On Values, Role Models, and the Importance of Being Me

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ABSTRACT

The recent National Position Paper for Women in Engineering in Australia identified shared explicit values as the basis for a new vision of engineering education, moving away from the existing themes of isolation and exclusion to the preferred themes of inclusion and integration. In this paper, we explore our own experiences and values as women engineering educators and researchers. We connect these personal explorations to prevailing theories about the disconnection between engineering and society and the myth of engineering and scientific objectivity. We then describe various initiatives we have developed within our research and our teaching which enable our student engineers, women and men, to discover their own values, and to live those values within the profession of engineering. Our belief in the importance of role models and having a commitment to living our values provides the link between our own values and these programs.

1. INTRODUCTION

1.1 A Structural Metaphor

This paper is structured after the model of the reflective practitioner - it's cyclical. The central core of the work is about values in engineering, and we attempt to examine values from various perspectives.

Sometimes metaphors are helpful in explaining concepts, so we would like to explain our approach to this paper in terms of a metaphor:

Imagine a complex sculpture - for those of you lucky enough to have been to Vigeland Park in Oslo, use Gustav Vigeland's masterpiece, the monolith, on a bright sunny fall morning as your image. For those who are not so fortunate, allow us to briefly describe it: it is a huge granite column, about 17m high and 3m in diameter, with 121 human sculptures. Vigeland's mastery was in his ability to capture people's emotions with wonderfully simple lines. You can find more information and pictures at http://www.oslonett.no/oslo/vigeland.html.

Imagine now several separate groups of tourists, each with their own guide, standing at different positions around the base of the sculpture. This particular sculpture has no right and proper and correct angle from which it ought to be viewed - no front, no back, no side - when you look at the sculpture from different angles, you see different things - different details, different stories, but all part of the same whole, and not all the stories are visible from a single vantage point… the only way to appreciate it in its entirety is to walk slowly around it many times, so that you see it from all possible angles and in all possible lights, stopping from time to time to take in the details of a particular view.

In the context of this paper, the sculpture is engineering, and the onlookers are groups of undergraduates, postgraduates, engineering researchers, engineering educators, engineering practitioners, and society at large. The way in which they view the sculpture represents their values in engineering.

1.2 Our Starting Point

The validity of this paper lies in the fact that our experiences are real. We would like to share our stories and our awakenings to the realisation and recognition of the need for different perspectives within engineering. This leads into a discussion of how we have changed our research and teaching practices to allow our selves to be a part of these activities, and in so doing, to be a role model for young women and men in engineering to do the same. In the spirit of the paper, our stories are different, but they often coincide.

2. VALUES AND UNDERGRADUATE ENGINEERING EDUCATION

In this section, we begin by exploring our own experiences in undergraduate engineering education a decade or so ago. We expand and legitimise these perspectives by comparing them with the current situation, and ask whether or not it may be the engineering culture as a whole that is at fault.

2.1 Our Experiences

Caroline studied a combined science and engineering degree in the UK in the mid 1980s.

> *I thought anyone could do anything so long as they tried hard enough (and were weak if they didn't); I thought feminists were not necessary any more, and were serving to provide distrust amongst the 'new men', who were, after all, trying their hardest; I believed the new men were great because they kept telling me they had done the washing up; and when I went along to a women in science and engineering group, I decided they were a bunch of man-hating old maids who probably couldn't get a boyfriend.*

Cynthia studied chemical engineering in the wilds of Queensland, Australia, also in the mid 1980s.

> *My parents thought I'd chosen engineering because I'd always been a bit of a tomboy. I believed that everybody could excel at some thing if they just put their mind to it; I believed I was successful because I worked hard, not because I had any particular talent or skill for what I was doing; I certainly was not a feminist (they were radical troublemakers who had no idea of how the world really was) and so I and my female engineering friends never took any interest in such separatist groups who just gave the rest of us a bad name, and made it more difficult for us to be 'one of the guys'.*

2.2 Current student experiences: being 'equal'

These ideas have actually developed even further in the last decade or so. Today, students are conditioned to believe even more in 'equality': there is no concept of 'difference' in most

school leavers' minds. Here is a recent comment from an interview exploring the need for a gender inclusive curriculum with a female engineering student:

