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THE MYTH OF "REAL WORK":

A CASE STUDY OF ENGINEERS' PREFERENCES AND THEIR JOB REQUIREMENTS

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ABSTRACT

In every occupation there are a subset of activities that are deemed the "real work" of the job, despite the variety of tasks required to actually do that job. Field research and Q-sorts conducted at one organization substantiated that engineers share a common definition of real engineering. However, the research further indicated that engineers do not spend most of their time doing real engineering, engineers do not all prefer to do real engineering, and the job of the engineer requires engineers to do more than just real engineering. This paper concludes that it is a myth that the subset of activities labeled real engineering are the most important part of the job of the engineer. However, it is suggested that engineers perpetuate this myth because of the status associated with real engineering as opposed to the rest of the job.

Whether one works in some famous laboratory or in the messiest vat room of a pickle factory, there tends to be a shared conception among the participants as to what the essential work of the occupation is or should be (Hughes, 1958). Police define their "real work" as the unpredictable elements of a regular shift: making an arrest, saving a life, quelling a dispute, preventing a robbery, catching a felon, stopping a suspicious person, disarming a suspect, etc. (Van Maanen, 1974). Engineers define developing a new product to be their most glamorous work, the essence of creative engineering (Kunda, 1992). Apartment building janitors conceptualize their role as the guardians of the building they maintain (Gold, 1964). As Ghidina (1992) has noted, "Doctors save lives, lawyers defend justice and custodians maintain the social cohesion of the building clients among whom they clean" (p.83).

Enhancing aspects of one's work tend to be deemed the core of one's trade -- one's "real work." While occupational members perform a variety of activities, it is those activities that provide the members the crucial justification to legitimize their positions which they consider to be their "real work" (Van Maanen, 1977). "Real work" is the status attributed by the occupational members to those activities that require a perceived occupational expertise (Emerson and Pollner, 1975; Ghidina, 1992; Hughes, 1958; Van Maanen, 1974); it is the status attributed to those activities that enable the display of skills workers possess and value (Hochschild, 1983).

While enhancing aspects of one's work tend to be embraced, negative or oppressive aspects are diminished (Goffman, 1961). Occupational members try to differentiate themselves from the work that they perceive to be below the standard of their occupation or profession -- the "dirty work" (Hughes, 1958). Members of the occupation tend to vocalize resentment about their "dirty work," and may even try to delegate this work to others. Mental health professionals, for example, are found to resent performing social gate keeping functions (Brown, 1989). The mental health professionals do not want to serve as agents charged with social control, a function that has been the target of much

criticism from those outside the occupation. Consequently, these professionals try to avoid such work, devaluing it and labeling it morally objectionable (Brown, 1989). Similarly, Hughes (1958) asserts that nurses try to delegate their bed-making and housekeeping responsibilities, librarians campaign to rid themselves of their clerical work, and teachers propose that there should be master teachers while others counsel pupils, correct papers, and keep discipline.

Much attention has been focused on the labeling of real work, particularly by Everett Hughes and his followers. However, this literature has not adequately addressed why certain activities are considered to be of higher status. It is not clear on what basis some activities are deemed enhancing and other activities are deemed oppressive. Furthermore, it has been claimed that real work affirms one's membership in one's occupation (Moore, 1970; Van Maanen and Barley, 1984) and therefore all individuals are assumed to prefer this work (Brown, 1989; Emerson and Pollner, 1975; Gold, 1964; Hughes, 1958). However, the implications of valuing work activities in this way has not been explored for either the employees or the employing organization.

THE CASE OF ENGINEERING

In order to explore why some activities are labeled real work while others are not, what the implications of this distinction are for both the employees and the employing organization, and why such a distinction perpetuates, I did an in-depth study of engineers, their definition of work, their preferences, and their job requirements. This paper first identifies the activities that engineers define as real engineering. It then introduces engineers' preferences in order to examine whether all engineers prefer the activities labeled real engineering. Finally, the paper discusses why engineers perpetuate a subset of activities as real engineering, despite the findings that the job of the engineer requires more than just real engineering, engineers spend much of their time doing work other than real engineering, and all engineers do not prefer real engineering.

This paper uses data from a field study of engineers in one product design group within the design and manufacturing unit of a Fortune 100 company. The company employs approximately 100,000 individuals worldwide, organized into three types of units: design and manufacturing; sales and service; and administration. The product design group studied consisted of approximately 300 members, all of whom were involved in the design of a specific product.

Within the product design group there were further subgroups, each responsible for a particular part of the final product. The subgroups ranged from just a few individuals to about fifteen members. They tended to consist of one to three engineers, several designers and technicians, and individuals from other functional groups who interacted throughout the design process, i.e. buyers, manufacturing engineers, and manufacturing coordinators.

The data were collected by two team members, in addition to myself. We spent three months in the field interviewing, observing, and shadowing members of the group. Formal interviews lasting one to two hours each were conducted with thirty eight engineers, sixteen managers (i.e. subsystem manager, product manager, Division Vice President and several of his direct reports), and twelve members of the support staff (i.e. manufacturing engineers, manufacturing coordinators, technicians, designers). Furthermore, to supplement our understanding of the work environment, we attended a variety of meetings (i.e. Division Vice President and his direct reports, launch meeting, change meeting, subsystem team meeting), shadowed two engineers, and conducted four round table discussions with combinations of these people. In addition, I ran Q-sorts with ten engineers in order to elaborate on the definition of "real engineering" that emerged from the field research, and to determine whether engineers had different preferences for the same work activities.

DEFINITION OF ENGINEERING WORK

Our understanding of engineering work, as documented in this section, evolved during the field research. First, we identified the distinction being made by the engineers

themselves between "real engineering" and the "rest of the job." Then, as we began to examine the relative importance of real engineering versus the rest of the job, we found that despite this distinction, most engineers recognized that both types of activities were critical for the functioning of the organization.

We began the interviews by asking the engineers "What do you do?" In response, the engineers contrasted what they themselves labeled real engineering with all other work that took time away from their real engineering. When pushed to further articulate what they meant by real engineering, one engineer explained that real engineering is "designing, sitting at a desk or a computer, using the laws of nature to create something." Everything else, whether it is managing, coordinating, administering, or helping, does not seem to be considered real engineering. Another engineer commented, "the biggest frustration of my job is always having to help others and not getting my own work done." And, another engineer complained: "Now that I manage two people this leaves me without a job. I spend my time telling them what to do, statusing things, and going to meetings."

