

# Project Management in Capstone Design Courses: Student Choices of Current Technologies

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Capstone design course implementations vary with regards to both the amount of project management instruction they provide, as well as expectations of what project management tools students should use and to what extent. There currently exist a large number of project management technologies, of various types and serving different project scopes. Traditional desktop-based tools are intended for large, organization-wide, structured projects. More recently, smaller and more agile web-based project management tools have become popular, in large part owing to their ability to function on mobile platforms and to enable real-time communication between team members. Traditionally, capstone design courses have prescribed the types of project management documents students must produce and favored industry-grade desktop-based tools such as Microsoft Project. In a recent offering of a capstone design course in a management engineering program the instructor did not set any constraints on the type and format of project management documents and tools students were expected to use. Instead, only high-level coaching on the components of good project management was provided. Student teams avoided desktop-based tools altogether and instead chose a variety of web-based tools, favoring those that enabled cloud-based document sharing and task progress monitoring.

Keywords: project management, web-based, technology, communication

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## ***Introduction***

Capstone design projects provide an excellent opportunity for students to practice and for engineering programs to evaluate student project management skills. To aid with the management of complex, multi-stakeholder projects, there exist a large number of project management software tools available to engineering students and professionals alike. Compared to traditional desktop-based tools, modern web-based tools emphasize and enable real-time, online progress tracking and social-network functionalities that facilitate team member coordination.

In a most recent offering of the capstone design course in a management engineering program, students were encouraged to research, select, and use available project management tools that best suited their project needs. This paper outlines a set of project management technologies that were most commonly chosen by students.

## ***Background***

The Canadian Engineering Accreditation Board has identified project management as one of the twelve attributes an engineering student must possess upon graduation<sup>1</sup>. While engineering programs may provide some project management instruction to students

throughout the curriculum and as early as first year (in step with an increased emphasis on design<sup>2</sup>), the most significant 'practice' of these skills is achieved in final-year design courses. Thus, capstone design projects provide an excellent opportunity for students to develop and for programs to assess student project management skills. In a 2005 US survey of capstone design programs, project planning and scheduling, economics, and risk assessment were taught in 72%, 61%, and 29% of programs, respectively<sup>3</sup>. Enabling students to practice project management skills and to maintain project ownership is also important when a capstone project directly addresses a client company's design problem<sup>4</sup>.

Traditional project management assumes the project manager (PM) handles complex projects by logically deconstructing project objectives into simpler, manageable tasks. The PM is assumed to be able to determine how best to schedule tasks using a formalized risk management tool and to integrate tasks into a finished product at the project's completion. Current project management approaches expect PMs to have a good understanding of the project task structure breakdown as well as resource and task scheduling and allocation at project initiation. In the context of capstone design, project management entails, at a minimum, the following sub-activities:

- Breakdown of the design activity into manageable tasks
- Estimation of task duration and interdependencies, as well as task assignment among team members
- Scheduling of tasks, taking into account task and schedule contingencies
- Identification of risks and risk mitigation plans; determining their impact on project schedule
- Management of capital, material and time
- Management of team members

Below we review some popular project management tools and identify common features that support the sub-activities highlighted above.

### Trends in project management tools

Desktop-based project management tools have been traditionally used for structured, organizational-wide scale projects. For example, Microsoft Project<sup>a</sup> requires a PM to input a certain number of hours per week to update an existing approved project plan. The PM inputs into the software the approximate budget, project-specific constraints, milestones, and a developed project task structure. Similarly, Project Kickstart<sup>b</sup> comes with a Gantt chart and a centralized document repository. A wizard assists the PM in creating the project plan using a series of streamlined questions for identifying project obstacles, risks, solutions, and goals, allowing him/her to gain a deeper understanding of the project being managed and to set task parameters for contingent scenarios<sup>5</sup>.

