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# ADDRESSING CHALLENGES TO TEACH TRADITIONAL AND AGILE PROJECT MANAGEMENT IN ACADEMIA

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## Abstract

In order to prepare students for a professional IT career, most universities attempt to provide a current educational curriculum in the Project Management (PM) area to their students. This is usually based on the most promising methodologies used by the software industry. As instructors, we need to balance traditional methodologies focused on proven project planning and control processes leveraging widely accepted methods and tools along with the newer agile methodologies. Such new frameworks emphasize that software delivery should be done in a flexible and iterative manner and with significant collaboration with product owners and customers. In our experience agile methodologies have witnessed an exponential growth in many diverse software organizations, and the various agile PM tools and techniques will continue to see an increase in adoption in the software development sector. Reflecting on these changes, there is a critical need to accommodate best practices and current methodologies in our courses that deliver Project Management content. In this paper we analyse two of the most widely used methodologies for traditional and agile software development – the widely used ISO/PMBOK standard provided by the Project Management Institute and the well-accepted Scrum framework. We discuss how to overcome curriculum challenges and deliver a quality undergraduate PM course for a Computer Science and Information systems curricula. Based on our teaching experience in Europe and North America, we present a comprehensive comparison of the two approaches. Our research covers the main concepts, processes, and roles associated with the two PM frameworks and recommended learning outcomes. The paper should be of value to instructors who are keen to see their computing students graduate with a sound understanding of current PM methodologies and who can deliver real-world software products.

*Keywords:* Project management, Agile Framework, Computer and Information Science Education, Information Systems education

## 1 INTRODUCTION

The value of teaching Project Management (PM) to computing students has been well researched. In a landmark research paper, “How University Professors Teach Project Management for Information Systems”, the authors assert that software projects fail not because programmers are technically incompetent but largely because software teams and leaders do not possess adequate skills in project management [3]. This useful study also surveys breadth of project management topics coverage in mainstream computing courses and indicate their course titles and frequency of offering in computing programs. In the light of such research studies, we need to research different teaching approaches and prepare our graduates with adequate skills in PM. A well-designed curriculum can produce qualified computing specialists and that is the objective of our paper.

Historically, the basic principles of PM involving the key subtopics of project planning, organizing and control has been introduced to computing and software engineering students using very different approaches. A review of academic PM or software engineering textbooks reveals a wide range of diverse approaches used to teach PM in academia. Today many are addressing the rising popularity of methodologies like the PMBOK® guide which illustrates the proven traditional project management approach [11], [2], [5].

Despite their increasing acceptance in the real world, teaching agile software development and agile PM at universities is lagging. This raises a lot of questions and challenges which we hope to address in this paper. In our study we propose an approach that balances the plan-based methodology with agile. We hope to provide a parallel education on the above two paradigms as both are widely accepted for software development by the industry.

## 2 COMPETENCY FRAMEWORKS IN PROJECT MANAGEMENT AREA

There is substantial focus on learning outcomes and competencies in academia today. The Cambridge English Dictionary defines *competency* as an important skill that is needed to do a job. *Learning outcomes* are statements that describe significant learning that learners should achieve in a course or a program. *Assessment* reveals if the students can reliably demonstrate such learning outcomes usually at the end of a program of study. Reacting to the accreditation bodies guidelines and expectations from employers, various colleges and universities have adapted their curriculum to workforce needs for essential competencies from our graduating students.

It is useful to determine what are key PM competencies and how our programs can address them. Next, we briefly analyse two well researched approaches:

- The PM Curriculum Task Force's approach
- PMI Competency Framework

### 2.1 The PM Curriculum Task Force's Approach

In late 2012 the Project Management Institute (PMI) responded to a global demand from PM Instructors and institutions for a good curriculum by introducing two exemplar courses and 30 knowledge modules that instructors could leverage to teach PM concepts across disciplines [13]. This process was done in a very structured manner and involved substantial funding from the PMI, the world's largest PM association. A series of workshops were conducted to gather learning outcomes and identify key competencies from a global pool of experienced authors and instructors teaching PM. Also in a systematic manner a research instrument gathered faculty input to validate the curriculum guidelines. The guidelines were reviewed by hiring managers at nine project-oriented organizations (e.g. Google, NASA, Oracle, Philips, City of Boston, and City of Winnipeg) who validated the curriculum guidelines and provided feedback to the Faculty Advisory Group [15].

### 2.2 The PMI Talent Triangle

According latest PMI investigation "Companies are seeking added skills in leadership and business intelligence to support longer- range strategic objectives that contribute to the bottom line. The ideal skill set—the PMI Talent Triangle – is a combination of technical, leadership, and strategic and business management expertise" [14].

