Open Organizing: Designing Sustainable Work Practices for the Engineering Workforce*

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Maintaining a high quality of life that encompasses work satisfaction and work-life balance is a critical long term need for the engineering practitioners. In this paper I argue that to grow professionally engineers need to design sustainable work environments for themselves through the productive use of information technology. I present a field study to identify 'open organizing' as a model to sustain engineering work. Open organizing refers to development of socio-technical infrastructure that allows people to successfully contribute to an endeavor irrespective of their physical location. Through a grounded theory analysis of field study data collected from an organization I call Digitech, I outline characteristics of open organizing practices and discuss their benefits for the engineers who worked there and for the organization. Overall, the findings reveal that successful creation and implementation of open organizing can result in better work-life balance for engineers and increase productivity and innovation.

Keywords: open organizing; sustainable work practices; engineering workforce; virtual work; socio-technical infrastructure; work-life balance

1. INTRODUCTION

From the environment to medicine, transportation to communication, household appliances to space exploration, engineers affect the world. Yet just as the technology born of engineering has transformed much about our world, so has it transformed the work of engineers [1].

ENGINEERS INHABIT, live, grow, and struggle, in a world designed to a large extent by them. This designed world is not just physical, but social too. The reality is that engineers design not just technical artifacts but socio-technical systems and this idea has slowly but surely found acceptance in the engineering design community [2]. In this paper I draw attention to the role of socio-technical design in the era of digitally enabled work and argue that improving engineers' own quality of life is a critical aspect of sustainable design. A productive and innovative context is essential to tackle the pressing problems and needs of society. Therefore, we need to pay greater attention to the design of engineering organizations, both our educational campuses and more critically the work environments where engineers work. To achieve this goal, we need to learn from new forms of working that have appeared and succeeded around the world and also study sites of 21st century engineering work. As engineering educators and researchers it is especially important for us to undertake these examinations if we are to prepare the emerging engineering workforce for the global knowledge economy [3].

Traditionally, the concept of sustainability has been examined and explored in relation to natural and physical resources. The most common definition of sustainability, that it is the use of current resources without affecting its use of future generations, represents this view. Yet, physical resources and their preservation can be seen as just one side of the equation. In addition to physical resources, social aspects of living are equally critical and strongly related to physical resources. For instance, reduction in commute is good for the environment but is equally beneficial to the quality of life in terms of the time it saves for the commuter to accomplish other tasks. It is in this vein that I use the term sustainability in this paper.

2. OPEN ORGANIZING TRENDS

The pervasiveness of information technology shapes communication and collaboration among engineers, how they design and construct artifacts, and even how artifacts are produced and manufactured. Significantly, information technology has made it increasingly common to work from anywhere anytime as a member of team or organization and be a productive contributor. I briefly discuss four trends that exemplify this development and point us in the direction of a new form of working that I term open organizing. I define open organizing as *designed environment that enables individuals to productively contribute to an effort*

irrespective of their physical location by using information technology to support their social practices.

2.1 Geographically dispersed work

The first example of a new form of working that has emerged supported largely by information technology is globally dispersed work [4, 5] where individuals from multiple locations work together on projects as team members. Although global trade is centuries old and multinationals have had an international presence at least since the 17th century [4, 6], certain elements of current global work make it unique; the extensive use of information technology in organizations, digitization of work processes, and the spread of technology to previously under developed regions of the world. These developments have brought about a sea of change in how global work is accomplished and where it has spread geographically. These technology driven shifts, coupled with a rise in service-related jobs in the global knowledge economy that are more prone to digitization, have led to a proliferation of anytime, anywhere work—giving firms access to necessary expertise and a 24×7 work cycle. Overall, a range of studies on geographically dispersed work highlight the existence and success of working together as teams through the use of information technology that leads to 'virtual teams [7].'

