

Systematic Change in Engineering Education: Preparing Effective Change Agents for Programs in Engineering

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Abstract In a very brief form this paper captures the highlights of a three to eight hour workshop. The brevity required for the paper presents the conceptual frameworks needed for someone to enhance their skills in being a change agent. The case studies in the workshop can be tuned to the changes expected. At the WEPAN/NAMEPA Conference the accompanying case studies will focus on efforts to address the concern over results and programs related to changing the demographic diversity of the engineering workforce.

Introduction

Evidence is beginning to mount, in spite of a historical and continuing counter evidence of making significant differences, that WIE and MEP, or appropriately renamed new generations of these programs, will not be supported at their current level, much less grow to the levels needed to succeed in changing engineering to more appropriate diversity levels. One reason for the difficulty in garnering support is captured by one of the leading proponents for diversifying engineering, William Wulf, the President of the National Academy of Engineering, who made the following statement concerning the efforts to diversify the US engineering workforce.

“The situation is simply unacceptable and will become increasingly unacceptable to industries that need diversity among their engineers in order to compete in a global market. I have no silver-bullet solution, but it is obvious to me that there is a crying need to coordinate the many good programs at various universities, professional societies, and the like. We’re not getting the ‘bang for the buck’ that we should.”(Wulf, 1998)

Looking at the last decade of enrollments, in the United States, of engineering students with respect to underrepresented groups (Fig. 1), we are not able to see trends that give confidence that change efforts being provided are giving us the ‘bang for the buck’. This does not mean that individual programs have not been successful. Numerous programs gather more data than ever to evidence the significant impact they have upon the participants, and often the impact on the local enrollments or retention of underrepresented groups in particular settings. But the data does not indicate that these efforts accumulate into overall systematic changes in enrollment, graduation, or workforce composition that might be expected given the investments. Questions arise about whether the investments have been too small, have focused at the wrong level, or can scale-up in a manner that will generate greater change.

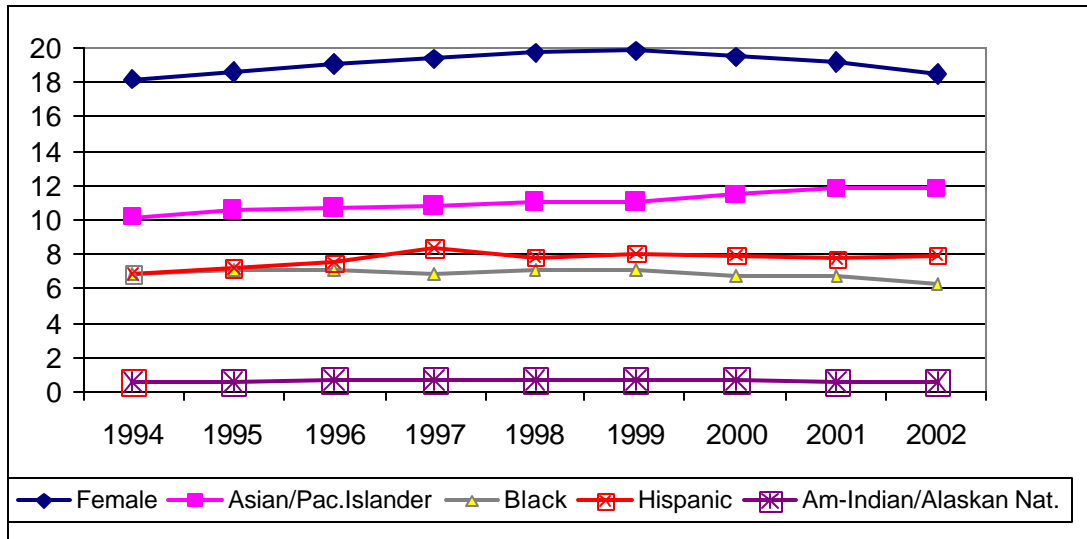


Figure 1. Percentage of Undergraduate Enrollment in Engineering who are Females and who are US Ethnic Minorities (NSF, 2004)

This paper does not purport to be able to answer such questions. We do not propose new strategies for diversifying engineering, nor do we present evidence of new successes in the diversification of engineering, nor even pretend we can help every program or administrator to meet the challenges of the situation in which they must operate. Instead, we will propose a process for framing, that is conceptualizing, the situation that may lead to better change agency. Or, at a minimum, the framing should reduce frustrations with the challenges because the factors affecting the change are better accounted for in administrators and advocates choices of operation.

