Human Factors/Ergonomics for Societal Transformation: A Tale of Two Cities

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Good morning. Welcome to the 61st Annual Meeting of the Human Factors and Ergonomics Society. I would like to talk to you today about how HF/E can play a role in solving some of our biggest societal problems. I want to also share with you some of my experiences over this last year that have inspired me in this regard including an example of amazing societal transformation.

Last year past president Bill Marras told us about the National Academy of Engineering Grand Challenges and encouraged us to take on these challenges. This is my starting point. There are 14 NAE Grand Challenges that include charges to "Enhance Virtual Reality," "Advance Personalized Learning," "Manage the Nitrogen Cycle," "Advance Health Informatics," "Make Solar Energy Economical," and more. These 14 Grand Challenges can be binned into four buckets of "Sustainability," "Human Health," "Vulnerability," and "Joy of Living." But I have asked (and have heard many of you ask), "How do we do that?" "What does that mean to take on the Grand Challenges?" How can HF/E help manage the nitrogen cycle?" "…or restore and improve urban infrastructure?" "and WHY take them on?" I want to share with you three lessons that I have learned over the last year (and indeed over my career) that I hope will shed some light on these questions.

Before doing that, I want to point out that we are already taking these challenges on in HF/E. We asked you to self-identify when submitting your work to the annual meeting as falling in one or more of the Grand Challenge buckets. We have 14 lectures or posters here this week on sustainability, 144 on human health, 44 on vulnerability and 17 on joy of living. So we should be proud that we are already taking on the Grand Challenges. Now on to the first lesson.

Number one – and this is related to the first lesson learned – I think we have to focus on a problem. We have the grand challenges, but there are a lot of other problems that we can focus on too; there are the NSF Big Ideas, and there is one NSF Big Idea that involves work at the human-technology frontier, which I think is near and dear to our hearts, and I just became aware of the NSF LEAP HI program: that stands for Leading Engineering for America's Prosperity, Health, and Infrastructure – something that seems relevant to us. And there's no end to the societal problems that we have, unfortunately. And there are many problems that you may be very passionate about, and I encourage you to take that on as your 'pet problem.' At any rate there are lots of societal problems and we are needed to help solve them. Why? Because who knows more about humans and their relation to society and technology than we do?

So what does this problem-focus buy us? For one, I think it helps communicate the relevance and impact of what it is that we do. When you say, "I'm working to solve the cyber-security problem" versus "I'm working on signal detection or workload measurement," even if you are, I think it helps communicate our relevance. It also advances science and engineering, because when we take on new problems that we haven't thought of before, they often raise new questions – new research questions – new research questions then lead to new results; findings that will advance science and engineering. And also, I firmly believe that taking a problem-focus excites young people – I think it excites some old people too – but I see in my day to day interactions with students that they are excited by solving a problem. I'll give you an example of my daughter. When we were looking at colleges and trying to figure out what she was going to major in, I asked her “What do you want to do? --be a biologist or philosopher or doctor or lawyer?” and she said, “I want to fix the rainforest. I want to save the rainforest.” I said “Well, we don’t have a major at ASU that’s called ‘save the rainforest’.” So, she’s now a junior at ASU and she is in the honors college, I’m proud to say, and she is majoring in biology slash conservation ecology with a multidisciplinary minor in philosophy and homeland security, and dabbling in law. So, I think that’s what you need to fix the rainforest.

So how can we then contribute to societal problems – big societal problems? Well, we understand humans. We understand human needs, capabilities, limitations. We understand their decision making. We understand barriers to use and adoption. And we know what will be useful.

We also can contribute our unique methods and measures: measures of human performance and need, usability, usefulness, cognitive and social processes.

But here’s something that maybe is a barrier to taking a problem focus, especially when it comes to the grand challenges as they were articulated. There are some of them like, the nitrogen cycle and energy from fusion problems, and some people say “well, what does human factors have to do with that? What do people even have to do with that? How are we going to engage in energy from fusion kind of problems?’”

And to that I say, when we don’t think that there’s a role for human factors and ergonomics, we likely do not understand the problem. And here’s a picture of me looking at a blowout preventer. It’s a long story, but I’ve been involved – and still am involved in – the National Academy of Science study on high-performance bolting technology for offshore oil and natural gas operations and basically, it’s about bolts: bolts that go in oil rigs that are deep under the water, and people are worried about them failing for good reason. I came onto this committee – there are about fifteen of us – I am the only woman, I am the only social scientist; they are all metallurgists and material engineers. I said, “What am I going to do? How is human factors related to this problem? How am I going to contribute to this committee?” And I learned about things like hydrogen embrittlement and cathode protection. I learned all about torqueing. And now, I am proud to say, that there is going to be a whole chapter, in or report, on human factors of bolting. Because, every step of the way, in the life-cycle of a bolt, a human touches it. From the time that it’s manufactured to the time that it’s installed and inspected, a human comes into contact with that bolt and there are lots of different work processes and lots of help from human factors is needed. So, don’t be afraid.

