Development of a Project Management Tool for Undergraduate Product Design Teams

by

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B.S. Mechanical Engineering
Worcester Polytechnic Institute, 2013

Submitted to the department of Mechanical Engineering in partial fulfillment of the requirements for the degree of:

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Submitted to the Department of Mechanical Engineering on May 18, 2016 in Partial Fulfillment of the Requirements for the degree of Master of Science in Mechanical Engineering

Abstract

A project management tool was developed for student use in a product development course, Product Engineering Processes (known as ’2.009’), at the Massachusetts Institute of Technology (MIT). The goal was to equip students with a management tool to support their work effectively throughout the class, and establish product development habits that will serve them professionally. Productive use of project management tools is often a challenge in industrial practice; requiring effort to learn, prescribing workflows, and is considered time spent away from actual product development efforts. Use of project management tools in an educational context presents similar challenges. It is an important issue, as good project management is shown to improve team effectiveness, and poor project management is regarded as one of the most significant influences on negative outcomes.

The primary intention for a custom project management tool in the product design course was to provide a core set of features that meets critical project management needs for student teams in the context of 2.009, without the distraction of additional features seen in other tools. Those core features include: a shared calendar, shared task lists, a file repository, and chat rooms, within a structure that allows for use of these features in sub-groups of a team, as well as a whole team.

The alpha prototype of this project management tool was developed and provided for student use in 2.009 during the fall of 2015, without chat functionality. Had the tool had been thoroughly integrated into a team’s workflow, such that every team member would refer regularly to the tool website, it was believed that it would have helped teams more efficiently schedule meetings, assign project work, and understand the current state of the team’s workload. Most teams did not use the new tool at all, while some teams used select features of the new tool with, however, only one or
two team members utilizing the functionality. After the course ended, students indicated that the provided tool did not sufficiently meet specific needs of their teams; that students preferred using collections of features in tools they were familiar with prior to the course, and that the project management tool was not well integrated with other tools that students already use. The selection of familiar tools of their own choosing, rather than learning a new, recommended tool seems to be a common trend amongst students. It might be compared to the phenomenon known as the ‘Ikea effect’, where a person finds greater value in assets that he or she influenced somehow, whether by making customization choices or contributing to the formation of the asset itself. While 2.009 students consistently choose to use project management resources other than those provided or suggested by the course, there was no evidence they enable better project management or greater team-wide adoption.

Results from implementing the alpha version of this project management tool in 2015 indicate that there are several challenges in increasing adoption by 2.009 students, but that there are also multiple mechanisms through which to encourage greater use; by both design and extrinsic motivation. The design of the tool must include the chat feature in its next iteration, for the communication channels of email and apps like Group.me and Slack were perhaps the most effectively adopted elements of project management for teams. In a broader scope of design, other features that would add to the usefulness of the tool include: timesheet entry, and a budget-tracking feature that helps course administrators interact with teams and MIT’s financial system more smoothly. In terms of extrinsic motivation, the tool should be marketed more forcefully; even intrinsic motivation by students to adopt alternate project management tools generally failed, so requiring teams to actually use this tool, and establish repercussions for teams who do not, might increase real adoption. This approach will more closely mimic the experience of working for a design firm, which will have certain tools and processes that employees are required to use.
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Kim Loomis
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Ben Peters

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I. Introduction

In an undergraduate senior mechanical engineering course taught at MIT, eight teams of 20-25 students are charged with developing a looks-like, works-like prototype and preliminary business model of a new product during a 3-month semester. The structure of this course is designed to emulate a process that teams might follow at a product design firm, or in a startup company. The course, Product Engineering Processes (known by its course number as 2.009: http://www.mit.edu/2.009), has been taught yearly since 1995.

While many aspects of the course have been optimized in that time, the student teams' ability to formally manage their projects has been consistently ad-hoc. No specific project management methodologies are required in 2.009, but specific web-based tools, such as custom wiki sites, and Teamwork Projects (https://www.teamwork.com/project-management-software) have been provided and configured with the intent to enable more effective project management for teams. Because project management has been, and still is, a persistent challenge for teams, and existing project management tools have insufficiently supported teams this course, it was decided that a custom project management tool should be developed and provided to students in 2.009.

Effective use of project management tools help teams manage their internal resources and project work during the course of a project effort (Ghioca, 2011). Conversely, poor project management is regarded as one of the greatest negative influences on project outcomes, resulting in cost, quality & time constraint issues, in addition to communication issues and inefficient use of resources (Alexander, 2015).

1.1 What is Project Management?

According to the Association of Project Management, the benefits of effective project management include: a greater likelihood of achieving a desired project result, ensuring efficient and best value use of resources, and satisfying the differing needs of the project’s stakeholders ("What is project management? | Association for Project Management," n.d.). The primary functions for which project managers use project management software include: planning projects, managing tasks, sharing and collaborating on documents, sharing calendars and contact lists, managing issues or bugs, and tracking time (Quinn, 2010).
In 2009, project management encompasses all the activities related to organizing the team and the team’s working efforts. Teams must coordinate a large group of people (compared to most educational settings), that is organized in a relatively flat hierarchy and whose members are working simultaneously on different parts of a changing project. Therefore, a project management tool should especially help clarify digital and physical project tasks for sub-groups and individual team members to complete, provide access to team documents, and help coordinate meeting and working times for subgroups and the team as a whole. As project management has become a more formalized practice in project groups, digital, often web-based tools have been developed to support project management practices. There is an abundance of tools available to support project management in different industry contexts, at different scales of team size, and for different working models.