Step 1 Situational Analysis

In virtually all planning exercises, whether personal or organizational, the first step is to conduct a meaningful situational analysis. It is often extremely important to have advisors and other stakeholders engaged in the analysis. Most resources on strategic planning will describe a process for this area. A very common tool for situational analysis is referred to as a SWOT analysis, which stands for the consideration of internal strengths and weaknesses, with respect to the externally generated opportunities and threats for the individual or organization. Examples of questions that should be asked by a program in a college of engineering are shown figure 2. The questions are not significantly different than the questions that should be asked in other contexts.

After the exercise of listing strengths, weaknesses, opportunities, and threats for the organization, we find which internal strengths and weaknesses will influence how well we meet each opportunity and each threat. For example, if we find that our current level of internal funding is weak and the broader funding situation is a threat because the college is experiencing budget cuts, then we couple this weakness and threat together. Each appropriate coupling should be recorded in a matrix such as shown in figure 3.



SWOT ANALYSIS WORKSHEET

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Program Strengths and Weaknesses	Strength	Adequate Capacity	Weakness
Staff overall			
Size			
Diversity in demographics			
Credentials and Clout			
Skills in planning			
Skills in delivering programs			
Skills in marketing for participants			
Skills in marketing for advocates			
Skills in generating funding			
Skills in research			
Funding overall			
Internal level of funding			
External level of funding			
Stability of funding levels			
Flexibility of funding			
Facilities			
For Staff is appropriate for needs			
For Programs is appropriate for needs			
Social Capital at this time			
Situated well in the College			
Visible internally to College			
Visible externally from College			
Many Involved non staff advocates			
Many Influential non staff advocates			
External Influences on the Program	Positive opportunity	Neutral at this time	Negative thus a threat
Alignment with College's espoused goals			
Alignment with College's actual reward structures			
Support from direct supervision			
Support from top of the College			
Breadth of the base of support			
Depth of the base of support			
External funding situations for such programs			
Internal funding situations for such programs			
Broader Political Situation			
Broader Funding Situation			
Broader Facility Situation			
Changes in the College or Supervisory Unit			

Figure 2. Instrument for SWOT Generation, copied with permission from CCCR

	Strength	Weakness
Opportunity	Areas where organization is currently positioned for excellence	
Threat		Areas where organization is currently positioned for serious failures

Figure 3. SWOT Matrix

If the goal of the situational analysis is strategic planning, then the next step in a process would be to generate a strategy for addressing each coupling in the matrix, followed by an exercise in prioritizing the generated strategies. However, here we are focusing on developing a plan for changing your organization or environment, so the next step is to focus on inappropriate or absent couplings and compounding weaknesses that present a clear threat to your organization's mission. This is where many programs inadvertently aid in the creation of major threats. For example, if the mission of an organization is to change a college's demographics of graduating engineers, but actually the program becomes so focused on survival that they convert all their energies to focus on early pre-college intervention because they are skilled and passionate here and funding is obtainable, then the program may inadvertently demonstrate that in spite of having excellent programs, the demographics of engineering graduating students at their institution is not likely to change in the time frame expected. This example does not imply that pre-college interventions are not an excellent strategy, but that failure to succeed in timely accomplishments of the primary mission can lead to perceptions of failure in spite of successes.

Step 2 Planning Change

Every organization can brainstorm a multitude of changes that might be desirable, but many do not actually plan and execute a change. For an organization to plan a change they must focus primarily on what they will change about themselves, not on what they will change about the environment (although some organizations can change themselves so that they are in a new environment). The goal of this exercise is to create a shared vision of what change is needed so those who must change.