2.2 Telework/Telecommuting

The use of information technology to enable workers to work away from the office has preceded the emergence of global work and has been studied under the umbrella of 'telework' [8]. Research on telework successfully predicted that the nature of working will change with the rise in use of technologies over the years. Since telecommuting emerged as a term in 1975 [9] it has been touted as a cure for many ills that affect workers and organizations such as environmental decay, psychological cost of commuting, real estate costs, and lack of work-life balance. But studies such as [8] show that the benefits of telework are still not clear and many downsides, such as challenges in communication and coordination, have surfaced. Still, the recent increase in bandwidth and digital nature of work has made a significant impact on attitudes about telework and it is gaining popularity as a new form of working. From the perspective of open organizing, telework forms a crucial element as it shows that virtual teams can be composed not only of members in distant locations, but even within a city members might be dispersed and working virtually. It also highlights the difference between workers working in a co-located fashion but making extensive use of information technology and those that are dispersed.

2.3 Crowdsourcing, wisdom of crowds, and collective intelligence

A recent phenomenon that has developed, largely with the rise of the Internet, is crowdsourcing and it refers to the ability to solve a problem through the collective involvement of a large number of users [10]. It is also often referred to as wisdom of crowds [11], the idea being that a large group of people are better at solving certain tasks than an individual regardless of expertise level. With the advent of information technology several of these claims have not only turned out to be true but even useful. The omnipresent example of this phenomenon is the growth and rise of Wikipedia which has further fueled and proved the idea that when a large number of individuals—irrespective of their geographical location—are given the right technology and social constraints they can produce innovative artifacts and their efforts can result in collective intelligence [12]. The common thread among these developments is that a new form of organizing has emerged which can productively combine efforts of individuals at a large scale, distributed in different parts of the world, many of whom have never met and do not know each other. The lesson with respect to open organizing is that a combination of technology and social interaction can produce large scale innovation. Moreover, firms can learn from these developments to develop and deploy strategy that allow them not only to leverage the in-house expertise dispersed around the globe, but also be able to utilize the knowledge of their users and customers.

2.4 Open source software development

The final example I want to discuss is open source software development which is now a successful, established, and dominant form of open organizing [13]. It has not only captured the imagination of software engineers around the world, but has also captured market share from many dominant players. From their humble beginnings with products such as UNIX, open source products such as Linux[TM], Firefox[TM], Moodle[TM], Gnome[TM], MySQL[TM], and Apache[TM] have become the backbone of many major firms, especially those that do business on the Internet. In addition to demonstrating the viability of a new business model what open source development has done is shed light on a new way of successfully doing innovative engineering [14]. By bringing together individuals interested in a technology, building and showing their expertise, and providing help to others [15], a new form of organizing has emerged. From the perspective of open organizing, open source development is a notable example as it combines the contributions of individuals from across the world, provides and builds specific practices around the use of technology, and results in innovative and useful products.

The four trends I discuss above point in the direction of successful open organizing but even they do not capture changes brought forth by the emergence of social software [16], especially the Web 2.0, and increase in the use of mobile devices [17]. Sites such as Facebook[TM] and LinkedIn[TM] are omnipresent within and outside workplaces

giving rise to new social practices. Almost one billion mobile devices are currently in use, not just for voice communication, but for email, browsing, and other activities. Taken together, the rise of digital communication and consequent changes in human practices point us in the direction of open organizing as a viable design principle for sustainable engineering work environments.

3. FIELD STUDY

To examine the realities of open organizing from a 'work practice' perspective, I undertook a field study. Overall, I was interested in understanding what open organizing looked like: What made it work? What were the barriers? Did it benefit the workers and the firm? The site for the research was a firm, Digitech (a pseudonym), which has engaged in an initiative—Open Workplace Initiative (OWI)—to provide open organizing support to its workers for the past decade. Digitech is a high-tech firm that works in the area of hardware and software development. Through the OWI initiative, the firm has designed and built the technical infrastructure and social and organizational guidelines for allowing people to work without having to come to a specific physical location. This initiative has enabled Digitech to cut carbon emissions by reducing energy use; it has helped reduce traffic congestion and reduced stress on urban transportation infrastructure; and it has allowed Digitech employees to be more participative in their communities—volunteering, mentoring, and contributing locally—by being more flexible with their time. The initiative has also received several awards for innovation and for its contribution to protect the environment [18]. Given the innovativeness and success of this initiative it provides us with a unique glance at what the future of work might look like for engineers.