Number two: I think we need to take a human-systems perspective. And this is something that is very familiar to us. We need to consider the entire system, not just the human but, the technology and the environment. And I think we do this pretty well.

And here’s an example from my work looking at the MQ-1/9 operator control station, otherwise known as the Predator ground control station for UAVs or, I like to call it, remotely piloted aircraft systems. And there are lots of problems – lots of human factors problems.

This slide is courtesy of Mark Draper. So I was lucky enough, to serve on the Airforce Scientific Advisory Board, and to be on a study that looked at remotely piloted aircraft systems and I contributed to the human factors part of it, along with some other people. I was also on another USAF study on sensor data exploitation and in a minute these two things come together. But there’s no end to the problems with the ground control station. I mean, twenty-two key strokes to turn on the auto-pilot, really? And lots more. And, so yes, there are problems and interestingly, some time ago I talked to an industry program officer who had a hand in developing this system and they said “yeah, well, it’s been ten years now since the Predator’s been fielded, it might be time to start thinking about human factors’. And I’m like ‘You’re way wrong, and it’s too late and now we’re stuck with this legacy system.’ This is a system that has lots of people crammed into a trailer somewhere around Las Vegas, Nevada and they’re using a zillion displays and trying to fly a remotely piloted vehicle.

But, is that the system? And this is the other lesson that I’ve learned: just when you think you’re taking a human-systems perspective, you need to think bigger.

Because really, this is a system, and it’s even bigger than this slide can depict. So, we have multiple ground control stations flying a Predator, some maybe flying multiple Predators – that’s the ultimate goal, and sending full-motion video to a distributed common ground station where young people sit and stare for hours, looking for a dog to come out of a house or a car to leave – a white suburban, or whatever – it’s a kind of grueling job, and then that information is interpreted and passed down to the ground to keep people out of harm’s way. So, this is a huge system. All of these things have to coordinate. And so, if you don’t take this huge system’s perspective, you may end up fixing something locally, but having even bigger consequences somewhere else. So, for instance, moving to multiple UAV’s – or remotely piloted aircraft – is going to, say if there were three, triple the amount of full-motion video data that somebody has to look at in the distributed common ground station, and if you don’t take care of that then you will overwhelm them and they won’t be able to do their job and so the whole system will basically collapse. So, that’s just an example of the bigger system. You may eliminate people at one part of the system only to over-tax people at the other.

The other lesson is to collaborate with other disciplines. When you take this big system’s approach, I don’t think that there’s any other way.

I also had the privilege to chair the committee that did the report on “Enhancing the Effectiveness of Team Science” for the national academies. Big problems, like I’ve been talking about, are not for the single investigator, or even the single discipline. And when you take this big system’s perspective you’ll probably identify other needed disciplines. And if you look at this graph, which is probably hard to see, - all of the different lines on the graph represent different numbers of authors, with the two lines on the lower right being papers that have been published with 1,000 authors or between 100 and 1,000 authors – that’s a lot of authors – and the numbers of papers are on the y-axis. The years, going from 1960 to 2015 are on the x-axis. So, the one thing I want to point out is that there’s an orange line there that’s increasing rather steadily, and those are papers that are authored by six to ten authors. So team science is on the rise. There are more and more papers, and we may be aware of this from our own publishing, but multiple authors is becoming the norm.

And I also like to point, when we talk about collaborating with other disciplines, to a lesson that I learned from Mica Endsley when she came to give a talk at ASU; she talks about the golden triad of design – and I think this is so true. She is talking about this in the context of user-interface design, that is that it is best done when you have a combination of engineers – software and hardware kind of engineers – and human factors specialists, like us – the glue, and users. And so there you have another multi-disciplinary group that is needed to solve that problem.

Here's the lesson with team science though – it's hard. If you've tried to do it, if you've tried to collaborate across disciplines, it's very hard. And I have done this quite a bit recently because our unit, which is basically a group of eight human factors psychologists at ASU, has been merged into the College of Engineering. And so now we are psychologists working a lot with engineers of all different types. It's very difficult to take the other's perspective. This is a two-way street, it's not about us going out there and preaching to the other disciplines about the wonders of human factors. We have to learn about their approaches, their problems, and we have to be able to communicate our contribution to the problem, and we have to communicate across disciplines and to me that's been the hardest part. Just to give you an example, I was working with a civil engineer on a nuclear powerplant problem and one day, in a meeting, he said 'we will be running an experiment tomorrow'. I said, "okay, so you're going to start collecting data tomorrow – within my lab" – and he said, "yes, I'm going to run the experiment, the whole experiment, tomorrow, in two hours." I was dumbfounded because my experiments take about a year to run because they are team experiments, and I couldn't understand, but it turns out that for engineers, experiments don't involve humans or variability – experiments are demonstrations of the technology. And finally, when I got it, we were able to move forward, but it was a stumbling point. So, it's hard, but when it works it's rewarding.

