AC 2012-3349: TEAM DECISION SKILLS DEVELOPMENT WITH MBTI
STEP II

Dr. Lawrence E. Whitman, Wichita State University

Lawrence E. Whitman is the Director of Engineering Education for the College of Engineering and Professor of Industrial & Manufacturing Engineering at Wichita State University. He received B.S. and M.S. degrees from Oklahoma State University. His Ph.D. from the University of Texas, Arlington, is in industrial engineering. He also has 10 years’ experience in the aerospace industry. His research interests are in enterprise engineering, engineering education, and lean manufacturing.

Dr. Don E. Malzahn, Wichita State University

Don E. Malzahn is professor of industrial and manufacturing engineering at Wichita State University. He received his B.S., M.S., and Ph.D. degrees from Oklahoma State University. In his 38-year teaching career, he has taught a wide range of industrial engineering courses and currently directs the department’s capstone design experience. His research interests are in systems engineering, decision analysis, and engineering education.

©American Society for Engineering Education, 2012
Abstract

As part of an Engineer as Leader course, students learn to dynamically take leadership in problem solving teams when their unique skills, abilities, or knowledge can contribute to the shared objectives. Part of this development makes use of Myers-Briggs Type Indicator ® Step II. This assessment provides scores on 40 facets of the eight Myers-Briggs Types. An objective of the course is to help students develop a richer vocabulary for thinking about themselves and others. An individual’s clearest facets are used in the course by each student as part of their weekly reflections on assigned readings. A visual display of the team’s integrated vocabulary is used as a guide in team decision making. A standard transition from Sensing to iNtuitive to Thinking to Feeling then back to Sensing is used as students learn to transition between decision making stages and individual team members’ facets. The paper will present the process through which each student’s vocabulary is developed and reinforced and the tools that support transitions and compensate for missing facets in the team decision process are described.

Why “Engineering as Leader”

“Effective leadership addresses problems that require people to move from a familiar but inadequate equilibrium – through disequilibrium – to a more adequate equilibrium”¹. All leaders must be able to formulate and communicate a vision that moves others to act.

How does the engineer as leader differ from other leaders? In addition to what is required for leadership in organizations, leaders in the engineering process must address:

- Design – a creative/innovative non-repetitive activity,
- Complexity – no single individual is capable of understanding the system being designed,
- Unique knowledge – each engineer brings a unique mix of technical and procedural knowledge,
- Collaboration – Integration multiple disciplines, and
- Continuous obsolescence of knowledge.

There are a variety of definitions for engineering. Below are just two as examples.

- ENGINEERING is the profession in which knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize economically the materials and forces of nature for the benefit of mankind².
- Engineering is “the application of science and mathematics by which the properties of matter and the sources of energy in nature are made useful to people” Merriam-Webster’s Online Dictionary.

The component that is often overlooked by the engineering student is the responsibility for improving the quality of life and the implicit breadth of knowledge and skill this requires³, 4, 5, 6, 7, 8, 9. Students typically experience engineering as “problem solving,” a skill that can be honed with repetition and some native ability. Design is a creative collaborative act that requires a
broader knowledge base and an ability to lead and be lead when it is appropriate for the quality of design. Modern engineers are only as effective as their relationships with their communities of practice. Students may have developed a level of “skilled incompetence” in performing class 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”. The same concept may well apply to student teams that measure their 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.

Language, self-efficacy, and leadership roles

The typical model that students have of an engineering leader is that of “the boss.” Students do not differentiate between leadership and management authority. This interpretation affects their self-perception of their own leadership potential. The concept of leadership is one miss-generalized to all situations. Therefore; since the students cannot see themselves in powerful positions until well into the future, they have not considered their own personal skills and abilities (efficacy) in regards to leadership.

The necessary step in the development of an individual's own self-perception is the development of a vocabulary that allows them to tie their experienced self to the image of an effective leader. Students come to the course with a very limited vocabulary for describing themselves. They identify with a gender, race, religion, academic major, hometown, etc. These are the concepts that they have available for describing themselves and for describing the similarity and differences between themselves and others. This leaves very little flexibility for meaningful differentiation involving the responsibilities and coordinated efforts required in many engineering projects. In an attempt to resolve the deficit of vocabulary with respect to leadership, an objective of this course is to develop an individual specific vocabulary that allows each student to describe themselves, their experiences, their behavior, and the behavior of others in a meaningful and accurate way. We use several common tools to assist students in developing their own vocabularies ontology of self.

