AC 2011-1411: ”THE ENGINEER AS LEADER” COURSE DESIGN AND ASSESSMENT

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"The Engineer as Leader" Course Design and Assessment

Abstract

A course was developed in response to the needs of industry and society at large. This course is targeted to those developing engineering skills who will, in the near term, assume leadership roles. This course uses the constructivist pedagogical model and was designed with the goal of facilitating "significant learning experiences."

The basic components of the course are a series of readings (24), videos (14), and interactions with practicing engineering leaders applying a "leaders teaching leaders" approach (5) used as probes to elicit responses from students who then reflect upon and discuss the issues. This is intended to build a vocabulary of leadership concepts that directly relates to their current cognitive and affective structures. Additionally there are several team lead workshops (10) designed to develop team management skills for the whole class (group decision making, presentations, conflict resolution, meeting management, and project planning and scheduling, etc.). Each of these experiences and activities is examined at the immediate and direct level then viewed "from the balcony" for analysis.

Multiple direct and indirect assessments of leadership development and skill mastery are used. These include detailed peer assessments using the new leadership vocabularies, progress in personal skill development, written examinations of skills, peer assessments and feedback from team members. This paper describes and discusses the assessment portion of the course.

Rationale

Courses in leadership are being developed across many disciplines, particularly professional degree programs. There is an emphasis in the popular press indicating that there exists a lack of effective leadership in industry, government, and academe alike. Significant confusion exists as to what a leader is or does and how leadership and management are related. Engineering programs have had some inclusion of leadership emphases in the past, but there is a definite increase in interest. Existing engineering leadership programs appear to have a strong bias toward the skill set and cross-disciplinary background of specific faculty members. The current focus is generally "extra-disciplinary" except in full programs directed at engineering management[1].

Is there something unique about an engineering leader? First we differentiate between a "good" and an "effective" leader. A "good" leader realizes behavioral change that maximizes the net present value of society. This is extremely hard to assess and requires global and time perspectives that are far removed from the leader's acts. On the other hand, an effective leader realizes behavioral change that supports their personal vision. "Effective leadership addresses problems that require people to move from a familiar but inadequate equilibrium – through disequilibrium – to a more adequate equilibrium." [2] We do have access to the degree to which a leader is able to formulate and communicate a vision that moves others to act. Therefore, we

focus on developing "effective" leadership skills. Our objective is to help students use a more realistic model of how coordinated tasks are performed rather than the "Boss" or command and control model. This is a deeper set of unrecognized assumptions than the differentiation between the "roles" of manager and leader.

Fundamental to assessing the desire of engineers to realize a vision is an understanding of what motivates an engineer. As a simple starting point we will assume that an engineer is motivated to act by:

a) "A desire to make something that they can be proud of.
b) Positive feedback and appreciation of their work by others.
c) A desire to be constantly learning new things and growing."[3]

What engineering leaders do

There are numerous descriptions of engineering leadership[4]. These range from functions that they provide, skills that they demonstrate, personal characteristics that they possess, or roles they perform. For the purposes of this course we use the following description of what an effective engineering leader does.

Effective engineering leaders define and communicate an issue to be resolved to those who have the skills, resources, and desire sufficient to solve the problem through the "engineering method."

- **Define**. The typical engineering issue is defined in terms of requirements to be met by a complex technical system. Whereas the problem to be solved is founded typically in an assumption that is not readily apparent. Definition requires a systems understanding at a level more abstract than the level of technology used to develop a solution. Solutions are realized in a larger context[5].
- **Communicate**. An issue defined is not resolved until those with the required capabilities commit to its resolution. Communication requires fidelity between the parties' that is increased through a common language and ongoing and open feedback. Persons outside of the technical community of practice cannot assess risks and opportunities as well as those with direct knowledge.
- **Skills and resources.** The leader must have the depth and breadth of technical background to identify the skills and resources needed for resolution as well as the political capital to acquire them.
- **Desire.** Participants must invest "discretionary effort" in the resolution of the issue. This requires the alignment of the solution space with the values and interests of the people involved. The issue must be important and interesting for others to invest significant effort as in "The Existential Pleasures of Engineering"[6].
- **"The Engineering Method.**" Engineering involves the iterative solution of a system of interdependent problems. "The engineering method is the use of heuristics for causing the best change in a poorly understood situation within the available resources."[7]

Our learning objectives and pedagogy are founded on assisting students develop these competencies. This fully realizes that "Leader development is, unfortunately, mainly an

individual process. Academia and businesses may set up programs and make training accessible, but in the end, it is fundamentally an individual endeavor."[8]