3.1 Data collection

In this paper I draw on archival and primary data collected from individuals and teams at Digitech that participated in the Open Workplace Initiative. The data collection occurred over 6 months with travel to different locations within the U.S. and one location in Europe. Overall, 50 informants were interviewed and supporting observation undertaken. The informants were spread across the world (U.S., Ireland, France, England, and New Zealand) with participants from multiple nationalities at any given location. The interviews were done either face-to-face or through teleconference and lasted anywhere from 45 minutes to 120 minutes. Informants were formally interviewed only once but additional informal conversations were held with many informants. The official hierarchy at Digitech was Executive Director, Director, Senior Manager, Manager, and Developer. The study sample included representatives from each of these positions with the majority of informants belonging to Manager or Developer designations. Different teams within the organization were selected for the study. All interviews were first transcribed by a professional transcriptionist and then proofed for any errors by the primary researcher. Observations were done at the workplace and typed up. Archival materials such as email and official organizational documents were collected where pertinent. In several cases the researcher was added to the informants' communication channel, such as IRC (Internet Relay Chat, a form of Instant Messaging). Observations were also done of face-to-face meetings and teleconferences. The findings reported here are drawn primarily from interview data.

3.2 Data analysis

The data were analyzed through an iterative grounded analysis process [19]. All interviews were first read and free codes developed that captured the primary analytical categories. NVivo 7 software was used for coding and analysis. They were grouped under broader themes that included: technology, managerial practices, and work-life balance. From the initial codes I developed memos and informal reports that guided subsequent data analysis and writing.

4. FINDINGS

Preliminary findings highlight the complex nature of open work involving individuals working from highly dispersed locations, on a diversity of projects, through multiple technologies, and for a variety of reasons. In this paper, I limit the discussion to work-life balance and how it is achieved through a balance of technical and social resources by engineers and managers.

4.1 Achieving work-life balance

Uniformly, informants reported that the opportunity to engage in open work had provided them with a better work-life balance and lifestyle choice by allowing them to work from home and from locations where they had moved due to personal preferences or partner dependencies. In addition, several informants, engineers as well as managers, mentioned that working from home made them more productive and efficient. For instance, when I asked one worker who worked from New Zealand as part of a team based in Dublin, why he moved to New Zealand he responded that balancing his personal and work life was one of the primary reasons he made that shift:

> For myself, I think it's the balance between your private life and your work. I can work in the day or I can work in the evening . . . take a break in the middle of the day. I can't do that if I was working in the office. For me, that's probably the most important—balancing life and work. For Digitech, I think, it's probably also important the employees are not stressed.

He further added that his productivity had increased as a result of working from home as he was more attentive to his work and also because he was able to put in more hours towards his work:

> My impression is that I can be more productive working from home than working from the office. I probably also work for more hours than if I was working in the office. So when I was in the office, I was interrupted very often.

Another developer in the Dublin office who worked from home 4 days a week cited personal and commute reasons for working from home. Working from home allowed him to live in a location that was conducive for both him and his wife. He was one of the first persons in his team to make use of the option to work from home. Following his lead, subsequently, many more of his team members exercised the option to work from home:

> I am originally from [a city north of Dublin] and my wife is a lecturer there. When we got married we bought a house somewhere in the middle. She goes that way and I come this way. Initially it was a concern [working from home] but I talked to my manager and since then we've had a lot more people start working from home.

