Playing Well with Others - Leading and Teaching Multi-Disciplinary Engineering Design Teams

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Multi-disciplinary teams are comprised of engineers stemming from many different backgrounds and cultures. Bringing a team together from many different backgrounds creates a cultural divide that may lead to strife among team members. Working for a multi-disciplinary team is a fundamental change in the way the members interact. This requires the presence of a change leader and a team atmosphere that is out of their normal cultural bounds. Integrating the disciplines into a System led Decision Process is fundamental to the overall functionality of the team and can be accomplished best by the role of the Program/Project Manager (PM). It is necessary for the PM to set the correct team atmosphere and organization that will last for the duration of the project life cycle. The team’s success relies on their ability to communicate freely, avoiding the “silo effect.” Organizing into heavyweight functional teams will allow for lower level members to incorporate core values and feedback into the team from the bottom up. The team will be able to maximize their output and longevity through utilizing this type of culture.

Multi-disciplinary teams are very prominent in industry today, which is why it is essential that we create and reflect this dynamic in the academic environment to better prepare our students for the “real world”. Bringing together students of various engineering and technical backgrounds to work on a design project together in the academic environment better reflects the current industry standards. As a result, an Academic Advisor leading (and grading) a group of students through a Capstone Design Project corresponds directly to the role of the Project Manager (PM) on a multi-disciplinary team in industry (from here forward, the term Project Manager (PM) will be used to represent the Academic Advisor as well). Similarly, these teams allow for both variety and technicality all under the same management and budget. They integrate a set of engineers from all different backgrounds into a cohesive group who work together to solve a complex problem. The paradox is, with many professionals all having degrees in problem solving processes, why do Academic Advisors and even PMs find it difficult to lead teams of this nature?

Each discipline has its own culture and is highly respected in its own way. The PM owns the role of changing the behaviors of the members to thinking like a team, instead of as individual technical experts. Having a multi-disciplinary team requires the presence of a change leader who will create and lead a team atmosphere that is out of their cultural bounds and into a System led Decision Process. A change leader is someone who will bring the team together and working towards the right goal. They always have the right mindset and the team will follow
them towards the end state of communication and interdependency in solving the problem at hand.

The System Decision Process (SDP) is a holistic and all inclusive philosophy that integrates multiple backgrounds into one design process. Its focus, communication and teamwork, lead to overcoming the cultural divide presented by a multi-disciplinary team. Integrating systems thinking into the overall strategy, a PM and an Academic Advisor can satisfy the requests and desires of all disciplines while still staying connected to the client’s and/or program needs.

The PM must find a way to make these teams work together and generate a solution to the client’s problem. To set a team up for success, the PM should rely on the systems decision process to integrate multiple disciplines together. The key tasks at hand for the PM are to create a team atmosphere, physical organization, and carry out their role as a change leader as they integrate all the disciplines into one cohesive unit.

Multi-discipline (MD) can mean multi cultural. Engineering disciplines may have a very narrow scope, but work extremely hard and brilliantly in their range of expertise. When many different disciplines are brought together, competition spurs from each believing that their subject is more important, or better, than the others. This cultural divide and pride factor creates competition and a push for the group to follow their respective thought process. After learning and working in a specific design process for many years, it is hard to change those beliefs towards an integrated design process. Bringing this technical expertise together is where multi-disciplinary teams can make extraordinary strides if utilized correctly.

Multi-disciplinary teams are difficult to lead. An integrated systems approach will help the Project Manager develop a solution to the problem in the most efficient way. The key takeaways of leading multi-disciplinary teams are as follows:

- Project Manager’s role as a change leader
- Overcoming the cultural divide early
- Physical organization is a tool to forge a true team
- Communication and teamwork lead to victory
- The client is always the decision authority

The Systems Decision Process has the holistic nature to combine a wide variety of disciplines into a working team. Each member has both their technical role and their team role to understand and carry out. The Project Manager must create the team such that both their roles can be carried out with ease and still allow for each member to be challenged and motivated throughout the entire life cycle. With the presence of a legitimate change leader, the members will be empowered to make decisions and actions on their own that reflect the true value measures put forth by the client.
Annotated Readings:


The authors discuss that the challenge for a mature, established organization and/or practice is to meet a changing environment and to respond to changes in a manner that will revitalize its structure and competitive edge. Engineers are often resistant to change and base much of their success on past performance and maintain a relatively stable demeanor and approach to problem solving. Globalization, reduced technology cycles, changing demographics and expectations among design team members and customer demands all lead to the importance of creating and working on a multi-disciplinary design team. The authors describe in detail the challenge of change, organization mindsets, life cycles, the principles of renewal, and that new mindsets must be created that are shared by all team members to ensure success.