Remarkably, the research effort for PM curriculum design by faculty, introduced in the previous section, proceeded concurrently and despite the anonymity of both studies, the competencies triangle turned out to be similar. One can conclude with confidence that most other major efforts to identify competencies associated with a successful career in project management such as APM will also conclude that our students should graduate with skills in three areas. That is, the competencies associated with people who manage projects and lead teams, should span into three main categories:

- Strategic and Business Management
- Leadership (Behavioral)
- Technical Project Management

Details associated with the above topics are described in the Figure 1, which presents major elements, considered in each area. It can be seen that the traditional technical competencies must be supplemented with business and behavioural oriented skills.

Table 1. The PM Talent Triangle Competencies

Strategic & Business Management	Technical	Leadership (Behavioral)
<p>Knowledge of and expertise in the organization, helping you align your team in a way that enhances performance and better delivers business outcomes.</p> <p><i>Examples:</i> Business acumen; Competitive analysis, Finance; Operational functions, Strategic planning/alignment</p>	<p>Knowledge and skills, related to specific domains of project, program and portfolio management. The technical aspects of performing your job/role.</p> <p><i>Examples :</i> Data gathering and modeling Requirements management and traceability Project controls and scheduling Earned value management Performance management Risk management Scope management (project, program, or portfolio) Time, budget and cost estimation Agile tools and techniques</p>	<p>The ability to guide, motivate and/or direct others to achieve a goal.</p> <p><i>Examples :</i> Brainstorming Negotiation Conflict management Emotional intelligence Interpersonal skills Problem solving Team building</p>

Finally, note that it is outside the scope of this paper, but if readers are interested in Learning Outcomes associated with the above competencies, they should read the curriculum guidelines [13]. Based on competencies a set of knowledge modules and corresponding learning outcomes ninety learning outcomes have been identified. Instructors can select any of interest to them and map them to competencies.

### 3 COLLATING SCRUM CONCEPTS WITH PMBOK KNOWLEDGE AREAS

In this section we provide basic information about two of the most used methodologies in the project management area – the PMI framework and Scrum.

To present common recommendations for all types of projects the PMI framework defines five Process Groups (Initiating, Planning, Executing, Monitoring and Control, and Closing) and ten Knowledge Areas (Integration management, Scope management, Cost management, Time management, Recourse management, Quality management, Risk management, Communication management, Stakeholder management, Procurement management). While the Process groups present processes of the operational management, the Knowledge areas summarize a wide set of useful concepts, methods, artifacts and tools that help project managers to manage projects efficiently. Also the PMI guidelines recommend to plan and develop a lot of deliverables during the project. These concepts are described in details in *A Guide of the Project Management Body of Knowledge (PMBOK® Guide)* [10] and widely discussed in the literature [7].

While the PMI methodology presents traditional approach in project management, Scrum is now established as the most used agile method. Focusing more on people and interaction [6], than on documentation, Scrum, recognize some of these deliverables but in the most cases doesn't provide straightforward recommendations on their creation.

To emphasize the role of a set of major artifacts and to direct students' attention to most important concepts in project management area a possible way to teach project management is to use the well defined by PMBOK categories in the Process groups and Knowledge areas and to compare how Scrum reflects their context.

Below we provide a short mapping of the PMI Knowledge Areas and Scrum practices that will also help to highlight the major differences in the two approaches.

## **Integration management**

Integration Managements coordinates all aspects of every project, from starting up the project to its closing. The area also coordinates activities such as developing Project Charter, Preliminary Project Scope Statement and Project Management Plan. During project development, other activities like directing and managing project execution, monitoring and controlling project work, as well integrating change control are performed [.

Scrum, on the other hand, implements implicitly some of the above mention concepts. Developing Project Charter is actually not a part of its implementation. As the requirements known at the project start define the Product Backlog, this artifact can be seen as a Preliminary Project Scope. It also could be considered as a Project Plan, as its items will be sorted and the time for their execution will be estimated in order to separate these items into Sprints. In general, the Product Backlog documents all required work during the project and of the work during all process groups.

## **Scope Management**

The main role of Scope Management in traditional project management is to ensure that the project will include the whole required work. To assure the management of the project scope, PMBOK defines processes that track scope definition, control and verification. The needed wok is decomposed through Work Breakdown Structure (WBS), which elements are further estimated and scheduled. During the project execution, the Change control process is initiated if any changes are required.