1.2 Why Develop Another Project Management Tool?

Staff members regularly identify project management as an unsolved problem for teams in 2009. Guidelines for effective team management practices are provided to students, and digital tools have been provided for use, as well. Generally, teams have not used the tools provided, often choosing alternative tools for what they envision their project management needs to be. Often students choose tools they are already familiar with, or a tool for which a small number of team members advocate. When alternative tools are used, staff has found that those tools often limit the students’ abilities to manage their projects.

With so many project management tools commercially available, one would expect that a tool already exists that meets the basic needs of 2009 teams or an educational setting. After exploring many popular project management tools (details of this exploration are presented in section 1.4), and observing 2009 project management activities closely, it appeared that the working model of students in 2009 is different from the working models that these tools are designed for. Often, there were additional features that created the impression of steeper learning curves. This mismatch could be one of the reasons that the effectiveness and adoption of existing tools remains low.
1.3 The Context of 2.009

The working model of students in 2009 is multifaceted. The course structure itself defines the iteration cycles that teams need to work toward throughout the semester. At the beginning of the semester, each team develops several ideas in parallel. The fidelity of subsequent iterations increase, and teams down-select which concepts to continue developing. This development progression is illustrated in Figure 1. Ultimately, each team presents one alpha prototype product at the end of the semester. The team structure also changes throughout the semester, to support the changing workload of prototyping different product concepts. The organizational chart in figure 2 depicts the overall personnel architecture of the course. The focus of this thesis aims to support student work, as the students drive the development of products in 2009, but several professionals act as consultants for the whole class, and many are assigned to each team to help guide the process, as well.

---

**Figure 1: A Team Structure and Milestones in 2.009**

**Figure 2: 2009 Organizational Chart**

---

**Lab Sections - Performing Product Design and Development Activities**

<table>
<thead>
<tr>
<th>Technical Managers</th>
<th>2 instructors</th>
<th>2 instructors</th>
<th>2 instructors</th>
<th>2 instructors</th>
<th>2 instructors</th>
<th>2 instructors</th>
<th>2 instructors</th>
<th>2 instructors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consultants</td>
<td>3-5 mentors from industry</td>
<td>3-5 mentors from industry</td>
<td>3-5 mentors from industry</td>
<td>3-5 mentors from industry</td>
<td>3-5 mentors from industry</td>
<td>3-5 mentors from industry</td>
<td>3-5 mentors from industry</td>
<td>3-5 mentors from industry</td>
</tr>
<tr>
<td>Consultant</td>
<td>6 Machine Shop Staff</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consultant</td>
<td>5 Communications Instructors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consultant</td>
<td>1 Course Librarian</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

**Lecture - Teaching Development Process and Methods**

<table>
<thead>
<tr>
<th>CEO</th>
<th>1 Course Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aides</td>
<td>4 Course Teaching Assistants</td>
</tr>
</tbody>
</table>
Each of the eight teams in 2.009 every year has 20-25 students and initially is split into two sub-teams. The sub-teams will merge into one with the selection of the final product the team decides to develop. For several weeks prior to that point, each of the 16 sub-teams in the course works separately. First, the sub-teams generate product ideas, then present three concepts in a pitch format. Next, each sub-team prototypes a critical component (considered a sketch model) for each of those three concepts. Then, the sub-teams select two of those three product concepts, building a more complete prototype (a mockup) of each. The sub-teams then merge and select one of the four product concepts. The next prototype involves creating a digital assembly of the whole system for the Assembly Review. The Technical Review evaluates the team’s implementation of a nearly complete version of the assembly, then the final prototype is built and presented.

Early in the semester, each sub-team assigns roles to its members. These roles include:

**System Integrator** – in charge of project management within the sub-team

**Financial Officer** – in charge of budget

**Tool Officer** – in charge of maintaining the workspace

**Information Officer** – to interface with librarians for research help

**Team Site Master** – in charge of maintaining the project management website

**Safety Officer** – in charge of enforcing safety procedures

**Yoda** – in charge of mediating conflicts and managing human resources

The roles help designate specific duties in an otherwise flat hierarchy. More details about the team roles can be accessed on the course website. Another layer of organization helps students self-organize for development efforts: task forces. Sub-teams typically assign work among ad-hoc groups of team members according to the product concepts that are in development for the next milestone (i.e. a group of four students might be designated the 'e-ink sign task force'). It is expected that new task forces are created regularly to appropriately organize and reorganize team members into working groups to complete project activities as the semester progresses. These changing task forces are part of the unique working model that exists in 2009 that is not typically supported in existing project management tools.

In addition to constantly changing task forces within teams, the actual product concepts that are developed in 2009 vary widely. Therefore, a project management tool that aims to be used by every team needs to be capable of supporting very different types of products.
1.4 Project Management Tools and their Limitations for the 2.009 Context

Web-based project management tools have been provided for use in 2.009 since 2006. From 2006 to 2010, teams were required to maintain wiki pages for project management purposes. Although rudimentary compared to current tools, the wikis enabled teams to collaboratively edit text documents, maintain a running task list, and share digital documents with primitive version control. The wikis generally proved to be useful (when adopted), but cumbersome to maintain. From 2010 to 2014, a more robust project management tool, Teamwork Projects (https://www.teamwork.com) was provided. Teamwork Projects introduced a more intuitive interface for project management to 2.009, that provided for collaborative document editing, shared file space, a task list with the ability to assign tasks to team members, milestones, messages and a shared calendar. There was relatively low adoption of the Teamwork Projects tool, as well. The tool is highly configurable, but with an abundance of options, became quickly cluttered. This may have had an unintended appearance of a steep learning curve, where it could actually be fundamentally useful within a few minutes’ worth of exploration.
Table 1: Comparison of Web-Based Project Management Tools