Process

We have chosen to follow Dee Fink's[9] guidance in designing the course. He suggests that we execute a **"**Backward design" of a course. The typical order of course design (Forward design) is:

- Identify content to be covered (pick a book)
- Sequence/schedule topics (assign chapters to calendar)
- Develop lecture content (develop slides and assignments for topics)
- Develop learning goals for topics (based upon the lectures developed above)
- Generate assessment (from selected homework like problems and "trick" questions)
- Modify to fit "situational" factors (snow days, lectures that went bad)

A "Backward design" orders these activities

- Identify important situational factors (identify resources, constraints, and external factors)
- Prescribe learning goals (specific expectations of behavior change)
- Develop assessment and feedback processes (these address the nature of each learning goal)
- Develop teaching and learning activities (with goals and assessments identified there is a wider range of potential learning activities available)
- Connect and integrate (develop the "story" of the course that provide the affective and cognitive "hook.")

The application of this approach to developing a "significant learning experience" for a course in engineering leadership is described.

Situational Factors

Some of the relevant situational factors considered for the course are that it (in the context of this course offering) includes students from all engineering disciplines, it is not part of a capstone project, and students have little or no formal experience in business or training in teamwork. Another important consideration is the difference between the experience of undergraduate students and the experience of those for whom most leadership development programs are targeted. Table 1 highlights some of the differences between industry and university students views of leadership.

Table 1. Situational comparison between employed engineers and student engineer.

Professionals	Students
Identified by others as having leadership potential	Taking a course for credit
Demonstrated commitment to continuing professional development	Currently participating in structured curriculum
Investing effort for likely economic/professional payoff	Investing effort for grade

Acceptance of and integration with organizational culture	Learning their role in society
Experience in long term (more than a year) projects	Experience in semester projects
Experience with multi-disciplinary teams	Experience in teams with members much like them
Experience with complex organizations	Experience with simple organizations (teams)
Some awareness of personal competencies/weaknesses	Little awareness of personal competencies/weaknesses
Strategic (big picture) perspective of individual activity/competence	Personal perspective of individual activity/competency

The nature of the effort (motivation) expended to develop leadership capabilities may be quite different for the groups. Professionals see this as an opportunity to advance in their organizations by participating in a visible program, already a form of recognition. They also bring with them an intuitive understanding of the culture, values, and competencies relevant to their respective cultures. The rewards, both intrinsic and extrinsic, to students are much less well defined and students have not developed a very sophisticated intuition when it comes to dealing with organized human action.

Students may have developed a level of "skilled incompetence" in performing group projects. Chris Argyris has discussed skilled incompetence as it relate to organizational learning. "Skilled incompetence is a condition in which people excel at doing what they shouldn't because it seems right. These managers are "skilled" because they act without thinking. They are "incompetent" because their skill produces unintended results."[10] The same concept may well apply to student teams that measure success by being "nice" to each other and obtaining a reasonable grade without excessive effort. These objectives reinforce behavior that is not conducive to deep learning or a quality product. Students get so good at this "team dance" that they are not aware of the important issues that they are avoiding.[11]

The course itself must provide the armature for experiential learning that they lack. The pedagogy of a course in leadership must consider these situational effects.

Learning Objectives

The learning objectives for this course are based upon a description of the desired content as communicated by the Industrial Advisory Board for the college (Table 2). Although these topics are not learning objectives, they along with expected outcomes identified in an ASEE survey[12] of engineering leadership courses (Figure 1) formed the basis of goals for this course.

Table 2. Topics identified by the Industrial Advisory Board as important for an engineering leadership course.

Overview	Fundamentals of Leadership (Overview and Self Awareness)
Self-Development	Developing our Leadership Capability, Capacity & Know-How (Personal Development…putting it all together)
Inspiring	Inspiring the Technical Professional & the Team and the Boss (Key Competency)
Technical Environment	Fundamentals of Effective Leadership in a Technical Environment (Overview of Fundamentals)
Technical Teams	Fundamentals of Leading and Managing a Team in a Technical Environment (Application of Fundamentals)
Communication	Effective Communication as a Technical Professional (Key Competency)
Strategy	Concepts in Strategic Leadership (Facing Business Realities)
Systems Thinking	Systems Thinking - What Engineers Bring to the Game (Key Competency)
Global Perspective	Working and Leading within a Global Value Chain (Facing Business Realities)
Innovation	On the Job Innovation, Creativity and Risk Taking (Facing Business Realities)