> *The biggest difficulty studying in Australia in this chronic endeavour to single out females; pro and con. Accepting oneself as equal is the only true barrier to equality. Then just do it.*

For Caroline, Cynthia, and most of the young women who choose engineering today, essentially all the role models are males, and a very high proportion of their colleagues are males. Most of us start out in the mindset of wanting to be equal. Those who don't, probably leave engineering, as evidenced by this quote from an interview with a young woman talking about her decision to leave engineering to take up another career. She described the people in the engineering milieu, both the work place and the education system, as:

> *incredibly arrogant and not just on a personal type level but in terms of the world in general, you know they can beat nature … building things big enough and strong enough and that's the only criteria for success…*

2.3 Does the problem really exist?

In a recent ethnographic study of first year engineering at The University of Queensland, it became clear that conditions exist that many women and some men would find difficult to cope with. The women students set great store on their ability to put up with difficult conditions and often feel a need to reject their femininity to survive [1].

Females who had come to engineering from both single-sex schools and mixed sex schools had adopted coping strategies, and neither group were keen on the idea of the Centre for Women in Engineering, even though the explicit mission of this centre is to improve engineering for all students. This routine, which is repeated around the world, becomes a self-fulfilling prophecy: generally speaking, the undergraduate women studying in engineering schools either do not see or tend to deny problems with the culture, and do not appreciate being singled out in any way, and are not supportive of initiatives aimed at specifically assisting women students. Male students in engineering are also quite vocal about the need for 'equality' (without affirmative action) in engineering:

> *If you want equal opportunity, why are you segregating by forming a women's group?*

The (essentially) male (but sometimes also successful female) academic staff see these responses as a very strong reason not to support initiatives aimed at dealing with these issues within universities. And so we go round in circles.

But is this really what most female engineering students feel? Gilligan is often credited with discovering the concept of a 'different voice', after finding a voice in her study of moral development that did not fit in with the theories of her colleague Kohlberg [2]. Women tended to talk about caring for others needs and valued relations between people, which the men had not mentioned in Kohlberg's all male study. Caroline rediscovered this different voice when, exasperated by a dismal focus group about experiences of studying with a group

of female engineering students, she talked openly about her own views. The next day there was a knock at the door:

> *I was very interested in what you had to say yesterday and I came to thank you. I had no idea that I could be 'myself' in my profession. I thought I had to become someone else or I wouldn't fit in. I really hadn't considered that I could bring some of who I am into my work and that that might be a good thing.*

What we have here is strong independent young women who have already made a significant, difficult decision in choosing engineering as a career. They do not want others to think that they have any problems with the way things are because it would look like failure on the part of the women. So, when asked, they respond with 'what gender bias?'.

3. VALUES AND ENGINEERING ACADEMIA

In this section, we explore our dissatisfaction with engineering as we moved through postgraduate studies, and then the realisation that we bringing ourselves into the picture would solve these problems.

3.1 Bringing Our Values into Engineering

When Cynthia went back to university for postgraduate work, she went to a biotechnology department:

> *I'd been working in the biotechnology industry, and I wanted to learn more about how cells function so that I could design better bioreactors - I'd come to the conclusion that chemical engineers were generally ignorant of the requirements of these little living things, and this lead to systems which did not meet their needs.*
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> *I did finish my PhD, but only just, and promptly 'went bush' for a year with a bad case of the screaming heebie-jeebies for science and engineering, swearing I would never work in these fields again - it all felt wrong, the priorities were in the wrong place, there was no consideration of people, and so on …*
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> *Environmental issues have been important for me for eons. In fact, when I was an undergraduate, my non-engineering mates used to question how I could possibly be doing engineering and yet still consider myself an environmentalist too - surely these were irreconcilable?*
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> *After a year of camping round the Australian outback, away from engineering and science, I realised that I could be passionate about engineering so long as I could do it on my terms. In other words, work on something I felt was worthwhile, had meaning, had connections to the rest of the world: in short, to work on 'environmental stuff'.*

Meanwhile, despite believing that she could do anything, after a very short time Caroline did not particularly want to do science or engineering:

I tried several times to leave engineering and become a psychologist, a teacher, a probation officer, a thespian, … in fact, anything that was diametrically opposed to engineering. I even re-did some careers questionnaires and found out that I scored highest at the personality traits leading to career paths in social work and lowest at those associated with engineering. Disillusioned, I tried to become involved more professionally in the theatre (my passion). However, finding that I couldn't pay the rent, I enrolled in a PhD course! The disillusionment continued during a period of misery in which an imposed PhD structure was thrust upon me. I soon found the courage to leave, find a job in Public Relations 'which involved people', and then finally to save up enough money to 'leave society' and travel.