Similarly, another worker in CA mentioned that flexible work hours and the ability to work from home have given him considerable work-life balance. He further explained how a typical day in his life unfolded. His day started with checking emails and was interspersed with personal work. Within a routine that he had built for himself, there was enough flexibility to be able to balance work and personal life:

> I have extremely varied schedule. So typically, I get up, log on and check e-mail. Mostly it is just monitoring and making sure everything is okay and then sort of marking a handful of messages for things that I need to follow up on. Sometimes I have enough time to do that follow up before taking the kids to school. Sometimes I don't. If I do, then I do it, if I don't, then I deal with it when I get back from taking the kids to school. Then, often I will take a break in the late morning and go for a bike ride for below one hour. Other days, my work out is over lunch and I go for a run or go for a Frisbee. My team they always aware when I will be gone and I generally say, 'Okay, I am going doing X now I will be back in N hours.' And I can set my IRC so they will know when I will get back. Then when I get back I catch up with whatever I miss, I go through the same thing.

Not all informants worked from home and certain engineers and managers preferred to work from the office. For them the option to be able to work from the office was 'work flexibility.' They said that they were disturbed more at home as their spouses stayed at home or worked from home or their kids were at home and therefore they were more productive in the office. Some of them reported that for them time management was an issue and they were able to better manage their time if they came to the office. Such reports though were infrequent compared to informants who preferred to work from home. The option to work from home was not only beneficial to the employees but also to Digitech. From the perspective of Digitech, giving workers the opportunity to work from home or from cities of their choice resulted in very low turnover with most engineers staying with the firm for a decade or more and feeling fully committed to the firm's future. This allowed the firm to keep its expertise in-house, especially in the highly volatile IT market, and maintain the core engineering prowess for which it was renowned. The engineers, many of whom preferred working for Digitech due to its engineering focus felt rewarded with the flexibility and opportunity to work on interesting technical problems. Therefore, Digitech was able to sustain itself as an organization and this sustainability was evident not just in issues related to the environment that working from home contributed to but sustenance of the workforce over time. Digitech also benefitted by not having to maintain fulltime offices for all employees. Employees could book an office space in advance if they planned on coming to the office that day.

4.2 Use of communication technology: multiplicity and personalization

Although working from home and from dispersed locations was seen as a positive option by many informants, it was not easy to implement in a successful manner. The Open Workplace Initiative required substantial institutional support but more important than that it required that teams develop work practices that would allow for all or certain members to be geographically dispersed. Not surprisingly, the primary concern that emerged in connection with working from home or from non-office locations was the use of technology. The engineers used several communication technologies in addition to digital technology they used to develop their products (servers, test machines, and so on). The most common communication technology was email followed by IRC (Internet Relay Chat, a form of Instant Messaging) and phone calls. Regular teleconferences that occurred once or twice a week were also common among most teams. When asked about their use of communication technology, most informants mentioned that they used a variety of media; this quote from an informant captures the overall technology use habits of most workers:

> Okay. I think the primary way of communication is through e-mail. We have e-mail list for the different groups . . . operations and development teams . . . each has their own list. Secondly, we communicate I guess will be next instant messenger which is kind of good for one of small communications like when we need to ask a quick question. We also have a chat room that we use usually. We pretty much use that for—if there is an issue that we need to all get together and work on or maybe we want to have a meeting. That might be a little bit different that we don't want

to do on phone. We might do that on instant messenger. And the third way of communicating is with the phone. It is either a conference call or just a one-on-one phone conversation.

