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Evolving the Teaching and Practice of Project Management: Lessons Learned on the Path to Living Order

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Jeff was honored in 2014 with an Outstanding Projects and Leaders Lifetime Achievement Award by the American Society of Civil Engineers. He holds a bachelor's degree in civil engineering from University of Cincinnati, master's and doctoral degrees from Purdue University, and is a registered professional engineer in Wisconsin.

Jeff grew up in a construction family where his father ran the field operations for a small regional contractor in northeast Ohio. He spent his youth working in construction, learning the value of hard work, integrity, organization, and leadership. He has always respected the important role of labor in achieving project success.

Strongly influenced by his sister, who has Down syndrome, Jeff values the importance of family, the joys of life, and the appreciation of differences and diversity.

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Introduction

The discipline of project management, as traditionally taught, seeks to precisely plan, budget, and schedule projects, then execute according to those predetermined plans, budgets, and schedules. Engineers seek to fully understand and avoid possible risks to project success. In this view, success depends on accurately predicting the future, developing a path to success, and ensuring all elements of the project remain fixed on that path.

The true success of any project depends on whether the project delivers its intended value to stakeholders. Whether the project follows the planned path to success is immaterial. The scope, schedule, and/or budget may evolve to the benefit of all, provided the target value is delivered.

To achieve project and career success, engineering project managers need to supplement traditional project management skills with the ability to navigate the rapids of living order in which their projects seek to survive. In the world of living order, agility, adaptability, and resilience are of paramount importance.

The authors have evolved what they teach and how they teach to help practicing engineers to build lean, value-focused teams and project plans that can quickly learn from changing project conditions, and agilely adapt to ensure successful project completion. The paper will address how course goals, topics, and formats have evolved to better meet the related needs and interests of practicing professionals.

Background

This paper draws upon the experience of the authors' research and practice, which informs how they teach a project management course for experienced, practicing engineers as part of the Master of Engineering Management (MEM) program [1] at the University of Wisconsin-Madison.

This paper significantly updates and expands upon a paper presented to the ASEE Engineering Management Division at the ASEE 2016 Conference [2].

Key features of the subject program follow:

Students

- All students are practicing engineers, working full-time, as they pursue their graduate studies. All entering students must have at least two years of professional practice. At present, students average about eight years of preceding professional experience, with some having as many as thirty or more years. This

broad base of experience among students is actively engaged throughout the program for collaborative, authentic learning grounded in real-world experience.

- Students range in positions from project engineers, to project managers, to chief executive officers of engineering organizations. The unifying goal is that all seek to be more effective managers and leaders.
- All admitted students have at least a B.S. from an ABET–accredited engineering program. Some students have subsequent engineering masters or PhD degrees, and occasionally MBA's; these students are seeking to complement their technical or general business skills with advanced engineering management knowledge and abilities.

Program Design

- The MEM program employs a cohort design in which approximately 30 students are admitted each year, and the group progresses through a mostly fixed curriculum as a cohesive, well-supported learning community. Courses are designed to enable students to customize their learning through the selection of individual and team projects in each course.
- All courses employ a problem- and project-based curriculum. Students pursue and apply their learning through required discussions with colleagues at their workplace, critiquing current practices, and applying appropriate new approaches to their real workplace projects and teams.
- Instructors intentionally and actively engage the experience and expertise of students, all of whom are experienced engineers leading real projects, as part of each course's learning. Student-student interactions occur as part of team assignments, asynchronous discussion forums, and student-led presentations during course web conferences.
- All courses have live, weekly web conferences, which enable high, meaningful interactions between faculty and students. Web conferences are designed as interactive presentations and discussion, typically including student-led sharings regarding best practices, tools and strategies.
- The program's curriculum is listed in Table 1.

Master of Engineering Management Curriculum

- Foundations of Engineering Leadership
- **Technical Project Management** (course addressed by this paper)
- Management Accounting
- Effective Professional Communications
- Marketing for Technical Professionals
- Engineering Problem Solving with Computers
- Engineering Law
- Effective Negotiation Strategies
- International Engineering Strategies and Operations
- Engineering Applications of Statistics
- Quality Engineering and Quality Management
- Applied Leadership and Management of Engineering Organizations

Table 1: Master of Engineering Management Curriculum

Program Track Record

- The Master of Engineering Management program has graduated over 500 engineering leaders since its inception in 1999.
- The quality of education offered by the MEM program has been recognized by major awards from the Sloan Consortium [3], the University Continuing Education Association [4], [5], and the U.S. Distance Learning Association [6].
- The program has been consistently ranked among the top 7 online graduate engineering programs by U.S. News & World Report.

The Course: Technical Project Management

The course examined in this paper is Technical Project Management, a 3-credit graduate course available to practicing engineers enrolled in the Master of Engineering Management program. Course weekly topics, and the elements of a semester-long team project are shown in Figure 1.

Course Learning Goals

The key overall goals for this course are to help students:

- Lead and contribute more effectively in your work environment, whether as a project manager, team leader, or individual contributor.
- Select and apply strategies to organize, plan, and complete projects appropriate to the complexity, culture, and context of individual projects and organizations.
- Lead and contribute to improvements in the project management strategies and practices at your current and future employers.