First you must prioritize what needs to change in your organization. Usually, the highest priority for change will be focused on the weaknesses that coupled with a threat in the situational analysis. However, often it will be important to address a weakness that is coupled to an opportunity, or even a mere adequacy that is coupled to an opportunity in order to assure that the program takes advantage of a particular environmental influencer. Prioritization of desired changes requires that you understand dependencies and consequences for each change. If for example we need more of the staff to have a certain skill that one staff member has, we may

actually inhibit the productivity level of the organization while the skilled staff member trains others instead of focusing on productivity. Many decision making processes can be chosen and leadership must take on the responsibility of choosing the process to be used in developing the choice of the change chosen to attempt. The authors worked on a document for the Foundation Coalition (Foundation Coalition, 2002) for student teams making decisions, but the elements in the document are effective for any team making decisions. Choosing a decision making process which appropriately engages the important stake-holders in the expected change efforts significantly influences the probability of success in making the changes. However, care must be taken if it is assumed that involvement in decision making at this point is always better. Situations can occur where the participants use so much energy in making difficult choices about what needs to change first, that they then have little energy available, at least for a while, to commit to the actual change efforts.

Leaders must choose the nature of the changes that your organization is currently prepared to initiate. A mentally exhausted staff is probably not easily energized for a difficult change unless the threat is overwhelming and imminent. Conceptualizing the energy required for change can be characterized by the three dimensions shown in figure 5. Using this figure you can expect that the further you would be positioned from the vertex of the axes shown, the more energy will be required for the change you are planning. Certainly group input in determining if sufficient energy exists is important, but ultimately the leader must take the responsibility of risking available organizational energy against the consequences of not succeeding in changing the organization.

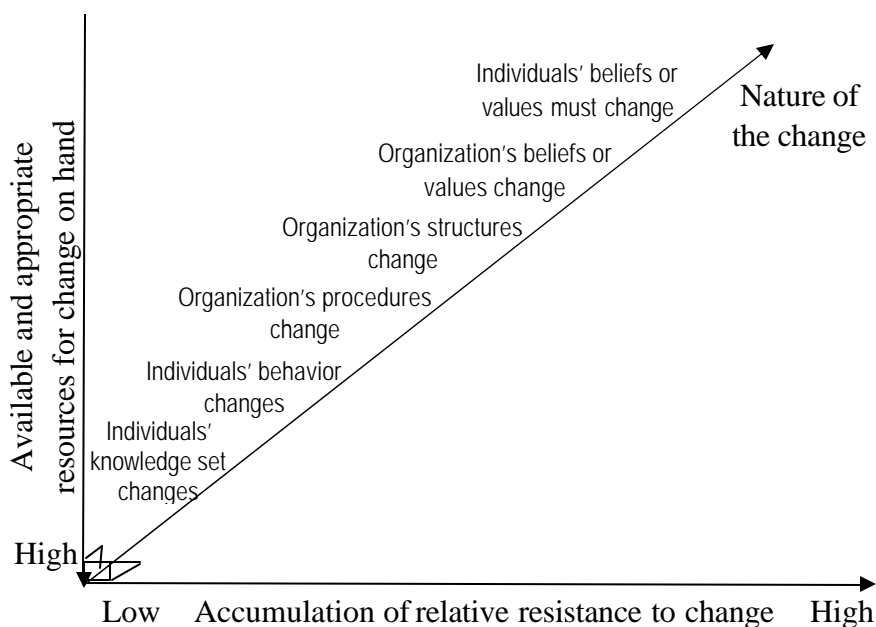


Figure 4. Gaining perspective on the energy required for change

Most, if not all, resources aiding in the planning of a change process point to the need for 'early wins' in order to build momentum for more complex or deep changes. Care must be taken to assure that early wins do not actually create avoidable barriers for the future. Examples might be when a program so focuses on aiding the weakest students of a particular group, that even with successes, stereotypes about this particular group being weak are actually fed. Early wins should

also avoid being so trivial that they are uninspiring or so unrealistic for scaling or transfer to other areas that they do not generate momentum for the bigger change. Examples might include taking in students from a particular group who have already demonstrated significant interest in a field and demonstrating with large sums of money and resources their interests can be raised. This kind of win may not convince others that they actually can afford to do anything to raise interests, or that anything was actually accomplished because there was already a high probability of appropriate interest level to achieve the desired outcome.