Unlike traditional approaches, agile methods anticipate changes in the scope. Even more – as the time and the recourses usually are fixed, the changes reflect the scope, redefining the Backlog and Sprints items.

## **Time Management**

This knowledge area concerns task definition, duration and scheduling. Traditional approaches define WBS, prioritize its elements and identify their order. Additionally, the needed recourses are assigned. Thus a project baseline is defined and it is used to track the progress of the project.

Time management in Scrum, on the other side, doesn't expect the project duration to be calculated based on the time estimation of the all tasks. At the start of project, it is not mandatory all requirements to be defined – only an initial list of task with a preliminary estimation is needed to define the Product backlog. During the project execution, when the Product backlog is updated, Scrum controls the tasks via their prioritization and separation into different sprints (Sprint Backlogs). The Scrum team estimates user stories (usually based on the *planning poker* technique) and defines which of them can be completed into one sprint. As all sprints must be finished on time, the uncompleted tasks are moved back to the Product backlog and reassigned to some of the next sprints.

## **Cost management**

To assure that the project will be completed within the approved budget, in traditional project management this knowledge area covers all processes concerning estimating and controlling the project cost. The connection between the project scope, project time and project cost is crucial in the project management area.

Scrum doesn't have explicit regulations concerning the project cost management, it follows the standard financial recommendations like return on investments, net value, etc. [10].

## **Quality Management**

“The purpose of project Quality Management is to ensure that the project will satisfy the needs for which it was undertaken” [7]. PMBOK notes three major components of Quality management - Quality planning, Quality assurance, and Quality control and recommends a lot of procedures like quality reviews to check if the defined quality criteria are met.

Despite Quality assurance is not explicitly defined in Scrum, the three core elements of the quality management are performed in specific way. In practice, quality planning is performed at the start of the project and at the start of every sprint, quality Improvement can be achieved through the sprints, based on daily meetings, sprints reviews and sprints retrospectives. During the sprint, items of the Sprint backlog are completely “done”, and the cross functional team easily take responsibility on the testing. At the end of each sprint, as well at the end of the project, the Product owner accepts or reject the results if they don't match the quality criteria.

## **Risk Management**

Risk analysis and management are core project management practices to minimize the potential project risks. PMBOK emphasizes on activities like risk identification, evaluation, prioritization, etc. As a risk management topic in Scrum can be considered, for example, the use of a risk-adjusted backlog approach to address first the most risk user stories [1].

## **Human Recourse Management**

Typically, organizing and leading the project team is a major responsibility of the project manager. He schedules and assigns the task among team members, motivate them, resolves the obstacles. Unlike traditional project management Scrum supports only three core roles – Product owner, Scrum master, Scrum team. The Scrum master is formally leading the Scrum team, trying to support the team members to complete the project through removing constrains and obstacles instead of just managing them. The Product Owner is mainly responsible for the business value of the project, prioritizing the Product backlog and accepting or rejecting the sprints outcomes [6].

## **Communication Management**

The main goal of project communication management is to provide an effective way of generation and dissemination of the project information. Three main processes - project communication planning, communication managing and communications controlling support the information collection and flow. Also different documents are considered to collect and communicate the information.

Scrum doesn't support formally these three communication processes. The Product owner coordinates the contacts with stakeholders. The communication within the Scrum team goes mainly through the daily meetings.

## **Stakeholder Management**

There is no typical project manager in Scrum, like in most traditional approaches. Here, the Scrum Master communicates effectively with the team members, organizes and facilitates the Daily Scrum. On the other side, the Product owner, as a representative of the customer, is involved in the defining and prioritizing the requirements and the quality control on them in order to assure stakeholders that the business value of the project will be achieved.

## **Procurement Management**

Procurement Management concerns acquiring goods and services for a project from outside the performing organization [7]. The agreements in the traditional approaches are based on specific contracts. Because of the constantly changing scope of agile projects, new formats of the contracts are needed that do not define an exact and unchanging project scope [12].

# **4 PRESENTING AN INTEGRATED CURRICULUM**

A key concern when we introduce new topics such as Scrum is to identify time slots to teach the new topics. We used a useful framework for traditional project management coverage by [4] to reframe the modules for teaching agile. The results are displayed in the tables below. Using the Curriculum guidelines, we identified modules where we might want to teach traditional project management fully and where we might want to introduce agile using Scrum topic coverage. Identifying this proactively allows us to minimize duplication and carve out time to teach a balanced curriculum of traditional PM and agile PM.

