Challenging the Norm in Engineering Education: Understanding Organizational Culture and Curricular Change

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Abstract

In the study of organizational behavior, several linkages have been made between organizational change and organizational culture. One link suggests that a "strong" culture is a prerequisite for corporate success, and attaining "excellence" often requires culture change. In the study of change in higher education, there have been suggestions that an institution must have a "culture" that facilitates change, and that change strategies are often shaped by organizational culture. Recently, as presented in the 2003 ASEE conference, Godfrey[1] made a considerable contribution to understanding the *culture of engineering education* by providing a theoretical model that may assist change leaders in understanding the dimensions of their own school's engineering education culture. She suggests that if the espoused values inherent in any proposed change do not reflect the existing culture at an "operational level," change will be difficult to sustain.

In the Foundation Coalition (FC) we have been studying the change processes FC partner institutions went through to restructure freshman and sophomore curricula. The six diverse FC institutions attempted major curricular changes based on an identical set of principles using similar change models. We noticed that similar change strategies produced different results. Using two examples from the same institution from our study, this paper will examine change strategies through the framework of *organizational culture,* a framework in which *engineering education culture* is subsumed. In showing how organizational culture was a critical variable in curricular changes undertaken by one FC institution, we will show how essential cultural analysis is to any change attempt.

Introduction

Many reports of curricular change in engineering education have focused on descriptions of changes, e.g., the content of new course materials, or the results of changes, e.g., how incorporating new teaching strategies affected student learning. Some of these reports have come from the work of faculty in the NSF-sponsored Foundation Coalition (FC), currently consisting of six institutions: Arizona State University (ASU), Rose-Hulman Institute of Technology (RHIT), Texas A&M University (TAMU), the University of

Alabama (UA), the University of Massachusetts at Dartmouth (UMD), and the University of Wisconsin at Madison (UWM)[2-11]. The FC, one of six NSF "engineering education coalitions" received a ten-year grant to support the design, implementation and adoption of new and innovative undergraduate curricula in their engineering colleges. Based on experiences of these schools, we have learned that the *process* of curricular change is also very important and requires consideration before undertaking a change effort. As a result, the FC initiated a study of the processes of curricular change as they occurred across the six member institutions. In a recent paper[12], we presented several issues that appeared from a series of qualitative case studies. In that paper we stated that assumptions held by faculty about how change occurs affects the process of curricular change. In addition, we saw that FC faculty could have given additional thought to certain *contextual issues* that affect the change process, especially during the development and pilot stages. When it came time to scale up the curricula to accommodate larger groups of students or an entire class, the change process had to alter to take into account the larger context. Faculty teams at each institution struggled with issues related to this larger context. Some of these were:

- persuading colleagues to adopt and use new teaching techniques,
- gaining departmental and college support and approval of the curricula,
- creating department- and college-level structures to coordinate, manage and sustain the new programs over time,
- sustaining collaborative relationships across disciplinary and college boundaries.

All of these issues relate to communication, an important element when undertaking change of any type. Strategies used to address these issues and the outcomes at each institution were different. These differences were attributed to the personalities of the people involved, the amount and level of administrative support, faculty absences due to sabbaticals, or just plain serendipity. The point is that there was no one strategy, no ideal change model, or no universal process that could be applied to each situation that would guarantee successful adoption of these new curricula. The FC teams had to understand their institutional context well enough to know which strategy or strategies would be the most effective. The clearer their understanding, the increased likelihood the change processes would be effective.

One way of looking at institutional context is through a cultural perspective. By cultural perspective we mean using a conceptual framework that helps identify the "pattern of basic assumptions"[13] held and shared by people in an organization that reflect the values, beliefs, feelings or ideologies about their organization and their work. As one definition of organizational culture, these assumptions form the "glue" that binds an institution together, and contributes a sense meaning and identity to its members[14]. In what follows, we are using *organizational culture* as one aspect of an institution's environment or context, as a contextual element and critical variable that affects the process of change.

In this paper we present and compare the stories of two curricular change initiatives at Rose-Hulman Institute of Technology, one that was sustained, one that was discontinued

in 2001. The first initiative, IFYCSEM (Integrated First-Year Curriculum in Science Engineering and Mathematics) was the highly innovative freshman curriculum that was a precursor to the FC efforts. It was offered at Rose for eleven years. The FC-sponsored sophomore engineering curriculum (SEC) was developed several years after the freshman program began. We show how leaders, learning from the freshman effort, carefully shepherded the sophomore curriculum towards adoption by the institute. By contrasting the strategies used by leaders in each of these efforts, we show how taking account of aspects of institutional culture can assist in promoting change.

In the next section, we briefly review some of the research related to organizational or institutional culture, specifically focusing on higher education. We then describe our research methodology. The third section provides a short description of Rose-Hulman Institute of Technology. Using the concepts developed in the section on the organizational culture in higher education, we next describe some elements of the organizational culture at Rose-Hulman. The next two sections describe the processes through which the freshman and sophomore curricula were conceived, designed, and implemented. We then discuss these change processes from a cultural perspective and conclude with recommendations for those attempting change in the future.

