



Leading Multidisciplinary Engineering Teams

An Online Continuing Education Course for Engineers

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Leading Multidisciplinary Engineering Teams

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1. Introduction

Project managers (PMs) and design managers (DMs) need leadership skills to drive an engineering team to successfully produce the required deliverables. On engineering design projects, this involves leading a team of design professionals from different fields.

Multidisciplinary engineering teams (METs), also called multidisciplinary design teams (MDTs), consist of members belonging to different professional and technical fields who combine expert knowledge to solve complex design problems and produce project deliverables. Example disciplines include civil, architectural, structural, mechanical, plumbing, electrical, process, systems, controls, drafting, BIM, surveying, geotechnical, costing, and permitting.

For the successful delivery of a design project, MDT collaboration is essential to meet innovation, quality, and sustainability goals. The larger the project, the higher the stakes and the more critical the collaboration. On a very large project, a PM may spend a good portion of each day overseeing design collaboration. See Figure for examples of large projects.



Figure 1: Large construction projects using MET design documents.

Left) Construction of the USS America amphibious assault ship.

Right) A tourism statue with an exhibit hall, galleries, a food court, and walking gardens.

Sources:

- ❖ commons.wikimedia.org/wiki/File:World%27s_Tallest_Shiva_Statue_in_construction_phase_at_Nathdwara,_Rajasthan.jpg
- ❖ commons.wikimedia.org/wiki/File:LHA-6_USS_America_under_construction_at_Ingalls_Shipbuilding_October_19_2001_mg_0184.jpg

Multidisciplinary collaboration helps organizations and projects to overcome the boundaries of disciplines and jointly develop solutions that would otherwise never have been developed in the context of one field. Collaboration also reduces the number of conflicts and inconsistencies, which often lead to serious construction costs and delays.

The need for cross-disciplinary teamwork is becoming more important because of the growing technical and social complexity of large-scale engineering projects. Globalization, digitization, and sustainability initiatives demand engineers to interface with cross-disciplinary and cross-geographic expertise. Leadership from a project manager and design managers is pivotal in creating cohesive professional design documents that meet project objectives and support the business case.

Studies have shown that METs can actually be more efficient than monodisciplinary teams when handled by integrative leadership practices supportive of shared vision, cognitive diversity, and facilitated decision-making procedures. This advantage of performance is, however, conditioned by the capabilities of the leader to handle ambiguity, balance between conflicting priorities, and maintain a culture of psychological safety that allows for open communication and close teamwork.

METs have challenges that persist despite their potential. Communication failures are frequent for a variety of reasons, including different interpretations of technical language, vagueness, not listening or participating in meetings, and inconsistent communication channels. Competing requirements of design optimization, cost control, schedule control, and regulatory requirements may create disjointed decision-making, with team members heading in different directions.

Another challenge is disciplinary "silos", which have their own knowledge base, document templates, techniques, and design approaches. Silos lean towards copying work from standards or other projects rather than developing a project-specific solution, such as through the process in Figure 2. Silos impede collaboration and innovation. Lack of shared frameworks and terminologies increases the likelihood of misunderstanding and degrades efficiency, with potential for delays or redesign.

To overcome the challenges with MET projects, adaptive leadership skills and shared mental models are approaches that promote the integration of knowledge and thinking on a system level.

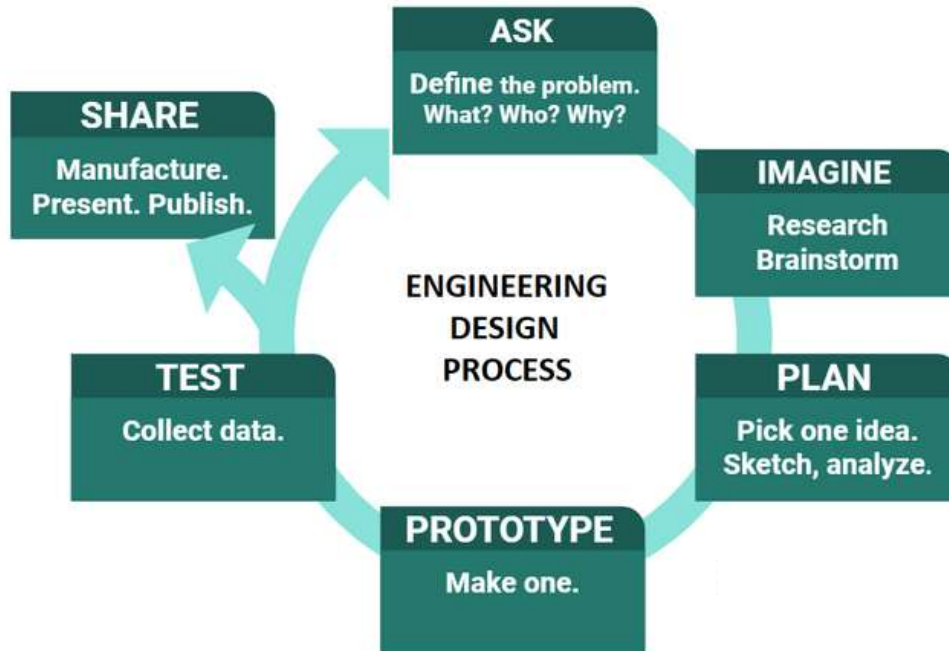


Figure 2: Example of a design process with iterative stages of problem-solving.