Intensive analysis of the thirty eight interviews indicated that engineers define real engineering as their assigned technical work; real engineering is their individual deliverables; it is the conceptualizing that goes into creating technical output. According to the engineers, the essence of real engineering is analytical thinking, mathematical modeling, and conceptualizing solutions. Real engineering to them is work requiring scientific principles and independent creativity. It uses the skills that they acquired in school. As one engineer summed it up, "Real engineering is what I thought I was hired to do."

The design group studied was in a late stage of developing a new product. The development process itself consists of conceptualizing, building, and testing models and finally launching the product. In the later phases of a project, engineers consider the majority of the work to be trouble-shooting, as opposed to real engineering. Therefore, the particular phase of the project studied provided a great deal of information about the activities engineers do besides real engineering.

There seemed to be a general feeling among the engineers that the project used to require more creativity, more conceptualization, and more lab work. As one engineer explained, "at this point, the project is so far along that there is a very narrow window in which to work; there is very little room for change and that which needs to be designed must fit within a great number of restrictions." The work in the later phases of the project was compared to that of a "glorified clerk:"

Now that we are in a stage of the program which is closer to production we do much more paperwork. It is a bureaucratic mess -- you have to dot all your i's and cross all your t's to get anything through. When you want to make a change you must communicate it to the world -- field service, spares people, service education documentation, manufacturing, etc. all must know about changes. At this point, the job is mostly paperwork. You stop doing engineering.

Despite the indication that there is limited real engineering and a great deal of other activities needing to be done, on a recent annual employee survey, engineers indicated that they do not feel that they have enough time to do their real engineering. As a result, the management formed a Quality Improvement Team (QIT) to address the issue, and after six months the team recommended that a position be created for an administrative aide. While many at the organization doubt that the position of administrative aide will ever actually be implemented, the purpose of the QIT itself provides important insights about an assumption shared among this organization's members. When the issue came up that engineers do not spend enough time doing real engineering, no one questioned it. Rather, the purpose of the QIT was only to determine how to resolve this issue. No one examined whether engineers should spend more time doing real engineering, or whether there was more real engineering to do, but only how to make it possible for engineers to have more time to do real engineering.

At a staff meeting, I questioned the assumption that engineers should spend more time doing real engineering. The Division Vice President responded to me that engineers have a "prima donna approach to the job." He explained that "in reality real engineering is

everything we do here. It is much more than one learns in college." However, in his next sentence, he referred to the other work as the "mundane nonsense which must be done." The Division Vice President recognized that engineers must do more than just real engineering, but he considered this other work a necessary evil that is best kept to a minimum.

While the engineers seem to desire to do real engineering and the managers seem to desire that their engineers do real engineering, the two groups do not seem to desire the same distribution of work activities for the engineer. Most engineers wish to spend all of their time doing real engineering. Engineers often consider everything that does not involve sitting in front of the computer screen or working in the lab solving technical problems to be unproductive, inefficient, or burdensome. On the other hand, while managers stress a desire for engineers to have more time to do real engineering, they tend to recognize that there are other activities that are a necessary part of the job. These other activities are often degraded and referred to as "necessary evils." Yet, as the Division Vice President said, while these activities are "mundane nonsense," they "must be done."

Listening to engineers complain about their lack of time to do real engineering, revealed much about the other activities that currently are part of the engineer's job. The two activities that engineers complained most about were paperwork and meetings. Several engineers described how they must cheat on their paperwork in order to have time to do their real engineering. One engineer told the following story:

The paperwork is not a problem, I just don't do it. If no one asks me about it I figure it can't be that important. If they ask me, I do it. I mean I'll do what I need to do in order to get what I need. But there are these reports, big huge things. I can't figure out why I need to read them and fill out stuff. So I just delete them and I haven't gotten in trouble yet. I save hours of time this way.

Many engineers also complained that meetings are a waste of time. One engineer explained, "You need meetings, but these standard meetings are an unproductive use of time. Most of the time these are status meetings and the information could just as easily be

written down and distributed." In particular, most engineers feel that design change meetings, where changes and their costs are authorized, are a waste. A common complaint is that "All the people at the [change meeting] care about is how much the change will cost and whether you've filled out the right forms. They don't really have any idea of the importance of the change."

At this point, one might wonder what is the function of all the paperwork and meetings? Why do they exist? What would happen if one day the organization announced that there would be no more meetings and no more paperwork?

In the interviews, engineers themselves provided explanations as to why both meetings and paperwork are critical for the functioning of the organization. They said things such as "without paperwork, vendors cannot make parts" and "paper work is necessary to ensure that the correct changes are made to those machines already in the field." One engineer, while complaining about the amount of time he wastes doing paperwork, told the following story:

The time consuming part is not filling out the forms but getting the right people to sign it and fill out their part Signing it forces people to know what is happening. Also, mistakes are caught. It ensures communication.

A similar contradiction emerged in terms of the value of meetings. Many engineers complained about having to attend meetings and yet they described how these meetings did in fact have value, although not necessarily for them personally. One example is that the engineers on the subsystem I was observing attend a team meeting three mornings a week. They complained that this meeting is "a waste of time." But then, as one engineer said, "The purpose of the meeting is to keep the subsystem manager informed, to make sure people are busy and aren't wasting time and to get everyone together so they all know what each other is doing."

In addition to the necessary evils of the rest of the job that have been discussed -- the meetings and paperwork -- there are also other more invisible interactive activities that are performed by some engineers, although these activities are not explicitly required by the

job. However, as with the meetings and paperwork, the interactive activities appear to be necessary for the organization to function. They seem to provide the "glue" that makes it possible for the work of each individual engineer to hold together in a larger project.

To elaborate on what is meant by such invisible interactive activities, I refer to a typology constructed by a member of our research team in her analysis of the same group of design engineers. According to Fletcher (1994, p.61) there are four main types of activities constituting the invisible interactive work of engineers: 1) Activities associated with *preserving* the life and well being of the project; 2) Activities related to *empowering* others to achieve and contribute to the project; 3) Activities empowering one's self to *achieve* goals and contribute to the project; and 4) Activities intended to create *the social entity team*.¹

Real engineering tends to be an independent, output driven process. It is about solving technical problems, individually. In contrast, the invisible interactive activities are about interactions that provide the social glue that hold the project together.