On closer analysis two distinct sets of issues emerged related to the use of information technology. The first element can be captured by the term *multiplicity* [20–21]. In the context of this study, multiplicity implies availability of multiple communication technologies or channels for interaction. The second element was *personalization*, which refers to the option to be able to use the technology that a worker preferred—if not all the time but for the majority of interactions. Personalization also went beyond the individual and could be seen as an aspect of a relationship—what two workers preferred to use when they interact— and even at the level of a team—what a certain team prefers to use as the primary communication channel. For instance, this quote from one of the developers highlights both the multiplicity of information technology and the personalization aspect:

My interactions with people primarily all electronic, e-mail or IRC. Occasionally, I might need to pick up the phone and talk to someone. But that's rare. Generally I send someone an email. Find them on IRC. I have whatever conversation is needed and keeping moving on. My manager is located in the Southwest [and] with him (communication) tend to be more on the phone than electronic although I would say it is probably a 50/50 mix.

Some workers were more attuned to the advantage of personalizing their use of information technology. They realized that different people have different preferences and for successful collaboration they have to calibrate their communication modes:

And I think depending on the person, depending on how they like to communicate, or what needs to be done. There is a different method of communications I would use. And usually the phone is—I would not say the last resort but when we really need it is important or otherwise the communication is not working there is always the phone that is available to talk to the person and work things out. But, if you need to get more to one person well with the communication. It seems that e-mail is always the best way to go for that.

Informants were also aware that different communication channels were useful for particular kinds of interactions i.e. multiplicity allowed different media to be used for specific purposes. For instance, many respondents mentioned that the use of IRC often substituted for hallway chatter and was a means for informal communication, unlike email which was often more formal or official. For instance, this informant used the metaphor of 'hanging out' when talking about the role of IRC in communication:

That's what our guys do, they hang out in the IRC channel. But I actually think it is important . . . There is some kind of initial socialization that is quite

important that we try and have people work here for. We've kind of almost involved a lot of people who are working remotely from the site and maybe not coming into the office every day. We try and make sure that we build social interaction into what we do.

The role of IRC in information communication was specifically critical for employees who worked from home. It allowed workers to have a feeling of being part of team—IRC helped in the maintenance of a common social identity.

I think IRC, for people who work from home, IRC is almost a way of just keeping in touch with everybody, you know, and feeling that you're still part of the team, you're still part of the group because when you're on IRC, you can see that this person is logged-in and this person's working. So you know that they're around. I know the engineers who work from home, they're on IRC all the time. It's just they're in the background [and feels like] all the people are sitting near you. You know, that way.

Phone conversations were useful as they allowed synchronous communication and allowed reduction in turnaround time. They also facilitated quick updates that put everyone on common ground immediately. But given the diversity of teams in the company, phone conversations had their drawbacks. Even though English was the common language across the firm, different people had different accents and style of speaking which often made it hard to follow them on the phone.

[Y]ou have to be sure that people can understand what you're saying over the phone. One feedback I got was that I talk too fast. So, it's very hard actually sometimes because you just naturally talk at your own speed and so sometimes, you have to almost ask a question when you're finished to make sure that people understood what you were saying because you might say at the end of it, 'Okay, is that okay with everyone?' and there is complete silence. And you think 'I'm going to have to go back again and maybe repeat it or just go back to the points again' because sometimes, I don't know, sometimes I find people [maybe] didn't hear what you said, or didn't understand what you said.'

During my field study I observed and talked with informants with the following accents: Irish, Spanish, Polish, British, American, Chinese, Malaysian, Indian, and Japanese. This increased the reliance on written communication and therefore email and IRC were often favored over phone conversations. Written communication, as in the case of emails and mailing lists, also had another advantage. They became a useful resource for posterity given their permanence. Many informants observed that when they were new to the organization they often developed mutual knowledge and impressions about their colleagues, especially of their expertise, by reading and browsing records of mailing lists or IRC transcripts.

When you read a development mailing list very quickly, you find out who the people who are very experienced and have very good insight are. Some-

times, just from reading the mailing list things that are [discussed are] very, very good for building your own experience. Basically just read the arguments. Just like in everyday life. You're listening to the different sides of an argument and I think it's . . . find out who the person is who usually gives good answers.