- Expected learning outcomes:
  - Effective demonstration of eight competencies
  - Understand the theory behind the practice of management
  - Demonstration of communication skills rhetorically, interpersonally , and in writing
  - Self-knowledge—character, communication, ethics, innovation/creativity, skills in economics, marketing, teamwork, global awareness/world view, project planning, sustainability
  - To learn the basics of leadership and start "to do it."
  - Differentiate between management and leadership
  - Learn the fundamentals of leadership and skills needed to become real leaders
  - Increase self-awareness - explore values and beliefs, culture and identity; develop confidence, pride in abilities, judgment
  - Build awareness of leadership issues facing our communities, the engineering field and society

Figure 1. Typical outcomes identified for engineering leadership courses. (Engineering and Leadership - ASEE)[12]

The Engineer as Leader course has multiple goals:

- to help students develop the basic skills required for effective participation in collaborative efforts. These include developing project charters, team formation, meeting management, formal and informal communication, and presentations. This is the most basic goal.
- to foster an appreciation of the nature of issues faced in modern organizations; virtual teams, multi-cultural projects, global supply chains, agile response to uncertainty, and a variety of management and leadership structures.
- to maximize each individual's potential for becoming an effective leader and follower. All of us are assessed by others and ourselves in order to provide the basis for development. These will typically be very personal. There is no improvement without change. This is the most challenging for students and instructor alike.

From these goals more specific learning objectives were developed. These then formed the basis for the design of content and assessment.

Upon successful completion of this course, students will be able to:

- Understand and discuss current international events and contemporary leadership concepts, principles, and theories in a way that facilitates practical application in real world engineering, business, social, and other professional settings; (Knowledge)
- Understand their own leadership skills, strengths and weaknesses; (Knowledge; Self-Growth)
- Demonstrate basic leadership skills; (Application)
- Practice teamwork; (Application)
- Assess leadership skills displayed by others; (Evaluation)
- Have a greater appreciation for and desire to continue studying and applying leadership over the course of their life in a passionate way; (Synthesis; Motivation)

Assessment Strategy

Because of the inherently subjective measure of competence on these objectives, multi-factor rubrics were used for each of the major components. The development of an individual's leadership skill has many dimensions, so too does the assessment process. There is a greater emphasis on formative assessment than summative assessment. To this end, mechanisms are provided for ongoing feedback to each student as to their performance from multiple perspectives. These include weekly individual feedback from the instructor, periodic feedback from team peers, periodic feedback from the class as a whole, and most importantly feedback from self-assessments.

Table 3. Source and method of assessment.

Source	Method
Instructor	Weekly comments on reflection assignments Rubrics for grading
Self	Multiple standardized assessments Personalization of assessments
Team members	Periodic anonymous CATME based teamwork assessments Team discussions of self-assessments
Class	Class assessment of team project outcomes

Teaching and Learning Activities

Constructivism[13,14] implies that educators focus on providing students opportunities for connecting previous learning with a new more sophisticated understanding. This requires a high level of student activity performing challenging tasks. Student-centered activities impose more responsibility on students for their own learning and imply that students play a more significant role in their personal assessment. Each learning activity required the explicit integration of new terms and concepts into their current understandings of leadership and their self-awareness.

Leaders Teaching Leaders

An important aspect of the course is the series of discussions with successful engineering alumni. A unique aspect of this course is the commitment of very successful engineering leaders to take an active role in the course. These individuals provide students access to the experiences of engineers who have had the same experiences that they are experiencing; the same student organizations, the same traditions, and many of the same instructors. These leaders directed a discussion related to one or two articles that were assigned beforehand. Students had already submitted a personal reflection on the material, thus they are able to engage the guests with relevant comments and questions. Each engineering leader was provided a "prep" sheet to help them guide the discussion and provide opportunities for "war stories" to illustrate points.

Reading and Reflection Assignments

Instead of a text for the course, a set of 24 articles (a majority were from the Harvard Business Review) and 14 TED lectures (http://www.ted.com/) were used for the course. Articles were chosen as the basis for several reasons. The articles are very well written with highly focused content that allows students to develop a reflection. The variety of topics provided a means of controlling the content that a single text may not. Texts and the books that are used to support engineering leadership courses tend to present a single point of view. Students may mistake the organization of the arguments in a text to imply that "leadership" is a well-defined discipline. Students are exposed to various viewpoints on leadership. The variety of readings and reflections also lead students to realize that "life-long" learning is an accessible objective. The TED videos were short, 12 to 20 minute, presentations by experts with very interesting perspectives on a variety of relevant topics. Also, reading the reflections on each of the readings and TED presentations provided the instructor with guidance as to which elements to include or exclude in the next course offering, which to supplement with an active exercise, and how to sequence that stimuli for effective learning. Reflections were submitted by students though BlackBoard "Safe-assignment" in order to discourage plagiarism.