Despite the need for such invisible interactive activities, neither managers nor engineers tend to encourage their performance. For example, one engineer referring to her natural tendency to empower others explained, "I cannot be the way I want to be with people. You can't nurture when you are working with them. It doesn't work . . . They don't understand that that is what you are doing. They see it as a weakness and they use it against you." Another engineer referring to her role in creating the social entity team said:

These things are important. . . . without them you can't do the real engineering. In particular without communication you just can't do it. . . . One of my functions in this job is often to get two people who should be talking to each other communicating. . . often some pretty high level people will stop by my office and ask me to do this kind of thing. . . . I mean they don't phrase it this way, they sort of drop by to talk about a problem they are having and that just seems to be part of the solution.

But expressing her own ambivalence about spending time on such interactive activities, she added:

I feel bad when others are feeling bad or having a hard time.
. . . It is not going to *kill me* to spend some time with them.
(emphasis added)

A third engineer emphasizing her preference for such invisible interactive work described how she recently switched from design engineering to marketing because "in design they simply don't communicate. . . I like the engineering. . . I am a good conceptual and analytical thinker, but I like most the interactive work and that is not real design work, that is not rewarded."

Other examples of such invisible interactive activities being critical but their contribution not being encouraged came up during one of our presentations to the managers. When presented with the findings that their engineers perceived that what matters most is individually-centered technical contributions and not team-centered supportive behaviors, most of the managers recognized they had a problem. They agreed that it takes more than a collection of individual contributors to make a complex product. Yet, they only know how to reward output, and therefore they did not know what to do differently. One manager recalled his own experience trying to promote an engineer who had provided the "glue" for his entire team. This engineer had played an instrumental role in preserving the project. Yet, the manager had run into difficulty when he tried to explain to his own management why this particular engineer should be promoted. The engineer had been critical to the success of the product, but there was no tangible individual accomplishment to which to point, and the promotion did not go through.

Similar to the distinction made by the engineers between real engineering and both the necessary evils and the invisible interactive activities, Bruno Latour, in his ethnographic studies in research laboratories, found scientist made a distinction between pure science and the rest of the work that was necessary to make that system function. Latour (1987) makes an argument about the paradoxical nature of pure science that applies to the importance of the real engineering as well:

The bigger, the harder, the purer science is inside, the
further outside other scientists have to go. . . isolation exists

only in so far as other scientists are constantly busy recruiting investors, interesting and convincing people. The pure scientists are like helpless nestlings while the adults are busy building the nest and feeding them (p.156). . . . When scientists appear to be fully independent, surrounded only by colleagues obsessively thinking about their science, it means that they are fully dependent, aligned with the interest of many more people; conversely, when they are really independent they do not get the resources with which to equip a laboratory, to earn a living or to recruit another colleague who could understand what they are doing (p.158).

Consequently, Latour concludes:

Those who are really doing science are not all at the bench; on the contrary, there are people at the bench because many more are doing the science elsewhere (p.162).

While Latour focuses on the other people who do these other activities, I am more concerned with recognizing the contribution of these other activities, whether performed by the same person or not. However, our point is the same: The current hierarchy of work, in terms of realness or pureness, is not correlated with the role it plays in facilitating the process of engineering or science.

Q-METHODOLOGY

While engineers in the same position with nearly identical responsibilities all defined the same aspects of the job as real engineering in the interviews, Q-methodology was used to confirm that real engineering is a shared reality among the engineers and to provide a better understanding as to the activities that the engineers consider to be real engineering. Furthermore, Q-methodology was used to determine whether engineers share a common set of preferences for the work activities.

Q-methodology provides a systematic and rigorous way to examine human subjectivity. From the standpoint of Q-methodology, subjectivity is regarded simply as the person's own point of view. Q-methodology is a method of impression where the contextuality of responses is what matters; intra-individual significance is of primary importance. In contrast, under methods of expression -- with the more standard R-

methodology -- the respondents are measured for traits, attitudes and external points of view. While R-methodology is used to correlate variables, Q-methodology is used to correlate people.²

After three months in the field observing, interviewing, and shadowing engineers, it was possible to construct a list of 60 activities engineers typically do.³ Each activity was represented on an index card. The engineers were given the 60 cards and asked to sort them twice based on two criteria: 1) The extent to which they consider the activity to be "real engineering;" and 2) The extent to which they like to perform the activity. The same sorting distribution (forced choice) on an 11 point scale was used for all subjects:⁴

| | | | | | | | | | | | | |
|-------------|----|----|----|----|----|----|----|----|----|----|----|-------------------------------|
| Rating: | -5 | -4 | -3 | -2 | -1 | 0 | +1 | +2 | +3 | +4 | +5 | |
| # of Cards: | 3 | 4 | 4 | 7 | 7 | 10 | 7 | 7 | 4 | 4 | 3 | (mean=0; s ² =.13) |

Once the sorts were completed, it was possible to cluster the engineers into groups based on their points of view. Using the computer program QMethod (Atkinson, 1992), I created correlation matrices and performed factor analysis. Factor scores were computed for each activity as a weighted average of the rankings of each of the individuals who clustered on each factor. The result was a factor score ranging from -5 to +5 for each of the 60 activities, for each of the emerging factors, for each sort (Like and Real Engineering). The mathematical steps followed are outlined in Appendix 1.

Each of the sorts was completed by ten engineers, five men and five women. The average age of the ten engineers was 31.5 years, 31.2 years for the men and 31.8 years for the women. Both the men and the women ranged from 25 to 42 years of age.

The first question to be addressed is whether real engineering is a shared reality. The answer seems to be an unequivocal yes. When factor analysis was conducted on the Q-sorts based on what is real engineering, one factor emerged with an eigenvalue of 6.9. This factor explains 69% of the variance and no second factor emerged.⁵ Furthermore,

each of the ten engineers was found to have a positive and significant factor loading on the Real Engineering composite (refer to Table 1). Therefore, it appears that, at least among these ten engineers, there is a shared definition of real engineering. But, what is real engineering?