Informants reported learning several lessons about communication and technology use from working on virtual teams. For instance, this one informant reported that communicating more or redundant communication was useful for working on virtual teams as it was hard for anyone to assess the value of information from someone else's perspective:

> I think I have learned that the communication, even if the things might not seem important. I have learned that at least just like sending e-mails, things that are going on that they are potentially might interest other people. One of the nice things about e-mails is that they may not pay attention that late and how quick they can go back and look at that later. Or at least there is something in their mind that or I am doing this task or I found this information out that there is a reference for them to go back to.

Of course, closely tied with the issue of using technology was the idea of meeting someone face-to-face. Informants universally mentioned that meeting team members face-to-face at least once a year was very useful as it facilitated knowledge brokering [Johri, 2008]. Still, many informants also reported that they had never met their teammates face-to-face and they were still able to work productively and had even established good working relationships with their coworkers:

> Sometimes, I found that when you have compatible personalities, it doesn't matter. My gatekeeper in [ ] is coming on board [soon], I never met him face- to-face yet. And yet we crack each other up all the time on IRC and e-mails, so I know when I meet him, what he is going to be alike because you get a strong sense of personality. I don't think it's happened that when you get people who are superficially outgoing and enough of your personality reflects through. An e-mail is a restricted meeting but IRC is much less so. So, you can crack jokes a lot and learn what sort of things people are into and what not. You get to know each other surprisingly well. In retrospect, I would say far better that I would have guessed.

4.3 Balancing social and technical aspects: managing open organized teams

The norms around working from home and geographically dispersed locations did not arise automatically and these practices had to be developed, often by the engineers through their own initiatives, but more often by managers who managed dispersed workers. At Digitech most managers were engineers who had moved in to those roles over time. In my entire sample there were only two managers (out of 10) who had a non-engineering background. The managers played a critical role in supporting and growing open work in their teams. Interviews also show that compared to the engineers and developers, managers often had to face the downsides of open work in terms of work hours and stress. Although they often developed a balance, it required different skills, purpose, and experience to be able to do so. The managers balanced the technical with the social creating the socio-technical infrastructure that sustained open work.

The diversity of locations that many mangers coped with was evident from the remarks of this manager in the U.S.:

> I have 3 people in the U.K., one in Canada, one in the North Western U.S., but one is in the North East U.S., one on the East Coast, one is in Midwest, one in the Southwest, I'm actually in Colorado and then I have 7 on the West Coast. So we are—we make heavy use of email, IM, phone, text messaging, you know you name it.

Although this was not the case with all managers, most managers I talked to reported that they either had people working from home 3– 4 days a week and/or a majority of their team members were dispersed. The managers reported that their primary duties related to keeping track of all the developments in the team and making sure that everyone was on the same page:

> You have to make sure that the information that's coming to you is filtered to all the right people and that I'm giving the same information to the guys here that I'm giving to the guys in Beijing. So, things like minutes are important and circulating agendas and minutes, that's important because sometimes you think, people aren't paying attention and then you get questions and you're like 'They do read them'.

They accomplished this by touching base frequently with team members and passing information around the team. They also reported that when newcomers joined the team they made special efforts to introduce them to team practices. Often, this was achieved by asking the newcomers to work closely with an experienced worker in a co-located manner and then gradually allowing them the flexibility to work from home. In other instances, managers also reported that they were trying to build new practices around hiring as well by recruiting newcomers who had extensive experiences of working in dispersed teams and often hiring them without a face-to-face interview. For instance, through online community involvement engineers were recruited without a face-to-face interview on the strength of their technical contribution:

> I did not see anybody interviewed with until I was working for about two months with Digitech. It was all over the phone. Some of the people I interviewed with I had contact with as a community member. But that was only through e-mail or through message words.

Overall, the data shows that managers had to be inventive in their approach and develop new team practices over time. They achieved this by building consensus around communication practices and

making efforts to build and maintain mutual knowledge and common ground [22].