<table>
<thead>
<tr>
<th>Tool</th>
<th>Primary Features (as of May 2016)</th>
<th>Milestones?</th>
<th>Task Forces?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Asana</strong></td>
<td>• Multiple task lists, a task can be assigned to only 1 person</td>
<td>No</td>
<td>Can create task lists for different task forces</td>
</tr>
<tr>
<td></td>
<td>• Full group threaded conversations, cannot message just a subset</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Shared calendar, can export to google calendar, iCal</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Can upload documents/import from connected services: Box, Dropbox, Google Drive</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Basecamp</strong></td>
<td>• Task lists, can have multiple assignees</td>
<td>No</td>
<td>Can make separate to-do lists according to task forces</td>
</tr>
<tr>
<td></td>
<td>• Full group chat</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Full group messages</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Individual ‘ping’ chat to one person</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• ‘Check-Ins’ ask every team member to respond to a question or prompt</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Shared calendar, can invite multiple attendees, export a calendar to iCal or google calendar</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Can upload documents, import from google drive, create new text documents</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Trello</strong></td>
<td>• Task list boards according to completion state</td>
<td>No</td>
<td>Can make separate boards according to task forces</td>
</tr>
<tr>
<td></td>
<td>• Can assign people to tasks, comment on tasks, and attach files to tasks</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Multiple boards can separate sub-groups of team members</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Can view a calendar that can export an iCal feed on a per-board basis</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Previously Used Tools**

<table>
<thead>
<tr>
<th>Tool</th>
<th>Primary Features</th>
<th>Milestones?</th>
<th>Task Forces</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Teamwork Projects</strong></td>
<td>• Task lists</td>
<td>Yes</td>
<td>Can create task lists according to task force</td>
</tr>
<tr>
<td></td>
<td>• Can assign individuals, groups, or anyone to tasks, comment on tasks, attach files</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Can post messages to specified message boards, does not filter according to user</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Can upload files/import from Dropbox and associate with tasks, organize into categories</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Shared calendar, can export a feed</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Wiki Pages</strong></td>
<td>• Collaborative text file creation (not live)</td>
<td>Can configure</td>
<td>Can organize according to task force</td>
</tr>
<tr>
<td></td>
<td>• Document repository, with primitive version control</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Can establish running task list, not complete-able like other tools</td>
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</tbody>
</table>
Increasingly, students use alternatives to the provided tools. Most commonly, students encounter alternative tools in other project-based classes with smaller team sizes, assuming that they will be effective for managing 2.009, as well. Instead of researching and testing to determine the most appropriate tool for use in 2.009, students will decide based upon their experience, often initiated by word-of-mouth recommendations for particular tools. Not only does this present a weakly informed basis for tool selection, but students entering 2.009 have not experienced the class before, so they do not understand what sort of project management support their team will need throughout the course. While this is a broad argument against early-semester selection of a project management tool by students, it is a notion consistently reinforced as staff members observe teams struggling to organize themselves.

The specific limitations of select commercially available project management tools that students have used in 2.009 are presented in Table 1, described according to the application of their features to the 2009 context. Wiki pages and Teamwork Projects are also included for comparison.

There are common functions among all of the project management tools described in Table 1, implemented in differing ways. Each offers tasks, a group calendar, association of files in a repository, and some sort of ability to communicate, via an actual chat function, or the ability to comment on specific tasks, events, or files. However, each of these tools has limitations in the context of a 2009 team.

In the case of Asana, task lists can be created for each task force’s assigned work during a given milestone or working period within a milestone, but each task can only be assigned to a single person, which is not necessarily the case for real task force efforts. Additionally, the messaging feature only allows general group messaging; there is no way to carry on a threaded conversation with just a subset of the team members, or another individual on the team.

Similar to Asana, in Basecamp, teams can create to-do lists for each task force, and it is possible to assign tasks to more than one person, which better maps to actual 2.009 effort. There are multiple chat features in Basecamp, which seem to have distinct intentions for use, but ultimately appear to overlap in functionality. It is possible to ‘ping’ another individual on the team, unlike Asana, but it is still not possible to chat with only the members of a task force; all non-'ping' communication floods the chat window of the entire team, which is not ideal. The 'Check-In' feature of Basecamp does not seem to be a function that would be critical to typical 2.009 project management practices.

Different from Asana and Basecamp, Trello uses a 'boards'-based user interface that focuses almost solely on tasks and their completion status. A 2.009 team could organize boards for each task force, but it would be difficult to get an overarching sense of the team's task status. It is possible to associate a calendar with each board, as well, but calendars do not maintain persistent data for the
user as he/she navigates through different boards – the calendars are separate instances from each other.

Teamwork Project seems to have almost all the components that could map well to 2.009 project activities for a team, but it too falls short. Teamwork even has the capacity to define milestones that can be associated with tasks as metadata, but there is really no apparent reason to do so. The ability to manually categorize files, tasks, milestones, and messages could be useful for teams that develop very structured organizational schema, but staff have found that 2.009 teams are not consistently capable of developing a suitable structure from the beginning of the course, and maintaining it.

Wiki pages became an obsolete option as more modern tools took their place for 2.009 project management.

