Industry Practices for Providing Engineers with Team Skills

By

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Abstract
The environment that engineers encounter upon graduation has changed dramatically in recent years, with technical skills being necessary but no longer sufficient for today's conditions. Industry practitioners, followed closely by deans of engineering schools and by ABET, have identified nontechnical skills that are of paramount importance for engineering graduates. Chief among these is the ability to work in interdisciplinary teams.

Given the historical lack of emphasis that engineering schools have placed on creating and improving team skills in students, it is natural that industry practitioners have created their own practices aimed at creating and improving those skills. In this paper, we report some of the practices identified in interviews with industry practitioners, and discuss the feasibility of transferring and implications for utilizing such practices in academic settings.

Interviews & Interviewees
Practitioners with extensive experience supervising engineers working in teams were identified through our Industrial Advisory Board members, through faculty members, through conference contacts, and through contacting targeted organizations and asking for a person with such experience. By this method, we were able to interview practitioners in manufacturing, service, transportation and government organizations. Interviewees hailed from relatively small manufacturing organizations (approximately $6 million in annual sales), to some of the largest and well known (UPS, FEDEX), and most respected engineering companies (e.g., Bechtel, Intel, Lawrence Livermore National Laboratories, Hewlett Packard) in the world.

As a group, our interviewees averaged 17.9 years supervising engineers working in teams and participated in an average of 68 teams each. They served as leaders or supervisors for 22% of the those teams, and served as non-supervisory team members on the remaining 78%.

Interviews were conducted either at the interviewees' place of work, or at California State University, Hayward, at the preference of the interviewees. Interviews utilized a semi-structured format, and ranged in duration from 50 minutes to 2 hours. Interviews were video taped and viewed by multiple research team members to extract relevant information.

During the interviews, we asked our interviewees a series of questions related to the training and practices they have had exposure to that were aimed at creating and improving team skills. Questions included identification of the training/practice and who provided the training and in what format. Additionally, we asked if the training was team or individual based, whether the training was in response to substandard performance, and if skills were acquired or improved because of the training. Interviewees were asked to identify training that they had participated in as well as training that they assigned or provided to their supervisees.

Results

We categorized responses into two categories, 'methods and practices' which is **how** training or practices were delivered or executed, and 'content' which refers to **what** topics or issues were covered (e.g., use of training videos would be a method, and what is covered on the video would be the content). Table 1a lists the content or focus of activities aimed at improving team skills of engineers identified by our interviewees. Table 1b lists the training methods and other practices that our interviewees had experience with.

Table 1a. Content of training aimed at creating or improving team skills of engineers.

CONTENT

Brainstorming technique
Taguchi methods
Training classes in JIT
'How to be a coach'
Communication training (active listening)
Communication training (verbal communication)
Communication training (non-technical written communication)
Communication training (technical written communication)
'dealing with difficult people'
'management of technical people'
'managing resource allocation in new product development'
Diversity training
'How to run an effective meeting'
Forming-storming-norming-performing group process cycle
Group processes
Group decision-making and problem solving
'KT'- or other structured framework for problem identification/solution
Learning styles
Personality types
Team building or team development

Table 1b. Methods and Practices aimed at creating or improving team skills of engineers.

METHODS & PRACTICES
Boot camp or off-site training lasting three or more days
Use of formal 'brainstorming' technique
Experiential Training
Feedback from consultants
Feedback from other teams
Group discussions
Lectures
On the job training
Physical training (High stress situations off-site)
Problem-based exercises or case studies
Reading materials
Role playing / simulation
'Ice breaker' activities
Team sports
Training courses
Videos
Clearly define a schedule for the project
Explicitly specify the project methodology cycle prior to start of project
Get to know individuals' skills in order to know their capabilities
Group presentations
Incentives/ rewards for individual contribution to team performance
Incentives/ rewards for team performance
Involvement in a lot of projects
Make sure everyone participates
Mentoring/ coaching
Problem solving circles
Rotation of responsibilities
Team competitions
Visual tools with tasks and timeframe
Use of team facilitator
Participation of team members in performance evaluation
Observation/Evaluation of team by consultants
Observation/Evaluation of individuals' team contributions by consultants
Required self-evaluation or self-assessment
Formal evaluation of team performance by supervisor
Formal team recognition
Periodic team meetings
Team building activities (mandatory participation of team members in non work activities, e.g., outings, etc.)
Workshops, seminars