Creating a distinctive advantage in the speed, efficiency, and quality of product developments is a major challenge for most multi-disciplinary design teams and trying to teach that to students is also challenging, yet extremely important in preparing them for industry. Achieving integration across functions/disciplines lies at the heart of that challenge. While many recommend teams as a way to effectively manage development activities, a successful team requires more than just naming members to a core team and designating a project lead. Care must be taken in selecting the project lead and also that team members encompass the disciplines and skill sets required for the project. The author establishes a framework for organizing and leading "heavyweight" teams and presents examples of companies that have made heavyweight teams a distinctive advantage. A competitive advantage in product development capability requires fundamental changes in how work gets done, the skills, capabilities, and tools team members bring to that work, in the support activities required from other groups inside and outside the organization, and finally in the responsibility and ownership taken by the project lead and core team for creating and executing the concept/design.


Companies that enjoy lasting success have core values and a core purpose that remain fixed, while their business strategies and practices endlessly adapt to a changing world. The dynamic of preserving the "core" while stimulating progress is the reason that companies such as Hewlett-Packard, 3M, Johnson & Johnson, Procter & Gamble, Merck, Sony, Motorola, and Nordstrom
became elite institutions able to renew themselves and achieve superior long-term performance. Truly great companies understand the difference between what should never change and what should be open for change, between what is genuinely sacred and what is not. This rare ability to manage continuity and change—requiring a consciously practiced discipline—is closely linked to the ability to develop a vision. Vision provides guidance about what core to preserve and what future to stimulate progress toward. A well-conceived vision consists of two major components: core ideology and envisioned future. These concepts are directly applicable to students on a multi-disciplinary design team and it is essential to implement such concepts in academia to ensure a smooth transition to the "norms" of industry. This article supports the importance of a vision, a change leader/project lead, and the adaptability of team members to adjust strategy to accommodate the evolution of technology, innovation, customer demands, and business practices.


The author discusses the importance of assertiveness from members of multi-disciplinary design teams. He describes the difference between assertiveness and pushiness, and also addresses the challenge of encouraging quiet team members to more actively participate in the group in order to avoid missing out on innovative ideas and the valuable exchange of ideas. He explains that assertiveness complements a wide range of critical leadership and team-building skills that are essential to improving group dynamics on multi-disciplinary teams and producing better results, designs, products, ideas, etc. Specifically, he illustrates how multi-disciplinary teams with the appropriate group dynamic and leadership can create a culture of innovation, be more customer focused, foster teamwork and collaboration, lead change, act with integrity, create a safe environment, and communicate more effectively as a group and as individuals.


This paper outlines an approach to teaching invention and design that combines elements from engineering, social sciences, and humanities. The author designed an experimental course with a collaborative learning environment in which students from a wide range of majors worked in teams on modules. Each module lasted several weeks and included both written and presentation/oral components. Standard university curricula tend to compartmentalize engineering, humanities and social sciences. However, real world engineering projects and problem solving decisions do not reflect such compartmentalization, which is what the course demonstrates to the students. There are four active learning modules in the course: a hands-on
A project based on the invention of the telephone, a computer simulator to teach driving, an energy-efficient house, and a medical decision support system based on a client’s needs. The author includes a thorough evaluation of the course, a detailed description of each module, and suggestions for future improvements.


Engineering lies at the interface between science and society. It is concerned with the systematic application of scientific and mathematical principles towards practical ends for the benefit of people. Traditionally the emphasis in engineering education has been on the scientific side, with students given a thorough grounding in the fundamental scientific and mathematical principles supporting their discipline. However, the constraints on engineering problem-solving today are increasingly not technical, but rather concentrate on the societal and human side of engineering practice. These changes require new approaches within the curriculum, to include promoting active learning, encouraging students to experiment and be more creative, and the incorporation of web-enabled learning (eLearning). The author discusses the modern context of engineering practice, its consequences for education and professional development, and the wider implications eLearning as important strategy for achieving the required paradigm shift.


The University of Edinburgh in the United Kingdom (UK) has developed a series of truly interdisciplinary design courses aimed at improving students' abilities to operate across disciplines and improve their preparation for industry. Led by a Visiting Industrial Professor, the course on hydropower design requires students to provide a full feasibility study of a small scheme in western Scotland addressing issues from hydrology through to grid connection. The course has had several very successful outcomes which include: appreciation of other engineering disciplines, experience of teams where different skills and expertise are available, demonstration of the links between engineering design and economic viability, introduction to non-technical areas essential to the UK Standard for Professional Engineering Competence, and enhancing interest in the hydropower sector in technological and career terms. The significant result from project is the importance of maintaining balance across all tasks, within groups, and staff support across disciplines.

