in more diverse, and therefore more consistently successful, groups.

The experience within the group project has also had positive effects on the students individually. In many cases, students have discovered or cemented a desire to pursue project management as their chosen field, and have attributed that choice at least in part to the class

project experience. Additionally, many students have reported that lessons learned within their group were immediately applicable in co-ops or other classes, and viewed group work differently than they had previously. Both PMs and group members have indicated that the experience also made them better team members, as they had a greater knowledge of the responsibilities of a PM and were able to assist in ways they previously had not even considered. These results have been in line with pedagogical goals, especially demonstrating the importance of process and project management in the academic and work environment.

Diversification of the final presentation has also had surprising effects. The PM groups, tasked with working together to make the final presentation more interesting and less repetitive, have come up with some very innovative ways of doing this. Some of the best results have come from simple ideas like combining all groups' slides into one deck for presentation — eliminating much of the downtime between presentations and some of the unfair advantage that later presenting groups hold over their predecessors. PMs have also served as timekeepers for other groups, monitored their team members to ensure they are paying attention, and have reviewed each other's planned presentation against the published rubric beforehand.

The most typical method of final presentation diversification has been to either divide by subject area (i.e. risks, methodology, etc.) or to focus more on what each group has done differently rather than repeating similar parts of their project implementation, and a list of example results is included in Appendix 3. In our opinion, the resulting presentations have been more interesting and have required students to be more engaged in both the preparation and disposition of their contribution.

Student feedback has been generally positive, and is discussed in the next section.

5. Student feedback

Students have expressed high satisfaction with various elements of the group project within the course. In a voluntary survey given at the end of the semester, students were asked to compare previous group work issues with those encountered during this class. Issues reported as previously common but reduced for the duration of this project included poor time management and organization, lack of leadership, complications with division of labor, communication breakdown, and failure of teammates to show up to meetings. The survey also asked for general feedback on the group project. Some of their responses were as follows:

> "I really like how the project managers volunteered for the position, because it meant that they were willing to put forth the effort to manage the group, and as a result I felt more motivated to participate as a member."

> "The use of project managers helped keep our group on track, moving forward and not waiting until the last minute to start working on each section."

> "The project managers were helpful because it gave our group a certain line of communication with the professor, which was more helpful than individually having questions answered. I liked the idea of all of us presenting one big presentation with each group in charge of a specific part."

> "I think the use of project managers really helped highlight the things we were learning in this class — at least that was the experience I had in my group. When you have a proactive PM who is good about getting people to show up to meetings and actually getting their work done, it becomes much easier to complete a project, and do it well."

Students were also asked questions related to learning, project success, and engagement with the field of project management. Questions were answered using a standard Likert scale. Table 4 lists statements and the percentages that agreed or strongly agreed. Respondents comprised of 90% or greater of classes surveyed. 21% of respondents participated as a PM.

Table 4: Survey questions and results (% who agree/strongly agree) from PMs and group members

The Field of Project Management	**PMs**	**Group**
The use of project managers in this course enhanced my understanding of project management as a discipline	100%	85%
The use of project managers has increased my interest in the field of project management	100%	84%
Project Manager-Led Groups		
The project manager group made time management and transitions between presentations easier or less intrusive	100%	91%
The opportunity to participate as a project manager increased my overall satisfaction with the course (even if I did not choose to participate as a project manager)	100%	73%
Overall, the use of an assigned project manager improved group dynamics	88%	84%
Overall, the use of an assigned project manager made my group project more successful	100%	91%
Diversification of the Final Presentation		
I feel that I learned more from diversification of the groups' presentations than I would have if each group had presented similar material	87%	87%
My preparation and engagement for the presentation was more interesting because of diversification of the groups' presentations	100%	86%
Other groups' presentations were more engaging because of diversification of the groups' presentations	88%	82%

In general, students who volunteered to lead a group as a PM were more engaged, stated that they learned more, and expressed greater satisfaction with the project. Students who did not choose to participate as a PM also seemed to have an improved experience, and in some cases have stated that they would like to lead project teams in future classes.

6. Related work

There has been significant development in the areas of both process and project management in the classroom. Previous works have stated the importance of such an educational focus and,

although varied, they lend credibility to providing a more realistic, PM-led team experience in the classroom. Oudshoorn, Brown, and Maciunas[16] discussed implementation of a more realistic problem solving situations for software engineering project teams. Similarly, Villarreal and Butler[23] and Henry and LaFrance[10] emphasized the importance of realistic experience and pioneered methodologies in this area, expressing the understanding that unrealistic classroom situations and projects do not provide as much value as some may believe. Providing a more realistic teamwork experience in the software engineering classroom has also been specifically focused upon by Walker and Slotterbeck,[24] showing the need to address the issue before students have reached their capstone class.

Tan and Phillips[20] outlined an example of bringing more realistic project management scenarios into the computer information systems curriculum. A comparison of project management instruction through heavy use of antipatterns verses patterns in instruction was the focus of research by Staemelos, Settas, and Mallini.[17] Goldin and Rudahl,[9] Albernethy, Piegari, and Reichgelt,[3] and Tan and Jones[19] have presented methodologies for presenting processes in such a way that they become meaningful, such as an experience-based approach or having teams interact directly with clients external to the classroom. Most of these authors have also included explanations of the additional demands that are placed on the instructor, and have in many cases built upon each other's work. When considered as a group, they show a need for more direct engagement by students in the disposition of the project itself, rather than more passive preplanned instructor project management.