With the exception of Wiki pages, Asana, Basecamp, Trello, and Teamwork Projects incorporates task lists, shared calendars, file repositories, and some form of communication between users. The shared calendars in each of these tools can be subscribed to – via either google calendar, iCal, or both. While the implementations of these features in the highlighted tools are not considered optimal in the context of 2009, observation of teams confirms that these features are a critical core set to any project management tool that is commonly used for 2.009.
2. Development of a Project Management Tool for 2.009

After comparing and evaluating features of previously used project management tools for 2009, a core feature set emerged, including: task lists, a shared calendar, file repository, and communication method. The implementation of those features in their respective tools do not align optimally with the working model of students in 2009, but observation of 2009 teams confirms that those features are critical to the 2009 process.

2.1 Functional Needs

At the most fundamental level in 2009, team members need to do work to meet milestone deadlines. The use of task lists, a shared calendar, file repository, and communication method should be able to convey the right combinations of that information clearly to a team, if designed to appropriately match the working model of 2009 that involves task forces and milestones.

The ‘who’, ‘what’, and ‘when’ of team efforts can be mapped as metadata between work tasks, so that it is clear to team members who is associated with what work, and when that work needs to be done.

2.2 Design Intent

This tool is intended to provide basic functions and enough utility in those functions that the tool’s use would streamline project management efforts in 2009, compared to the generally ad-hoc methods that students have been observed using previously. Additionally, a goal of this design is to encourage flexible habit formation; the architecture of this tool is different from other tools that students are familiar with, and its optimal use will require students to deliberately learn and adopt this new tool.

The implementation of the tool's features should aim to draw traffic to the tool, rather than away from it. There is a paradox of connectivity and familiar conventions to consider when determining
what features will be best suited to achieve a balance of value to project management yet require user investment when working with this tool. It is conceivable to try connecting the most used tools of 2009 students (such as shared Google Drive folders and Google calendars, Dropbox, emails describing tasks assigned to team members, and availability tools like when2meet to determine meeting times) in order to support their use of a variety of tools. As staff members have remarked, though, many of those tools are poor resources for robust project management. At the opposite end of the spectrum, using entirely unfamiliar models for organizing project activities could present a learning curve students may consider too high, leaving the tool entirely ignored. Therefore, the proper balance of connectivity with already-used tools and familiar use patterns will need to be struck with features that are actually more effective for 2009 project management. A tool that can be flexibly used is also important. Because the model of 2009 encourages the development radical innovation, rather than incremental improvement to existing products, Leenders, Van Engelen, & Kratzer conclude that minimizing systematic design methods, especially early in the development process, will enable more creativity within a team. To support this notion, the tool must be capable of full-team activities, but in a manner that does not restrict unique use cases (Leenders, Van Engelen, & Kratzer, 2007).

2.3 Description of Features

Hierarchical Nested Structure with Filtering Mechanisms

Within a team, there are student team members, staff members, and ad-hoc groups that form throughout the semester. Since certain tasks and events are associated with differing combinations of these groups, there needs to be a way to view assets associated with different groups, sub-groups, and individuals on the team. This was accomplished by developing a filtering hierarchy that allows a user to select which sub-set of the whole team to focus on while performing project management activities.
Changing the top bar selection within a team hierarchy filters the content that populates the page below. The content that populates a page is determined by which function the user has selected. The functions available to the user show on the menu to the left side of the screen. They include the dashboard, tasks, calendar, team organization, and statistics.

**Milestone-Based Structure**

Between and sometimes during each milestone in the course, task forces in each team can change substantially. To support changing resource allocation, task force designations in the tool allow these ad-hoc groups to organize tasks and scheduled events according to their fluctuating structures. Where a task or calendar event can be assigned to or attended by a list of individuals, it can include ad-hoc groups.

![Nested Hierarchy Navigation](image)

*Figure 3: Nested Hierarchy Navigation*

![Task Force Creation based on Milestones](image)

*Figure 4 Task Force Creation based on Milestones*
This flexibility also allows deprecated task forces’ data to remain in the past, maintaining its association with the previous task forces, while a new set of task forces is created for the next milestone that the team is working toward. Sub-task forces can also be created, to support a finer granularity of team organization.

Dashboard

The *Dashboard* provides a snapshot view of the shared calendar and shared task list for the actively filtered group or individual designated in the top navigation bar. If the *Dashboard* function is selected, and a user navigates within the top navigation bar, the appropriate filter will be applied to the shared calendar and shared task list in the Dashboard view. In the user’s own home *Dashboard* view, an additional panel shows the user what tasks are assigned to him or herself.

The shared calendar in that home view can be filtered in a custom manner. Instead of just seeing the active user’s own calendar entries for meetings and other scheduled time, he or she can choose to view any combination of the entire team’s calendars, to view events from any individuals and task forces.
Tasks

*Tasks* can be viewed, created, and completed via the Dashboard function or the *Task*-specific function on the left sidebar. A *task* must have a description in order to be created, but can also have one or more individuals or *task forces* who are assigned to complete the *task*. A due date is also optional. Assignees and other optional attributes are selected when the task is created, but can be modified by either the creator of the *task* or by any assignee of the *task*, as well. That same group of people can mark the *task* as complete. A *task* that designates a task force assignee will appear in that task force’s task list, in addition to all the lists of the individual members of that task force. Similarly, if a task designates an individual as assignee, the task will appear in that individual’s personal *task* list. Additional features of *tasks* are comment threads, so that people associated with the *task* can discuss on the *task* itself, and the ability to attach a file from the shared *file space* to the *task*. *Tasks* can also be deleted by the task creator.
Calendar

Calendar events can be viewed and modified via the Dashboard function or the Calendar-specific function on the left sidebar. A calendar event must have a title and a time to be created, but individuals and task forces can be designated as attendees. When individuals or task forces are designated as event attendees, the event itself will appear in that task force’s or individual’s event calendar. Additional features of events, similarly to tasks, include comment threads and the ability to attach files to events. The owner and attendees of an event have permission to edit or delete the event, as well.