Once decisions have been made about what will be changed, the dynamics of change must be orchestrated. This process requires the generation of numerous change narratives. Data is often necessary for these narratives, but seldom sufficient for a narrative. Each narrative must concisely capture five essential message elements:

- Who has to change?
- What has to change?
- Who wants the change and why?
- When must we change and why?
- How does the change benefit the changer?

Rarely should these narratives be presented all at once. Individuals must work through a transition process in order to accept the change challenge, and an appropriate narrative and set of activities must be presented for the changers at each stage of development shown in figure 5. One important aspect in this conceptualization is that the arrow shown must point somewhere. That direction must be set enough to avoid random acts, but no so narrow that variances of style, method, or creative enhancements are totally inhibited.

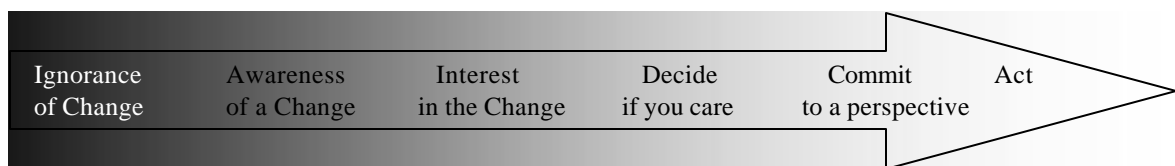


Figure 5. Stages in Moving Individuals Toward Actions to Change

A plan for change will involve the following steps:

- 1) Determining the ultimate goal of the change effort in a specified time period.
- 2) Selecting the major objectives in an appropriate sequence.
- 3) Considering the appropriate time and resources needed for each objective and aligning each strategic start toward an objective so appropriate time and appropriate and prepared resources are available.
- 4) Determine peoples' major roles and make sure that they see the significance of their success to the overall progress for the change.

Step 3 Managing Change

When change occurs certain variables will accompany that change, namely resistance, stress, conflict, and a tendency to go back to our natural behavior styles even if maladaptive for the event. All of these factors must be anticipated and addressed in order to effectively manage change.

Resistance. We consider resistance to change to come at three intensities (Maurer, 1996).

- ◆ Level 1: Resisting the Idea Itself- a cognitive difference of opinion.
 - Misinformation, missing data, conflictive data, misunderstandings about tradeoffs...
- ◆ Level 2: Resistance due to deeper emotional issues
 - Feelings of being undervalued, taken advantage of, distrust, fear of isolation, lack of incentives, loss of respect, world issues...
- ◆ Level 3: Deeply Embedded
 - Historic animosity, basic differences in values, totally different goals...

In addition, an individual needs sufficient time to think about the change, grow interested in the change, and commit to the change, or even to working against the change, as shown in figure 5. Figure 6 depicts the normal shift in time that occurs as people are confronted with a change. The time scales for individuals and for a particular change may vary tremendously. We must realize that at any given point in time different people in a group may be in different stages of figures 5 and 6, and have differing levels of resistance intensity. Part of managing change involves handling the complexity of people being in different stages to resisting or accepting the change. Acknowledging where a person is in the change process, providing information to decrease their resistance, and presenting the benefits and costs of the change process to individuals and the organization can decrease the resistance.