Team Workshop Presentations

The Comprehensive Assessment of Team Member Effectiveness (CATME) was used to form teams before the first meeting of class.[15] The most important criteria for team formation were schedule compatibility, female students must have another female team member, and teams should include a variety of disciplines. Each team had five or six members. Teams were assigned two topics to present as workshops to the rest of the class. The requirements (the complete rubric is shown in Appendix A) for the design, development and delivery of these workshops are:

- A significant team activity,
- Learning a new skill identified by the topic,
- Presentation and management of a learning workshop,
- A paper describing:
    - What are the implications of the skill/knowledge to engineering leadership?
    - What are the specific learning objectives of the workshop?
    - What are the factors considered in an active learning component of the workshop?

Some examples of the types of topics used in the workshops are:

- Meetings (agendas, minutes, management),
- Group decision making,
- Legal aspects of engineering,
- E-mails, letters & proposals,
- Active listening,
- Conflict resolution,
- Having difficult conversations,
- Leading a problem solving session, and
- Building a team.

These topics will likely change on a semester by semester basis.

Self-Assessment

The Myers-Briggs Type Indicator (MBTI) Step II Interpretive Report was used as a foundation for self-assessment and discovery. The traditional 16 MBTI types provide a shorthand tool for discovering and delineating individual differences. Because there is so much information available on the MBTI, this analysis can be applied to friends and significant others. As a topic of conversation, this may be increasingly relevant to engineers typically focused on the physical world. An advantage of the Step II version of MBTI is that it includes "facets" of each of the 8 MBTI types, Table 4.

Table 4. Facets of MBTI types

Extroversion	**Introversion**
Initiating	Receiving
Expressive	Contained
Gregarious	Intimate
Active	Reflective
Enthusiastic	Quiet
Sensing	**Intuition**
Concrete	Abstract
Realistic	Imaginative
Practical	Conceptual
Experiential	Theoretical
Traditional	Original
Thinking	**Feeling**
Logical	Empathetic
Reasonable	Compassionate
Questioning	Accommodating
Critical	Accepting
Tough	Tender
Judging	**Perceiving**
Systematic	Casual
Planful	Open-ended
Early Starting	Pressure-prompted
Scheduled	Spontaneous

Methodological	Emergent

The 17-page computer generated report also includes sections on specific recommendations for:

- Communicating
- Making Decisions
- Managing Change
- Managing Conflict

For each of the MBTI facets (e.g. Initiating – Receiving), the report provides four to eight descriptive phases that indicate behavior that may be associated with each individual's responses. Students were asked to choose the most accurate phrases from the list and share with team members on a team discussion board. They were requested to describe what individual behaviors support their conclusion. The objectives of this exercise are to provide each student a richer language for self-description, root self-awareness in personal history through a constructivist activity, disclose self to others, and to become aware of the range of individual differences. The distribution of MBTI Types for this class (Table 5) is similar to that reported for engineering student developed by McCaulley as reported in Wankat and Oreovicz.[16]

Table 5. Distribution of MBTI types of class participants.

ISTJ 23%	ISFJ 4%	INFJ 8%	INTJ 8%
ISTP 4%	ISFP	INFP 15%	INTP 4%
ESTP 8%	ESFP 4%	ENFP 12%	ENTP
ESTJ 8%	ESFJ 4%	ENFJ	ENTJ

A range of other self-assessments were used by the class including:

- Index of Learning Styles
- Emotional Intelligence
- Negotiation Style
- Rokeach Value Survey
- Task-Person Orientation

Typically the results of these self-assessments were discussed with the vocabulary developed though the MBTI facets.

Self-Mastery Plan

In order for this course to be a meaningful experience and for students to achieve their potential as engineers, students need to design a reasonable plan for their continued development. Based upon readings, personal assessments, and planning tools, students developed a personal mastery

plan based upon the general outline shown in Figure 2. The details of the personal mastery plan are shown in Appendix B.