Figure 8: Calendar View

The calendar does not have a subscription option; this aims to draw traffic to the tool and encourage habit formation, rather than allow students to have a subscribed calendar supposedly
inform them of 2009 events. If every student on every team instead imported their active calendars to the tool, scheduling meetings among team members would become a more manageable task. By filtering the upper navigation bar to view the calendar of the task force or individual with which a user needs to meet, the availability and non-availability of the other party is already shown to the user. This could address the low-efficiency methods of scheduling meetings that take place over extensive email threads, texting, and on easily-forgotten websites like when2meet.com and doodle.com.

Chat

A chat feature is in development. Different methods of communication are associated with different levels of formality, and somewhat informal communication is proven to be beneficial to teams (Pinto, 1990). This will support a style of somewhat informal communication, compared to email, that is similar in style to Slack, but it will not have the ability to input anything other than text. The chat function will incorporate real time notifications and separate chat rooms that a user can designate to include different groups of individuals or sub-groups of the team.

Team Organization

In order to associate tasks and calendar events with task forces, a mechanism must exist to create task forces. The Team organization function shows the members of the team, including staff...
members. Anybody can create a new *task force* on this page that includes members of this team. A task force must have a milestone, title and selected members to be created. *Task forces* can also be edited and deleted, but with the milestone association, they are not intended to be deleted for archival purposes. All the *task forces* created with this function are then available to navigate to in the upper navigation bar, and can be assigned to *tasks* and invited to *calendar* events immediately.

**File Space**

Each team has a dedicated file repository, connected to a Dropbox folder in an unlimited storage account. In the *File Space* in this tool, students can interact with files in a manner similar to Dropbox’s own website. Uploading, downloading, and previewing files is possible. New folders can be generated in the *File Space* as well. It is also possible for users to comment on each file, like the commenting feature on calendar events and tasks. Any file in the team’s *File Space* can be attached to a calendar event or task. Since the files are actually stored in a shared Dropbox, users can also still use Dropbox features to access files locally, through Dropbox’s desktop client. This is the only feature in this project management tool that connects to an external tool that is familiar to most students.

![File Space View](Figure 10: File Space View)

Version control is an area of importance that the *File Space* aims to simplify, as well. From report drafts, to multi-user CAD assemblies, there are many types of digital information that are collaboratively developed in 2.009. At the end of the class, in 2015, each team had roughly 2,000 files in their separate Dropbox folders. Solutions to version control often involve complex naming conventions, which can be difficult to keep track of. With the sheer volume of documents that a 2.009 team generates throughout the semester, the use of Dropbox aims to ease the challenge of manually keeping track of new versions of a file. Although many users still do use some form of
incrementing naming system to designate versions, Dropbox itself is able to keep track of iterations of a preexisting file with the same name. It also informs users if there is a conflict with another copy of the same file. While Dropbox does not completely solve challenges with version control, it does provide a sound platform for large teams to deal with lots of documents, and backup versions of deleted documents are retrievable.

Stats

The *Stats* feature allows a user to see a snapshot of a task force’s or user’s past and present activity. The graphs generated for viewing collect data once per day on the number of files in the *File Space*, the number of tasks yet to be completed, and the number of events scheduled for that day. When viewing the whole team’s data or the entire class’s data, three lines are visible: the total number of files the team(s) have, the number of events occurring on a given day, and the number of tasks yet to be completed. As a user filters to view a task force within a team, the lines on the graph includes: the number of events for which that *task force* is an attendee and the number of *tasks* that *task force* is assigned. Filtering to view just a single user reveals four lines: the number of *tasks* that user owns, the number of *tasks* that user is assigned, the number of events that user owns, and the number of events that user is attending.

The graphs generated throughout the semester are intended to provide a sense of the relative workload of each student, and provide abstracted information to teammates and staff about task completion efforts. Staff and students on each team are able to view each other’s graphs.
3. Results of Alpha Prototype Implementation

During the fall of 2015, very few of the eight teams were observed using the project management tool provided. Every team created at least one task in the tool and three teams created more than ten. All of those tasks were created and completed early in the semester, suggesting that users may have tested task use in the tool, but abandoned it quickly. Only one of the teams, Red Team, used the tasks for an extended period of time. Upon inspecting that team’s statistics, the two Project Site Masters were the primary creators of tasks. It is uncertain, given that data, whether it was the Project Site Masters who also marked the tasks ‘complete’, or if the assignees themselves went into the tool to ‘complete’ tasks assigned to them. In either case, it is clear that the attempt to use the tool did not extend sustainably beyond the Project Site Masters, for their assignment of tasks (and the overall number of tasks) decreased over the course of the semester instead of increasing, as would be expected of continued use. Two teams made attempts to populate the shared calendar somewhat, using repeating events. This resulted in few students’ indication of ‘I have class at this time’ throughout the semester, so at least some members of the team made their general non-availability known to their teams. It can be presumed that the calendars were not, therefore, used widely to help determine when students were in fact available to meet or complete work together outside of scheduled class or lab time.