This was a groundbreaking article when originally published and the concepts still hold true today. The authors say that if managers want to make better decisions about teams, they must be clear about what a team is. They define a team as “a small number of people with complementary skills who are committed to a common purpose, set of performance goals, and approach for which they hold themselves mutually accountable.” That definition exemplifies the discipline that teams must share to be effective. The authors discuss four elements that make teams function: common commitment and purpose, performance goals, complementary skills, and mutual accountability. They also classify teams into three varieties: teams that recommend things, teams that make or do things, and teams that run things. Furthermore, they describe how each type faces different challenges. Most executives advocate teamwork. Teamwork represents a set of values that encourage listening and responding constructively to views expressed by others, giving others the benefit of the doubt, providing support, and recognizing the interests and achievements of others. Such values help teams perform, and they also promote individual performance as well as the performance of an entire organization. But teamwork values by themselves are not exclusive to teams, nor are they enough to ensure team performance. Nor is a team just any group working together. Groups do not become teams simply because that is what someone calls them. The authors distinguish between teams and other forms of working groups. That distinction turns on performance results. A working group’s performance is a function of what its members do as individuals. A team’s performance includes both individual results and what is called “collective work products.” A collective work product is what two or more members must work on together, such as interviews, surveys, or experiments. Whatever it is, a collective work product reflects the joint, real contribution of team members. This is an essential aspect to incorporate into the academic environment when managing and teaching multidisciplinary design teams and greatly represents industry standards.


Interdisciplinary cooperation among people trained in technical and economic fields has been identified as an important success factor in new venture teams. However, empirical findings also indicate that individuals often refuse to engage in close and trustful relationships with representatives of other disciplines. As a result, the author investigates the question of whether education programs on interdisciplinary cooperation may be suitable to prepare students for future activities in multifunctional business start-up teams. The author discusses the psychological effects of an interdisciplinary business planning course held at the Vienna University of Economics and Business Administration with the intention of promoting
cooperation between technology-oriented professionals and business management students. Students who enrolled in this course found the experience change their attitudinal beliefs with respect to representatives of the technical discipline by reducing stereotypical assumptions. At the same time, the course fostered awareness of the challenges involved in multi-disciplinary cooperation. The more students communicate with their technical counterparts and the more they familiarize themselves with the technical aspects of the project, the stronger these effects became. Ultimately, students from various disciplines working on a start up team enhanced and added value to process and outcome of solving a complex problem.


Over the seven years in which Carnegie Mellon University's multi-disciplinary Engineering Design Projects course has been offered, the processes for forming the student teams and then associating the teams with client-sponsored projects have developed into a pair of best practices. The authors describe suggested best practices for team formation and associating teams with projects. They further describe the path they followed in developing these processes, and compare these processes with some benchmarks and standards. Their results indicate the importance of combining societal aspects such as law, economics, psychology, ethics, and social management skills along with engineering and science. Results also highlighted the importance of interpersonal skills such as teamwork and communication.


Developing a multidisciplinary and truly innovated design team involves three important factors: “manage creative friction, bring creativity to the center, and stand for delivery”. Overcoming friction on any team is important, but even more important for multi-disciplinary teams at the very beginning because everyone will have a different approach or way of doing things. The author discusses the importance of encouraging the “good creative friction” first with sharing the experience – the whole team, including the client, work together through all steps of the ideation process before the traditional “divide and conquer” method to achieving the final product/idea. In addition, removing communication barriers and to just “have at it” are important factors in removing bad team friction and sustaining only the good, creative friction in a multi-disciplinary design team. The second important factor – “bring creativity to the center” involves the location of the project room and where the team interacts. Finally, the “stand for delivery’ factor refers to getting the ideas to market – turning an idea into a finished/final product/design. This is where
mult-disciplinary teams are successful because the diverse experience and variety of creative ideas can come together to ensure implementation of the idea/design in the most effective manner.

**Additional Resources:**


Carroll, John. “Building an Leading Effective Teams”. Course in Organizational Studies at the Massachusetts Institute of Technology (MIT) Sloan School of Management. Cambridge, MA.

System Design and Management (SDM) Graduate Degree Program at the Massachusetts Institute of Technology (MIT)