1) Self assessment
   a) Values
   b) Mission/Goals
   c) Skills/Abilities
      i) MBTI
         (1) Creativity
         (2) Communication
         (3) Decision Making
      ii) Task/Person
      iii) Conflict/Negotiation
      iv) Technical/Academic
2) Assessment of current personal level of leadership development
3) Personal development plan
   a) Short-term (next year)
      i) Development objectives
      ii) Plan for achievement
   b) Long-term (1 to 5 years)
      i) Development objectives
      ii) Plan for achievement

Figure 2. Suggested content of self-mastery plan

The students were informed of the criteria that would be used to evaluate their plans (Table 6). Rough drafts of plans were submitted two weeks before the final due date and assessments and recommendations were shared with each student. The criteria for evaluating the likely effectiveness of the plan referred to an article reviewed in class that described the requirement for effective change.[17]

Table 6. Elements required for effective change[17]

	Motivation	Ability
Personal	Link to Mission and Values	Over Invest in Skill Building
Social	Harness Peer Pressure	Create Social Support
Structural	Align Rewards and Assure Accountability	Change the Environment

The Story

The "story" of the course is developed by the sequence of reading topics, the objectives of self-assessments, and periodic reviews and summaries.

- We are responsible for our own development
  - Not the system, school, or employer
  - We have limited self awareness (what should we improve?)
  - Self-assessment "View from balcony"

- Leadership is necessary
    - It is natural for people to make poor decisions
    - The cooperative discretionary effort of multiple people (tribes) can accomplish more than the effort of one individual (leverage technical ability)
    - Tribes require a unifying vision
- Nature of leadership
    - Leadership and management are different but complementary skills
    - Managers plan and control
    - Leaders communicate vision
    - Leadership is rooted in a consistent reference to values
    - Values and self-awareness are revealed in crucible experiences
- Organizational and personal development
    - Strategy links vision to action
    - Action implies change (innovation)
    - We don't change because of:
        - Competing commitments (5 Whys)
        - Unconscious assumptions ("In order to – I must – Because")
    - Personal development requires change (influence w/o power)

Each of these topics is rooted in some personal experience through a constructivist strategy with the objective of providing a foundation for efficient recall.

Discussion

Our experience with each of the learning activities will be discussed and the results of preliminary analysis presented.

Leaders Teaching Leaders

A debriefing with the class after their discussions with the engineering professionals revealed that they found most meaningful were:

- The importance of consistent high values and ethics,
- Their willingness to accept new challenges,
- Successes and failures were part of the development process,
- Technical competence must be maintained, and
- Every day holds a learning opportunity.

When asked to identify the speaker that they "liked" the best, the results were fairly evenly divided. Each of the speakers connected with a different set of students.

Readings and Reflective Writing

After the first few reflections, students developed a more personalistic interpretation of the probes and improved their writing. Many were better writers than they gave themselves credit for. Assessment of this activity was difficult because of the variety of levels of development that the class revealed. A rubric was of some use for formative assessment but the fundamental objective of this activity is individual development.

Several times during the semester, students were asked to identify the readings and TED videos that had the greatest impact on their development and those that had the least. Much as with the guest lecturers, the response was quite dispersed. Some reading spoke to some students while the same reading was of little value to others. There were a few readings that were not effective and will be dropped. An interesting note is that each of the TED videos was ranked first by at least one student. This may warrant further study.

Team Workshops

The effectiveness of every team's workshop presentation was assessed by the rest of the class and determined 20% of the course grade for each team member. Class members individually scored and turned in their assessment using a standard rubric (Appendix A). The rubric was designed to include eight attributes measured on scales with four levels and was designed to illicit subjective assessments of workshop effectiveness. After individuals submitted their individual assessments, teams met to develop a consensus evaluation of the workshop. This provided an opportunity for the team to discuss their individual perspectives and develop a clearer understanding of the assessment dimensions. The average of all team's consensus assessments determined the grade receive by the workshop presenters.

The two exams in the course covered only material presented in the workshops (20% of semester grade). Students took learning the workshop material seriously and performed well on the exams.

Plan for Self-Mastery

Students developed their personal plan for developed from the compilation and integration of writings throughout the course. Each of these writings had been commented on and some shared with teammates. There were numerous and varied assessments and feedback. The ultimate mastery plan was graded using a rubric provided to the students. The rubric (Appendix B) is focused on the likelihood of achieving significant behavioral change and assesses the requirements for change presented in Grenny.[17]

General Conclusions

Although students were able to describe the characteristics and actions of their personal visions of effective engineering leadership, they appeared to be unable to assess the effectiveness of their own teamwork. A summary of the comments provided students in regular CATME assessments indicate that students perceived an effective team as one that "got along with each other" shown in Figure 3. This supports Holmer's[11] contention that students are learning "skilled incompetence" when it comes to teamwork.