With the rise of social media and the need to improve collaboration among team members, web-based tools have been quickly gaining popularity, with an increasing focus on supporting communication among team members, and less so on the budget and milestone tracking capabilities of desktop tools. Their features are similar to social media platforms, including using user comments and mentions on tasks to bring other team members' attention to the tasks, displays of streams of

activities in a project's progress, and integration with major web-based applications such as virtual cloud storage systems. For example, Google products such as Docs<sup>c</sup>, Drive<sup>d</sup>, Calendar<sup>e</sup>, and Hangouts<sup>f</sup>, allow for real-time, synchronous communication as well as file and calendar sharing and editing. Another web-based tool – Basecamp<sup>g</sup> - focuses on connecting geographically remote team members and neglects the ability to create task dependencies and Gantt charts, or to define deadlines or budgets. Similarly, Asana<sup>h</sup> promotes task management by encouraging users to group tasks into projects and providing automatic notifications in the Asana inbox sent directly to users' emails. It also includes a comprehensive dashboard on project progress indicating tasks completed and remaining, as well as a seamless search feature through projects, tasks, and tags. Another such tool - Trello<sup>i</sup> - takes a unique project management approach with its adoption of the Kanban-like to-do boards for tasks, with sub-tasks integrated as drag-and-drop cards. All reviewed tools have downloadable mobile application versions.

The table below summarizes common features shared by current popular project management tools – both desktop and web based. *Task management* refers to the ability to add, delete, modify, view, comment on, mark as complete, and assign tasks to project team members, or have them follow the task. *Sharing and collaboration* refers to file sharing and management, as well as calendars' syncing notifications. This feature overlaps with the *communication and notification alerts* feature, which also includes the ability to send messages, mention team members on tasks, and automatically receive updates on tasks and projects assigned or following. *Budget and milestone tracking* allows users to manage projects' finances, time, costs, and completion progress. *Issue management* is more widely applicable to software project management tools, such as JIRA<sup>j</sup>, which specialize in quality assurance, bug control, and code testing.

	Task management	Sharing and Collaboration	Communication & Notification Alerts	Budget/Milestone Tracking	Issue Management
MS Project	x	x	x	x	
Project KickStart	x	x		x	
Google products*		x	x		
Basecamp*	x	x	x		
Asana*	x	x	x		
Trello*	x	x	x		
JIRA*	x	x	x	x	x

**Note:** Tools marked with an asterisk are web-based.

### ***Managing the capstone design project***

One of the decisions that capstone design course instructors must make is with regards to their involvement in the students' project management activities. Depending on the capstone program, course instructors might differ greatly in the extent to which they dictate the format of project management activities and documentation. Requirements may vary - from providing templates of the project management documents the teams must maintain, to enforcing the use of a particular project management tool<sup>6</sup> (e.g., MS Project), to providing general guidelines on the types of documents students must maintain and allowing them to generate their own.

Below, we describe a new approach to project management in capstone projects and discuss its effectiveness, shortcomings, and directions for future improvements.

#### **General overview of the program**

The context of this investigation is the capstone design series of courses of the Management Engineering program at the University of Waterloo. It is comprised of two required courses taken by students in their final year. Projects cover a mix of management engineering sub-disciplines, including applied operations research, inventory and supply chain management, and information and decision support systems. By the end of the first course, student are expected to have formed groups of approximately four students, selected a project topic, analyzed the problem, identified the design requirements and specifications, developed a minimum of three conceptual designs, and proposed and delivered a low-fidelity prototype of a chosen design. This preliminary design is then further worked on, implemented, and verified in the second course of the series.

#### **Project management requirements**

Throughout the project duration, student teams are expected to take ownership of the management of their project and to produce and maintain basic project management documents, such as a project schedule and risk register. Formal project management instruction is not provided at any time prior to this course. Since this a co-op program, it is assumed that students will have gained some project management skills in prior work experiences.

In offerings prior to Spring 2015, students attended a two-hour lecture on project and client management at the beginning of the first capstone course. The lecture broke down the various components of project management, as identified by the Project Management Institute<sup>7</sup>. Students were then instructed to use

Microsoft Excel tables or Microsoft Project to produce documentation that addressed a majority of those components, specifically the development of a detailed work breakdown structure, a schedule, a budget, and a risk register. In some earlier offerings, students were even provided specific templates through which they were expected to report their progress in design review meetings. However, students found the effort to complete these templates to be an unhelpful overhead. Rather than serving the goal of improving project management, completion of the template to a satisfactory level became a goal in itself, resulting in the creation of a lot of unhelpful documentation. Overall, the endeavor to prescribe project management tools and specific project management documents was shown to be only partly meeting the goal of improving and assessing student project management skills. To many student teams, project management activities were considered required course work to be completed in parallel with their design project, but not necessarily directly deriving from or assisting the successful completion of the project.