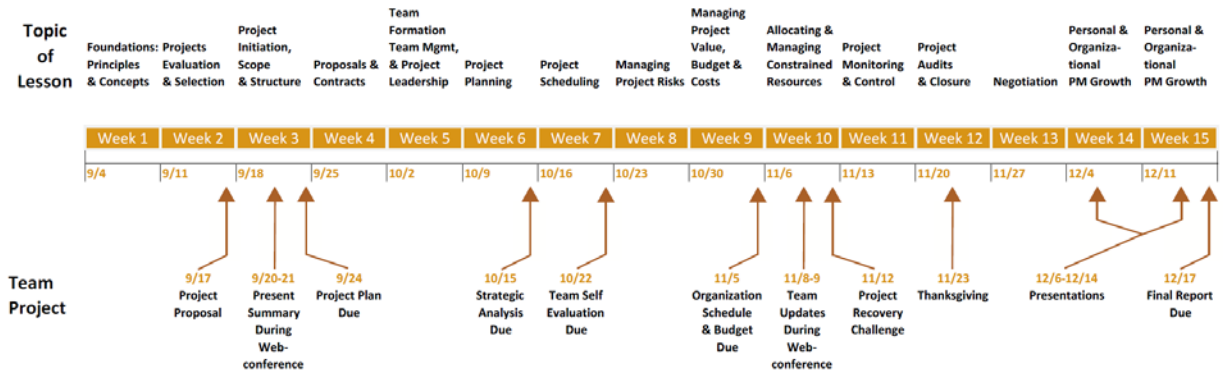


Figure 1: Course Elements of Technical Project Management

A key part of the course is the semester-long team project. At the initial Summer Residency session on campus, students are divided into teams of three or four students. Teams are formed to include members of different organizations, cut across different geographic and cultural boundaries, and group students with similar interests (i.e., either capital projects, software/information technology (IT) projects, or product development/manufacturing projects). Students choose a major, actual project at one of their workplaces to form a case study for the team's applied learning. Over the course of the semester each team will prepare: (1) a proposal, which details the project charter; (2) a plan detailing the team's organization and approach to the case study; (3) a strategic analysis addressing how to best ensure project success; (4) a plan detailing the project's proposed organization, schedule, and budget; (5) a recovery plan that addresses a major unexpected crisis in the project; and (6) a team presentation and (7) final report prepared for an executive review committee. Teams are required to self-assess their functioning on two occasions during the semester and to share what they are learning about improving their teamwork with the rest of the class. Consistently, these graduate students, all of whom have considerable professional experience, say the course's team project, while very challenging and time-consuming, is a high quality learning experience that sharpens their project management skills and their abilities to effectively collaborate virtually as members of a geographically distributed team.

Re-Examining Projects and Project Management

Despite significant advances in project management theory, education, and standard practices, far too many projects still fail to deliver expected results. A 2016 survey by the Project Management Institute [7], summarized in Figure 2, shows that only 62% of surveyed projects met original goals or business intent, with only 53% completed within the original budget and 49% completed on time.

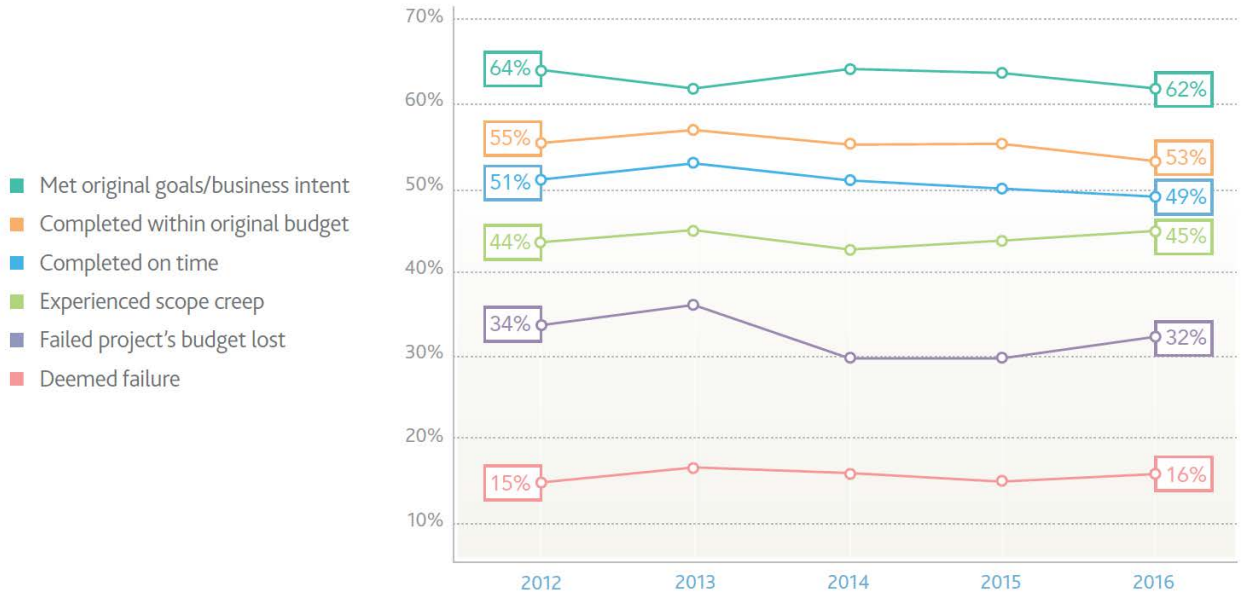


Figure 2: Consistent Project Success Remains Elusive [7]

Matta and Ashkenas, in an insightful article on project failure in the Harvard Business Review [8] note that:

> *Big projects fail at an astonishing rate … The problem is, the traditional approach to project management shifts the project teams' focus away from the end result toward developing recommendations, new technologies, and partial solutions. The intent, of course, is to piece these together into a blueprint that will achieve the ultimate goal, but when a project involves many people working over an extended period of time, it's very hard for managers planning it to predict all the activities and work streams that will be needed.*
>
> *Managers use project plans, timelines, and budgets to reduce what we call "execution risk"— the risk that designated activities won't be carried out properly—but they inevitably neglect these two other critical risks—the "white space risk" that some required activities won't be identified in advance, leaving gaps in the project plan, and the "integration risk" that the disparate activities won't come together at the end. So project teams can execute their tasks flawlessly, on time and under budget, and yet the overall project may still fail to deliver the intended results.*

Matta and Ashkena's observations about project failure suggest:

- Traditional project management practices often lose focus on value-based outcomes, diverting that focus to push-driven activities that may, in the end, deliver little customer value.
- In complex problems, it is very difficult, at the start of a project, to identify and plan for all needed work, risks, and possible adjustments.
- Even when the "project plan" is executed flawlessly, the project may not deliver the desired outcomes. Needs of stakeholders, market conditions, and other externalities may have required a mid-course correction that was not taken.

In a 2012 Business Journal article, Benoit Hardy-Vallee [9] offers the following perspective on the frequent failure to focus on following a predetermined plan rather than focusing on achieving core success of a project:

> *"Open A Guide to the Project Management Body of Knowledge, and you will see an array of techniques for controlling quality, risk, budget, schedule, and scope… None of this is wrong. But again, these techniques mainly address rational factors such as planning and controlling. They only provide more methodologies and processes and more charts and graphs, which is hardly emotionally engaging for project team members -- or project managers, for that matter. The problem with a single-minded focus on processes and methodologies is that once people are given procedures to follow, compliance replaces results. Everybody is concerned about how to do the job, not about the outcome if the job is done well.*

The bottom line here is that we often fool ourselves by thinking that project success is best ensured by developing the perfect project plan, then ensuring that all project partners know and follow the prescribed plan. The reality is that we rarely know the future as well as we think we do, project circumstances change, and unless our project strategy and plans adapt, we are liable to miss the moving target of project success. Project management educators know and experience that in their lives and projects daily. However, too often our teaching of project management fails to fully embrace this reality and prepare our students to succeed in a world of projects that shift frequently and often unpredictably in project requirements, resources, and time demands.