A short survey, sent to the sixteen Project Site Masters after the course ended, asked about the tools that each team used for project management. A 50% response rate, unattributed to team, indicated that a wide variety of alternative resources were used to support project activities, and the resources each team used changed throughout the semester. Of the five students who indicated their team did try to use the provided tool to an extent, two indicated that it was used to organize task forces, two indicated that the custom Dropbox interface was used, three indicated use of tasks, and four indicated use of the shared calendar. The alternative tools used, listed by the eight respondents include:

- **Asana**: task and project management
- **Trello**: task and project management
- **Dropbox**: document repository
- **Google Drive**: document repository with live collaborative editing capabilities
- **Slack**: messaging app for teams, multi-platform
- **Group.me**: group chat, primarily by mobile phone, also multi-platform
- **Gmail**: email
**Github**: version control for code

**Doodle**: scheduling tool for teams

Additionally, an informal survey was distributed to the instructors of the eight teams during the fall of 2015. Responses supported the notion that 2.009 teams consistently struggle with project management. Many indicated that the lack of successful selection and consistent use of a project management tool or tools contributed to weak project management. Instructors pointed out instances of lacking support from team leadership and non-understanding of project management more broadly as contributors to poor project management, as well.

Broadly, 2.009 presents a challenging mixture of large-team dynamics, high expectations, tight deadlines, and ambiguous, nascent product concepts. While project management has consistently been considered a problem area in 2.009, it is important to recognize the multitude of other challenges in 2.009 that students face. Ideally, a properly matched and used project management tool will alleviate some of the organizational and administrative challenges in this environment. The results of the alpha implementation of this project management tool provided during the fall of 2015 lead to several conclusions about students’ approaches to project management and their willingness to change habits and learn new tools as individuals and groups.
4. Conclusions

A project management tool was designed and developed for 2.009 and its alpha prototype was implemented for student use during the fall of 2015. Low adoption rates of this tool and generally ad-hoc project management practices of teams using this and other tools in 2.009 during this test implementation indicates that good project management requires more than a new tool to provide a path to better project management practices. The teams of students who are the users of project management tools need to be prepared to change individual and group habits in order to really benefit from project management activities. Perceptions of students and staff regarding the selection and use of project management tools also influences student willingness to try project management tools, but does not necessarily mean that better project management will result.

Specifically, students resist using tools provided for use in 2.009 because students think they know what tools will meet their teams’ needs best during the course, according to survey responses. This is often an incorrect notion as the choice requires knowledge that the students making these decisions do not have until well into the semester.

Students’ general approach to selecting project management tools, then, is not particularly preemptive, but reactive to organizational problems as they emerge. Several staff noted that their teams changed project management tools several times throughout the semester, but that their teams never thoroughly adopted one effectively. With this ad-hoc approach to selecting and switching tools, teams often selected specific, familiar features from several resources, rather than maximizing the utility of fewer resources that could provide those same features. This approach may result in negative consequences from multitasking. The use of multiple services, each of which may serve other teams in other courses or student groups, may serve to distract students as much as help them communicate, organize meetings, or complete tasks for 2.009. Multitasking may seem a necessity to students at MIT, but as Krishna summarizes in *The Best Interface is No Interface*, multitasking will lead to poorer outcomes than focusing on one thing at a time (Krishna, 2015). The design of this tool aims to bring together features from what could be separate services, while minimizing features and elements unrelated to productive efforts for 2.009.

Another student survey response indicates that students prefer to use tools they are familiar with and are not interested in learning new tools. As described previously, the Ikea effect may be at play here, such that a person associates more value with something that they have somehow influenced the selection or design of; in the case of project management tools, students consciously selecting and perhaps customizing alternative project management tools could lead the students to value their selection and perhaps be more interested in using this alternate selection compared to the provided resources. In a broader sense, one might be concerned that undergraduate mechanical engineers at MIT are not interested in learning new tools. The willingness and ability to
learn new tools and processes cannot be overlooked as a critical aspect of engineering and innovation at the grandest scale. This notion is reinforced, as Barczak and Kahn found that a major differentiator of the best performing new product development firms in a 189-firm survey involves those firms’ “willingness to continually experiment with new tools and technologies”, including project management tools (Barczak, Griffin, & Kahn, 2009). Even though these students are already working incredibly hard to succeed at MIT and set themselves up for future success, the educational environment needs to encourage a culture of willingness learning new tools.

Every student survey response indicated that concerted efforts were made to select a suite of tools that provided useful support for team project management activities. From both the student and staff perspectives, however, it was apparent that the intrinsic motivation of students to use these tools mostly failed. Whether it was a student who refused to check email and did not have a mobile phone, or a student who could simply not keep up to date with a heavy workload, teams struggled with adopting project management tools in a way that actually benefitted the management of their development activities. Some staff members remarked that part of this adoption breakdown was due to poor leadership or poor understanding of what effective project management could contribute to student teams.

It is clear that a good project management tool cannot help a team perform better if teams are not motivated to explore what the tools might offer. Staff in 2.009 aim to supplement what is designed to be a challenging process for these student teams. Staff additionally aim to provide insight and knowledge about the product design process that can decrease some of the challenge in developing a new product. A new project management tool aims to help teams organize themselves in a more streamlined manner, but it needs more development and an environment that will support higher rates of use, and ideally, be more useful at the same time.
5. Future Development

Students will continue to struggle with project management activities unless they build habits around a tool set. It is clear that the current tool provided for use was not well-adopted, especially due to lack of some features, but alternative suites of tools sufficient for project management were not well-adopted, either. In order to increase adoption and utility of the tool designed for 2.009, changes can be made within the tool, by design, and changes can be made surrounding the tool, by extrinsic motivation.