Over the course of the semester, students developed a vocabulary based upon the Felder-Solomon Index of Learning Styles (Table 1), Rokeach value survey (Table 2), Myers-Briggs Type Indicator (MBTI) Step II (Table 3), and, later in the course, a negotiation style assessment. For each one of these assessments the students evaluated their results and chose a few of the terms from each that they felt comfortable with in describing themselves. Table 5 illustrates the vocabulary selected by one student. They communicated these selections to the rest of their team members and discussed the similarities and differences within the team. The verbalization of these terms allowed the students to integrate them into their normal conversations and self-concepts. This also provided a mechanism for students to see the similarities and differences among team members.
The Myers-Briggs Type Indicator presented some unique opportunities and problems when used in this fashion. Obviously, the 16 Myers-Briggs types have significant literature in texts and on the web available to examine the applicability of the type as a tool for understanding oneself and others (Table 3). The popularity of this assessment allows students to reference sources whenever the desire but it can also reinforce the oversimplification of personal awareness and reflection.

An extension of Myers-Briggs type indicator is the MBTI Step II. This assessment has five facets for each of the eight MBTI preferences and provides an 18 page report with detail relevant to the specific individual. As each of the Myers-Briggs preferences; Extrovert-Introvert, Sensing-Intuitive, Thinking-Feeling, and Perception-Judgment are modeled as opposing ends of a continuum, the 40 facets are modeled as 20 scales with facet terms at the extremes (Table 4). The Step II approach allows for some facets expressed by an individual to be out of type. We found that students perceive this as a more accurate representation of themselves in it they could see some personal attributes that did not fit within a standard Myers-Briggs type (example; an Introvert who is also Active).

There was a conscious effort to direct the students away from identifying with a specific type (I am an INTP). The object is not to “belong to” some group or be classified from an external authority. Instead, we focus on each individual choosing the attributes or terms that they want to use as expressions of themselves. The standardized assessments provide a vocabulary of terms that are presented in some depth that have multiple characteristics – functional, affective, attitudinal, etc.

**Table 1 Rokeach Instrumental Values**

<table>
<thead>
<tr>
<th>Ambitious - hardworking and aspiring</th>
<th>Independent - self-reliant; self sufficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broad minded - open minded</td>
<td>Intellectual - intelligent and reflective</td>
</tr>
<tr>
<td>Capable - competent; effective</td>
<td>Logical - consistent; rational</td>
</tr>
<tr>
<td>Clean - neat and tidy</td>
<td>Loving - affectionate and tender</td>
</tr>
<tr>
<td>Courageous - standing up for your beliefs</td>
<td>Loyal - faithful to friends or the group</td>
</tr>
<tr>
<td>Forgiving - willing to pardon others</td>
<td>Obedient - dutiful; respectful</td>
</tr>
<tr>
<td>Helpful - working for the welfare of others</td>
<td>Polite - courteous and well mannered</td>
</tr>
<tr>
<td>Honest - sincere and truthful</td>
<td>Responsible - dependable and reliable</td>
</tr>
<tr>
<td>Imaginative - daring and creative</td>
<td>Self-controlled - restrained; self-disciplined</td>
</tr>
</tbody>
</table>
### Table 2 Felder-Solomon Index of Learning Styles

<table>
<thead>
<tr>
<th>Dimensions of Learning Styles</th>
<th>Sensing</th>
<th>Intuitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perception</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input</td>
<td>Visual</td>
<td>Verbal</td>
</tr>
<tr>
<td>Organization</td>
<td>Inductive</td>
<td>Deductive</td>
</tr>
<tr>
<td>Processing</td>
<td>Active</td>
<td>Reflective</td>
</tr>
<tr>
<td>Understanding</td>
<td>Sequential</td>
<td>Global</td>
</tr>
</tbody>
</table>