Content identified by our interviewees includes a number of areas that are common in academia, and likely to be included by engineering faculty utilizing teams. These include brainstorming, forming/storming/norming/performing group process, and possibly group decision-making and problem solving. A number of others are sometimes taught by engineering faculty in specific classes, but are not typically associated with team activities or projects. These include Taguchi techniques, and Just-In-Time. A few other content areas are now recognized as important enough to require of engineering students, but typically are taught outside of engineering. These include communication training and perhaps learning styles and personality types (depending on requirements to take psychology courses). The remaining content areas identified by our interviewees are typically not taught to engineering undergraduates. Many of these appear to be highly relevant for ability to function in teams, such as 'dealing with difficult people,' 'diversity training' and 'how to run an effective meeting.'

Methods and practices identified by our interviewees include a number that are commonly utilized by engineering faculty, including lectures and reading materials, group discussions, and use of case studies. Faculty attempting to teach team skills are likely to use one or more of these methods. Less common are videos, seminars and role playing/simulations aimed at improving team skills. Some practices identified by practitioners are also commonly utilized by engineering faculty, such as 'providing a clearly defined schedule for projects,' 'periodic team meetings,' 'group presentations,' 'team competitions,' and 'rewards for team performance.' Less commonly utilized are other practices such as 'participation of team members in performance evaluation,' 'ice breaker activities,' 'use of formal brainstorming technique,' and 'rotation of responsibilities.'

Methods and practices mentioned by our interviewees that are typically not utilized by engineering faculty include 'boot camp off-site training,' 'physical training' and 'feedback from consultants.'

Discussion: Implications for Academia

It is important to note that some of the content, methods and practices utilized by practitioners are also commonly used by engineering faculty to teach team skills to engineers. This includes lectures, problem-based exercises or case studies, group discussions, group presentations, reading materials, and clearly defining the schedule.

Also, some content areas though not as common, have been used and results reported by engineering faculty, for example personality types [1,4], verbal communication [10], written communication [5], forming/norming/storming/performing etc. [7], diversity training [1], and effective meetings [7].

Similarly, some methods and practices are less commonly used, but have been recommended or utilized on a trial basis by some engineering faculty. These include internal and external based peer reviews [4, 6, 7], team building [4, 9], physical training [9], team based problem solving [1], and simulations [8].

Utilization of these innovative applications of content, methods and practices by engineering faculty is validated to some extent by the finding that similar content, methods and practices are

utilized in industry. Similarly, unless it is understood to be an experimental innovation, faculty might want to reconsider utilization of content, methods and practices that were not found to be present in industry.

However, the most important contribution of this line of research lies in identifying content, methods and practices that are in use in industry but are not taught in engineering programs. These will provide the biggest opportunity for consideration and inclusion by engineering faculty interested in improving their students' team skills.

At this stage of our research effort, it is premature to provide a complete, ranked list of such content, methods and practices, as our on-line survey (currently underway) is not complete. However, with slightly more than half of our anticipated surveys completed, early indications show that the following are top contenders for being 'widely disseminated in industry, while typically lacking in Universities':

- Content
  - Dealing with difficult people
  - Diversity training
- Methods
  - Workshops, seminars
  - Feedback from consultants
- Practices
  - Mentoring/Coaching
  - Use of team facilitator

Many teams fail. They fail for numerous reasons, including personality or style clashes. These are situations where one or more team members are perceived as being 'difficult.' Similarly, diversity is an acknowledgement that individuals are different, with the idea that training in those differences allows people from different backgrounds and experiences have a better understanding of 'where the other is coming from,' and consequently on how to work together. Lack of such understanding can lead to labeling of team members as 'difficult to work with.'

College is a place where many students encounter their first experiences with diversity, and where many find they are required to work closely with people that have very different experiences and perspectives. Given these circumstances, college provides an important opportunity for introducing diversity training. Such training is just beginning to appear in engineering curricula, typically in a 1st year lecture series (e.g., [11]). Our study suggests that this trend should continue and expand. 'Dealing with difficult people,' is a content area typically not covered in engineering curriculum, and our study suggests there is an opportunity for further exploration and development of course content in this area.

Workshops and seminars, are distinct from lectures or courses in the following respects: workshops are typically hands-on; occur intensely for a short period of time; and are focused on application of a particular process or method to the circumstances of the attendees. Seminars typically are one-time, advanced interactions about a particular topic, with knowledgeable interactions between attendees and providers. Providers are acknowledged experts in the topic area.