During my travels, I became aware for the first time of the idea of doing science/engineering for myself to suit myself: I met a boat builder in Cairns who needed advice on the materials in his luxury yachts. One thing led to another and I returned to the UK to continue with a PhD. This time, I was going to do it because I wanted to. Because I could do whatever I wanted, talk to whoever I wanted, and experience absolute freedom in learning.

3.2 Recognising our Different-ness

Cynthia decided to rejoin the ranks of academia, and took a position lecturing in environmental engineering five years ago:

Still, something was not right. In my teaching, I could see differences between classes that had 5 or 10% women and those that had 30-40% that I couldn't explain. And I did not fit in engineering academia. It was not until I stumbled across a women in science and engineering listserve discussion just a few years ago that I suddenly realised why I was different from my colleagues and what my implicit exclusion meant for the profession.

Caroline has been lecturing in materials science and engineering and education development for six years now.

When I began lecturing, I suddenly realised that there were hardly any girls taking the course. Funny that it hadn't occurred to me as odd before, considering I had been one of only two in my own course. I guess I thought things were changing slowly but surely. However, it was becoming apparent that bullying girls into taking non traditional subjects in schools was not working. This forced me to rethink my own situation. I was trying so hard to be like the others around me who had succeeded: all of my role models and all of my colleagues were male. I was stuck in a mindset of wanting to be equal. It was not until I started researching the reason why girls were not taking engineering that I began to come across a literature that was saying, 'why should girls take engineering the way it is?'.

Midgley and Hughes [3] sum it up nicely in their book 'Women's Choices':

'Feminists demanded that women should be treated as men, but we need to ask whether men ought to be treated like this in the first place.'

Says Caroline:

> *I was not even aware that my values were different to those around me.*

4. LIVING OUT OUR VALUES WITHIN ENGINEERING

In this section, we explore the myth of scientific objectivity and the need for balance and beauty in science and engineering, and link these concepts to our own approached to research and facilitating student learning.

4.1 Values and Scientific Objectivity

Values are central to this discussion because they implicitly guide how we choose to direct our energy and time. Our values are the lens through which we view the world: they stem from our underlying beliefs and assumptions, which are generally neither articulated nor questioned.

Kuhn [4] is generally credited with opening the debate about the 'insufficiency of methodological directives … to dictate a unique substantive conclusion'. He argues that an arbitrary element 'compounded of personal and historical accident' is necessarily a 'formative ingredient of the beliefs espoused by a given scientific community at a given time'. In other words, the people involved in science and their particular context have an inextricable impact on the output of the scientific (or engineering) activity.

Hubbard (in [5]) goes further, stating that the myth of scientific objectivity obscures more than it reveals:

> 'How much better and more honest it is to try to identify the source of one's subjectivity, to acknowledge one's position within nature and society, and to try to proceed from there'

Sandra Harding [6] makes a similar comment:

> 'Untouched by these careful methods are those values and interests entrenched in the very statement of what problem is to be researched. We need to investigate the relation between the subject and the object rather than deny the existence of or seek unilateral control over this relation. It puts the subject or agent of knowledge in the same critical causal plane as the object of his/her inquiry.'

However, this line of reasoning is heavily frowned upon in the practice of engineering research and teaching.

4.2 Problem Solving, Problem Finding and Creativity

The methods referred to in Harding's quote above are scientific methods. Harding suggests that the part of knowledge which is considered to 'truly scientific', ie research by controlled experiments, is actually justification rather than discovery. 'Real science' has to be measured by a method with appropriate rules and controls, but such methods are by definition only able

to deal with hypotheses which have already been formulated. If this is true, then problem finding (as opposed to problem solving) is not possible using scientific method.