Evolution of What and How We Teach

As described earlier, the authors teach graduate project management to students who are all working professionals, most with considerable to extensive project management experience. These, like nearly all adult learners, want education that is authentic, relevant, immediately applicable to their work, and substantiated by experiences of their own or credible peers [10], [11], [12], [13]. As the authors have taught this course over the past eight years, a shared, consistent goal and commitment to our students has been to make the course "authentically real," speaking directly to the experiences and learning goals of these project-experienced professionals. Following is a brief description of a few key ways in which our teaching of effective, real project management has evolved.

An Emphasis on Living Order

"Living order" is a concept that the authors have found helpful in exploring the definition of project success and how to best strategize to achieve success. Alex Laufer has written extensively about living order and its application to project planning and management [14]. Laufer draws upon the French philosopher Henri Bergson's 1907 book, Creative Evolution [15], describing Bergson's two orders in this way:

> *Bergson claimed that there is no such thing as disorder, but rather two sorts of order: geometric and living order. While in "geometric order" Bergson related to the traditional concept of order, in "living order" he referred to phenomena such as the creativity of an individual, a work of art, or the mess in my office."* [16]

Applying these two forms of order to projects, Laufer writes:

> *…all projects aim to reach a perfectly functioning product with geometric order. At the start, they may face great uncertainty – living order – that does not completely disappear over the entire course of the project. Gradually, some parts of the project approach geometric order, though in an era of 'permanent white water,' the project as a whole does not assume geometric order until late in its life.* [17]

As applied to projects, the concept of living order recognizes that projects happen in dynamic environments. The occurrence of unexpected events should be understood as a part of most projects' life cycle. Project managers, their teams, their culture and practices should highly value the agility that is needed to anticipate and adapt to change. Strategies and plans must remain flexible and need to intentionally incorporate practices that enable the project team to learn from each step and adjust, just like the whitewater canoeist adjusting his planned course as the route unfolds.

We will return to the consideration of living order and its application to project managements after addressing lean management practices, a second major evolution in the authors' approach to teaching project management.

Integration of Lean Management Strategies and Practices

Lean management practices are foundational for leading global manufacturers in America [18], [19]. These practices have systematically identified and attacked waste, defined as anything that does not add value. A primary change in manufacturing operations is that processes are driven by pull from customer orders, rather than a push to create available inventory.

Increasingly, project management practices are seeking to integrate lean thinking into project practices. A good example is the adoption of agile project management in software development, placing increased value on intermediate, working code than comprehensive, documented, complete systems. Nevertheless, most legacy project management systems and practices continue to rely on push-oriented activities that fail to capture efficiencies that can be gained from pull-driven, value-focused strategies [20].

The authors have adapted their teaching to explore with students how lean principles and practices can be integrated into every project. A helpful resource that the instructors use for

readings of example strategies and practices is, the joint MIT-PMI-INCOSE Guide to Lean Enablers for Managing Engineering Programs [21]. The following six lean management principles were adapted from Lean Enablers and are used as the basis for lean-focused discussions with students during each week's web conference:

- Focus on project value as defined by customer stakeholders
- Clearly map the value stream and eliminate waste
- Optimize the flow of work through planned, streamlined, value-adding steps
- Use pull-based project planning and scheduling
- Create and foster a culture of pursuing perfection, while not allowing perfection be the enemy of the very good
- Show respect in relationships with team personnel and partners

A New Course Roadmap

To help students holistically visualize throughout the semester the integration of living order concepts, along with increased emphasis on lean practices, the authors developed a new Course Roadmap, shown in Figure 3. The Roadmap shows:

- The theme for each of the course's 15 weeks.
- A separate "swim lane" for geometric order and living order. The swim lane shows for each week how management by living order and geometric order might offer differing approaches and practices.
- A vertical band showing how lean practices apply to the theme for that week, applicable to both geometric and living order approaches to project management.

The Course Roadmap is re-presented at the beginning of each week's web conference, reminding students each week where we are in the overall progression of the course, and providing a launching point for exploration of geometric and living order applications, bridged by relevant lean management practices.

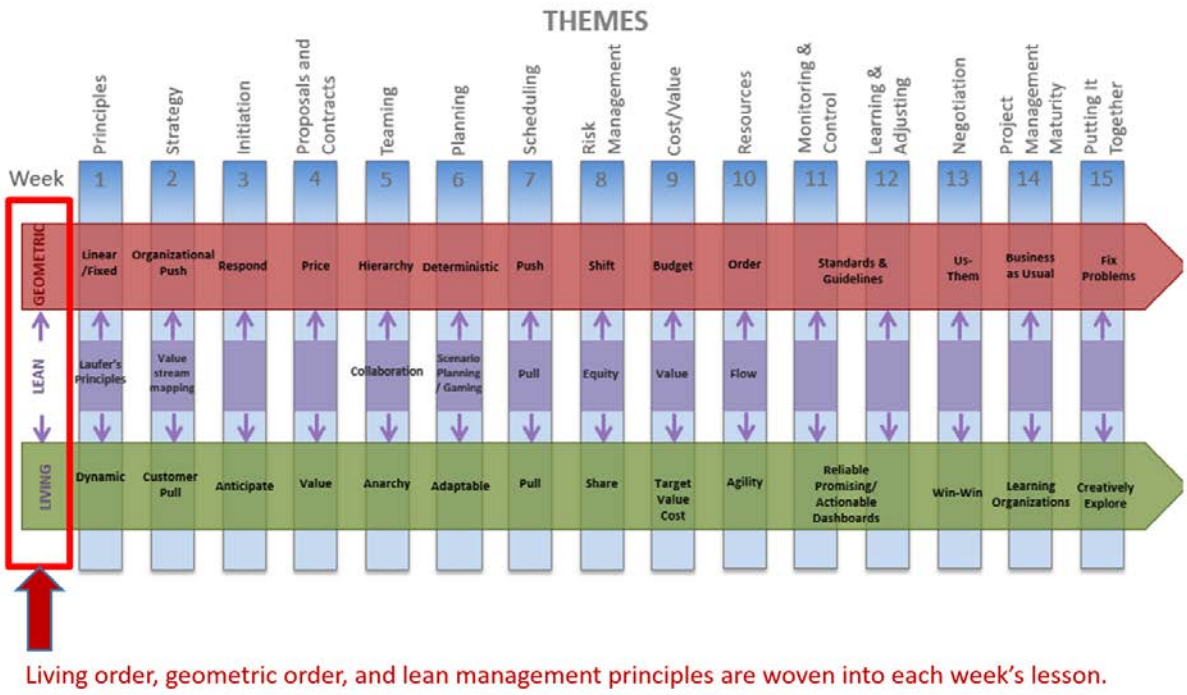


Figure 3: Course Roadmap for Technical Project Management [22]

Examples of How the Course Roadmap is Applied in What and How We Teach

Our teaching and working with practicing engineers continues to inform and evolve what and how we teach as we interact with students and their real-world projects. While we continue to teach fundamental project management concepts and tools, much more of our emphasis is placed on application of these tools and concepts in a project environment that requires a willingness to embrace ambiguity and turbulence, and to confidently, strategically lead their teams through a stream of predictable and unpredictable challenges.