INSERT TABLE 1 ABOUT HERE

A complete list of the sixty activities sorted by their adjusted factor scores on the Real Engineering q-sort is enumerated in Table 2. Examining this list, it appears that those activities that are the epitome of real engineering -- those activities that rank highest on the Real Engineering sort -- are all activities directly related to the individual engineer's own conceptualization and design of the product. Very few of the activities ranking high on the Real Engineering sort seem to involve other individuals. Of the top eleven activities (those activities with scores of +3 or more, which represent the top 18% of the activities sorted), 10 (91%) involve the individual solving technical problems, and even the eleventh (working with designers and technicians) -- which does involve interaction -- is directly related to the engineers solving technical problems.⁶

INSERT TABLE 2 ABOUT HERE

Examination of Table 2 makes it clear that real engineering is about producing a product. It tends to be an independent, output-driven process. The engineers define it as those activities they could do alone in a room with limited interaction with the world around them. The invisible interactive work necessary for the organization to function plays no part in the definition of real engineering.

The second question to be addressed is whether engineers share a common set of preferences for their work activities. The same ten engineers sorted the same 60 activities

based on what they like to do and two factors, not one, emerged (refer to Table 3).⁷ These two factors will be referred to as Like1 and Like2.

INSERT TABLE 3 ABOUT HERE

The first factor (Like1) has an eigenvalue of 4.7. The second factor (Like2) has an eigenvalues of only 0.9. These factors explain 47% and 9% of the variance, respectively. Even though the second factor had an eigenvalue less than one, it has been retained. When using Q-methodology, it is important to recognize the distinction between statistical and substantive importance of factors. Each of the factors seems to represent a different set of preferences for work activities, and there are individuals who load significantly onto each factor. Furthermore, the two individuals who load significantly onto the second factor do not load significantly onto the first factor.⁸

The emergence of two factors indicates that engineers do have different preferences: not everyone prefers real engineering.⁹ The correlations between what engineers like to do and what they define as real engineering seem to substantiate the claim that different types of engineers exist. The correlation between Like1 and Real Engineering is highly positive and significant. However, Like2 is not correlated with Real Engineering. In addition, Like1 and Like2 are not correlated with each other (refer to Table 4).

INSERT TABLE 4 ABOUT HERE

To further understand the different preferences of the engineers that emerged -- Like1 and Like2 -- those activities that are ranked high by each group have been identified. Table 5 includes two lists: 1) The top eleven activities as ranked by Like1; and 2) The top eleven activities as ranked by Like2.

INSERT TABLE 5 ABOUT HERE

As shown in Table 5, of the eleven activities ranked highest by Like1, nine of them were also ranked in the top eleven on the Real Engineering sort. On the other hand, of the top eleven activities ranked by Like2, only one of them was ranked in the top eleven on the Real Engineering sort. A closer look at those activities ranked high by the people composing Like2 indicates that those people prefer activities that involve the invisible social interaction necessary to hold the project team together (only one of the eleven -- the same activity which was ranked high on the Real Engineering sort -- does not directly involve other people). Therefore, contrasting Like1 and Like2, it seems that these composites represent different types of people -- people who prefer individually solving technical problems versus people who prefer solving problems, but indirectly through invisible interactive activities.

The existence of such different types of engineers was substantiated by the interviews. Carol exemplifies an individual with a preference for technical problem solving (Like1). According to Carol, after college she "lucked out and got a typical design engineering position -- with real hands on lab work." However, within six months, her job shifted and she explains: "I got stuck working on X, which is part of the reliability aspect of the project." She went on to say, "and I still haven't been able to get away from it." It is two years later and she has new responsibilities on the project, but as she explained, "I am still stuck. It hasn't changed. I haven't been able to shake the role. I am still the program expert. . . People constantly call for help with this part. I hate it."

Carol prefers solving her own technical problems, not interacting with others. She says, "I used to want to go into management, but now I am realizing that interpersonal skills are the most important part of management. . . . I no longer am so sure. Instead, I am considering computer science. . . . then, I can be an individual contributor."

On the other hand, Kim exemplifies an individual with a preference for interactive work (Like2). She explained, "most of my job is spent out on the machines or in talking to people. I waste a lot of time trying to find the right people who have the authority to fix the problems." During the interview Kim spent very little time talking about her own engineering work and much more time describing the work environment. Kim said, "It isn't bad that everyone doesn't do the real engineering. If they did who would do the work? Someone needs to do the other stuff. It is a different matter to make something a practicality. I like the brainstorming and the coming up with ideas, but just as much I like making it work."

In describing her skills, she said, "I have been told that I am good at getting a given task done, even without knowledge of how to solve it, I jump in and fix it. . . . Also, I am good at working with people and getting them to do what I need." Kim said, "I think of myself as a very directive person. . . directing designers and technicians and planning and leading meetings, those are things I like to do."

Kim also spoke of ways in which she is more attuned to her environment than many others around her: "I can see what is going on with people. Like I can sit in a meeting and tell who is bored, who is motivated, who is nervous. It's like people are wearing big neon signs. But others don't see it. Sometimes it makes it harder for me because I can see when people are having a bad day and still I have to be demanding."

The emergence of engineers with different preferences for the same work activities indicates that understanding the shared value system is not enough to determine individuals' preferences for their work activities. Both the Q-sorts and the interviews indicated that while real engineering is a shared reality, engineers' preferences do not necessarily mirror the "realness" of their work.

DISCUSSION

Previously, it has been argued that an occupational-organizational tension exists (Raelin, 1985; Van Maanen and Barley, 1984): engineers' preferences are thought to clash with the requirements of the job of the engineer. This argument is based on two assumptions: 1) Engineers share a common set of preferences for real engineering; and 2) Real engineering clashes with the requirements of the job of the engineer. However, the research reported in this paper does not support either of these assumptions. It was found that engineers do not all prefer real engineering. Furthermore, it was found that the job of the engineer requires both real engineering and the rest of the job -- the necessary evils and the invisible interactive activities. These findings indicate that real engineering does not clash with the requirements of the job, but rather is a subset of the activities required to do the job.

Zussman (1985) has previously argued that engineers' orientations are not in conflict with the organization's needs. His argument is that engineers' orientations align with the organization's reward system. However, by neglecting to consider the activities that actually compose real engineering, and the individuals' preferences for these different activities, Zussman (1985) has failed to recognize that engineers' shared value system, even if organizationally aligned, discourages engineers from valuing activities that the organization requires to function. The invisible interactive activities identified in this research have previously been overlooked in this literature. Such activities are not captured by either the organization's reward system or the engineers' shared value system. Whether or not the shared value system of the engineering community is organizationally or professionally aligned, it does not necessarily include all of the activities required to get the job of the engineer done. Therefore, even if Zussman (1985) is correct that the engineer's shared value system and the organization's reward system align, his assumption that engineers' orientations are towards the work most needed for the organization to function does not directly follow.