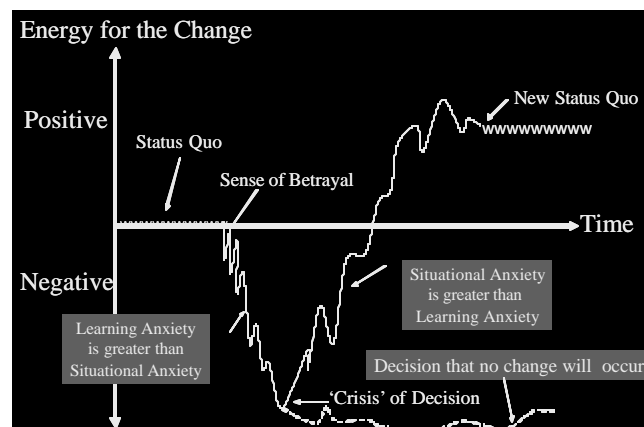


Figure 6. Individual energy for change (positive will aid change and negative will resist)

Stress. Managing stress also involves helping individuals to understand the source of their stress about the change idea. For example, an individual may be stressed due to the concern her/his role may change, she may lose power in the organization, he may be out of the loop, and many other reasons. By helping each individual identify their source(s) of stress, determining what stress responses are reactionary (fear based) and which stress responses are legitimate, and determining ways to decrease the stress is essential in managing change.

Natural Behavior Styles. People have different behaviors in varying situations, but most people have a natural style of behavior that they prefer. They then adapt this style to a particular situation as they think or have learned is appropriate. A group may push people into this adaptation or an individual may simply assume that it is expected. However, most people under sufficient stress will slip back into their natural style. An instrument to describe behavioral styles

is the TTI DISC behavioral profile. (see Figure 7). This profile asks questions to position how an individual prefers to use power to meet or Dominate a challenge; how they Influence others; how they react to Steady or unsteady paces and situations; and preferences in Complying with others rules. Using these four dimensions people can be placed on a wheel, not to pigeon-hole people but to facilitate discussions of their own tendencies and explore understanding of others behaviors. Behavior is a choice that can change, but habits will tend to drive people to learned responses. It is essential, in effective change management, to help people work through their immediate behavior responses or actions and determine if ‘this is the behavior they want to be displaying?’ Figure 7 illustrates common descriptors of the spectrum of responses expected for differing behavioral styles.

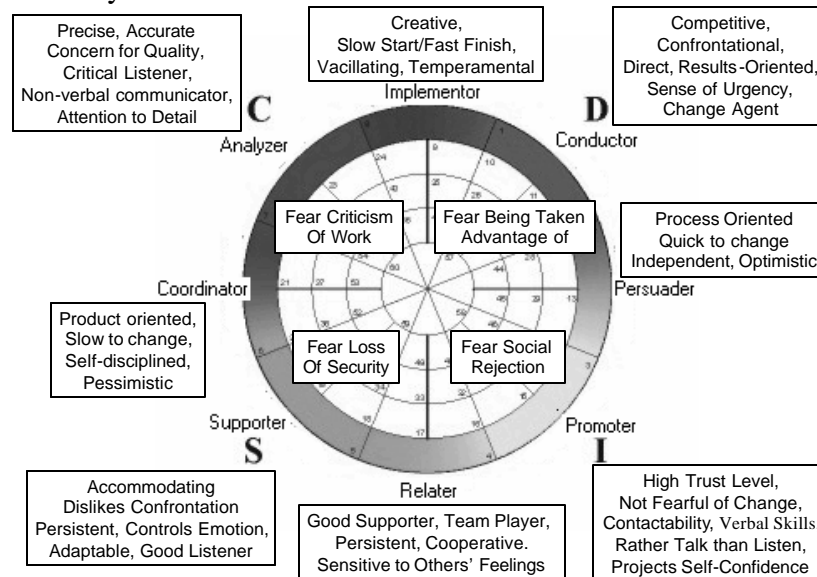


Figure 7. Behavioral Styles as Delineated by the DISC Behavioral Profile (Bonstetter, etal, 2001)

Conflict. An area of change repeatedly overlooked is the idea that some level of conflict will always accompany change. Our definition of conflict is defined as a struggle or contest between people with different ideas, values, needs, beliefs, or goals. Opatow found that adults, on average, experience five conflicts per day (Opatow, 1989). When change is occurring we can anticipate even more conflicts within an organization (Algert & Watson, 2003). Determining and implementing effective conflict management skills are essential to managing change. The conflict management skills that need to be addressed are individual and organizational in nature.