Organizational Culture in Higher Education

The concept of organizational culture became popular during the OD (organizational development) movement in the 1980's, gaining exposure in popular books like Peter's and Waterman "In Search of Excellence.[15]" The concept was adopted by the Total Quality Management (TQM) movement and is now associated with business process reengineering, organizational learning, knowledge management, and most recently, competence-based management.[16] In a comprehensive review of the literature, Lewis[17] categorized research in organizational culture into four themes:

1. work related to whether organizational culture can be directly observable behavior or only lying in tacit assumptions
2. work investigating whether culture should be viewed as one variable within an organization or used as a root metaphor for the organization, i.e., "is it something an organization has or something an organization is?" (p. 14)
3. studies related to culture's effect on an organization, e.g., does a certain 'type' of culture effect productivity?
4. studies concerning how culture is created or transmitted

Researchers studying institutional culture and organizational behavior in higher education have borrowed heavily from the studies and concepts coming out of the corporate and management spheres. In comparison to the business world, higher education has been slow to take up the study of its organizational cultures. This may be due to the confusion about what is meant by culture within the higher education context. There are studies of academic culture, faculty cultures, student cultures (and counter-cultures), disciplinary cultures, management cultures, and teaching cultures (e.g., the culture of engineering education).

In the context of engineering education reform, it appears that one way "culture" has been used is as "a code word for the subjective side" of engineering education, similar to how Meyerson[18] characterized cultural studies of organizations that began appearing in the business management literature in the early 1980's. But as a code word or something tangible in the minds of change agents, references to "culture" and culture change have been plentiful in literature of the engineering education reform movement. From the beginning of the Engineering Education Coalitions, NSF saw that for undergraduate engineering education reform efforts to succeed, the "culture of engineering education" had to change. From that point on, many coalition publications echoed this call. Yet in progress reports and descriptions of curricular changes attained, rarely was engineering education "culture" defined nor was it clear exactly how new curricular changes might impact that culture.

Yet clearly, "culture" had been recognized as an important factor when initiating change. But how can culture, specifically organizational culture, be a tool in our understanding of and preparing for change in higher education?

A large contribution comes from the American Council on Education's reports on their Project on Leadership and Institutional Transformation. In this project, 26 colleges and universities sought to accomplish institution-wide changes on their campuses. Their study of six of these institutions found that change processes "at each institution were clearly influenced by deeply embedded patterns of behavior, expectations, values, and beliefs about how that institution function[ed]"[19]. Leaders at each institution had to "craft" change strategies that "fit" their institutional cultures. The culture was the modifying element of the change process, and was manifested in the people within the organization.[20]

From a case study of a state college, Tierney[21] developed a framework to diagnose organizational culture in order to understand management and organizational performance. His framework consisted of questions relating to six "essential" cultural concepts:

- environment (how is it defined? What is the relationship between the school and its environment?),
- mission (what is the mission and how is it used?),
- socialization (how are new members socialized?),
- information (what information is prized? How is it shared?),
- strategy (how are decisions made and by whom?), and
- leadership (who are the leaders? What is expected from them?)

Frost and Teodorescu[22] assert that any curricular change involving improvement of teaching must be viewed as change in *institutional culture* because it entails enhancing the value placed on teaching.

> [T]he greatest impediments to valuing teaching appropriately lie not with the intentions of individual faculty but with institutional structures and cultural forms that frustrate, prohibit, render invisible, or even penalize teaching excellence and effectiveness.[22]

Researchers studying the work of the Greenfield Coalition (another of the NSF-sponsored engineering education coalitions) tackled the culture and culture change problem directly. They recognized that without an understanding of the existing cultures in their institutions, attempts at "culture change" would be difficult. In their study, coalition faculty partnered with a team of anthropologists to document the "culture change" through the use of ethnographic research methods. By making "cultural knowledge explicit" it allowed change leaders and other stakeholders to reflect on their change strategies and adjust them for future action. Defining culture as "shared systems of meaning and practice emerging from collective learning and taught to a group's newcomers as the correct way to think and behave," the research team identified nine cultures involved in the change process - classroom, student, faculty, engineering, professional, teaching and learning, organizational and engineering education.[23]

Clearly, as mentioned above in the Greenfield Coalition study, when focusing on one institution, there are many subcultures or super-cultures, especially at large research universities. When looking at academia in general, many institutions may have disciplinary or professional cultures in common, as well as academic culture in general. These cultures serve several purposes: to convey a sense of identity to its members, to instill group commitment and loyalty, to stabilize the group's social system, and provide guidelines for behavior, and for interpreting and making sense of the surrounding world.[25]

The important point for this paper is that culture is bound to context, or as some researchers have said, culture is one element of context, so every institution will have a different institutional culture. "Thus, descriptions and interpretations of events and actions from an institution are not generalizable to other institutions."[25]

Methodology

The data from which this paper are drawn comes from a study of the process of curricular change the engineering colleges in the FC experienced as they developed, piloted and implemented new undergraduate curricula (a more detailed description of the research methodology is provided in Clark *et al.*[12]). The data for our qualitative study was collected primarily through interviews and documents. The first step in our analysis was to describe the context within which the phenomenon of study occurred, taking into account how participants spoke or wrote about that context.