### Table 3 The 16 Myers-Briggs Types with their equivalent Keirsey Descriptions

<table>
<thead>
<tr>
<th>ISTJ</th>
<th>Inspector</th>
<th>Do What Should Be Done</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISFJ</td>
<td>Protector</td>
<td>A High Sense of Duty</td>
</tr>
<tr>
<td>INFJ</td>
<td>Counselor</td>
<td>An Inspiration to Others</td>
</tr>
<tr>
<td>INTJ</td>
<td>Mastermind</td>
<td>Everything Has Room for Improvement</td>
</tr>
<tr>
<td>ISTP</td>
<td>Crafter</td>
<td></td>
</tr>
<tr>
<td>ISFP</td>
<td>Composer</td>
<td></td>
</tr>
<tr>
<td>INFP</td>
<td>Healer</td>
<td></td>
</tr>
<tr>
<td>INTP</td>
<td>Architect</td>
<td></td>
</tr>
<tr>
<td>ESTP</td>
<td>Promoter</td>
<td></td>
</tr>
<tr>
<td>ESFP</td>
<td>Performer</td>
<td></td>
</tr>
<tr>
<td>ENFP</td>
<td>Champion</td>
<td></td>
</tr>
<tr>
<td>ENTP</td>
<td>Inventor</td>
<td></td>
</tr>
<tr>
<td>ESTJ</td>
<td>Supervisor</td>
<td>Life's Administrators</td>
</tr>
<tr>
<td>ESFJ</td>
<td>Provider</td>
<td>Hosts and Hostesses of the World</td>
</tr>
<tr>
<td>ENFJ</td>
<td>Teacher</td>
<td>Smooth-talking Persuader</td>
</tr>
<tr>
<td>ENTJ</td>
<td>Fieldmarshal</td>
<td>Life's Natural Leaders</td>
</tr>
</tbody>
</table>
Language through reading and reflection

Weekly reflections were based on a set of 15 articles and 14 videos. These were chosen to provide “probes that required student to respond and include some important concepts relevant to leadership (Table 6) with some being controversial. Students were asked to relate how the concepts or ideas presented could be interpreted using some of the terms they had chosen to describe themselves. This allowed the vocabulary they developed to become a scaffold for new concepts and further integrate them into a functioning vocabulary.

Table 5  Examples of the probe topics provided by readings and videos to broaden the language of leadership used in personal reflections.

<table>
<thead>
<tr>
<th>Personal development</th>
<th>Humility</th>
<th>Opportunity</th>
<th>Influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Responsibility</td>
<td>Courage</td>
<td>Followership</td>
<td>Systems Thinking and Strategy</td>
</tr>
<tr>
<td>Interpersonal</td>
<td>Continuous</td>
<td>Failure of common</td>
<td>Tribal organizations</td>
</tr>
<tr>
<td>Communication</td>
<td>improvement and change</td>
<td>sense</td>
<td></td>
</tr>
<tr>
<td>Communities of practice</td>
<td>Innovation</td>
<td>Personal risk</td>
<td>Negotiation</td>
</tr>
</tbody>
</table>
A rubric was used to guide students in reflecting on the assigned articles and videos. The rubric is structured to reinforce and more fully develop the language and associated mental model developed for each student. The rubric included:

- What is the “take away” or big idea in the reading or video?
  - This encouraged the student to summarize their experience with the probe into a few simple ideas. The conscious consideration of the probe forces the translation of the stimulus into the student’s current language – a logical rational process. The “Big idea” now is a tag which the student has available for recall.

- What specific term, phrase, or concept did you find most interesting, meaningful, likable or dislikable?
  - This requires an affective response through which the student interprets the probe in terms that have meaning to them. This encourages the student to be aware of the emotional aspects of learning by being challenged at an emotional level.

- What is a specific example from your personal experience that relates to the article or video?
  - By examining one’s own experience for an example of the concepts involved, students can integrate the concepts into their personal “sense making.” This follows the constructivist view of learning.

- How do the topics in this reading relate to your concept of an effective engineer as manager?
  - By projecting the concept(s) identified by the student onto a vision of what they might expect to become, the concept(s) become integrated in the student’s vision and thus can have an impact on the day to day decisions that they make.

- Halfway through the course, after students have developed a vocabulary of terms that they believe most closely represent themselves; the last section of the rubric was changed. The question as to how does this concept relate to your perception of an effective engineering leader was deleted.

### Table 6 An example of the vocabulary for self-description selected by a student ISTJ

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Selected Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning Style</td>
<td>Sensing</td>
</tr>
<tr>
<td></td>
<td>Active</td>
</tr>
<tr>
<td>Rokeach Instrumental Values</td>
<td>Ambitious</td>
</tr>
<tr>
<td></td>
<td>Logical</td>
</tr>
<tr>
<td></td>
<td>Loyal</td>
</tr>
<tr>
<td>MBTI Step II</td>
<td>Practical</td>
</tr>
<tr>
<td></td>
<td>Logical</td>
</tr>
<tr>
<td></td>
<td>Reflective</td>
</tr>
<tr>
<td></td>
<td>Pressure Prompted</td>
</tr>
</tbody>
</table>

A rubric was used to guide students in reflecting on the assigned articles and videos. The rubric is structured to reinforce and more fully develop the language and associated mental model developed for each student. The rubric included:

- What is the “take away” or big idea in the reading or video?
  - This encouraged the student to summarize their experience with the probe into a few simple ideas. The conscious consideration of the probe forces the translation of the stimulus into the student’s current language – a logical rational process. The “Big idea” now is a tag which the student has available for recall.