Following are a few examples of how we have adapted our curriculum and its instruction to meet the highly application-focused needs of these experienced engineers we are privileged to serve as teachers.

1. Planning and Scheduling: Beyond CPM
   Traditionally, much of the Planning and Scheduling lessons in this course focused on development of a project network and corresponding analyses, including forward and backward passes, calculation of activity slack, activity-on-node and activity-on-arrow exercises, and analyses of critical and near-critical paths. We still cover all of these concepts (except activity-on-arrow networks), though we place these concepts within a larger, application-focused context. It is vitally important that a project manager understand that by identifying a project's critical path he/she can see those tasks that control the project's duration, and can therefor give special focus to the on-time completion of those tasks. Understanding that concept, and enabling one's team to apply

it to projects simple or complex, is far more important to the career success of *most* practicing engineers than being able to run sophisticated optimizations of activity networks.

A helpful perspective on this topic is found in the words of statistician George Box, who said, "Essentially all models are wrong, some are useful" [23]. We help students see the value of critical path analysis in focusing theirs and their team's attention, and in identifying slack that can be used for a project's advantage. At the same time, we caution about being overly rigorous in adhering to a detailed pre-launch schedule, when adjustments along the way may be to the project's and team's advantage. During live web conferences and in the asynchronous discussion forums, we discuss practical situations in which students are making judgment calls about adhering to a predetermined path versus adjustments made on the basis of midstream-acquired intelligence.

We have also modified our teaching of project planning and scheduling to emphasize lean management principles. A key principle here is teaching students to begin their planning and scheduling from the end of the project rather than the beginning. The goal is to ingrain pull-focused thinking and planning. We ask students to consider, "What is the final major task to be completed for the project to be considered successfully completed?" What then is the next major upstream milestone, and what has to occur between the two to ensure successful completion? Then keep working upstream, major milestone to major milestone, to the beginning. The result is a high-level plan pulled by project value rather than a plan driven by conventional ordering of activity. The difference is usually expressed in more integrated, cross-team collaborative work rather than serial hand-offs and repeated review-revise cycles.

We then examine how an overall plan and schedule for a project is often best implemented through a series of time-related windows. For example, schedule windows for a construction project could include:

- A phase window (typ. 3 months), which starts from a completed set of work and moves backward to lay out what needs to be done to get there;
- A look-ahead plan (typ. 3 weeks), which addresses planning for materials delivery and pre-work;
- A weekly work plan, conducted with all active project partners at the end of each week and commits to what should be done and can be done. Success is measured each week in terms of how well the week's commitments were met.

We explore alternative models for frequent review and adaptation in other types of projects. For example, we explore stage-gate phased project planning and scheduling for new product development. Correspondingly, we explore how sprints are used within scrum agile project management for productive cycles that produce results and continually refine project focus.

We also discuss with students about how the specificity and use of schedules need to be adapted to the needs of the project and the culture of the members of the team. Team members need to have enough information to know: what they need to do; when they need to do it; and how their efforts fit into the bigger picture. Information that is insufficiently detailed or overly ambiguous information fails to give needed direction to project team members. Conversely, too much unfiltered information may cause team members' eyes to glaze over and fail to focus on priorities for their attention. We discuss how some teams and projects are more like large orchestras, and need highly scripted, detailed schedules to enable coordinated, successful completion. Other teams and projects may thrive more like jazz ensembles, in which highly trained specialists function best with a general plan and schedule, improvising details along the way.

In summary, our revised approach to teaching CPM:

- emphasizes pull planning to define key milestones as targets that must be hit rather than model output values;
- values CPM as a potentially useful tool for teams to collaboratively identify critical and near-critical activities for complex projects;
- cautions students to be alert, adept project navigators more focused on the evolving path ahead, rather than rigorous followers of a pre-project CPM-derived schedule
- advises students that use of CPM, or any analytical tool, is only of value to the extent it facilitates efficient, pull-focused progress toward core success of the project.

2. <u>Defining and Delivering Value</u>

The course lesson previously titled "Project Budgeting" has been retitled "Project Cost and Value" and revised to reflect that: 1) in the end, project sponsors care far more about how much the project cost than its original budget; and 2) the most important monetary consideration for project managers is delivering owner/sponsor-defined value.

Effective project managers have thoughtful, probing discussions with project sponsors of project value. Every project has deliverables, which might, for example, include a facility, a product prototype, or functioning software. The goal, however, is to produce project <u>outcomes</u>; e.g., a hospital that provides regional care for children, a refrigerator that is x% more efficient, or an enterprise management system that supports increased asset management. Project managers deliver value to their clients when they help those clients clearly articulate the whole life value (see Figure 4) of the project they are planning to fund. These discussions help to establish a budget in line with the project's value, and help to clarify particularly important aspects of a project's value. For example, the value of the pediatric hospital is not defined in x thousand square feet of floorspace, but in terms of, for example, the facility's ability to enable care for certain numbers of various levels of patients and its supporting a target number of various types of operations over a defined lifetime. Ancillary elements of the facility will have less

contribution to core project value and may be more subject to cuts if cost reduction measures are later required.

As part of this lesson, the course teaches bottom-up and top-down cost estimation, with an emphasis on an integrated, iterative process. In addition to improving accuracy of results, this approach builds buy-in from all involved project partners. This message reinforces that conveyed during the planning and scheduling lessons: get all partners meaningfully involved as early as possible in project development. Enable the project to benefit from their expertise and develop a shared understanding and commitment to overall project success, not just to their portion of the project.