- Our team worked well together, no conflicts
- I answered that we did not go to the instructor with problems very often because, frankly, we didn't have a lot of problems. Our group worked exceedingly smoothly together, or at least that was my own view.
- Everyone in the group was nice, and talkative. I like to listen and participate in group by doing

my work alone.

- Our team was great. Everyone had good ideas and contributed.
- Overall, the team have fun and enjoy working together. The work load were evenly distributed to everyone, so nobody have to do too much of anything
- ---everyone in our group have done a good job, and try the best we can to finish our project.
- I have enjoyed our team's discussions and think that we are very open minded to new ideas. Our current project is going well with all members contributing equally.
- For the best part our team worked great together. Two of the members, X and Y, would show up late, not do their assignments, and rarely contribute to discussions. The rest of us worked great together and made very efficient use of our time and all put in equal or nearly equal amounts of work.

Figure 3. Comments of students describing teamwork experience.

Data from other assessments support this contention. Figure 4 plots the assessment of the effectiveness of each workshop by the rest of the class. Scores of workshop effectiveness ranged between a high of 25 and a low of 19. The score for each workshop is the mean of the class evaluation using the rubric in Appendix A. Workshop effectiveness is plotted as a function of the presenting team's perception of the quality of collaboration. Each team's perception of the quality of its collaboration is derived from CATME scales and is represented by the mean self-assessment of the team. The higher the CATME score the greater the degree of perceived collaboration. There appears to be little or no relationship between each team's self-perception and its observed effectiveness. Teams were not able to judge the effectiveness of the team's product.

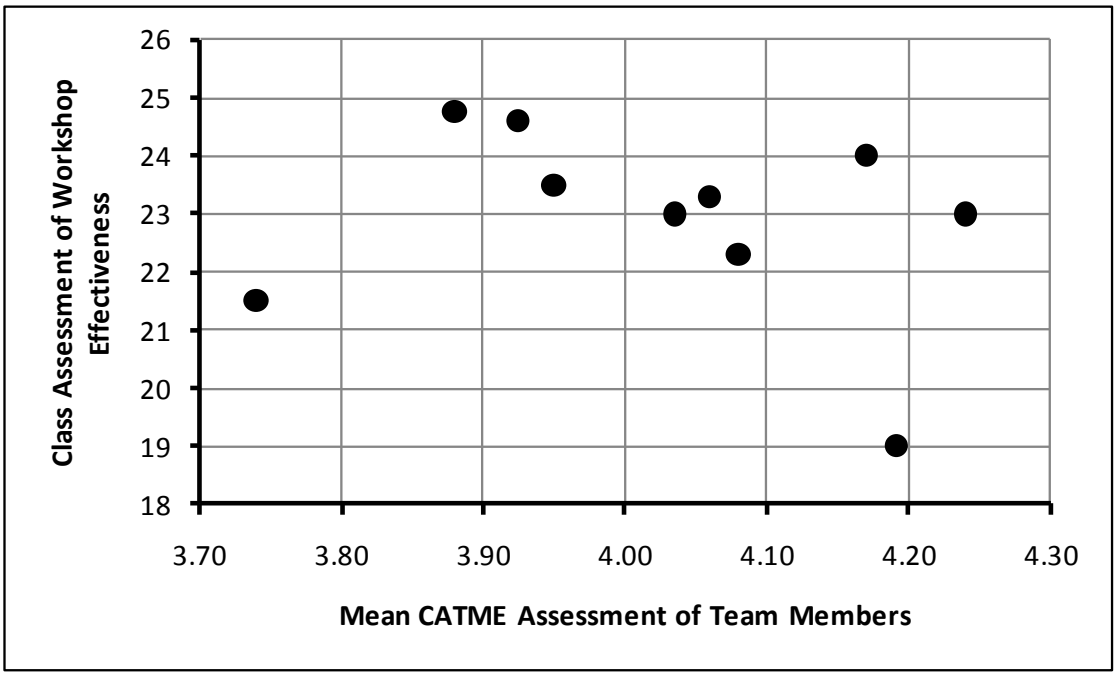

Figure 4. Comparison of team self-perception and assessment of outcome quality

The same general lack of relationship can be observed in Figure 5. In this analysis a measure of each individual's impact on group decisions is plotted as a function of their teammates' assessments of the individual's contribution. The "Impact" measure for each team member is estimated with an index of relative impact on team consensus. The "Contribution" score for each team member is the mean of the CATME assessment of an individual's contribution by their teammates. Again there appears to be no strong relationship. Team members are not able to discriminate between levels of individual contribution.