Design

A key feature that was missing during the fall of 2015 in the tool was chat. The first implementation of this feature should be complete by summer 2016. The chat feature is modeled after slack, so it is a threaded, running conversation rather than a forum-like design. It will allow users to create ad-hoc chat groups, chat groups that correspond to defined task forces, and one-on-one chat with team members.

A timesheet entry module is used by students on the 2.009 course webpage to document the hours that students spend on different 2.009 working activities throughout the semester. If this module is ported into the project management tool, it will increase initial traffic to the project management tool because the timesheet entry activity is already required of students.

Budget tracking is an important element of 2.009 projects, as well. While typically, it is possible for the financial officers to perform budget tracking activities on behalf of the team, without much support, the subsequent administrative activities can likely be streamlined to support the course administrator. A feature to supplement the purchasing and reimbursement process could begin to extend utility of the tool beyond students and teaching staff, to the administrative staff as well.

More broadly, the design of the tool should not move into ‘social media’ territory. Traditional tools used in New Product Development practices, such as Computer Aided Design and email, are proven to have positive influences on development outcomes. Newer-style media tools, such as cloud-based file sharing, are also shown to have a significant positive impact on development outcomes. Social media, however, has proven so far to have no impact on development activities (Marion, Barczak, & Hultink, 2014). Students in 2.009 often already have history as acquaintances and friends. The design of this tool should remain out of social media territory in order to deliberately separate its utility from social media offerings and establish a deliberate tone for its use in 2.009.
The tool could also involve some strategically developed use case elements that make it more delightful to interact with, and easier to form habits around. The Power of Habit helps us understand the neurological underpinnings of habit-forming, so using the “cue, routine, reward” model in some features of the tool may support more substantial use by design (Duhigg, 2014). A similar model, introduced in Hooked: How to Build Habit-Forming Products, can provide insight into designing these sort of interactions in the context of product design. It considers four steps: the trigger, action, variable reward, and investment, to develop and reinforce habits that can be designed in this tool (Eyal, 2014).

Extrinsic Motivation

Because intrinsic motivation by students is not enough to drive project management tool adoption during 2009, additional habit-forming mechanisms will be necessary to increase user adoption. When the tool is introduced to students during the fall of 2016, it should be done in a more authoritative manner. This introduction should be followed up with reminders on individual- and group- scales, in order to reinforce the expectation of use by students. It will also be necessary to enforce the use of the tool via instructor and mentor members of the staff. New software tools require substantial buy-in from leadership and users alike in order to be truly adopted in a team (“How to Get Your Team to Use Project Management Software,” n.d.). It is not necessarily the tool itself that provides uniquely increased efficiency, but how it is introduced and implemented that will provide a practical pathway for its use (Thomke, 2006).

Using a more forceful approach would actually serve to make 2009 more similar to real design firm contexts, as well. In the workplace, it is not optional to fill in timesheets, expense reports, and use whatever additional tools a certain office may prescribe to. If an employee does not adopt these practices in the real world, it is usually not a matter of the CEO offering alternatives; that employee is fired.

Next Steps for Code Base

The code base of this project will be available open-source on Github. Refer to instructions for setting up and using this tool in Appendix A & B.

An additional intention of this project is to provide raw data for future research on teamwork, from the stats module and any other analytics tied to the site.
References


Appendix A: User Guide

Tips for First Time Users of OpenCPM

• First Login: click the link in the welcome email that was sent to you and enter the username and randomly generated password at the link provided. For security purposes, it is suggested that you change your password upon first login.

• To change your password, select Settings from the right end of the upper navigation bar.

• Selecting the Change password... link on that page will open a new tab where you can change your password. If this tab does not open, check your browser’s popup settings.

Your account

Change password...

• To edit your profile information, click on your photo icon (which will be populated later) in the top left corner of the website (below the navigation bar) and select the pencil icon on the main page for editing.

• This will open a window that will allow you to edit specific profile information.
• Students may self-assign team member roles in this profile page. These roles may be modified at any time.

<table>
<thead>
<tr>
<th>Roles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add role</td>
</tr>
<tr>
<td>Student</td>
</tr>
</tbody>
</table>

Functions and Navigation

• The default view upon login is your Dashboard. The left sidebar provides navigation between the Dashboard, Tasks, Team, Events, Files, and Statistics.

The Dashboard provides a snapshot of events, tasks, and indicates other online users from your team.

Tasks require only a name, but can be associated with specific due dates and times, and be assigned to individuals and sub-groups of the team (task forces) as well as associate with files in the team Dropbox. Sub-tasks can be created, too.

Team organization can be supplemented by creating Task Forces, comprising of sub-sections of the larger team sections. Task Forces can be created and edited at any point during the semester. They can be assigned to tasks and events.

Events are shown in a calendar that can be edited by the entire team. Like tasks, users and task forces can be invited as attendees, and files can be associated with events. Repeating events can be generated on a daily basis. The calendar has been pre-populated with lectures, lab times, and milestones already.

Files are stored on a central staff Dropbox. This Dropbox folder cannot be linked to others, however, so we have provided the basic functionality of Dropbox in order to provide files for association in the other functions of this tool.

Statistics are collected on a daily basis to monitor a team’s activity throughout the course. Team members can view their own data being collected, their team’s aggregate data, and the overall class data. This information provides a relative measure of different activities on the site for both students and staff knowledge.
• The top navigation bar acts as a filter. By default, the filter selects the logged in user as the active team member.