- What specific term, phrase, or concept did you find most interesting, meaningful, likable or dislikable?
  - This requires an affective response through which the student interprets the probe in terms that have meaning to them. This encourages the student to be aware of the emotional aspects of learning by being challenged at an emotional level.

- What is a specific example from your personal experience that relates to the article or video?
  - By examining one’s own experience for an example of the concepts involved, students can integrate the concepts into their personal “sense making.” This follows the constructivist view of learning.

- How do the topics in this reading relate to your concept of an effective engineer as manager?
  - By projecting the concept(s) identified by the student onto a vision of what they might expect to become, the concept(s) become integrated in the student’s vision and thus can have an impact on the day to day decisions that they make.

- Halfway through the course, after students have developed a vocabulary of terms that they believe most closely represent themselves; the last section of the rubric was changed. The question as to how does this concept relate to your perception of an effective engineering leader was deleted.
Students were asked to discuss how the concept(s) related to at least two of the terms they had selected as their self-descriptive vocabulary. This required the student to build the new concepts into the integrated vocabulary they used to describe themselves. Again, this builds upon a constructivist view of learning.

There were numerous team activities that provided opportunities for students to realize their own self-concept and interact with others doing the same. Each team designed and delivered two half-hour workshops on assigned general topics. The assignments were open to a variety of interpretations thus encouraging significant team interaction and opportunities for leadership. The workshops provided a significant component of the final grade for the course. These workshops were taken very seriously by teams. Every student in the class independently evaluated and graded each of the workshops using a rubric. Teams then met, discussed their individual assessments, and produced a consensus assessment that became the grade received by the presenting team.

Characteristics of Students

We will limit the discussion of some of the results of the experience with the class to the components having a direct relationship to MBTI Step II. The data presented is an aggregation of three semesters experience with a total of 72 students.

![Figure 1 Distribution of MBTI preferences for class and US population](image)

Figure 1 compares the relative frequency of MBTI preference for the class and the US population. The Engineer as Leader course students demonstrated significantly greater clarity in
iNtution and Thinking compared with the general population. Students may be assumed to respond intuitively to considering possibilities through iNtution and analysis through Thinking more than the general population. The course content was modified to address this with open-ended decision/design activities.

Another comparison that demonstrates the unique characteristics of engineering students is shown in Figure 2. The distribution of student MBTI types is sorted by their relative frequency. This highlights the unique nature of engineering students and reinforces the need for a different approach to leadership development.

Students would have preferred a step by step procedure for leadership (what are the five types --, what are the four steps---). They are, after all, higher in Sensing and Thinking. The course is purposely designed to stay away from a “procedural” approach to leadership. Instead, a developmental approach was the foundation. Students initially had difficulty in seeing the value of this approach because it was so difficult to assess how each was doing. The feedbacks on reflection rubrics over time helped the student think more clearly about themselves and the situations in which they are involved.

![Figure 2. Frequency of MBTI types for class and US population](image)

One way of analyzing the MBTI is to examine the “Functional” pairs. The MBTI preferences can be grouped into “attitudes or preferences” measured by the Introvert-Extrovert and Judgmental-Perceptive scores or “functions” measured by the Introvert-Extrovert and Sensing-Thinking scores. The combinations of functions scores focus on how information is obtained and how decisions are made. This approach produces four classes; Sensing-Thinking, iNtuitive-
Thinking, Sensing-Feeling, and iNtuitive-Feeling. The distribution of function pairs for the class is shown in Figure 3. Note that Sensing-Thinking makes up almost one half of the students and iNtuitive-Thinking contributes another quarter. This clearly demonstrates the dominance of Thinking types with a bias towards Sensing.

Peer assessments were collected several times during the semester using the CATME\textsuperscript{22} survey tool. When these scores are compared for students with different function pairs the only significant difference was that the NF pair was significantly lower than any other pair (Figure 4). Their peers saw the students with NF profiles as making less of a contribution to team activities. This deserves further study into how to bring a student with this profile into an active role in team activities.

![Figure 3. Distribution of Functional pairs for class](image-url)
Figure 4  Mean CATME peer assessments by MBTI Functional pairs

Figure 5  The Zig-Zag sequence for problem solving\textsuperscript{23}
Application of Vocabulary to Team Processes

A fundamental activity of teams is decision making. For engineering teams this more typically realized as a design process. It is a creative process with embedded decisions. Jessup proposed a “Zig-Zag” model of team decision making based upon the MBTI. Typically this assumes that the team moves between the four function domains starting with Sensing to identify the facts in the situation, moving to Intuitive to generate alternatives, then to Thinking to analyze the alternative, and finally to Feeling to assess the impact. Examples of the types of questions at each stage are presented in the text box. For a design activity, the cycle would start again by moving from Feeling to Sensing etc. This follows the spiral form of the systems development model of continuously repeating the stages with increased clarity.