In the Table 2 and Table 3 below, we illustrate best practices for Technical and Behavioral KMs, as Business KMs are usually not covered on undergraduate level. **C** implies *Complete* coverage of the topics, **F** describes partial or *Fractional* coverage of the topics and **X** implies almost no coverage or *None*.

Table 2. Summary of Students Performance. Technical KMs and the topics in PM Course and Project.

The Technical Knowledge Modules	PMBOK	Agile
Project Management Principles [T-PM]	C	X
Project Phases and Processes [T-PP]	C	X
Project Planning and Integration [T-PI]	C	X
Project Resource Management [T-PR]	F	F
Estimating Costs [T-EC]	C	F
Project Scheduling [T-PS]	F	X
Opportunity and Risk Management [T-OR]	C	X
Plan and Control Quality [T-PQ]	C	X
Procurement and Contract Management [T-PC]	X	X
Finance and Cost Budgeting [T-FC]	X	X
Project Scope Management [T-SM]	F	C
Project Control [T-CP]	F	F
Business Analysis & Requirements Management [T-BR]	X	X
Project Handover, Closeout, and Reviews [T-HC]	C	C
PM Information Systems and Information Management [T-IS]	F	F

As shown in Table 2, for the Technical Knowledge Modules the traditional approaches cover more elements, in the most cases even *completely*. The same trend is preserved for the Behavioral Knowledge Modules – Table 3. In this area the lack of coverage of a number of elements in the agile methodologies courses is even more pronounced.

Table 3. Summary of Students Performance. Behavioral KMs and the topics in PM Course and Project.

The Behavioral Knowledge Modules	PBBOK	Agile
Plan, Distribute, and Manage Project Communications [B-DC]	C	C
Project Team Building and Motivating [B-TB]	F	X
Project Leadership [B-PL]	F	X
Identifying and Engaging Stakeholders [B-SE]	C	X
Project Organization and Context [B-OC]	I	X
Managing Global Projects [B-GP]	F	X
Virtual Project Management [B-VP]	F	X
Ethics and Professionalism [B-EP]	C	X

With the above two tables we identified a set of lecture modules for teaching traditional agile and PMBOK. Providing these modules for traditional and agile methods, we give students not only knowledge about steps, but also about tools and skills that could be used in both frameworks, as presented in Table 4.

Table 4. Lecture Modules to Teach Traditional and Agile Methods.

Module	Lectures & Topics	Discussions & Assignments & Video Tutorials & Quizzes
1	Lecture 1 - Projects and Project Managers; Core Concepts, Plan-based vs. Agile Approaches	<b>Team Assignment 1</b> - Team Project - Scope and proposed charter (PMBOK) Instructor to approve form teams and assign project as Agile project <b>Discussion 1:</b> Comparison of plan-based approach with agile approach to managing projects.
2	Lecture 2 - Mission, Goals, Objectives, Project Portfolios; Agile Portfolio planning, Products and Alignment with Business	<b>Team Assignment 2 Agile – Project Start</b> Goals for the Product Alignment with Business Product Owner <b>Discussion 2:</b> Team can decide if they want to use pure “Scrum” or “Scrum Kanban” or other Agile hybrid approach for their methodology.
3	Lecture 3 - The Fundamental Importance of Scope; Agile release planning and Product Backlogs	<b>Discussion 3:</b> Scope management, agile vs. plan-based.  <b>Team Assignment 3 – Agile Release Planning</b> Define Stories and requirements, create a backlog, prioritize them, estimate work, assign work
4	Lecture 4 - Work Breakdown Structure (WBS); Scrum and sprints and user stories	<b>Discussion 4:</b> Compare traditional planning and WBS and Sprint planning Video Demo: Compete Project Libre or MS Project WBS, create network, and Resources;