Of course, not everything was positive when it came to open work practices. From the perspective of managers their work hours were quite long although with flexibility built in. For instance, a manager in Ireland reported this about his schedule:

> So, what I would probably do is, I am usually in the office for 8 o'clock, and then, at some point, I will take time to go eat and maybe get a bit of exercise or something like that. So typically, I would maybe be out of here by 4 o'clock or 5 o'clock, be back online for 6:30 and then usually go to the gym maybe at 7 or 7:30 and then I could be at that meeting for 9:30. So that's that day. We have flexible work and so, I make a judgment as to whether I am going at the office for the meeting or whether, particularly, if it's going to be late in the evening, I would often work from home. We have facilities to work from home which we can talk about. We have some pretty extensive work-from-home facilities. So that I can pretty much join any meeting, get any data, get email, get files, and so on wherever I am.

When I then asked him about his schedule the day after the interview, he responded:

> Tomorrow my day starts at 8 o'clock, so my staff meeting at 8 and . . . then I have a one-to-one with one of my [China] staff at 9. Then I have a one-to-one meeting with [staff member] on a meeting on 10:30 which mightn't happen actually. Then, I have a one-to-one with [the facilities manager here] and I have that on roughly a monthly basis and that's to look at issues of concern . . . And a one-to-one with [one of my senior managers], at 1 o'clock. Then, at 6:30 in the evening, there is the [product approval committee] meeting. Then on 9:30 in the evening until 11 o'clock, I've got the [team meeting] which is like a core meeting of managers with responsibility for delivering [the product]. That's not a typical day. That's a long day, right? So that's a day that goes from 8 o'clock to 11 o'clock.

These two quotes represent that variation in work schedules that the managers had to deal with. They justified it by saying that this was required in order to provide flexibility to other team members. Moreover, when I asked them what changes they will like to make or get more support for from Digitech they answered that they would like to have fewer processes in the organizations so that they can be more flexible:

> So I think that'll be the #1 thing people would like to see and I guess, less of the process so that people can get their job done a lot more easily. It is sort of piss or get off the pot. Either we're doing it or we're not doing it. Doing it in a half-hearted way is very wasteful of resources because you end up having people struggle against, you create friction inside the organization and people spend a lot of their time just struggling against that friction.

In my sample several managers were of the opinion that it required the same amount of effort to handle a co-located team as an open team although qualitatively the experience that was required and the practices that were needed to be developed were different:

> It's always nice to get face time but I'm a pretty strong believer that teams that—when I hear managers say, 'My person in location XYZ must come every month in order for us to get work done,' I question it. Because we work all the time with people all over the place, when my team got together in October '08 it was the first time we'd all been in one place together up since January of '07. So it's then- gosh! Almost two years. And we decided that that's a little long, we decided that optimally once a year would be really good just because you can sit with whiteboards, and have lunch together and you know just really get time. By being in different locations doesn't seem to impede communication or getting work done you just do it a little differently.'

But overall, the work-life balance of managers still remains an open question to some extent. Even though most managers reported that they were able to handle an open team, dispersion beyond a certain extent led to high stress. One manager in the U.S. captured this irony thus:

> Of course you know what the problem is if you have a global organization like this, right. That means some of us don't sleep very much. My work day is kind of a little bit crazy because I typically get up at 5in the morning and go to the gym here first and I get in the office as about 7:30 or 8am. And then I usually stay here until 6 or 7pm; go home, get back online until about 11 o'clock. And then the day starts all over again the next day. Otherwise, I don't really base real time with Asia for example or Europe the morning.

The preliminary findings support the overall literature that reports that open organizing is becoming an increasingly common practice, at least in certain engineering professions, and that it has numerous benefits. It allows engineers with the requisite expertise to contribute to a project irrespective of location constraints and even provides a much better work-life balance. The success of Digitech in recruiting and retaining highly trained and experienced engineering staff was a testimony to this as reported by the informants. There are some limitations to this study as reported here. I have not discussed the downsides of open work arrangements mentioned by informants such as: lack of informal communication, more effort to form working relationships, its unsuitability for certain forms and stages of project work like the design phase. But all these concerns were recognized by both the engineers and the managers and were either being addressed or on the list of improvements to be implemented subsequently.