Individually speaking one must be aware of their own conflict style(s) (Fig 8a) used when conflict occurs in their life. Secondly, people should be able to assess a conflict situation and determine what conflict styles are being used by other individuals. Further, it is important for individuals to determine the nature of the conflict; what specifically are the reasons/sources for the conflict. Different styles are better for different situations, but as in any behaviors, habit, and in this case personality, may tend to push us to a preferred or habitual style of dealing with a conflict. When looking at organizational conflict, understanding and discussing the organizational conflict culture is necessary to manage change. While there is much literature on the overall culture of organizations, we focus on the conflict culture, the unwritten, unspoken, and often avoidance based of conflict, behavior. Often we have not laid the groundwork to deal

with a meaningful conflict. Sometimes we want people's sense of accountability first, before we have truly helped them understand the commitment asked for. Ideally an organization will always establish a growth to accountability based on trust (Fig. 8b) and deal with the meaningful conflicts within this growth.

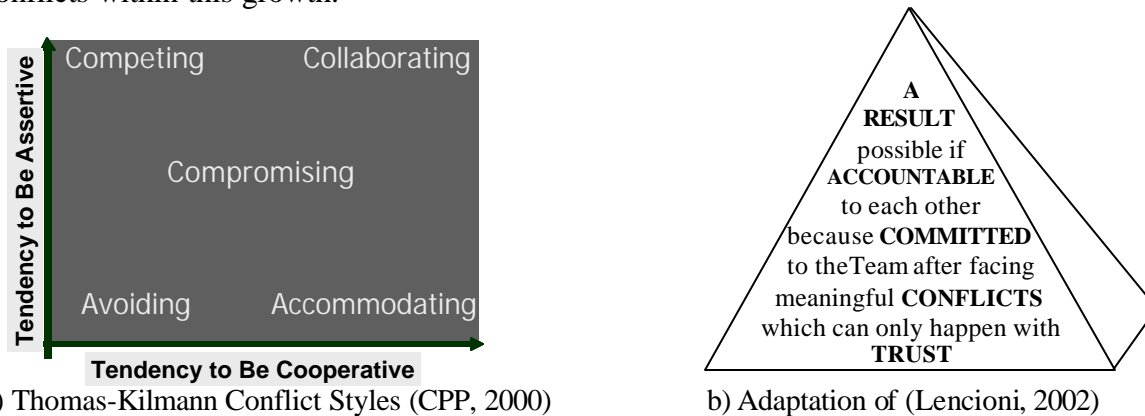


Figure 8. Two Important Concepts for Conflict:

a) Styles of dealing with conflict and b) Best place to face conflicts for a group

The four variables mentioned above, resistance, stress, behavior styles, and conflict will always accompany change. In order to effectively manage change we should anticipate these variables, address these variables, minimize the intensity and consequences of these variables as appropriate, and communicate with people in the organization that it is common to personally and organizationally experience these four variables. Further, providing opportunities, whether individually or in groups, for people to discuss these variables and the effect of these variables is critical for effective management of change.

Much of the literature on change agency emphasizes the advantage of predicting and preparing for change instead of pretending it can be eliminated or being stressed by the presence of resistance. Program administrators have to understand that proof of concept with data is a necessary but not sufficient motivator to outweigh the natural resistance to the exertion of energy to change. Administrators need to acknowledge that change always causes the changed some level of stress and always introduces a myriad of conflicts, whether major or small. Thus, they need to manage not only their own programs, but if they want to be change agents they must be sensitive to the indicators shown in peoples behavior styles when stressed or in conflict, and then, as a change agent, they must address these realities.

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