Much of what qualitative researchers collect through interviews, observations in the field, and document, can be analyzed in ways that help distinguish an institution's culture. Collecting many people's views and perceptions of the same event through narratives and people's stories allows access to the multiple as well as the shared meanings given to any

particular event. This is particularly true with the data we collected at Rose-Hulman for the freshman and sophomore curricula change case studies. Faculty members were especially candid about their experiences and feelings of the events that were part of the change process. The organizational culture description that follows draws mostly from the transcripts of interviews with faculty. Aspects of the school's institutional culture were apparent in the way they spoke about their relationship with the school, their work, their colleagues, and in particular the students. There were two main elements that contributed to our interpretation of the organizational culture. The presence and content of an institutional story, an "organizational saga" and how values, beliefs and expectations faculty members held in common with their colleagues were evident in their interviews.

Organizational Culture of Rose Hulman Institution of Technology

Rose-Hulman Institute of Technology (RHIT) is a small private college in Terre Haute, Indiana, which offers degrees in engineering and the sciences. It enjoys a national reputation for excellence; in 2003 *US News and World Report* ranked it first for the fifth consecutive year among colleges whose highest degree is a master's degree. The mission of the school is to be the best undergraduate science, engineering, and mathematics institution in the world. The school enrolls approximately 1650 students and employs about 115 faculty members. The academic administrative structure is similarly uncomplicated with one president, one dean who also serves as academic vice-president, and ten department heads. Rose-Hulman is unique in both its size and its mission. For students this translates into small classes and a high level of individualized attention. For faculty it means working in an institution that places a high value on teaching and one which is more intimate and collegial than that offered by most larger colleges and universities. The campus itself is modern and welcoming; with spacious grounds and well-designed buildings that house not only sophisticated technical equipment but also an impressive art collection covering the walls of the main building's hallways.

In its 130-year history Rose-Hulman has seen significant change and its leaders take pride in the school's ability to evolve. The major changes in more recent years include the admission of women and the requirement that all students have laptop computers, both occurring in 1995, as well as extensive building and remodeling of the campus facilities.

Organizational Saga One of the first things a visitor notices from talking to faculty at Rose-Hulman is a sense of its distinctiveness as an educational institution, not only within the Foundation Coalition but also among engineering schools in general. If culture works as a kind of "social glue" that binds an organization together under a common identity[26], one way of accessing that identity is through an organizational saga, or institutional story. During our research, as we became more familiar with Rose-Hulman, a story or "organizational saga" began to emerge. Burton Clark[27] first described the concept of organizational saga in his study of Antioch, Reed and Swarthmore Colleges. He defined it as a "unified set of publicly expressed beliefs about the formal group that (a) is rooted in history, (b) claims unique accomplishment, and (c) is held with

sentiment by the group" (p. 374). Clark wrote that organizational sagas are initiated under three kinds of conditions: 1) when an organization is being created, 2) when an organization is in crisis, and 3) when an organization is ready for evolutionary growth. We believe that Rose-Hulman was ready for evolutionary growth in the 1980's, and that the innovative undergraduate efforts reported in this paper were one manifestation of that evolution.

The organizational saga embodies the distinctive character of the organization. For Rose-Hulman the theme of their organizational saga is to be "the world's best at undergraduate engineering, mathematics, and science education," a goal first articulated by Rose-Hulman's current president, Samuel Hulbert, who has been in that office since 1976 and will step down in 2004. Several Rose-Hulman documents credit the Institute's current reputation for excellence to the Hulbert presidency.[28] Campus facilities have expanded due to several successful capital campaigns; the size of the student and faculty population has doubled while maintaining a student-faculty ratio of 13:1; the institution made the transition to coeducation and the use of computer technology (requiring laptops for students), and as mentioned earlier, Rose-Hulman has maintained the #1 ranking in the engineering and technology schools category by U.S. News and World Report for five years. An administrator who expressed concern over the eventual retirement of President Hulbert, told us,

> I think once you see the facilities and the quality of this place, it truly is outstanding… [O]ur president, who has been here for over 25 years and has transformed this place… partly because he has surrounded himself with people that I think are just outstanding in terms of the ability to go out and get funding and resources for us to do really good things. And, he's very, very committed…, he says "we only exist for one purpose and that's for students. And we are going to be the world's best and I'm going to do what I can to see that we are."