In Spring 2015, a new approach was taken. Specifically, while a one-hour lecture on project management was still held in the first capstone course, it was less prescriptive in nature, instead engaging students in brainstorming a variety of elements that would result in a successful project and letting *them* identify project management components that would be relevant to and useful to consider in their design projects. Students came up with a number of relevant components, largely overlapping with those prescribed to previous cohorts. During the term, teams had to produce four main deliverables covering four design stages: problem analysis, requirements/specifications, conceptual design, and preliminary design. In all deliverables, they were also expected to report on their project management efforts; however, this time the requirements were kept less prescriptive. Specifically, teams were instructed as follows: *"It is up to each team to use whichever project management tools they are familiar/comfortable with. However, the chosen tools need to address (to a suitable extent) all identified components of good project management, including, but not limited to scheduling and milestones, risk management, budget, etc.)"*

Teams varied significantly in the tools they used, the extent to which they used them, and the features they seemed to most benefit from. Below, we identify some main themes that emerged from the class.

#### **Choice and use of project management tools**

No teams reported using Microsoft Project. Although one may assume that this was cost related, the software is provided for free to students at our university. In

contrast, at least four of the fourteen teams chose to rely exclusively on Microsoft Excel and to forego the use of any other project management tools. Excel worksheets were widely used for producing project management tables such as the schedule, the risk register and budget.

Google products were also very popular. In particular, Google Drive and Google Docs were extensively utilized for project document storage, organization, sharing, and for keeping change history logs. Teams also reported using Google Calendar to schedule meetings and record course deadlines.

Of particular interest was the reported use of various communication channels for coordinating work between team members. For example, Facebook Groups and Facebook Messenger were used to enable real-time communication between team members. It appears that for many students, this (in addition to text messages) is a more speedy and reliable form of communication, especially when compared to email.

Four teams reported successfully using or intending to use Asana as their primary project management tool. The most used features were the Gantt chart, calendar, scheduling of due dates, task assignment, communication of tasks to team members on the part of the team leader, and the ability to comment on tasks. Teams lauded Asana's capabilities to function on web and mobile platforms, further indicating student's increased reliance on mobile computing and communication.

Trello and Jira were significantly less popular tools, only chosen by two teams – both working on software-heavy designs. The team that indicated using Trello commented on its ability to track tasks and software features that they intended to implement throughout the term. The software allowed the team to thus manage both course deliverables and their software's features in one platform. The team that sought to use JIRA was also attracted to its fit with software project management. In particular, the team appreciated that JIRA enabled them to manage bug fixes and mitigate launch risks through the use of its release hub.

Some teams chose to also use some lesser known tools. For example, one team reported using Bitrix24<sup>k</sup>, a web-based project management tool. Another team reported using Gantt Project<sup>l</sup> (a free, open-source tool) for very basic project scheduling.

### ***Conclusion and implications***

In summary, we have described an implementation of capstone design course in which students were given flexibility with regards to type of project management tools they could use. Overall, students demonstrated a strong preference for smaller and more agile web-based tools, rejecting large traditional desktop-based tools such as Microsoft Project. An increased emphasis on

and orientation towards mobile computing increased the prevalence of those tools that enabled real-time communication between team members.

While the diversity of tools used poses some difficulties for the course instructor in evaluating student project management efforts (at least in the traditional sense), it also offers significant trade-offs in terms of increased student ownership and buy-in of project management efforts.

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<sup>a</sup> <https://products.office.com/en/project/project-and-portfolio-management-software>

<sup>b</sup> <https://www.projectkickstart.com/>

<sup>c</sup> <http://docs.google.com/>

<sup>d</sup> <https://drive.google.com/>

<sup>e</sup> <https://calendar.google.com/>

<sup>f</sup> <https://hangouts.google.com/>

<sup>g</sup> <https://basecamp.com/>

<sup>h</sup> <https://asana.com/>

<sup>i</sup> <https://trello.com/>

<sup>j</sup> <https://www.atlassian.com/software/jira>

<sup>k</sup> <https://www.bitrix24.com/>

<sup>l</sup> <http://www.ganttproject.biz/>