These indicate that an important learning objective will be proving opportunities to unlearn their "skilled incompetence" in assessing their contribution, other's contribution, and the quality of team outcomes.

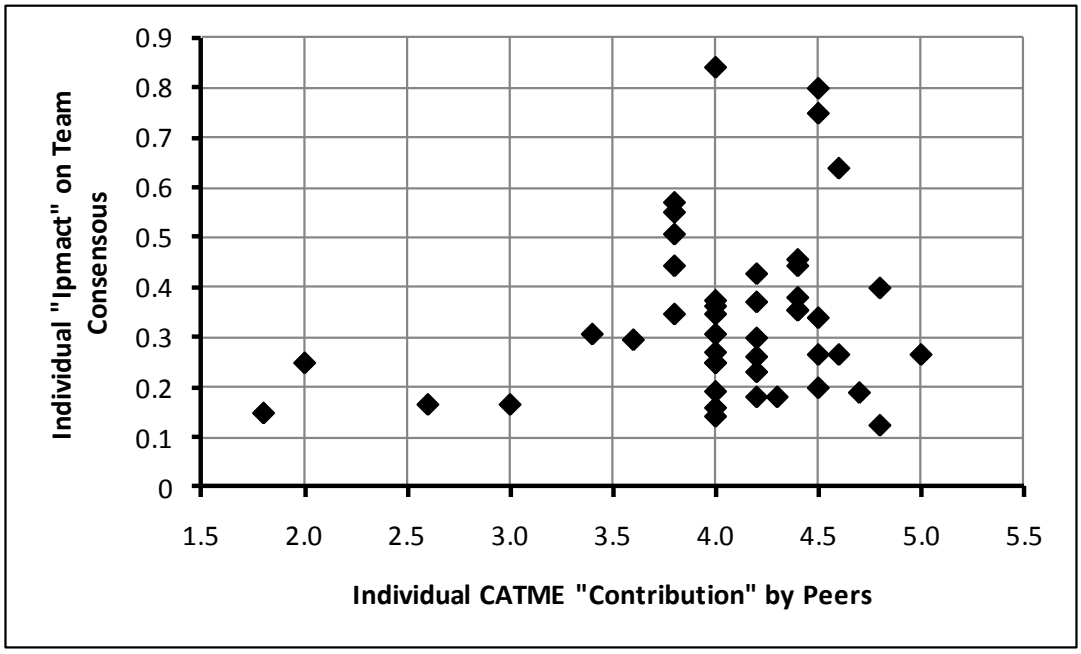

Figure 5. Individual impact on group consensus compared to peer perceptions of contribution.

Developing and delivering the course required the collaboration of a group of individual contributors (including students) and has been a positive experience for all. Generally the objectives of the course have been achieved but analysis of the assessments indicates that there are deeper issues that should be addressed as engineering students move to professional practice.

References

1. Crawford, Andrew S. (1998). "Leadership education at the University of Michigan," *Proceedings of the 1998 ASEE Annual Conference*.
2. Parks, Sharon Daloz, (2005) *Leadership Can Be Taught: A Bold Approach for a Complex World*, Harvard Business School Press.