Source: commons.wikimedia.org/wiki/File:Engineering_design_process.png, Bennett Brown, CC-BY-4.0.

This course covers the core concepts, approaches, and instruments of successful leadership in multidisciplinary design settings. This includes communication patterns, conflict management strategies, and collaboration utilizing technology that improves team performance. The first section is on the nature of MET projects, followed by leadership models, digital transformation, innovation, and professional competencies. The last section provides practical advice to project managers and design managers working in complex interdependent design settings.

2. The Nature of Multidisciplinary Design Teams

A multidisciplinary engineering team (MET) has members belonging to different professional and technical fields, each responsible for different aspects of the design work (civil, structural, etc.), but together producing shared deliverables (reports, drawings, specifications, cost estimates, etc.). MET projects provide multidisciplinary design solutions that address complex multidimensional engineering problems.

As mentioned in the introduction, example design disciplines include civil, architectural, structural, mechanical, plumbing, electrical, process, systems, controls, environmental, drafting, BIM, surveying, geotechnical, costing, and permitting.

2.1 Design Stages

Design projects typically follow a waterfall approach, which has a linear progression through design stages. This differs from an Agile or iterative approach. An example of a project with design phases is as follows:



Often, the project starts with the initial study stage, then a go/no-go decision is made on whether to proceed with the design stages. Subsequent stages can either be managed as changes to the project (with the same project number) or as one or more new projects.

Often, all the design stages will be a single project. At the same time, engineering services during construction are a separate project and can even have a different project manager who is more experienced with construction projects. If the project is a design-build approach, then all stages will be part of a single project.

2.2 Interdependencies

Most projects have several design areas with significant overlap and interdependence between design disciplines. It is helpful to view design activities as coupled systems and not linear processes. Although the design stages may be linear (Study, 30%, 60%, 90%, Final), the actual design work within each stage is closely coupled and can be described as iterative.

Early design choices by one discipline (e.g., choice of materials, motor size, foundation type, control strategy) are carried forward to later design stages and end up impacting the design work by other

disciplines. The full impact of these early decisions is often difficult to predict, but made worse if there is a lack of early collaboration.

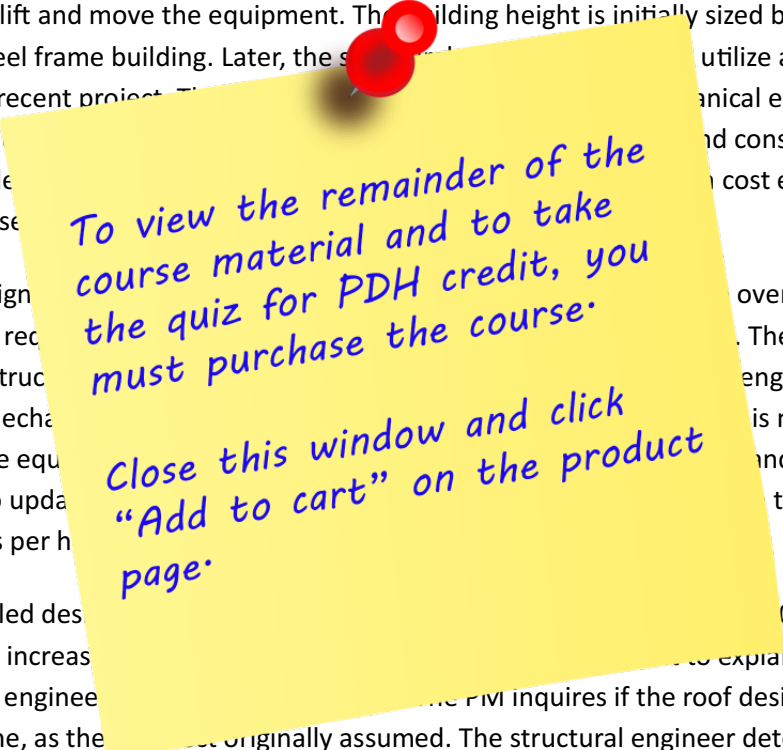
Without collaboration, silo-based assumptions in one area may lead to rework and an increase in construction costs. Collaboration can consist of iterative feedback processes, formal interface control, and multidisciplinary reviews.

2.3 Example Scenario: Roof Design

As an example, a project includes the design of a new building with mechanical equipment and an overhead crane to lift and move the equipment. The building height is initially sized by an architect based on a rigid steel frame building. Later, the structural engineer determines to utilize a truss-type roof design based on a recent project. The mechanical engineer selects equipment and assumes a building height. The structural engineer develops a preliminary structural design element and cost estimate. The project manager reviews the preliminary design and cost estimate and prescribes a building height.

In the detailed design phase, the structural engineer specifies the crane requirements. The project manager requests that the structural engineer confirm the design is adequate. The mechanical engineer determines the crane to lift and move the equipment. The structural engineer requests other disciplines to update their design to accommodate greater air changes per hour.

At the end of detailed design, the project manager determines a cost of 100,000 related to the building height increase. The project manager explains to the project sponsor, and value engineer determines the cost. The project manager inquires if the roof design can be changed back to a rigid frame, as the structural engineer originally assumed. The structural engineer determines that it can be changed; it will take 40 hours of rework. Also, the construction cost of the building will still be over the preliminary construction cost estimate since the truss design is more economical.



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