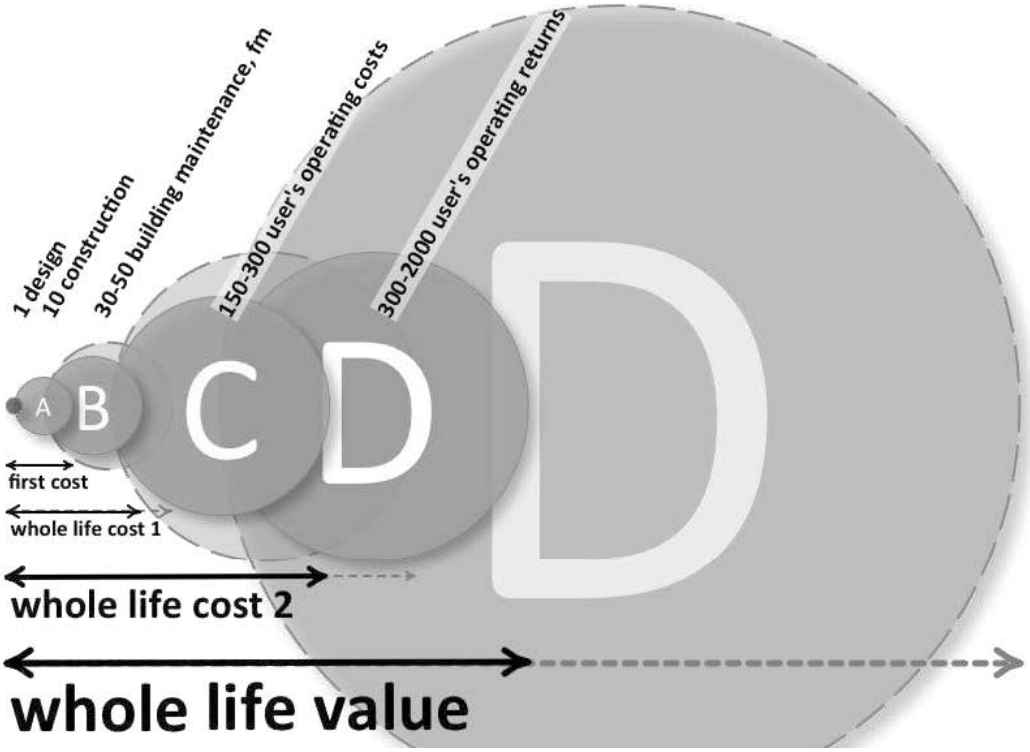


Figure 4: Project Whole Life Value Extends Far Beyond First Cost
Credit: Mossman, Ballard, & Pasquire [24]

A concept that we present and explore in this lesson is target-value budgeting and design. The focus in this approach is to establish a budget based on a clear understanding of project value, then allow that value-based target drive design and implementation decisions. In the words of the Lean Construction Institute [25]:

- *Target-Value Design (TVD) turns the current design practice upside-down.*
- *Rather than estimate based on a detailed design, design based on a detailed estimate.*
- *Rather than evaluate the constructability of a design, design for what is constructible.*

- *Rather than design alone and then come together for group reviews and decisions, work together to define the issues and produce decisions then design to those decisions.*
- *Rather than narrow choices to proceed with design, carry solution sets far into the design process.*
- *Rather than work alone in separate rooms, work in pairs or a larger group face-to-face.*
- *TVD offers designers an opportunity to engage in the design conversation concurrently with those people who will procure services and execute the design.*

3. Negotiating Success

One way that course instructors attempt to keep content fresh is by intentionally focusing part of the course on evolving, current topics. For several years this "current topics" lesson was focused on sustainability. In this lesson, students explored how considerations of sustainability influences how project success is defined and measured, project risks, market opportunities, and portfolio management.

Most recently, a lesson was introduced to the course focused on helping students understand effective negotiating abilities as a critical project management skill. We explain how negotiations are an important element of life in general, and specifically in project management. Example applications of negotiation in project management include: definition of project scope; development of budget and schedule; management of conflict between team members; analysis of requests for changes to scope, schedule, cost, and specifications; handling results of project audits; and resolution of issues at project closeout.

A key emphasis in our instruction in negotiation strategies and practices is to emphasize collaborative negotiation rather than competitive negotiation. These two approaches are contrasted in Table 2.

Aspect	Competitive Negotiation	Collaborative Negotiation
Mentality	"Me first" mentality	"We first" mentality
Focus	Individual gains	Joint/collective gains
Outlook on Resources	Resources are limited and everyone wants to claim their share of the pie	Resources are abundant and the pie should be expanded so everyone get more
Outlook on Other Parties	Other parties are enemies who should be defeated	Other parties are partners, teammates, and community members with shared interests
Result	One party wins and gains the vast majority, if not all, of the benefits of the negotiation; the other party loses	Both parties win and each gains something from the negotiation; greater trust is established for the future

Table 2: Comparison of Competitive and Collaborative Negotiation

4. Helping Students Intentionally Assess and Grow Their PM Mastery

   This course is one step in each student's development as an effective project manager. As instructors, we believe that one of the most important outcomes of the course should be setting each student on a course of intentional, continued growth in mastery of key project management competencies.

   We have always had a pre-course and post-course self-assessment that students take. Recently we improved this self-assessment to focus on a clearly defined set of competencies, and which is used throughout the course to bring greater focus to each student's learning goals and selected work.

   Key clusters of project management competencies are illustrated in Figure 5. These clusters include:

   - Strategic thinking: selection and planning of project to advance organizational strategy
   - Project execution: the "blocking and tackling" that makes the right thing happen at the right time
   - Team management: enabling a team to work cohesively and nimbly toward success
   - Project leadership: leadership of self, team, and the broader organization to enable enduring success