So how can human factors and ergonomics help solve big societal problems? I think it is by doing these three things: focus on a problem – and don't be afraid if you don't understand the problem at first – take a human plus systems perspective – and take a very big one – and collaborate with other disciplines and be ready for the challenge.

Now, a tale of two cities – a tale of societal transformation. So, I was very inspired by a trip that I took to Medellin, Colombia, to participate, as president of Human Factors and Ergonomics Society, in the International Ergonomics Association council meeting. So, I was able to go to Medellin, and I found the whole thing very inspiring on a number of perspectives, but in particular I think this example that I'm going to tell you about is exactly what I've been talking about. And by the way – I want to put a plug in – in your bags you have this International Ergonomics Association brochure for the congress that's going to happen in August in Florence and, what a great place to go. So, okay, back to Medellin. So, here we have pictures of two cities. We have Medellin – the poor Medellin – it's up in the mountains, people build houses on top of one another, the children build houses on top of the parent's house, and as you need to get more land you move up the mountain. It would take two hours to walk down the mountain, to get to the Medellin that's on the right of the screen, the Medellin that's almost like Singapore, the Medellin that has all the jobs and the culture and the education. And people who are wealthy and middle class - they all live down in the valley, kind of the opposite of us – we have the Beverly Hills people up in the mountain – but no, the poor people live up the mountain. Two hours to walk down the mountain, to get to anything, like a grocery store.

So it's really not two cities, it's one city – geographically separated. A huge geographical barrier.

Not only that, but in 1992 Medellin was labeled 'The Most Dangerous City in the World'. It was the murder capital of the world. In the 1980's – and you may know this – Pablo Escobar, the drug cartel leader, created a criminal empire, and by the early 90s the murder rate was – and I get numbers like, between 300 and 800 per 100,000 people, which is a lot. In 1993 Escobar was gunned down by the police on a Medellin rooftop, but the cartel continued on under new leadership, and took on para-militaristic functions. There was more gorilla-warfare, gang-warfare, and urban-warfare, and lots more deaths. So, there was definitely a societal problem.

What happened? In 2004 a program of social transformation was launched. This was done through multi-disciplinary collaboration of planners, designers, politicians, university professors, and gang members. Now, was human factors involved? I cannot find the answer to that question, but they could have been, they should have been, and definitely people were involved that understood the human condition. Now, what they did was to place botanical gardens, schools, museums, and cultural sites, in the poorest neighborhoods.

And so, this was really interesting, and we got to see this, a metrocable transportation system connected the poor and the wealthy. So you had cable cars running up and down the mountain, and a light-rail as well, and…

outdoor escalators, that even the dogs were using – that was really interesting to see – and this changed the commute from two hours to fifteen minutes, and it connected these two different cities.

And Library Parks were built in poor neighborhoods. This is Parque Biblioteca Espana, and this is in a neighborhood that no one would ever think of going into back in the 1990s, the early 1990s, and now they take tourists there. And the Library Parks are really cultural centers: places where you can get on the internet, places where you can do a resume, places where you can learn, and have community.

And gang members turned to expression through beautiful graffiti murals decorating the neighborhoods. And I want to put a plug in for – while you're here, go see graffiti wall, which is very similar. But now, in Medellin, in the poorest of neighborhoods, they became very proud of their neighborhoods and started decorating them with these graffiti murals.

The homicide rate dropped, and I get numbers from like 400 in 100,000 to 50 in 100,000. Gang violence decreased. Unemployment decreased.

It was a complete transformation, and here are the lessons learned, as told by the World Economic Forum on Latin America – and I really like some of these, in particular the last one. They are: architecture should never be a barrier to human interaction, public and accessible urban services reduce inequality, education drives change. I firmly believe that too. And using technology as a means and not an end in itself.

Medellin was transformed – it was a new city, so we have two cities: one old, one new. And it happened by focusing on the problem innovatively, by understanding the human system in a very big way – how humans, transportation, and culture all interconnect – and by collaborating with other people, including the gang members.

Thank you. I want to thank for allowing me the privilege to serve as your president over this last year.