Shared Values While the organizational saga about becoming the "best" focuses on the distinct quality and reputation of the Institute, what seems to be a more common and shared commitment held by faculty is their dedication to the student. In his discussion of the varied contexts of academic culture, Burton Clark[29] wrote that professors align themselves around three different interests, self-regarding, other-regarding and ideal-regarding,

> Academics may believe in the academic life because of direct personal payoff, such as the achievement of tenured job security; or because it advances the interests of a larger group—a department or an institution; or because it seems to support a broad principle—scientific progress or enriching the literary culture. Other-regarding interests connect persons to each other; ideal interests bind the individual to general principles that orient action. (p. 106)

For faculty, becoming "the best" means dedication to the student and his or her academic growth. This commitment was very apparent in our interviews. Faculty members were consistent in speaking about Rose-Hulman and their professorial life as first and foremost focused on "what's best for the students." The students are aware of this, a professor commented, "they meet with faculty and they know that they're not second class citizens and that they're really cared for." We were told that Rose-Hulman's student-centered values attracts faculty who "love teaching," and who were not afraid to "change and try new things." Faculty members and administrators described themselves as being part of a community whose members were "talented" and "extremely creative." Atypical of many academics, most professors come to Rose-Hulman and wind up staying for the duration of their careers. More than one interviewee described Rose as "a wonderful place to work." An engineering professor remarked that faculty "wouldn't have remained here if they weren't good and they weren't dedicated to teaching. That has been the hallmark of how we hire and how we retain faculty." So in addition to the organizational saga, the "other-regarding" interest" – the overriding dedication to the student – is also part of Rose-Hulman's institutional culture. It is a commonly-held value held by both faculty and staff alike.

Another indicator of this sense of "oneness" is how faculty identified their primary loyalty. Allegiance to one's discipline is more the norm in higher education[20,.25, 30,31], but the faculty members we interviewed identified primarily with Rose-Hulman over their discipline. This allegiance is somewhat different from the loyalty created through the organizational saga. The saga's audience is the outside world. The loyalty expressed by the faculty in interviews tended toward community, a sense of belonging. They often prefaced what they were about to say with "here at Rose, we…," speaking for the whole rather than just speaking for themselves or their department. Rose-Hulman was not a collection of separate programs and departments divided by discipline but an entity joined under a common institutional umbrella, a unified institutional body with a common mission. Faculty articulated a concern for what was happening in other parts of the institution. In the words of the dean, "on this campus, we believe that if mechanical engineering has a problem, then we have a problem." A faculty member from the humanities and social sciences attributed the Institutes' ease at adapting to the recent changes (coeducation, requiring laptops) to this sense of "oneness" in the school:

> We are one college. So my department is part of the engineering college, we all are. And also because just the size of our faculty. The engineers and the physicists and the mathematicians and the humanities folks talk to each other every day. We have lunch with each other. We're not off in different buildings somewhere. So that sort of coordination and working together comes really naturally to us…[Geographically]…it's much easier for us to all be in this together. And here, in my department, we think of ourselves as engineering educators. Teaching the engineers is not service work to us--It's our job.

This sense of being part of one organizational entity was very strong at Rose-Hulman. Though there are nine academic departments (granting 12 degrees) there is not the

bureaucratic or disciplinary fragmentation seen at most universities. This institutional "oneness" and its governing structure also create an expectation for inclusiveness. Faculty members expect to be informed about new initiatives. What changes in one part of the institution will usually affect the whole. In contrasting Rose-Hulman's recent experiences of curricular change to what might occur in larger institutions, a computer science professor said,

> [at a big university] you could probably get away with a lot of stuff that you can't get away with here, or you shouldn't get away with here…In order to get things done, you have to actually ask the question "What is the important group that does have to be actively supporting the end result?"

The high value placed on teaching and learning, the primacy of Rose-Hulman's institutional mission, and the commitment to inclusiveness categorizes Rose-Hulman as an example of what Bergquist[31] calls, a "developmental" academic culture. Within this culture, meaning is derived from furthering the personal and professional growth of all members of the community, and activities and programs are judged based on how well they serve that goal. Most decisions are made through democratic processes, and all members of the community are free to question administrative or departmental decisions and participate in changing strategic or curricular plans. Within this kind of environment, people feel free to experiment and grow, but there is an expectation that what they learn, especially if it could help others in their development, should be shared.

> Even if somebody is going to go off and do their own thing, the rest of the institution has to support it. We have people in this department who do their own thing different[ly] than other people in the department would do. But the support that they have from the rest of the department is real support. It's not "Well you do that and I don't want to have anything to do with you," it's "Oh, you're going to teach that course that way? Fine, that's really neat. I'll learn a little bit from you, I'll talk to you about it. I won't just let you go off and be an isolationist.