		<p>Agile Tools to consider: Video Demo: Jira, Version One ...</p> <p><b>Team Assignment 4 – Sprint Planning</b> Compare with sticky notes approach for WBS</p>
5	Lecture 5 - Organizing Projects and Project Structures; Scrum Team Structures & Roles	<p><b>Video:</b> Show YouTube video: Scrum in 10 minutes</p> <p><b>Discussion 5:</b> Compare Sprint Team Structure with Traditional Structure</p> <p><b>Team Assignment 5 – Sprint 1</b></p> <ul style="list-style-type: none"> <li>• Introduce the Scrum team and role played by the various members.</li> <li>• Introduce the User Stories</li> <li>• Daily Scrum</li> </ul>
6	Lecture 6 - Project Networks; Sprints; Sprint planning & execution; Sprint review and retrospective	<p><b>Discussion 6:</b> Project Network, critical path and comparison with agile approach (example Sprints)</p>
7	Lecture 7 - Cost Estimation & Schedule Estimation; Scrum Estimation and Velocity	<p><b>Discussion 7:</b> Cost estimation comparison of agile with plan-based</p> <p><b>Team Assignment 5 – Sprint 2</b></p> <ul style="list-style-type: none"> <li>• Daily Scrum</li> <li>• Sprint Review</li> <li>• Sprint retrospective</li> <li>• Monitoring Sprint Progress-Measuring “Done”.</li> </ul>
8	Lecture 8 - Quality and PM; Agile Methodologies and Quality Management	<p><b>Discussion 8:</b> Compare Traditional Quality management with Agile</p> <p><b>Team Assignment 5 – Sprint 3</b></p>
9	Lecture 9 – Tools and techniques to measure progress; Introducing Earned Value (traditional PM); Role of Velocity; Tools	<p><b>Discussion 9:</b> Compare Traditional PM tools with Agile tools to measure project progress and predict project completion.</p> <p>Video Demo: MS-Project; focus on the multiple views (Gantt, Network Diagram, Resource Use) Video Demo: Jira, Version One ...</p> <p><b>Team Assignment 5 – Sprint 4</b></p> <ul style="list-style-type: none"> <li>• Daily Scrum</li> <li>• Sprint Review</li> <li>• Sprint retrospective</li> </ul> <p>Monitoring Sprint Progress-Measuring “Done”.</p>
10	Lecture 10 - Project Team Leadership and Resource Management	<p><b>Discussion 10:</b> PM, Servant PM, Scrum Master, Product Owner</p> <p><b>Team Assignment 5 – Final Sprint</b> Monitoring Sprint Progress-Measuring “Done”.</p>

11	Lecture 11 – Project Risk Management	<p><b>Discussion 11:</b> Comparison of traditional project Risk management with Agile - the Daily Stand-up, Sprint Review and Retrospective</p> <p><b>Team Assignment 5</b> Students wrap up Sprint Project</p>
12	Lecture 12 - Closing and Transitioning a Project to Operations	<p><b>Discussion 12:</b> Comparison of traditional PM closing with Sprint Students wrap up slides for presentation</p>
13 - 15	Course Summary	<b>Project Presentations by Teams</b>

While the grading structure can vary from one instructor or program to another, for the above outline we would prefer a substantial weight be given to discussions and projects. So the following structure is recommended:

- Discussions 30%
- Team project, report and presentation 40%
- Assignments and Tests or Exams 30%

## 5 CONCLUSIONS

In this paper we have articulated a course to provide students with a comprehensive overview of the principles, processes illustrated in the PMBOK Guide, and practices of agile PM using Scrum as a baseline for the methodology. Integrating these topics can offer instructors an opportunity to streamline what students need to know in academia.

We wanted to make sure that students learn industry standard practices and techniques for initiating, planning and executing computing projects using agile methodologies but also are aware of comparable approach using the PMBOK body of knowledge. With our outline students can obtain practical knowledge of agile development frameworks and be able to distinguish between agile and traditional project management methodologies. Students learn how to apply agile tools and techniques in the software development lifecycle from project ideation to deployment, including introducing the agile team environment, roles and responsibilities, and through discussions appreciating both traditional and agile communication and reporting methods.

We have described a unique structure that integrates the traditional plan-based principles and processes from the PMBOK guidelines – a worldwide ISO standard and Agile methods. The PMBOK concepts embraced include the processes of Project Initiation, Planning, Execution, Monitor & Control, and Closing and within this context knowledge area such as Project Integration management, Scope Management, Schedule Management, Resource Management, Cost and Risk Management, Communications Management, and Quality Management. We have illustrated how through a live project implemented only using Scrum, students get to master the Agile approach and the value of Self-Organizing Teams. As they implement the group project in teams of 4 to 6 students they get to master Scrum and the various team roles, Sprint Planning, Reviews and Retrospectives. Even though students are not implementing a traditional plan-based project, the rich discussions that compare traditional processes, tools and techniques with Agile assures us that students get a rich appreciation of both philosophies.

The next steps are to compare the execution of this course in both Europe and America, as well with other implementations as described in [17], [18]. This is critical as the number of lecture hours is slightly different due to the different educational systems. We anticipate that from a learning outcomes perspective that there should not be a significant difference, however, it is worthwhile documenting and comparing student learning and satisfaction. We also will consider adapting other common methods in software specialist education based on the considerations in [8], [9] and [17].

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