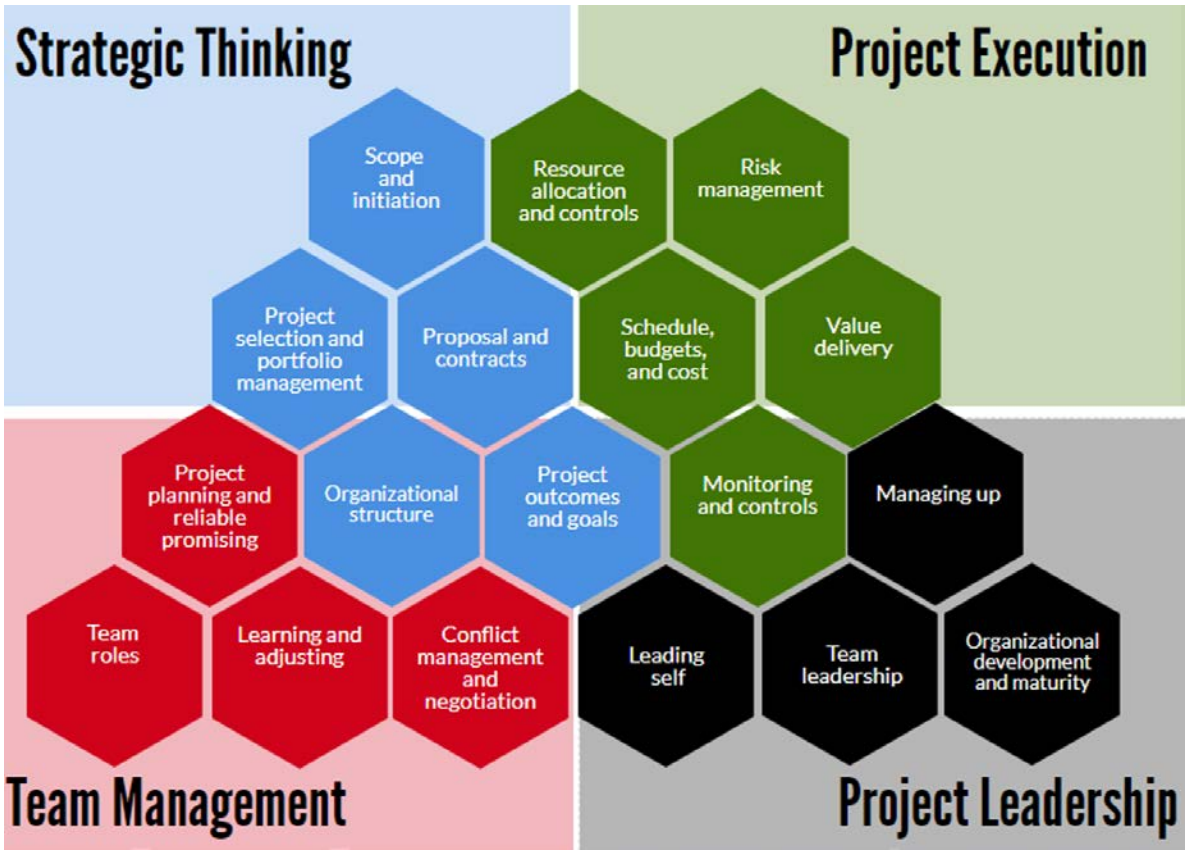


Figure 5: Clusters and Elements of Project Management Competency

Each student completes a self-assessment via an online questionnaire at the beginning of the course. The survey returns to each student a score for each competency cluster via a dashboard. Dashboard results for members of each project team are provided via a team dashboard (see Figure 6) to help teams make strategic decisions about how teamwork will be divided among members. In the words of one recent student, "The dashboard helped my team and me leverage each other's strengths and work on our challenge goals and weaknesses. We divided work according to who would do a great job, but also according to who would grow the most from each task."

TEAM DASHBOARD

FA17 Team 1 : Team 1

Name	Strategic Thinking	Project Execution	Team Management	Project Leadership
Olivia	20	23	14	13
Wesley	10	17	9	8
Kyle	21	28	14	16
Nicholas	18	27	13	15
Team Average	17	24	13	13

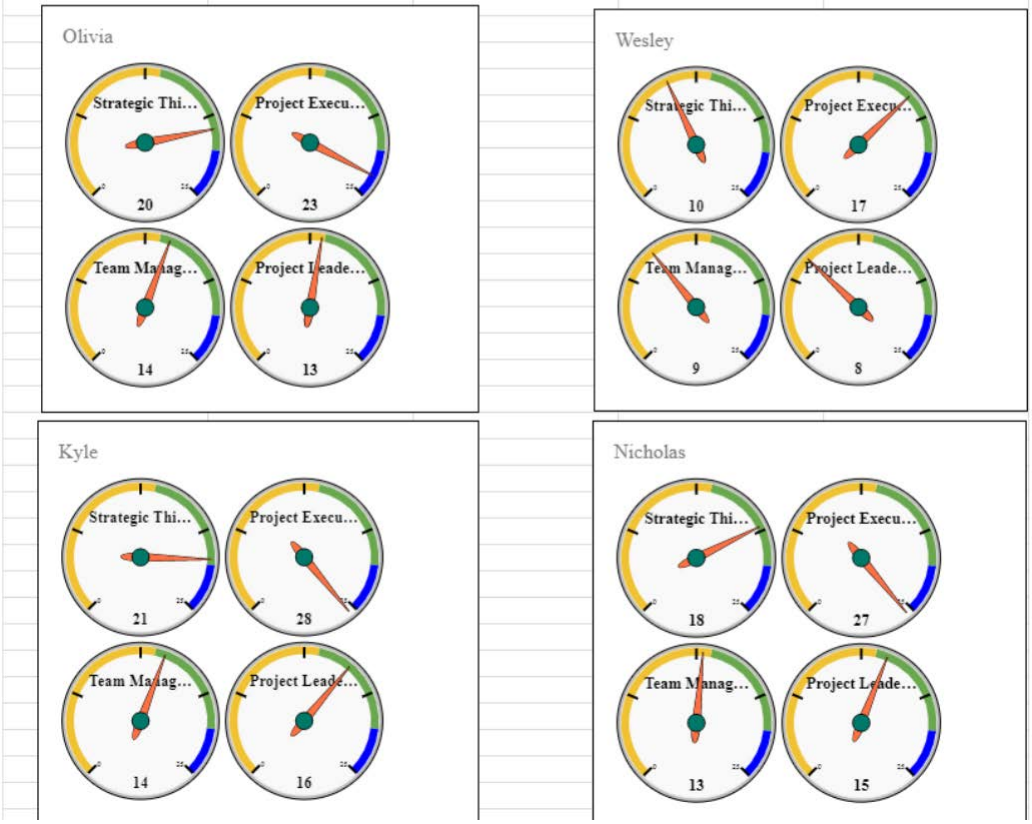


Figure 6: Team Dashboards Help Students Share Strengths and Learning Goals

Students retake the self-assessment at the end of the course, then reflect upon the results and identify next steps in their continued development as effective project managers. Often students will note that their self-assessment scores in some areas are lower than they were in the pre-course self-assessment. Students correctly recognize this as now having a better understanding of mastery and their recognized need and desire to continue to grow in those areas.

Pre- and post-course results of the self-assessment from the class of students who completed the course in Fall 2017 are summarized in Figure 7.