In an institutional culture like Rose-Hulman, faculty members are often aware of what their colleagues are doing. There are many informal ways of sharing information and a formal curricular change process. Course modifications, adding new courses, and removing obsolete courses are expected of faculty, and there is a formal Institute-wide curriculum committee in place through which all curricular changes must be approved. Its members are the department chairs and the dean. In order to assure that their decisions represent the Institute, the committee has a rule that if there are two dissenting votes on any issue, the decision gets sent to the entire Institute. The Institute is the formal governance structure in the school where Institute-wide issues are debated and voted upon. Every faculty member and staff of faculty rank attends Institute meetings and each has a vote. The President of Rose-Hulman presides as the chairman.

Lastly, a value which emerged from our interviews is faculty's wish to maintain their autonomy and independence, especially in the classroom. This is a value characteristic of the wider academic community. A professor who taught in the sophomore program said, "I don't think anyone can tell me how I can teach my individual course. I think they can tell me the material to cover... [but] if they prescribed...active learning, no lectures at all...I don't think I could do that."

In summary, Rose-Hulman's unique organizational culture is distinguished by an organizational saga which iterates the institutions striving to "be the best" engineering education institute. Members of the faculty have a dedication and commitment to the student and what is best for his or her learning. There is a widespread sense of belonging to a community, to one institution, rather than to a department. This sense of loyalty easily bridges disciplinary boundaries. Unlike research universities, teaching is the highest priority for faculty. Faculty members know and care about what is going on within the school and with their colleagues and there is an expectation that information, especially if it is related to teaching or curricula, be widely shared. The formal governance structure allows faculty to participate in curricular (as well as other decisions impacting the school) and there is a striving for consensus in decision-making. Despite the unique character of Rose-Hulman and its faculty, academic freedom is highly prized, and maintaining faculty autonomy and independence is highly valued.

It is in this kind of environment, this institutional culture, which the freshman and sophomore curricular innovations that are described next occurred.

The Integrated, First-Year Curriculum

In the fall of 1987, an interdisciplinary faculty group began discussing issues related to redundancy in the first-year curriculum and how students were having difficulty seeing connections between engineering practice and mathematics and science. They discussed how the curriculum might be changed to address those issues. Two professors quickly surfaced to become leaders of an effort to obtain funding and gather together other faculty who would be interested in designing an innovative first-year curriculum. They were extremely successful in writing winning proposals for grants to support their project. It took three summers (1988, 1989, 1990) to develop the curriculum, gather the resources and secure support for implementation. The curriculum packaged calculus, physics, general chemistry, engineering design, engineering statics, computer science, and engineering graphics into three twelve-credit courses.[2,32,33] It was offered to 60 first-year students who volunteered to participate in the 1990-91 academic year.

During the summer of 1988, the development team (two mathematicians, an electrical engineer, a chemist, a physicist, and a mechanical engineering professor) concentrated on developing the topics and concepts, clustering them and then forming a rough outline of a curriculum that integrated engineering, mathematics and the engineering sciences. It took the following summers to actually construct the courses and develop syllabi.

The faculty members in the initial discussions were described to us as "upbeat" and "positive." The notion of an integrated curriculum really excited them and that early development period was extremely creative and energizing for those who participated. There was also early and steadfast support for the effort from the president and dean. The view from outside the group was mixed, however. When members of the development team presented the rough outline developed in the summer of 1988 to each of the departments, it became clear that not all professors agreed on the premise of integration. There were strong dissenters in the mathematics department. They objected to changing the order in which mathematics topics were introduced, the lack of a textbook that offered the proposed order of topics, and that certain mathematics topics might be dropped altogether. Another disagreement was over the idea of helping students make conceptual connections among disciplines. One professor later told us that realizing those connections on his own as a student was a "great joy" and that part of student growth in learning is coming to those relationships unassisted. Still another disagreement centered on the usefulness of computer algebra programs. But the main concerns revolved around the efficacy of the two most prominent features of the proposal: 1) offering the curriculum as a single twelve-credit course with a single grade each quarter and its potential effects on student grades and progress, and 2) the notion of integration, particularly the requirement that faculty members would teach the twelve-credit course as a team.

Despite these objections, the development team was provided an opportunity to offer their program. In 1989, the Institute voted to allow the program to be implemented as an "experimental" program, pending the award of grants that would support faculty and purchase equipment. The first implementation of the Integrated First-Year Curriculum in Science, Engineering and Mathematics (IFYCSEM) was in September of 1990.

The year-long freshman program was designed as a sequence of three 12-credit per quarter courses. Topics from 11 traditional freshman courses in mathematics, physics, chemistry, engineering design, computer science, engineering statics, and engineering graphics were integrated around four themes: rate of change, conservation, accumulation, and properties of materials. In addition, the design incorporated the use of a computer algebra system called *Mathematica*. Students received one grade for the 12-credit block each semester. These courses comprised about 75% of a typical freshman course load. They were also designed to accommodate any disciplinary trajectory, that is, students were prepared to continue into any major discipline in their sophomore year. Students took an elective each quarter in the humanities, or social or life sciences. There were 18 class hours during the week, half of which were laboratory hours.