5. OPEN ORGANIZING AS A DESIGN PRINCIPLE FOR SUSTAINABLE ENGINEERING WORK

The NAE Grand Challenges [23] report identifies as its core mission the improvement of quality of life while sustaining civilization's continuing

advancement. For engineers, this mission is at the core of their function in society but I argue that it also needs to be a concern as they reflect on the future of their profession, in particular a healthy sustenance of future engineers. Development of new technologies, by engineers, has created new challenges for the engineering profession itself and one of them is achieving a work-life balance. Yet, advances made by engineers when combined with organizational and social understanding of their profession can also provide solutions that allow them to be increasingly productive and innovative; for instance, the creation of open organizing practices is one viable approach balancing work and life. The findings from this study suggest that open organizing is not easy to establish. Technological tools are available but their use is often constrained by social factors and adoption and adaptation is gradual. In spite of the challenges, for most engineers in this study the advantages of open organizing far outweighed the implementation problems.

In addition to the engineering workplace, there are implications from this study for the organizing of engineering education as well. Our current forms of organizing follow an industrial mode of production model necessitated by lack of resources—physical classrooms and trained teachers. This in turn led to the course structure—classes of an hour or so each—and the curricula that would fit those constraints [24]. In this age of digital access to information and expertise the model derived from making industrial production more effective seems anachronistic. Established and institutionalized models are hard to change but the need has never been greater and access to technology and useful applications is reaching a tipping point [25]. Therefore, new models of education and learning, which go beyond delivery models such as distance learning, need to be developed and tested. Online classes that can connect different locations and lead to meaningful learning through deep interactions can prove especially beneficial [Johri, 2005]. There is an opportunity to connect students with practitioners and experts to create useful products and learn through apprenticeship, a model exemplified in open source.

practices, we need to understand how we can better sustain and nurture human effort by designing environments that can support innovation and creativity. Engineering design educators in particular have the responsibility to bridge the gap between researchers and practitioners, between the worlds in which students currently reside—educational institutions—and the ones they will one day inhabit—the workplace. We need to design for work satisfaction but also prepare them to work with technology in meaningful ways. John H. McMasters recognized these needs—multidisciplinary thinking that engaged both social and engineering aspects and meaningful partnerships with the industry [26]. It is important to think of organizing in non-locational terms as advances in technology as well as our daily practices are making location-based organizing redundant. This is not to say that localized communities and economies will fail to exist, on the contrary they might even be stronger, but that they will be driven and supported significantly by people who are based in other locations.

Novel modes of organizing will be increasingly required to solve the critical problems faced by the world today. To address issues of global warming, climate change, and sustainability, people from all over the world have to come together and contribute. To be able to enable and support this kind of a collaboration we have to learn and teach ways of working in an open world—open organizing is a step in this direction [27]. The term open as used here is not meant to convey that 'anything goes.' Design is omnipresent in how humans achieve any goal via collaboration and even an extremely fluid environment is constrained in certain dimensions, therefore the element of open is about allowing for contribution regardless of location (and diversity that stems from it) and being open to changes and shifts in a fast moving global environment. Findings from this study also shed light on the diversity of roles that engineers need to occupy as they advance in their careers. Most of the managers had an engineering background and had received almost no training in supporting open work or dispersed team members. Therefore, more than anything else, emerging engineers have to be open to learning from diverse experiences. They should be able to develop requisite skills not only through institutionalized education but also personal experience, over time, through trial and error. In an open world, learning, working, and innovation emerge as interlinked and intertwined elements with each supporting and extending the other [28].

6. CONCLUSIONS

As we think of sustainable design we also need to examine it in the context of engineering work

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