This paper raises the possibility that the literature to date on the orientation of engineers may have focused on the wrong question. The question that has been asked repeatedly,

and with no uniformity of response, is whether engineers' orientations are professionally or organizationally aligned (Raelin, 1985; Van Maanen and Barley, 1984; Watson and Meiskins, 1991; Whalley, 1986; Zussman, 1985). The question that needs to be asked instead is why engineers perpetuate a subset of their activities as the most fundamental part of their job, despite variation in both activities required to do the job and individuals' preferences for these activities.

To address the question as to why only certain activities are perpetuated as real engineering, we must first consider the difference between real engineering and the rest of the job. In the language of Hannah Arendt (1958), to label an activity real engineering as opposed to the rest of the job is to make the distinction between "work" and "action". According to Arendt (1958), work produces an output; action produces relationships. The process of acting and speaking leaves behind no tangible objects. "But for all its intangibility, this in-between is no less real than the world of things we visibly have in common. We call this reality the web of human relationships, indicating by the metaphor its somewhat intangible quality" (p.183).

More recently, Knorr-Cetina (1981) distinguished between work and interaction. She defined work as an instrumental, non-communicative and solitary act of purposive-rational utilization of means. In contrast, interaction rests on intersubjectivity of mutual understanding of intention. Interaction involves practical versus technical interests.

In response to this distinction between work and action, Piore (1992) poses a critical question: "How is it possible to ensure that production serves as an effective means for the community's survival without having the members of the community become so preoccupied with income that action, which makes the community dynamic in the first place, loses its centrality in the community value system?" (p.26) This problem has been central to the discussion in this paper. The community has become so pre-occupied with real engineering that it fails to recognize the importance of interactive work, which is critical for the organization to function.

It turns out that within the context of the job of the engineer, the significance of real engineering in particular is not grounded in organizational requirements, or individual preferences. This paper documents that while engineers uniformly subscribe to the "fact" that real engineering is the core of their job, real engineering is only one aspect of the job of the engineer; it is not preferred by all engineers; and the organization could not function if engineers did only real engineering. It therefore seems to be a myth that real engineering is the essence of the whole job of the engineer; a myth that seems to perpetuate because there is legitimacy associated with it, independent of any individual or organizational criteria (Meyer and Rowan, 1977).

As Latour (1987) finds in his ethnographic research on scientists, "The two faces of Janus talk at one and they say entirely different things that we should not confuse: When things are true they hold versus when things hold they start becoming true" (p.18). It is this distinction which is critical to understand the myth of real engineering. As Janus' second side tells us -- real engineering is considered more valuable because it is perpetuated as being more valuable. However, real engineering is not necessarily more valuable in terms of getting the job done nor satisfying individuals' preferences; its value exists only as a myth.

The myth of real engineering seems to be a myth of status. Real engineering differentiates a subset of activities that are considered the most valuable work of the engineer, by both the internal members of the organization (i.e. managers and engineers but also designers, technicians, buyers, and manufacturing coordinators) and also the external constituencies (i.e. professional community). As the literature on skill and the professions (Berg, 1971; Collins, 1979; McKinlay, 1973) explains, it is the perceived image of technical expertise -- generated through extensive education and intensive socialization -- and not the whole job of the engineer that makes the engineer's work of high status.

In our society we value rigorous technical problem solving based on special scientific knowledge, even though this does not reflect in consistent and predictable ways

the knowledge actually needed in practice (Schon, 1983). The negotiation, the integration, the exchange, the consensus building are all part of shaping the resulting artifact (Buccialerri and Kuhn, forthcoming), but these activities are not recognized and valued in our society. Therefore, to emphasize the whole job and not just real engineering would only serve to devalue the job of the engineer. Even engineers who prefer the whole job would not be expected to desire such a change.

This paper has focused specifically on the work of engineers, and explored the myth of real engineering. However, in every occupation, a subset of activities are designated as real work, and assumed to be preferred by the occupational members (Hughes, 1958). In each case, it is likely that real work is promoted at the expense of getting the whole job done and satisfying the preferences of all members. Capra (1982) reflects on the inherent sadness that our society has become so fixated on scientific methods and rational thinking that we have lost perspective on what it takes to get the whole job done. Capra points out:

The Chinese sages seem to have recognized the basic polarity that is characteristic of living systems. Self assertion is achieved by displaying yang behavior; by being demanding, aggressive, competitive, expanding, and -- as far as human behavior is concerned -- by using linear, analytic thinking. Integration is furthered by yin behavior; by being responsive, cooperative, intuitive, and aware of one's environment. Both yin and yang, integrative and self-assertive tendencies, are necessary for harmonious social and ecological relationships. . . . Aggressive competitive behavior alone, of course, would make life impossible (p. 43-45).

In our society, we have come to promote technical problem solving at the expense of invisible interactive work. Yet, it is the whole job and not any one part that is necessary to make the organization function, and to create balance in the lives of individuals. It is time, we as a society begin to rethink what we value, and the implications of those decisions both for ourselves and for the organizations in which we work.

APPENDIX 1: USING Q-METHODOLOGY

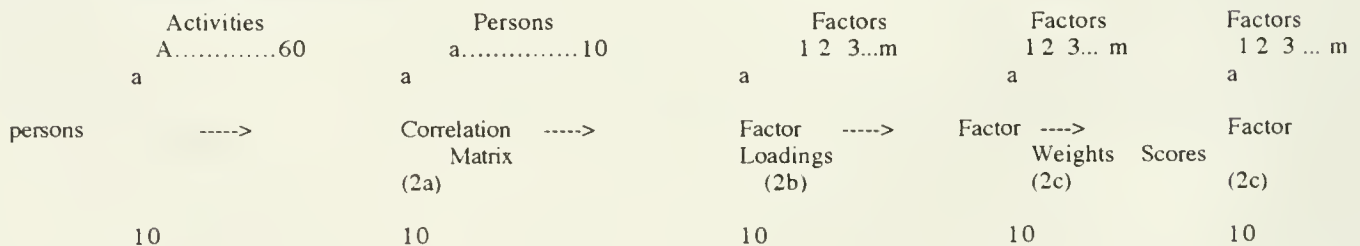
Step 1: Data Gathering

1a: Q-Sample: These are the statements to be ranked by the individuals. In my case, the Q-sample was composed of 60 activities performed by design engineers. These activities were drawn directly from respondents' comments during interviews and through observations made while shadowing engineers. (For a listing of the 60 activities refer to Table A.1.)