The logged in user can view a task force or team member as they would themselves, for each of the functions previously described.

As a user selects another function in the sidebar, then selects a different user from his/herself in the top navigation bar, the user’s data for that function will persist on the right side of the page, and the data of the task force or selected user will appear on the left side of the page.

Because the Team and Files data is constant across all users, filtering the upper navigation bar while viewing one of these functions will not affect the content displayed.
Appendix B: Setup Guide

This is a setup guide for administering and hosting this tool on Heroku. Setup on other platforms is not described in this guide.

Setting up the Tool

1. Find the public Github repository for OpenCPM at: http://github.com/aellqaz/openCPM-static
2. Fork the Github instance. Note that potentially sensitive user data and profile images (if uploaded) will be documented in Github if the forked instance is in a public repository.
4. Under the ‘Resources’ tab in Heroku for this App, provision free versions of the following Add-ons:
   a. Mailgun
   b. Redis Cloud
   c. Heroku PostgreSQL
   d. Heroku Scheduler
5. Create and connect a Dropbox App with sufficient space for team use where files will be stored (visit developer.dropbox.com to create an App)
   a. Select the Dropbox API with Full Dropbox Access when creating a new App
   b. Configure the webhook function by entering the appropriate URL and suffix in the URL entry: “https://{HOST}/api/files/dropbox-webhook/”
6. Under the ‘Settings’ tab in Heroku, select ‘reveal config vars’
7. Input ‘Key’, ‘Value’ pairs for several new config variables
   a. From the Dropbox App page
      i. DROPBOX_APP_KEY = app key as shown on the App page
      ii. DROPBOX_APP_SECRET = app secret as shown on the App page
      iii. DROPBOX_ACCESS_TOKEN = access token as shown on the App page
      iv. DROPBOX_BASE_PATH = the absolute path to the folder within dropbox, referenced from the root directory (ex: “/opencpm-test”)
         1. Folders that match team names must be created within this folder
   b. DJANGO_SETTINGS_MODULE = “opencpm.settings.heroku”
   c. SECRET_KEY = substantially long random number & letter combination
      i. For production use of this tool, it is suggested that the SECRET_KEY is generated by a script in the code base at /tools/gen_secret_key.py
   d. EMAIL_FROM = the sender of ‘welcome’ emails generated on the site
8. Under the ‘Deploy’ tab in Heroku, connect to your Github account by entering appropriate credentials
9. Find the forked repository and connect to it, under the ‘Manual Deployment’ section
10. Select ‘Deploy’, to build the App
11. In the Heroku CLI, migrate the database information with the command:
    a. Heroku run –app [app name] “python manage.py migrate”
12. Verify the app has loaded properly by visiting its URL.

Loading initial Data for a Course with a large number of users

13. Create a superuser for the tool while using Heroku Toolbelt’s CLI with the command:
    a. “Heroku run –app [app name] “python manage.py createsuperuser”
14. Load in User data using “dumpdata” and “loaddata” commands
    a. Log in to the admin page of the newly setup website: URL.com/admin
    b. Manually add entries for one course, team, role, user-team-mapping and user-role-
       mapping, using your user information to associate with a team and a role
    c. Export the table schema for these tables via the Heroku CLI in order to properly
       generate data to load into the database
       i. “Heroku run –app [app name] “python manage.py dumpdata --indent=2”
       ii. The JSON data generated will contain automatically generated entries for
           several tables that can be ignored. Data corresponding to the manual entries
           are important to save to a file for reference, and include
           1. Admin.users
           2. Users.team
           3. Users.role
           4. Users.userteammapping
           5. Users.userrolemapping
d. Using the example .csv and python script for generating JSON fixtures in /tools,
   populate .csv’s with data to generate tables for:
   i. Admin.users
   ii. Users.team
   iii. Users.role
   iv. Users.userteammapping
   v. Users.userrolemapping
e. Compare the headers for columns in these .csv tables to the data model for the
   JSON exported field entries. Not every field in the JSON entry requires a column in
   the corresponding .csv, but critical entries include “pk” values that can be
   sequentially generated in the spreadsheet, and associations between tables that
   reference the “pk” value for entries in other tables
f. Modify the generate_json.py script according to the input .csv and the desired output, that should match the model of one JSON entry for a particular table in the list of tables previously described.

g. Generate JSON with the appropriate .csv and model pair in the script, verify that the trailing comma “,” in the file is deleted.

h. If the information contained in these files is appropriate for publication on Github, then commit the set of files into the fixtures folder in the Github repository.

i. If the information should not be committed to Github, then copy the files into a Dropbox folder.

   i. Connect to the Heroku CLI for this app and for each JSON fixture, use the Curl command to copy the data to a temporary directory through a dedicated terminal.

   1. Heroku run bash –app [app name]

   2. To copy the data to a temporary file: “curl -L [dropbox URL] */tmp/tablexxx.json”

   3. To view the data uploaded: “cat /tmp/tablexxx.json”

   4. To load the data into the database: “python manage.py loaddata /tmp/tablexxx.json”

   5. Refresh the Admin page to verify that the data has properly loaded.

15. Invite users to log in to the website by automated email

   a. In the admin page, select a group of users and in the dropdown menu options at the top of the page, select “send welcome email”

   b. The contents of this email can be modified in its associated file located at /opencpm/apps/webapp/templates/webapp/email/

   c. The source email address can be configured by altering the configuration variable “EMAIL_FROM” in the Heroku interface.

At any point, the superuser can log in to the admin page of the site (URL/admin) and modify entries in the database.