IFYCSEM (which was colloquially referred to as the IC for integrated curriculum) was offered as an "experimental" program throughout its eleven year existence at Rose-Hulman. The first three years were rocky. The first year one-third of the students transferred out due to the faculty team's "overzealous and gung-ho" readiness to "unleash" all the exciting and innovative ideas all at once. Adjustments to student workload were made for the following year, but this initial "misstep" cast a negative light

on IFYCSEM in the eyes of the institute, a reputation that was difficult to change in subsequent years.

Although revisions were made, especially in the first few years, the percentage of students who began the program and completed it remained around 60%. Students leaving IFYCSEM, either through voluntary transfer or failing (at the end of the first five weeks, at the end of fall quarter, or at the end of winter quarter) were accommodated in the traditional curriculum with either remedial courses, or admitted into comparable courses on a grade replacement basis

During spring 1992 (the third year in which IFYCSEM was offered), the two leaders became involved with the Foundation Coalition proposal team. Carl Erdman, the executive associate dean at Texas A&M College of Engineering, was a member of the outside advisory board for IFYCSEM. He was impressed by the innovative program and wanted to include it in the proposal as a model that FC institutions would use for developing their first-year curricula. Once the grant was awarded, a sophomore curriculum development team was created, on which one of the IFYCSEM faculty leaders participated.

We were told by one of the leaders that being a partner institution in the Foundation Coalition influenced the innovative freshman curriculum and the IFYCSEM faculty team in two major ways. First, it introduced teaming skills which faculty incorporated into their own meetings in addition to training student teams. Second, leaders became aware of how important the "politics of inclusiveness" was at their school. The sophomore team used several methods to assure all faculty members had opportunities to participate in the curriculum development process as much as possible.

Sophomore Engineering Curriculum Development

The proposal stated that IFYCSEM would be a model from which the other FC institutions would start their first-year year development. Because their first-year program was already being piloted and modified, the faculty at Rose-Hulman had 2 years to work on their sophomore curriculum while other FC institutions began work on their first-year curricula. RHIT began by forming a local management team, one faculty member assigned for each of the four FC thrusts: 1) active/cooperative learning and teams, 2) technology-enabled learning, 3) curriculum integration, and 4) assessment and evaluation. These four began to work on building faculty interest in the Foundation Coalition. They worked closely with the Dean and VP for Academic Affairs. First they solicited proposals and ideas from the entire faculty about changes in the sophomore year. Then, during the spring quarter, they met weekly on Friday afternoons with interested faculty to discuss these ideas. After two months of meetings a Summer Sophomore Curriculum Development Team (SSCDT) was formed which consisted of ten faculty from all the engineering departments, plus mathematics and physics.

This group met during the summer of 1994. They started out the summer with a weeklong series of workshops on active and cooperative learning, curricular design, and

training in working as a team. Previously, they had also invited representatives from Texas A&M University to talk about their sophomore engineering science core curriculum.[3-7] The goal was to develop the conceptual foundation of the curriculum. The team prepared a draft outlining their ideas and that fall they made a formal presentation to the entire Institute (consisting of all the faculty and members of the administration). This presentation outlined the "skeleton" of the proposed new sophomore curriculum.

In order to build support for the program further, team members visited each individual department. At least two members of the SSCDT were at each of these meetings, one always taking notes of faculty concerns and questions. Notes were then typed and distributed back to respective departments to ensure the team understood faculty concerns. Once the feedback had been returned to the departments and clarified, the team met in March of 1995 and came up with what they termed as a "consensus curriculum." This was then presented to the Institute for approval in April. The Institute approved the curriculum that came to be known as the Sophomore Engineering Curriculum (SEC). Serendipitously the Electrical and Computer Engineering department, who were in the midst of a departmental curricular revision, adopted the SEC and required it for all their sophomore students that coming fall. This decision meant the SEC would be offered for an entire department without piloting it first.

In summer 1995, another team was formed to work out the details of the SEC. Twelve faculty members, some of whom served on the conceptual team the previous summer, as well as three students, met to develop the details of the program: the course objectives, materials, and syllabi. Again, as in the previous summer, training in teaming and curricular design preceded these meetings.

In September of 1995 the new sophomore engineering curricula ran with all sophomore ECE students and some volunteers from mechanical engineering. Mechanical engineering decided to phase in the SEC as a requirement, so in the fall of 1996 they decided to require it for all entering freshman in 1997 (the class of 2001). As of this date there are no plans to require the Sophomore Engineering Curriculum for students in the other two remaining engineering departments, the Departments of Chemical and Civil Engineering.