The sample is semi-structured as the 60 activities were not randomly chosen which is typical of unstructured sampling, but nor were a specified number of activities chosen to represent each of several pre-designated conditions which is characteristic of structured sampling. Rather, I have tried to create a complete list of the activities that I have observed or was told about.

1b: Q-Sorts--The sorts themselves can be done by many (*Extensive*) or as few as one person (*Intensive*). For logistical reasons, I decided to use ten engineers, five men and five women. Each respondent was given a pile of cards--each card listing one of the activities to be ranked--and asked first to sort the cards into three piles: those which they like to do, those which they don't like to do and those which they are neutral or uncertain about. The Q-sort then begins with extremes because extremes are easier to spot and extremes are critical in correlational studies. Therefore, the respondents were asked to choose from within the "like" pile those 3 activities which they most like to do. Having chosen the activities they most like to do, respondents were then asked to choose the 3 activities they most dislike to do. Then, respondents were asked about the 4 activities they second most like to do and then the 4 activities they find they second most dislike to do. This pattern of flip-flopping back and forth continued until the entire pile was sorted. The final q-sort was of the form 3 4 4 7 7 10 7 7 4 4 3. Once a card was placed in a certain pile, this did not prevent the respondent from changing his/her mind and moving the card. When all the cards were placed in piles and the respondent was satisfied, then I recorded which activities the respondent had placed in each pile. The same sort procedure was repeated for real engineering. A brief interview followed the completion of the two sorts, which served as an opportunity to ask questions about why they had made certain decisions.

Step 2: Statistical Techniques:



2a: Correlation Analysis--To calculate the correlation matrix the Pearson's correlation coefficient was used:

$r_{a,b} = 1 - \frac{\sum d^2}{2NS^2}$ where $\sum d^2$ is the sum (Σ) of the squared differences in scores (d^2) for each item in the two q-sorts being compared; N equals the number of items sorted; and S^2 equals the variance of the forced distribution which is equal to $\frac{\sum fx^2}{N}$ where f equals the number of items of a given rank and x^2 equals the numerical value of the rank itself squared (Brown, 1980: 204). In Q-technique studies, little attention is usually given to the correlation matrix itself. Rather it usually represents only a transitional phase between raw data and factor analysis (Brown, 1980, 207).

2b: Factor Analysis--Once Q-sorts are collected and correlated the mathematics of the factoring process are virtually identical to those followed in the R-method. There are several ways that the data can be factor analyzed. Centroid (or simple summation) and principal components are the two most suited for this type of data. I have chosen to use the centroid method for the simple reason that this is the method that was chosen to be used in the only available Q-Methodology computer application package (Atkinson, 1992). And, given there was no preferable reason for an alternative method, this seemed as good a reason as any for choosing a method.

The result of the factor analysis is m factors which are the number of underlying dimensions on which the 10 engineers cluster together. The important characteristic of the final set of factors is that they should account for as much of the variability in the original correlation matrix as possible. The percent of total variance of the correlation matrix accounted for by each factor is given by $100(\text{eigenvalue}/n)$ where n equals the number of subjects.

An engineer's positive loading on a factor indicates his/her shared subjectivity with others on that factor; a negative loading is a sign of rejection of the factor's perspective. To determine whether the factor loadings are significant involves a simple computation of standard error: $SE = 1/\sqrt{N}$ where N equals the number of items in the Q-sample. Factor loadings in excess of .33 [which was calculated as $2.58(1/\sqrt{60})$] are statistically significant at the .01 level.

To determine whether the factor itself is significant is more complex. Eigenvalues can be used whereby a factor's significance is estimated by the sum of its squared factor loadings. If the eigenvalue is greater than one it tends to be considered significant. However, one must be careful because factors may be produced that are significant, but are substantively without meaning, and other factors may hold theoretical interest even if they don't explain a significant portion of the variance.

2c: Computation of Factor Weights and Factor Scores--The purpose of this step is to generate a factor array or model Q-sort -- one for each of the newly determined factors-- with scores ranging from +5 to -5 (these being the values anchoring the positive and negative ends of the opinion continuum when the Q-sorts was administered.) First, a factor weight must be assigned to each subject's Q-sort as a reflection of the fact that some Q-sorts are closer approximations to a factor than others. The factor weight is computed as follows:

$w = f/(1-f^2)$ where f is the factor loading and w its weight.

Then, based on the factor weights, factor scores will be computed for each factor. Factor scores are linear combinations of each individual's rating of a statement

multiplied by their weight summed over all the individuals considered to compose the given factor. Finally, factor scores are arrayed and then adjusted (assigned integer values from +5 to -5) to resemble a model Q-sort.

Step 3: Interpretation of Factor Scores--Having clustered the engineers into m factor types and having arrayed the statements on the +5 to -5 scale individually for each factor, it is possible to examine the similarities and differences between the engineers on each factor. Table A.1 lists the 60 activities and the scores they received on the Real Engineering composite and the two Like composites.

INSERT TABLE A.1 ABOUT HERE

NOTE: The actual analysis outlined above was carried out by the computer program, QMethod (Atkinson, 1992), created specifically to analyze Q-sort data. To use the program one inputs the Q-sort data for each individual and the program outputs correlation matrices and unrotated factor scores. The program then enables the user to rotate the factors as many times as desired. Once the factor rotation is complete, the program computes rotated factor loadings, factor weights, and factor scores.

NOTES

¹In her dissertation, Joyce Fletcher further subdivides each of the four types of invisible interactive activities into several subtypes and provides a few examples of each subtype. Refer to Fletcher's dissertation for extensive examples of invisible interactive activities -- enumerated by type and subtype -- as performed by the design engineers in this study.