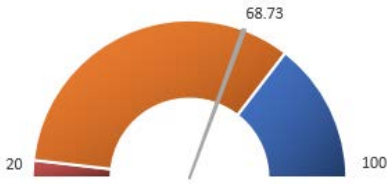
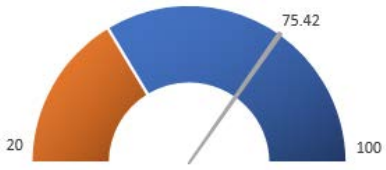
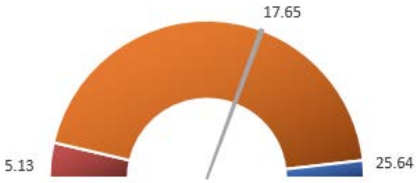
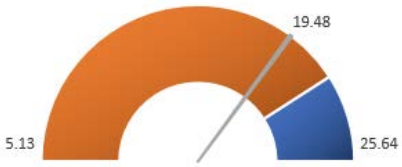
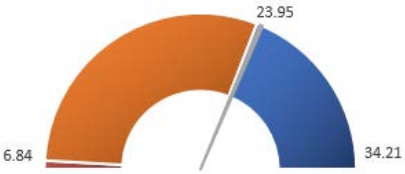
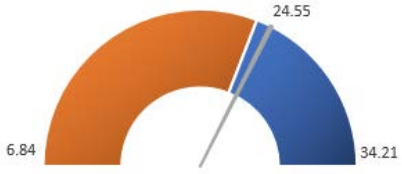
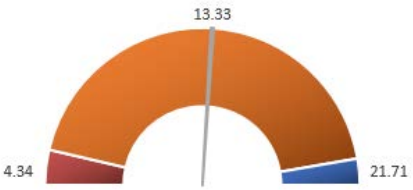
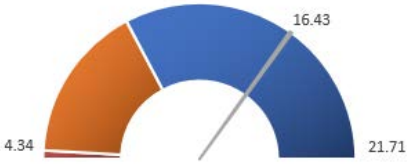
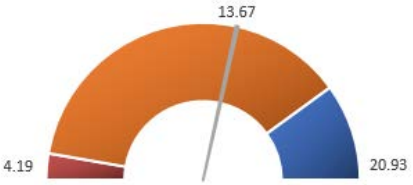
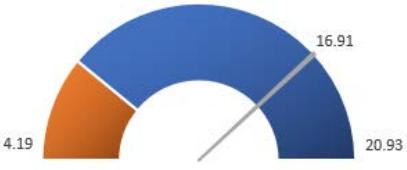
	Pre-assessment	Post-assessment
	■ Beginner ■ Intermediate ■ Advanced	
Overall Range 20-100	 **Min** 32.00 **Mean** 68.73 **Max** 84.00 **Median** 70.00 **Mode** 70.00 **StDev** 8.79	 **Min** 58.00 **Mean** 75.42 **Max** 85.00 **Median** 76.00 **Mode** 76.00 **StDev** 5.50
Strategic Thinking Range 5.13-25.64	 **Min** 7.10 **Mean** 17.65 **Max** 22.60 **Median** 17.80 **Mode** 17.70 **StDev** 2.62	 **Min** 14.93 **Mean** 19.48 **Max** 23.14 **Median** 19.64 **Mode** 20.21 **StDev** 1.99
Project Execution Range 6.84-34.21	 **Min** 12.80 **Mean** 23.95 **Max** 28.70 **Median** 24.60 **Mode** 24.60 **StDev** 3.06	 **Min** 19.71 **Mean** 24.55 **Max** 29.87 **Median** 24.43 **Mode** 24.21 **StDev** 2.09
Team Management Range 4.34-21.71	 **Min** 8.90 **Mean** 13.33 **Max** 17.40 **Median** 13.40 **Mode** 11.40 **StDev** 1.80	 **Min** 9.81 **Mean** 16.43 **Max** 19.71 **Median** 16.57 **Mode** 17.21 **StDev** 1.73
Project Leadership Range 4.19-20.93	 **Min** 6.20 **Mean** 13.67 **Max** 18.90 **Median** 14.00 **Mode** 14.60 **StDev** 2.16	 **Min** 11.86 **Mean** 16.91 **Max** 20.93 **Median** 16.93 **Mode** 18.93 **StDev** 2.00

Figure 7: Pre-and Post-Course Self-Assessment Results, Fall 2017

Students' self-rating of their project management competencies pre- and post-course, as summarized in Figure 7, showed wide variations in increases or decreases. All students rated at least one of their competencies higher post-course. Forty percent rated themselves higher post-course in all 5 categories; sixty percent rated themselves in at least one category lower post-course.

In course evaluations, all students reported a significant growth in understanding and application of course concepts; see the section of this report titled, "Student Feedback," for additional details.

The result that all students reported significant growth in understanding, coupled with the fact that many students reported a lower post-course score in their self-assessment, leads to the conclusion that many students grew in their understanding of true competency and developed a more realistic assessment of their current mastery of those competencies.

Student Feedback

The exploration of contrasts and complements between geometric and living order approaches has afforded a rich ground for discussion and learning for students, as well as faculty. Students have engaged with the contrast and comparison as they have initiated and contributed to asynchronous discussions, live discussions during web conferences, and in writings they have prepared for individual and team assignments. Students have also shown great interest in lean project management practices and have written and presented about ways they can move practices within their organizations to more fully embrace lean project management approaches.

As part of the end-of-course evaluation students are asked:

- To self-rate their achievement of specific learning goals for the course;
- To rate the quality of various elements of the course (e.g., readings, web conferences, individual assignments, discussion forums, quality of interactions with faculty, responses to requests for help);
- To identify the most valuable and least valuable lessons;
- To suggest at least one improvement for the course;
- To rate and comment on their team project experience; and
- To rate the usefulness of what they learned in the course to (a) their current responsibilities or job, and (b) their future responsibilities/positions.

Within the Master of Engineering Management program, faculty place great weight on student feedback on the usefulness of what they learn in each course. Recall that these students are all practicing professionals, with an average of eight years' professional practice. Accordingly, the judgment of these students is grounded in substantial workplace experience. They have returned to graduate studies to fill gaps that their preceding undergraduate and graduate education has not provided as they advance in management responsibilities. Most of the course's emphases that have been described in this paper have evolved over the past three course offerings (2013-2015);

feedback from students, summarized in Table 3, show that over that period they have rated the course's relevance to their current positions 4.42-4.70, and relevance to their intended future responsibilities as 4.56-4.81, both on a scale of 1 to 5.