3. Smith, Jon. (2002). “How to motivate, control and keep good engineers,” *IEEE International Engineering Management Society Conference.*
4. Salmani, D. and Bagheri, O. (2010). “Engineering Leadership,” *Academic Leadership: The Online Journal*. 8(1).
5. Altshuller, G. (1994). *And Suddenly the Inventor Appeared: TRIZ, the Theory of Inventive Problem Solving*, Technical Innovation Center.
6. Florman, Samuel C. (1976), *The Existential Pleasures of Engineering*, St Martins Press.
7. Koen, B. (2003). *A Discussion of the Method*, The Oxford University Press.
8. Farr, J. and Brazil, D. (March 2009). “Leadership skill development for engineers,” *Engineering Management Journal.* 21(1), pp 1-8.
9. Fink, L. (2003). *Creating Significant, Learning experiences: An Integrated Approach to Designing College Courses*, Jossey-Bass, San Francisco.
10. Argyris, C. (1986). “Skilled incompetence,” *Harvard Business Review*, Sept 1, 1986.
11. Holmer, L. (2001). “Will we teach leadership or skilled incompetence? The Challenge of Student Project Teams,” *Journal of Management Education*, 25(5). pp. 590-605.
12. ASEE. (2010). Engineering and Leadership, Survey Results Summary, June 13, 2010.
13. McHenry, A., Depew, D., Dyrenfurth, M., Dunlap, D., Keating, D. Stamford, T., Lee, P. and Deloatch, G. (2005). “Constructivism: The learning theory that supports competency development of engineers for engineering practice and technology leadership through graduate education,” *Proceedings of the 2005 American Society for Engineering Education Annual Conference*.
14. Prince, M. and Felder, R. (2006). “Inductive teaching and learning methods: definitions, comparisons, and research bases,” *Journal of Engineering Education*, 95(2), 123-138, pp. 123-138
15. Ohland, M., Pomeranz, H. and Feinstein, H. (2006). “The Comprehensive Assessment of Team Member Effectiveness: A New Peer Evaluation Instruments,” *Proceedings of the 2006 American Society for Engineering Education Annual Conference.*
16. Wankat, P. and Oreovicz, F. (1992). *Teaching Engineering,* McGraw-Hill College.
17. Grenny, J., Maxwell, D. and Shimberg, A. (2008). “How to Have Influence,” *MIT Sloan Management Review,* 50(1), pp. 46-52.

APPENDIX A
Rubric to assess workshop.

	Not a Clue	Still Feel a Little Lost	Well Done	Exceptional
Definition of topic	Other than the title, don't know what this was about	I get the basic idea but am not sure what this all includes	I understand what the specific topic includes and does not include	Very memorable, they put a nice wrapper around the topic so that it will be easy for me to remember
Relevance of topic and Importance	This is pretty useless information	I am not sure that this topic has anything to do with me.	I now understand the importance of the topic.	I know how important mastery of this topic is to my success,
Key Learning Objectives	I can't tell you what they were trying to accomplish	I can identify some of the objectives but I am unsure as to what they were trying to accomplish	I can tell you what were the specific learning objectives	These objectives relate directly to my success.
Exercise or Learning Opportunity	No real hands on experience was provided	I see what I was supposed to be able to do but am still unsure of my ability	I was able to try out the skill during the activity.	I feel very confident in my capability.
Explicit consideration of individual differences	It looked like a straight lecture	They may have tried to address learning styles but I could not tell what, when, or where.	I could identify elements of the workshop that addressed my learning style	It was clear as to what learning styles the team was addressing
Personal skill assessment	No individual assessment provided	I may have been assessed but I a not sure what it means	I know my ability to accomplish this skill	I can teach this to another individual
Means of continued development	I don't have any idea as to where to start	They demonstrated a need for development but gave minimal direction	I have a general idea of where to go for additional development	I know what specific actions I need to take to improve my competency
Implications for Leadership	I just do not see the relevance of this topic	This looks interesting and useful	It is clear that this is an ability that is relevant to success in leadership	I am convinced that I must master this in order to achieve my potential as an engineer

APPENDIX B

Rubric used to assess personal mastery plan.

Assessment	Does Not Make Sense	Fuzzy	Described	Clearly Delineated
Effective technical leader	No clear description of skills or behaviors	Description of general attributes	Several characteristics described but not integrated	I can envision a real human like this
Self-assessment	Incomplete, not based on objective information.	General skills and abilities identified	Several characteristics described but not integrated	A clear definition of strengths and weaknesses
Development goals	No personal development needs or goals identified	Development needs identified but no goals	General needs and goals presented	Specific actionable goals clearly identified

Development Plan	Not Discussed	An Idea	Actionable	Done Deal
Link to Mission and Values (Motivation)	No obvious tie to personal values	Mission and values mentioned but no clear linkage	Mission and values are part of plan	Plan is based on achieving fundamental personal mission and values
Over Invest in Skill Building (Ability)	The skills needed are not identified	Skills identified but not fully addressed	Skills identified and addressed	The skills will be at an "expert" level
Harness Peer Pressure (Motivation)	Sources of emotional support not identified	There are some who might be happy if I succeed	I will make some people proud of me	The people closest to me are active participants in this process
Create Social Support (Ability)	No support identified	No one other than me really cares whether I succeed or fail	It is generally considered a "good" thing for me to do	Everyone is rooting for me to achieve this
Align Rewards and Assure Accountability (Motivation)	No accountability discussed	The results that I get are due to good or bad fortune	I can take credit for any successes, but not failures	I am obviously the only person accountable for the success or failure of this effort
Change the Environment (Ability)	No change	Some change to provide support	Significant changes provide support	The world is designed for my success