²A major drawback of Q-methodology is that it loses information on absolute comparisons between individuals. With Q-methodology, all individuals by design have the same mean and standard deviation -- all information on elevation or scatter is therefore lost. Because the Q-sort is a forced distribution, one subject could detest all the items and another subject might like them all and yet their ratings might look identical because what is being measured is intra-subject comparisons not inter-subject comparisons. However, in this study, I am more concerned with how Engineer A feels about activity 1 relative to activity 2 than I am interested in how Engineer A feels about activity 1 relative to how Engineer B feels about activity 1. My interest is in understanding how a given individual experiences different aspects of his/her work. Therefore, Q-methodology is appropriately suited for this study.

³These 60 activities represent a comprehensive list of the activities I observed or was told about. Given the method of choosing these 60 activities, inferential statistics would be problematic. Inferential statistics require a definable population from which the sample has been drawn, a definable sampling unit, and a random sample. None of these three requirements is easily met in creating a Q-sample (Nunnally, 1978, p. 620). Therefore, I have imposed a serious constraint on the generalizability of the data. The behavioral domain to which we can generalize is not the experience of work in general, but only those 60 activities done by design engineers at this organization.

⁴Using a forced choice distribution violates the independence assumption underlying much of statistical analysis. Because individuals are forced to place the cards in certain piles and they are ranking the items relative to each other, the end rank of each item is not independent of every other item. The primary concern is whether such an ipsative procedure--forced choice procedure--is a serious enough violation that correlation analysis will fail. It is certainly not the case that an 80 item Q-Sort has 79 degrees of freedom, but it is unclear how serious the violation is. Kerlinger (1973) recommends that one falls back on Fisher's advice: raise the requirements of statistical significance. Instead of accepting the .05 level in Q-sorts, Kerlinger advocates requiring a .01 level of significance (p.595).

⁵The second factor had an eigenvalue of only 0.4, and no one loaded on it significantly.

⁶In this company, engineers are organized by subsystem and work directly with designers and technicians in order to solve technical problems.

⁷There was also a third factor with an eigenvalue of 0.7. However, only one person loaded significantly onto this factor, and this person also loaded significantly onto the first factor. Furthermore, the person composing the third factor seemed to share many of the characteristics of the people composing both of the other two factors. Further research is necessary to determine whether a third factor exists.

⁸While Like2 includes few individuals, it is important to further recognize that this alone does not affect its validity as a factor. Q-methodology does not use a randomly selected sample but rather one hand-picked by the researcher. In this case, I chose 10 engineers based on their availability to do the sorts and made no attempt to include what I thought from the interviews would be a fair representation of different types of engineers. Therefore, the relevant finding is not the number of individuals on each factor, but how these different types of people sorted the activities. The fact that there are only two engineers who load significantly onto Like2 is as much a result of the sample I selected as a characteristic of the engineering population being studied.

⁹Given the non random nature of the engineers sampled, no claim can be made that these two viewpoints exhaust the full range of attitudes. If one suspects finding other perspectives, nothing precludes adding subjects.

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TABLE 1: Engineers' Loadings on Real Engineering Composite

| Engineer | Factor Loading |
|----------|----------------|
| 1 | .89** |
| 2 | .82** |
| 3 | .88** |
| 4 | .82** |
| 5 | .83** |
| 6 | .92** |
| 7 | .68** |
| 8 | .91** |
| 9 | .76** |
| 10 | .77** |

**p<.01

Factor Eigenvalue = 6.9

TABLE 2: Activity Rankings on Real Engineering Composite

+5

Conceptualizing solutions/ having a new idea
Analytical work/ mathematical modeling
Architecture concept development/ thinking analysis

+4

Investing time in upfront conceptualization
Finding a truly innovative solution (versus just solving a problem)
Trying to fix a problem but being unsuccessful
Evaluating test results

+3

Solving minor problems
Fixing problems on the line
Designing
Working with designers and technicians

+2

Working on assigned problems
Self-initiated creative design work beyond the scope program
Redesigning/ minor changes
Making drawings
Checking drawings
Interaction with vendors
Training for specific on-the-job technical skills

+1

Defining own problems to work on
Collaborating with colleagues
Giving advice/ answering questions about sub-system
Interaction with manufacturing engineers
Getting updates from designers/ technicians
Asking designers/technicians to do work
Engineering refresher courses

0

Cost analysis/tracking
Getting advice from colleagues
Coordinating activities of people you work with
Providing positive feedback to designer/technician
Interaction with your manager
Helping others in group
Helping others not in group
Doing paperwork to disseminate information (business proposals, analysis, reports)
Attending subsystem team meetings
Professional development/ skills workshops/ training

TABLE 2 (cont.): Activity Rankings on Real Engineering Composite

-1

Working with commodity specialists
Criticizing designers/ technicians
Interaction with chief engineer/ his direct reports
Interaction with buyers
Face-to-face communication
Preparing for meetings
Planning/ organizing meetings

-2

Facilitating communication between two people who are having difficulty communicating about work related problem
Interactions with planner analysts
Interactions with union employees on the line
Communication through memos, e-mail, etc.
Attending standard meetings
Making/ returning work related phone calls
Having performance reviews

-3

Caring/ responding to personal needs of those you work with
Doing paperwork required for production
Preparing for performance reviews
Walking around

-4

Getting signatures--getting approval
Lunch
Listening to colleagues' personal problems
Coffee breaks

-5

Personal calls
Gossiping
Joking around/ teasing

TABLE 3: Engineers' Loadings on Like Composites

| Engineer | Factor Loading | |
|----------|----------------|-------|
| | Like1 | Like2 |
| 1 | .90** | .04 |
| 2 | .64** | .20 |
| 3 | .77** | .15 |
| 4 | .74** | .10 |
| 5 | -.15 | .54** |
| 6 | .70** | -.08 |
| 7 | .53** | .19 |
| 8 | .53** | .14 |
| 9 | .80** | .25 |
| 10 | .24 | .63** |

Note. Like1 is composed of persons 1, 2, 3, 4, 6, 7, 8, 9;
 Like2 is composed of persons 5 and 10.