The Impact of Organizational Culture

The curricular changes initiated through IFYCSEM and the SEC were intended to improve the quality of the first and second years experiences for students, bringing Rose-Hulman closer to its vision articulated through the organizational saga. Both President Hulbert and the Dean of Faculty at the time, Jim Eifert, purposefully couched the proposed implementation of the freshman integrated curriculum within the framework of the organizational saga. They viewed it as another accomplishment to add to distinctions that were already part of Rose-Hulman's crusade to becoming "the best." In the March 1988 memorandum to faculty from President Hulbert which asked for volunteers to serve on a Presidential Commission to investigate the potential of the yet-to-be piloted freshman integrated curriculum, Hulbert listed a number of accomplishments that placed

the Institute at the forefront of undergraduate engineering education. Among those listed were:

- Role as a pioneer in bioengineering and applied optics
- Only educational institution with a technical translator program in German and Russian
- One of three engineering schools offering language instruction in Japanese

In the eyes of the President and the Dean, faculty members volunteering to participate on this commission would be contributing to Rose-Hulman's achievements. They unequivocally supported the integrated freshman year curriculum. It was compatible with the image of Rose-Hulman created by the organizational saga, but the change processes used by the programs leaders often countered many values held by faculty. The "ideal-regarding" interests epitomized in the vision of *being the best* was characterized by one professor as possibly conflicting with the "other-regarding" commitment to *what's best for the students:*

> I think if it were up to the administration that we would adopt [IFYCSEM] 100%. But for the wrong reasons. Sometimes they want to make moves like that just so Rose-Hulman can appear to be on the cutting edge of everything. Those are the wrong reasons. You want to adopt it because it's the right program for your students. But that's a constant battle that we fight all the time. The faculty tries to analyze the [decision to] change from "what's best from my students" point of view, and the administration may have another agenda. Hopefully the system is structured so that the two balance each other out.

As Clark[27] stated, the most important outcome of an organizational saga is the "capturing of allegiance, the committing of staff to the institution" (p. 235). It contributes to a sense of community. Yet IFYCSEM challenged that sense by not including the community in their development and implementation work.

Viewing the story of IFYCSEM within a culture that strongly valued inclusiveness, we can see one way that resistance to the program may have developed. Isolation was an issue from the beginning. When they received their first Lily grant, the development team made no effort to communicate to the rest of the faculty about the purpose of their meeting. The two leaders, however, did ask President Hulbert to appoint a presidential commission of faculty to "provide an external perspective"[32]. The commission served for only the 1988-89 academic year, and while they leaders intended the commission would help with implementation issues, the members themselves thought they would have much more input about the structure of the curriculum. There was no agreement on the purpose of the commission, and members had little opportunity to contribute to the development of the program.

IFYCSEM faculty became aware of the lost opportunities to create a better relationship with the rest of the Institute. A candid assessment appeared in a 1995 FIE paper[33],

> [I]nsufficient opportunity was provided to suggest changes in the curriculum. Although faculty were informed, faculty believed that they were provided with little or no opportunity to suggest changes which would be implemented. Since faculty believed their suggestions would not affect the prototype curriculum, they began to view [the innovators] as a separate entity, and a "we versus they" syndrome formed. (p. 5)

Another factor that contributed to this situation was the heavy workload for IFYCSEM faculty. Managing and teaching in the first iteration of the program, as well as disseminating information about the program throughout the country, consumed a tremendous amount of faculty time. Computer software and hardware were new to faculty and students alike, "integrated" exams and projects took time to develop and evaluate, and addressing student feedback meant altering and refining daily and weekly schedules. In the words of one developer, "…we were of necessity on the fly creating all of these links, all of these relationships and everything, we just didn't have time to be sort of more politically savvy, I think. And what you did is you tend to isolate yourself that way." In addition, the large-credit course structure of the curriculum, using different software and hardware than the rest of the Institute, and teaching the twelve-credit courses as a team, all these differences between the way IFYCSEM was taught and the way the rest of the Institute operated, contributed to isolation. Isolation, which Senge *et al.*[35] has identified as one of ten challenges to initiating, sustaining, and growing any pilot program, contributed to general distrust and ambivalence about IFYCSEM. This is especially true at Rose-Hulman where a sense of oneness and knowledge about what is happening in other parts of the institution are highly valued.

In contrast to the change processes employed by the IFYCSEM team, the faculty leadership developing the SEC went to great lengths to involve the rest of the institute and not to isolate themselves. This was due partially from not wanting to be identified with the earlier effort and the negative image associated with it within the school. In addition, however, how Rose-Hulman became a member of the FC in the beginning created some antipathy. When NSF accepted the proposal of the Foundation Coalition in 1993, each participating institution formally joined the FC through agreements signed by their college deans or presidents. At no institution was there faculty input at this stage. However, at Rose-Hulman faculty are accustomed to having a say in curricular decisions, so there was some discussion among upper administration about involving the faculty in this decision. They decided not to do so, at least for the first five-year commitment, and this created resentment among some of the faculty. One professor gave voice to this concern:

> I was extremely irritated at the fact that the proposal for the money from NSF was made without prior consultation with the people who were important. And then after the money was here, [we were essentially told] "Well, we have a commitment." The way to make a curricular change is to have broad support, not to have money come in from outside to be used

> in the way the money says, because people then feel it has been forced on them. I think that was a fundamental mistake.