Usefulness of Technical Project Management Course as Rated by Students (on scale of 1-5)		
Year	**Useful in current responsibilities or job**	**Useful in future responsibilities or job**
2006	4.09	4.55
2007	4.20	4.60
2008	4.00	4.60
2009	4.33	4.85
2010	4.35	4.69
2011	4.40	4.70
2012	4.13	4.50
2013	4.70	4.81
2014	4.44	4.81
2015	4.67	4.82
2016	Course not offered in 2016	
2017	4.42	4.56

Table 3: Usefulness of Course as Rated by Students

Targets for Continued Improvement of the Course

At the conclusion of each semester, the course instructors meet with course instructional designers to collectively review students' course evaluations, discuss our experiences as instructors, and identify plans for continued course improvements. A few of the key targeted improvements for future offerings of the course are described below.

Improving the value of asynchronous discussions

Presently, each week includes an asynchronous, student-led discussion focused on the week's topic. All students are expected to add to the week's discussion, and participation is graded. Over the past five years, the average score for the asynchronous discussions in student course evaluations is 3.88 of a possible 5.0; this is the only element of the course that scores below 4.0. Student discussion leaders typically do very well at asking open-ended questions that focus on real-world application of topics, then offer a synthesis of the discussion at the end of the week. Some students report that the number of comments to be read excessive, especially when class size exceeds 20 or so students. We will continue to explore options for dividing students into smaller groups and other modifications that will make this graduate –level sharing of experiences and insights a higher return on invested time for students.

Improving the value of web conferences

Each week includes a one-hour web conference focused on the week's topic. Over the past five years the average score for web conferences from student evaluations is 4.33 of a possible 5.0. By intent and design, these are not streamed lectures. Our goal is engage students in graduate-level, high value discussion and learning. We see these real-time, live connections as important, valuable opportunities for active learning and building of student-instructor and student-student relationships. We continue to experiment with how to make weekly web conferences the best possible non-redundant complement to course recordings, readings, and assignments.

Improving the design and impact of the self-assessment

Prior to Fall 2017 the self-assessment was a form that asked each student to rate himself/herself in each competency area. Students completed the form at the beginning and end of the semester, and were asked to reflect on results. The modified assessment introduced in Fall 2017 posed a series of questions that then produced score in each competency area. Like before, students completed the self-assessment at both the beginning and end of the semester. Individual students and teams were encouraged to use pre-course results, reported in the team dashboards, to help refine learning goals and planned work. In the initial semester for use of the new assessment, students reported mixed comments on the assessment's usefulness. Using feedback from students and related research, we will continue to evolve the design of the survey and its use to improve student learning.

Deepening learning via personalized learning

Many of the efforts we have made and continue to pursue in improving the subject course converge in their contributions toward enhancing personalized learning. Adult students especially appreciate the ability to improve the practical value of their learning by choosing assignments and projects that are cognizant of their current level of knowledge, and enable them to intentionally refine their learning to best align with achieving their educational and career goals. The self-assessments in this course are a key element of enabling students to actively engage in identifying their competencies and developing appropriate, informed targets for growth. Also, within the course, we have increasingly included assignments that focus on application of concepts to the student's current work environment. For example, for many assignments we ask students to interview a senior manager or review current practices at their workplace, then use their understanding of concepts from the course to constructively review those practices and recommend improvements. These individualized assignments, while highly valuable for most students, are especially time-intensive to grade and provide meaningful feedback from instructors, in highly enrolled courses. We believe that finding the best ways to enable high-impact personalized learning is one of the most important focuses in this course going forward.

Conclusions

As course instructors, we remain challenged to help practicing engineers with as little as two years' experience, and as much as thirty, find the course highly relevant, practical and valuable.

Some of key observations and learnings over the past eleven years collaboratively teaching this course are:

- The semester-long team project, despite the logistic challenges for students and instructors, remains a high-value learning experience. Students are challenged to come together quickly to choose a team project, then plan and execute the several deliverables that demonstrate their application of course learning. In addition to demonstrating their knowledge, this team project challenges them in scheduling of work and team communications, efficient execution of team analyses, collaborative document development and revision, and team presentation skills. These team projects also are challenging for instructors to review and grade, and provide coaching for teams that are struggling. Despite these challenges, we have seen how this semester-long team assignments provide important applied learning for students, and helps to build stromg peer to peer relationships that continue beyond the course.
- Students coming into the course are often looking for training in tools (e.g., MS project and CPM analysis). As instructors, we seek to grow students to be savvy capable, adept leaders of teams and projects. We teach fundamentals and tools, but emphasize that the success of their projects will be far more dependent on their ability to strategically navigate in the midst of ambiguity, uncertainty, and risk.
- The contrast and juxtaposition between geometric and living order has proven to be valuable to students' understanding of project planning and execution. We see students applying these concepts to the writing that individual students do for their weekly assignments, and in the team assignments.
- Student presentations during weekly web conferences provide valuable contributions to class learning. Students present case studies and tools from their professional practice that add new perspectives and insights for all students. Students consistently rate this peer-peer sharing as a much appreciated element of the course.
- The pre-course and post-course self-assessments are important opportunities to have students reflect on their current practice and plan their continued development. We have targeted continued refinement of the self-assessment and its use within the course as important objectives for continuous improvement.
- We continue to grow the teaching, discussion, and practice of lean project practices within the course. As instructors, we present examples of lean practices in capital, software, and product development projects. Students share how they are presently or seeking to incorporate lean practices in their work. Inertia and conventional practice create hurdles to innovative lean practice. Fertile opportunities remain for improving relevant, impactful learning and practice.
- The instructors have recently written an electronic book [26] that seeks to provide student with a deeper understanding of applications of living and geometric order within project management. The document is available for download to project management instructors, students, and practitioners.

As project management instructors, we need to ask ourselves, “Are we preparing our students academically and experientially to face the technical, managerial, and strategic issues they will face as their projects encounter unexpected challenges?”

We seek to continue to evolve this course and related Master of Engineering Management curricula to go beyond teaching conventional, geometric order, and teach students to adapt and thrive in the living order of their fast-paced, complex, constantly evolving projects.

Credits

The authors extend their sincere thanks and appreciation to the following colleagues whose work contributed to key elements of the course addressed in this paper. Dr. Mary Thompson and I-Pang Fu led the development of the competency questionnaire and associated dashboard described in the paper. Ann Shaffer is a key contributor and chief editor for the e-text used for the course. David Pagenkopf, Brian Price, George Watson, and Susan Ottmann reviewed the e-text and provided valuable additions and edits. Mark Millard and Stacey Binder have contributed their instructional design expertise to help evaluate and continuously improve the subject course.

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