The appearance of these methods high on our list of those utilized in industry suggests a few strategies regarding time commitment and expertise level. If team skills are to be imparted to students, sufficient time needs to be reserved and emphasis placed on skill acquisition. Workshops focused on team skills in conjunction with specific teams and projects are indicated, along with time for mutual reflection and learning from the experience after students have acquired a certain level of expertise. This reflection activity needs to be provided by someone with a high level of expertise in team skills.

Consultants are used widely for teaming in industry. Activities include team facilitation, team observation and critique, individual observation and assessment, and team training. 'Feedback from consultants' is a method that again suggests a certain level of expertise is needed to allow team members to improve skills. Further, it suggests that observance of the team by a neutral, non team member is valuable.

One of the most important functions of team consultants is that of facilitation. This typically occurs in the team meetings, helping to encourage communication and to diffuse tense situations, keeping activities task focused and devoid of personal conflicts. It is this function that is unlikely to be feasible for most faculty to accomplish given time constraints [3].

Mentoring is the long term guidance and counsel between (typically) less experienced and more experienced individuals. It is usually between two that are following a similar career path, but are at different stages of their careers. Mentoring of all undergraduates in an academic setting is difficult to accomplish beyond a certain level due to student faculty ratios. In a professional setting a mentor may have one or two, or at most a handful of mentees. In an academic setting the reality is that for each student to have a mentor, each faculty member would have scores of mentees. While mentoring is common between faculty and graduate students, it is much less common at the undergraduate level in an inclusive way such that all students have a mentor and that goes beyond advising on course schedules and career opportunities [3].

If mentoring and consulting practices are to be successfully transferred to the academic setting, it will likely require resources beyond what faculty can offer. However, such practices might be implemented using experienced students to mentor and consult less experienced students. While not widespread, such practices are meeting with success, such as utilizing juniors and seniors to act as team facilitators for 1st-year design teams [2].

Conclusions

Many practices are used by organizations to improve team skills of engineers. Lack of a universal uniform practice or set of practices may indicate that different contexts require different strategies, and/or that engineers with different learning styles respond to different strategies. Alternatively, it may simply indicate that some organizations are better at instilling team skills in their engineers than are others.

While we are making gains in identifying content, methods and practices that are used in industry, there is still a long way to go to make this information useful for engineering faculty trying to develop curriculum and modules appropriate for instilling team skills in engineering students. The sheer number of these that have been identified as important by practitioners,

makes it apparent that it will be difficult if not impossible to incorporate all of them into the undergraduate engineering curriculum. What is needed is a sense of what skills are most valued by practitioners, and what content, methods and practices are most effective at creating and improving those skills.

As a first step towards determining these relationships, we have interviewed a small number of experienced practitioners and asked them to identify the content, methods and practices that they have had experience with, as well as the team skills they value in engineers [3]. Our next phase of research is to conduct a survey of a large number of practitioners (on-going), to determine degree of consensus and relative value that practitioners place on team skills.

We have identified content, methods and practices in use by industry to improve team skills, and are currently investigating their level of dissemination. Early indications are that there are some areas within these were academics can learn from industry best practices and incorporate them into the engineering curriculum. Based on preliminary findings, we provide some recommendations and insight as to where emphasis should be placed in this effort to transfer practices.

The results of the research reported here suggest a few potential strategies to be employed:

- -Provide engineering students with content that covers 'diversity', and 'dealing with difficult people',
- -Provide adequate time and expertise resources via workshops aimed at improving team skills and provide further training after students have gained some team skills via seminars
- -Provide team members with feedback from someone who is knowledgeable and neutral
- -Provide individual team members with mentoring/coaching, and provide teams with facilitators

Methods and practices not commonly used in academic settings may require innovative tactics to be employed in order to successfully transfer them to the university setting. It may turn out that some of these practices may not be well suited for utilization in academia, or may require special adaptations, funding, or policy changes before they can be successfully utilized in academia. For this reason initial transfer attempts/experiences will need to be well documented and assessed to facilitate adoption by follow-on users.

Further study is also required to determine the efficacy of content, methods and practices for creating and improving team skills of engineers. Given the large number of methods and practices, combined with a long list of valued skills, it is not enough to know that a particular practice has a positive influence on development of a particular skill. What is needed is a comprehensive list of which methods and practices in combination with which content best serves to improve the most valued skills. Only then can faculty make informed decisions regarding development of team skills in their students.

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