Despite this weak start, the SEC leaders designed their development and adoption strategies to be as inclusive of the rest of the institution as possible. In addition, the program itself was designed not to create any additional work for faculty. One developer told us, "we didn't think we could sell a curriculum where we were asking a group of faculty to meet all the time." Teaching in the SEC was comparable to teaching in the traditional courses.

Another feature of the freshman curriculum that was purposely avoided by the SEC was the emphasis on active and cooperative learning. Despite the focus on teaching at Rose-Hulman, it was clear that faculty resist being told exactly how to teach, reflecting the desire to maintain their autonomy. The SEC faculty leader was direct about this: "If we had come into this curriculum and said, 'OK, from the start we're going to have teams,...every faculty member has to use cooperative learning as spelled out by Karl Smith...', we wouldn't be here, because I couldn't find enough faculty members to do that." One professor who teaches in the program contrasted how each program was perceived when it came to faculty participation:

> I think one of the great concerns among faculty regarding the freshman program was that people would be forced to participate and forced to teach in this way. Nobody ever has been, but [there was] a great deal of resistance over the prospect. Sophomore year the cooperative learning aspect was played down considerably from the very beginning. The idea was that it would be encouraged but it would not be built into the curriculum and nobody would be required to participate at all.

The leaders of the two programs handled communication with the Institute differently as well. As mentioned earlier, faculty members in several department meetings where the initial curriculum proposal was presented in fall 1988 expressed concern about the twelve-credit course. The leaders of integrated, first-year curriculum project failed to address this concern and this created strong resistance from many faculty members. From the perspective of the development team, the twelve-credit course was an essential vehicle for stressing integration. For many faculty members outside the development team, the twelve-credit course was a terrible idea. Since the development team did not change an element over which many faculty members were concerned, outside faculty members became convinced that the development team wouldn't listen to their concerns, wasn't willing to accept input from outsiders, and was only concerned that their ideas were implemented. This communication barrier may have limited the program's prospects for acceptance and growth. The program never expanded beyond enrollment of a small percentage of the entering freshman class.

In contrast, SEC leaders included faculty at every step in the process, asked for and incorporated their feedback, and made sure the final product reflected a consensus. Instead of being able to build on IFYCSEM's achievements, leaders of the FC sophomore

curricular change effort went to great lengths not to have their new curricula sound or look like the freshman program.

Conclusion

IFYCSEM and the Sophomore Engineering Curriculum had a significant impact at Rose, within the FC and beyond in the engineering education community. IFYCSEM in particular, was instrumental in putting RHIT on the map. It brought lots of attention to the campus and contributed to the school being rated the top engineering school by U.S. News and World Report in their classification for five years in a row. Faculty and administrators from other schools came and observed the program. Several other engineering schools, in addition to the FC partners, have instituted programs modeled on the principles espoused by the program. For many FC faculty members at partner institutions, observing IFYCSEM in action and talking to the teaching faculty in the program was a catalyst for change and convinced many faculty of the value of FC ideas. It was an educational laboratory for experimenting with computer technology and software in the classroom, certainly contributing to the decision in 1995 to require all students to purchase laptops. More Rose faculty became exposed to project-based learning, the use of student teams in the classroom, and the power of cross-disciplinary faculty teamwork. As we've seen at other FC partner schools, even if innovations promoted by developers didn't become part of new curricula, there was considerable dissemination, especially in pedagogy. This is especially true at Rose. A professor of chemical engineering told us he saw that happening:

> I like the diversity of offerings and programs and the things they have brought to campus, absolutely positive, it's been a great skunk works for new ideas. I mean these folks will try anything and have tried everything. I think especially at a place like Rose Hallman, that's a very important thing to have going on, because the successful ones wind up spinning out into the other curriculum.

As the FC as a formal organizational entity comes to an end, there is no doubt in the minds of those faculty intimately involved in the project that the curricular experimentation at Rose gave them a proving ground for many innovations and change strategies. As we have shown, though, there is a price to not being attentive to the elements of the "subjective side" of an institution's environment- values, assumptions and beliefs held by its members. When not reflected in change processes, these elements can undermine sustainable change.

Planned curricular change is a complex process. There is no "blueprint" or model for change strategies that will guarantee any change will be adopted and sustained for all educational institutions. There are, in fact, many change processes, and the success of any change attempt depends on congruence between what is being changed, how it is being changed, and the particular organizational environment within which the change is to occur. The story of these curricular change efforts at Rose-Hulman Institute provides an example of the impact that organizational culture, as a critical variable, has on

institutional change efforts. Change agents need some tangible guidance in how to deal with "culture" in order for their work to make an impact. Though there are a few guides in the literature[1,13,14,19,20,25,31,35-38] related to change in higher education, there is much more research required. This paper gave us an opportunity to reflect on the relationship of change and organizational culture, and we encourage prospective change initiators to incorporate strategies and practices that help them be aware about organizational culture before change is initiated.

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