**p<.01

Like1 Eigenvalue = 4.7

Like2 Eigenvalue = 0.9

TABLE 4: Correlations between Composites

| | Real Engin. | Like1 | Like2 |
|-------------|----------------|-------|-------|
| Real Engin. | -- | .64** | .13 |
| Like 1 | | -- | .15 |
| Like2 | | | -- |

** p<.01

TABLE 5: Preferred Activities

| Preferred by Like1 | Preferred by Like2 |
|---|---|
| <p>+5</p> <ul style="list-style-type: none"> • Finding a truly innovative solution (versus just solving a problem) • Conceptualizing solutions/ having a new idea • Architecture concept development/ thinking analysis | <p>+5</p> <ul style="list-style-type: none"> • <i>Providing positive feedback to designers/ technicians</i> • <i>Interactions with chief engineer</i> • <i>Professional development/ skills workshops/ training</i> |
| <p>+4</p> <ul style="list-style-type: none"> • Working with designers and technicians • Investing time in upfront conceptualization • Designing • Helping others in group | <p>+4</p> <ul style="list-style-type: none"> • <i>Giving advice / answering questions about subsystem</i> • <i>Interactions with buyers</i> • <i>Coordinating activities of people you work with</i> • <i>Face-to-face communication</i> |
| <p>+3</p> <ul style="list-style-type: none"> • Analytical work/ mathematical modeling • Solving minor problems • <i>Collaborating with colleagues</i> • <i>Self-initiated creative design work beyond the scope of the program</i> | <p>+3</p> <ul style="list-style-type: none"> • <i>Facilitating communication between 2 people who are having difficulty communicating about work related problem</i> • Solving minor problems • <i>Collaborating with colleagues</i> • <i>Getting updates from designers/ technicians</i> |

Note. Activities in bold are also in the top eleven (+3,+4,+5) on the Real Engineering sort.



TABLE A.1: Activities Done by Engineers

3 9080 00824081 1

| Activities | Factor Scores | | |
|---|---------------|-------|-------|
| | Real Engin. | Like1 | Like2 |
| 1. Investing time in upfront conceptualization | 4 | 4 | -1 |
| 2. Finding a truly innovative solution (versus just solving the problem) | 4 | 5 | -1 |
| 3. Defining own problems to work on | 1 | 2 | 1 |
| 4. Working on assigned problems | 2 | 1 | 2 |
| 5. Conceptualizing solutions/ having a new idea | 5 | 5 | 1 |
| 6. Self-initiated creative design work beyond the scope of program | 2 | 3 | -4 |
| 7. Analytical work/ mathematical modeling | 5 | 3 | -1 |
| 8. Evaluating test results | 4 | 2 | 2 |
| 9. Designing | 3 | 4 | -4 |
| 10. Architecture concept development/ thinking analysis | 5 | 5 | -5 |
| 11. Cost analysis/ tracking | 0 | -4 | -2 |
| 12. Solving minor problems | 3 | 3 | 2 |
| 13. Trying to fix a problem but being unsuccessful | 4 | 0 | -4 |
| 14. Redesigning/ minor changes | 2 | -1 | 0 |
| 15. Making Drawings | 2 | 1 | -3 |
| 16. Checking Drawings | 2 | -2 | 0 |
| 17. Fixing problems on the line | 3 | 1 | 1 |
| 18. Collaborating with colleagues | 1 | 3 | 3 |
| 19. Giving advice/ answering questions about sub-system | 1 | 2 | 4 |
| 20. Getting advice from colleagues | 0 | 0 | 2 |
| 21. Working with commodity specialists | -1 | -3 | 1 |
| 22. Working with designers/technicians | 3 | 4 | 2 |
| 23. Coordinating activities of people you work with | 0 | 0 | 4 |
| 24. Getting updates from designers/ technicians | 1 | 0 | 3 |
| 25. Asking designer/technician to do work | 1 | -2 | 0 |
| 26. Providing positive feedback to designers/technicians | 0 | 2 | 5 |
| 27. Criticizing designers/technicians | -1 | -4 | -5 |
| 28. Caring/responding to personal needs of those you work with | -3 | 1 | 0 |
| 29. Facilitating communication between 2 people who are having difficulty communicating about work-related problem | -2 | -3 | 3 |
| 30. Interactions with planner analysts | -2 | -1 | 2 |
| 31. Interactions with vendors | 2 | 2 | 1 |
| 32. Interactions with manufacturing engineers | 1 | 1 | 0 |
| 33. Interactions with your manager | 0 | 1 | 1 |
| 34. Interactions with union employees on the line | -2 | -1 | -2 |
| 35. Interactions with chief engineer/ his direct reports | -1 | -1 | 5 |
| 36. Interactions with buyers | -1 | -1 | 4 |

TABLE A.1 (cont.): Activities Done by Engineers

| Activities | Factor Scores | | |
|---|----------------|-------|-------|
| | Real Engin. | Like1 | Like2 |
| 37. Helping others--in group | 0 | 4 | -2 |
| 38. Helping others not in group | 0 | 2 | 0 |
| 39. Communicating through memos, e-mail, etc. | -2 | -3 | -1 |
| 40. Face-to-face communication | -1 | 0 | 4 |
| 41. Doing paperwork to disseminate information (business proposals, analysis, reports) | 0 | -4 | -1 |
| 42. Doing paperwork required for production | -3 | -5 | -5 |
| 43. Getting signatures--getting approval | -4 | -5 | -3 |
| 44. Attending standard meetings | -2 | -5 | -3 |
| 45. Attending subsystem team meetings | 0 | -1 | 0 |
| 46. Preparing for meetings | -1 | -4 | 2 |
| 47. Planning/organizing meetings | -1 | -3 | 2 |
| 48. Making/returning work related phone calls | -2 | -2 | 0 |
| 49. Preparing for performance reviews | -3 | -2 | -1 |
| 50. Having performance reviews | -2 | 0 | -2 |
| 51. Professional development/ skills workshops/ training | 0 | 2 | 5 |
| 52. Engineering refresher courses | 1 | 0 | 1 |
| 53. Training for specific on-job technical skills | 2 | 1 | 0 |
| 54. Personal calls | -5 | 0 | -2 |
| 55. Lunch | -4 | 0 | -1 |
| 56. Listening to colleagues' personal problems | -4 | -2 | -2 |
| 57. Coffee break/ social time | -4 | -1 | -3 |
| 58. Gossiping | -5 | -2 | -4 |
| 59. Joking around/ teasing | -5 | 0 | -2 |
| 60. Walking around | -3 | -2 | 0 |

Date Due

AUG 31 1985

JUL 18 1987

SEP 06 1987
OCT 16 1989

APR 19 2007