7. Future work

This updated project format has been successfully utilized in several sections of the Process and Project Management course, but there are enhancements planned for future sections. Moving forward, one of the main objectives is to provide a group project environment that more realistically simulates both the actual and the ideal project in the real world soon to be encountered by the students. In relation to this, the structure of the deliverables could be organized differently, with more guidance related to individual parts, such as sample risks, less reliance upon the instructor to define what should be included in functional and nonfunctional requirements, and the possible introduction of a mid-project requirements change.

One risk that has so far not been encountered is a lack of or severe surplus of volunteers for the role of PM. This may require more explicit definitions of both the role and contingencies. The role the PM fulfills within their group could also be more explicitly defined by requiring agendas, meeting minutes, and lessons learned at regular intervals throughout the class.

Given that the PMs in the class are relatively inexperienced leaders, surprisingly few issues have been encountered in this area. The negotiation process by the PMs to select team members is not well documented and can vary with personalities and circumstances. The meetings between the PMs in preparation for the final presentation have not encountered any issues, no group has

expressed the wish to expel their PM, and no PM has dropped the class or explicitly chosen to discontinue the role as of yet. While these risks could be solved as they are encountered, mitigation and management strategies should be put in place.

Use of an explicit PM role and deliberate differentiation of the final presentation is something that could be adapted for use in other courses, especially those that have similar projects conducted by multiple groups. As an example, in a class where multiple groups have solved the same problem, the final presentation could, through interaction between groups, completely omit problem definition and instead focus on the differences of the groups' results.

8. Summary

We feel that it is important for students, as part of a process-oriented study, to have the opportunity to experience a PM-led team, either as a voluntary PM or as a team member. This experience could prove valuable to any technical student, because modern work environments frequently require team interaction, with or without a PM or team leader. In response to this, we have developed an innovative project structure which not only fulfills this need but also serves to increase variety and student attentiveness to the final group presentation.

We have witnessed an increase in student satisfaction, improved group dynamics, interest in the field of project management, and a greater understanding of the modern team-driven computing environment. Instructors and surveyed students have noted that groups more thoroughly engage with the project as well as the other students participating in the final presentation. It is our sincere hope that others will find the ideas and results outlined in this paper inspiring, possibly resulting in the choice to make similar improvements to courses or academic programs in which they participate.

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10. Appendices

Appendix 1: PM activities and expectations

Project Manager Activities

The main project component of this course will involve groups with voluntary Project Managers.

Project Manager Responsibilities

- Coordinate team activities, meetings, and deliverables for the duration of the term starting approximately week 6
- Meet with the professor at the start or during class to discuss individual group dynamics/activities or cross-PM coordination
- Meet with other project managers outside of class to conduct cross-PM coordination
- Ensure that team deliverables reflect the available time, resources, and given scope

Project Manager Selection

- Early in the class, individual students should consider whether they would like to fulfill the role of

project manager for the main group project that will start around week 6.

- Project managers will be chosen on a first come-first serve basis around week 6. The position is voluntary, but once a student has committed to the role, he or she must follow through to the end of the semester.

Cross-PM Coordination

Because each group will be presenting similar material, project managers will have the opportunity to differentiate their group project presentations. This will be achieved by meeting and coordinating with other PM's at least twice during the term. Areas of division could include emphasizing differences between groups, presenting separate parts, or focusing on individual subject areas, such as risks, methodology, etc. One of the PMs should also report back to the professor with meeting results and differentiation strategies.

Project Manager Deliverables

- A roster of potential team members, participation in team member assignation negotiation
- PM Feedback Form, to be turned in with the final exam. This form will rate other PM's performance and will contribute to your group feedback score.

Appendix 2: Group size, grade averages and grade distribution before and after including a PM role

Class	Average Group Size (end)	PM Comparative Grade Average (Percentile Rank)	% PMs w/ Highest Grade in the Group	Average High Grade in Group (Percentile Rank)	Average Low Grade in Group (Percentile Rank)
-2	4.3	-	-	80	27
-1	3.5	-	-	77	17
	4 Students	**-**	**-**	**78%**	**20%**
Project changed to include PMs					
1	4.8	38	20	85	21
2	5.2	48	20	90	19
3	4.1	52	33	82	25
4	4	55	25	83	13
5	3.6	56	60	77	20
6	5	60	14	82	13
7	4.1	52	13	85	27
8	4.1	57	38	80	23
	4.4 Students	**52%**	**27%**	**83%**	**21%**

Note: Grade data is based on Midterm 1, which occurs before group selection and is expressed as statistical percentile (not actual grades) Average group sizes are reduced by students exiting the course. Totals are weighted averages.

Appendix 3: Presentations before and after project change

	Focus / Approach	Result(s)/Examples
Prior to Project Change	Comprehensive coverage of project plan and other artifacts	Similar presentations from each team. Main differences in grading (aside from the quality of the artifacts themselves) resulted from better prioritization and time management • Each team puts high priority on the breadth rather than depth of their presentation

After Project Change	Diversification of individual presentations via PM coordination	Distinct presentations, not only team-to-team, but semester-to-semester. Examples have included: • Individual teams emphasizing core areas of the syllabus, such as one team focusing on Risk Management, another on Estimation, etc. • A round-table type discussion (scripted) of how each team approached the problems, emphasizing the differences in their approaches • A 'play' in which each team simulated a phase of project planning resulting in the project plan artifact (their main deliverable) • A TV show format in which each team presented their material in the form of a game show (i.e. 'Requirements Jeopardy', 'The Risk is Right'), complete with commercial breaks advertising things like the Agile Manifesto