The course structure provided ample opportunity to experience the teaming and leadership processes of moving from sensing, to intuition, to thinking, to feeling, and back to sensing. There were 10 formal teaming exercises provided by team workshop design and delivery and the assessments provided by teams in the rest of the class.

- We begin with Sensing to discover "what is."
  - What do we know for sure? (just the facts, ma'am!)
  - What is the situation - exactly?
  - What has gone before?
  - Who is involved?
  - Collect the data, keeping an open mind uncolored by sentiment or leaping to conclusions.

- Then use Intuition to speculate on patterns and connections formed by the facts.
  - What are the possibilities?
  - What solutions tend to jump out from what is known?
  - Do some brainstorming on ideas.
  - Develop a range of alternatives - without critically analyzing them at this stage.

- Once Intuition has been allowed to flower, it is Thinking's turn at the wheel.
  - Subject the product of the Intuitive & Sensing phases to an objective analysis, weighing facts against speculations.
  - Use logic to determine cause and effect.
  - Draw distinctions, weigh and rank the pros and cons, quantify your conclusions.

- End the first cycle of the process (or start it) by utilizing Feeling judgment to incorporate the human consequences:
  - the impact on people,
  - the impact on values and sensibilities, and
  - all the emotional components.
  - In addition acknowledge the subjective elements affecting those involved in the analysis or the making of the decision.

Figure 6 Use of MBTI

In order to link the personal vocabulary developed by each student and a team decision/design process, a graph was developed for each team (Figure 7). Each individual’s results on the function preference on the MBTI are plotted and compared with similar plots of their team
mates. As the team moves through the design cycle (Sensing, iNtuitive, Thinking, Feeling), it is apparent which team members show a preference and the specific nature of that preference. This provides a map for individuals to transition from leader to follower and back.

In examining a team plot as in Figure 6, the mean of the team members’ scores (the heavy line) indicates that this team may have difficulty in the assessment (Feeling) phase. No one showed a preference for this. The team will have to decide that it is logical (Thinking) for it to force itself to answer the type of questions that a person with clarity in Feeling would ask (see text box).

![Team 1 Processes](image)

**Figure 7 MBTI function preferences for a specific engineering student team.**

There is also clarity in the Sensing and Thinking domains. This team may be drawn to a single solution where there is significant experience (Sensing) and analysis (Thinking). This pattern is fairly common in engineering student teams that get into a single alternative data collection followed by analysis followed by more data cycle.

Both the weak Feeling and the Sensing/Thinking cycle are perspectives provided to the team as a functioning entity. The graphic can also support individual development by indicating which stages of the design process they should take a leadership role and in which they could follow. For example, student ES will tend to focus on getting a clear perspective (Sensing) on an issue with the help of KN. There particular vocabularies indicate the viewpoints that they will take.
Their language may focus on their experience in the problem domain. Obviously, other team members can make contributions but these two have clear preferences and likely to have a “gut feel” for this. With the relative strength shown by this team in the Thinking quadrant, there may be a rush to analysis (Thinking). The transition to alternative/possibility generation (iNtuitive) may need to be forced/lead by DT with clarity in “theoretical” and DC with clarity in “imaginative.”

The next stage is “Thinking”. Given that there are several students with preferences in this domain there may be some competition between members for who has the best approach to analysis. This focus can take the team away from a quality process if it is not managed. The graph may be able to indicate which specific individuals may get caught in the data-analysis-data loop.

Obviously, for this team, the assessment phase (Feeling) with take some leadership beyond the “gut feel” level. It will require a decision to examine possible future impacts (iNtuitive), experience in similar situations (Sensing), or logic of considering a human perspective (Thinking) in order to develop a fully considered design.

Conclusion

Current experience with this approach is encouraging. A procedural approach to leadership and focus on corporate leadership misses the need for individual engineers to take specific leadership acts at appropriate time in team processes. The development of individually relevant vocabulary that focuses on leadership concepts allows students to reason about themselves. By seeing one’s own personal MBTI preferences in relation to others that you work with, provides a unique opportunity for personal development. Participating in a team moving through the stages of the design/decision process (Zig-Zag) highlights the need for shared leadership and sharpens leadership transition skills.
References

8. ASEE, Engineering and Leadership, Survey Results Summary, June 13, 2010.