Barhaim and Wilkes [7], who have considered this paradox within the context of the engineering profession, state that men who study engineering are more often problem solvers (and therefore suit the profession), whereas women who choose to take on this non-traditional career path are often problem finders (and therefore do not suit the profession).

This gender preference for problem solving and problem finding was also illustrated in the values workshop which led to the production of the first National Position Paper on Women in Engineering in Australia [8]. The women at that workshop saw engineering as being focussed on problem solving, but needing to expand to include problem finding.

Recognising the existence of a relationship between the subject and the object in research, and including problem finding within the ambit of engineering suddenly expands the scope for creativity. This recognition is beginning to permeate engineering education - the European Journal of Engineering Education has commissioned a special issue on creativity, for which we have both prepared invited contributions [9, 10].

We have also proposed a project which explores different modes of creativity within engineering education and practice. It builds on the experience of educators and industrialists who have attempted to implement such programmes, and examines how these attempts may be fostered and assessed. The project then develops a framework for implementing and evaluating programmes designed to encourage creativity and innovation in engineering students, as one of the necessary steps in preparing graduates for a rapidly changing future.

5. ON THE NEED FOR BALANCE AND BEAUTY

In 'The Turning Point', Capra [11] suggests that what is missing from the equation of society is the ancient Chinese concept of yin values. The ancients believed that reality was continual flow and change. The polar opposites of yin and yang set the limits for the cycles of change - not opposing, but poles of a whole, and all people experienced both yin and yang phases.

In modern Western culture, yin has been strongly associated with femininity and passivity, and yang with masculinity and activity. Men are now expected to be yang at all times, and women yin.

Capra suggests a more useful approach might be to consider yin as responsive and conscious of the environment and yang as dominating and conscious of the self. In our society, the balance is towards yang values: rational knowledge rather than intuitive wisdom; science rather than spirituality; competition rather than cooperation; and exploitation of natural resources rather than conservation, to name a few examples. Yang values are not bad in and of themselves. It is the lack of balance which leads to our current problems.

Capra goes on to suggest that the strong divide between mind and body leads us to view the universe as 'a mechanical systems with separate objects - material building blocks whose properties and interactions determine all natural phenomenon.'

If we, as subjects, are separated from the world, the object, then must we necessarily all see the world in the same way? Where do our feelings fit into this world view? Where does empathy come in?

Reanney [12] advocates another way of knowing: he suggests that logic ought to be the tool of insight, rather than its guide. He considers that paradoxes defy logic and tap into a different way of knowing. For example, the best way to learn is to teach. Poetry and music defy logic too. However, aesthetic criteria are usually ignored in scientific discoveries. Should they be? On discovering the DNA structure in 1953, Watson is said to have commented:

> 'It's too pretty not to be true.'

Similarly, Dirac once said:

> 'A theory with mathematical beauty is more likely to be correct than an ugly one that fits some experiments.'

Such a comment defies logic completely, and puts aesthetics and intuition, and therefore subjectivity and values, fairly and squarely in the middle of scientific discovery.

5.1 Acknowledging Our Values in Research

We do not accept the myth of scientific objectivity. We believe in balance in our research, and in the inherent beauty of excellent science and engineering. We believe that we all need to be aware of our own values and filters all the time, particularly in our engineering work. We simply have to consider our own perspective when we make scientific and engineering judgements. In this way, we live out our values, act as role models, and help to transform science and engineering.

Caroline has expanded her research interests into biomimetics:

> *That's where we study natural materials in order to learn from them so that we can create artificial materials which combine and optimise natural structures and synthetic properties. The hoof work I have just completed has involved quite a complex microscopic analysis, but it has allowed for creativity. No-one has explored the structure of cow-hoof the way we have, and it could be any way we feel it might be. We have submitted a beautiful 3D drawing of what we think it looks like at a microscopic level. I have discovered the aesthetic beauty of my work and now I can own it.*

Cynthia now specialises in environmental management and decision making, clean technology, and the practicalities of low energy, resource recovery options for waste treatment, incorporating the social and ethical dimensions of these issues.

> *For me, the crux is about recognising the connections between people, nature, and our social structures as a crucial step in moving towards sustainability. So my research deals with new options which meet a broader set of criteria than traditional engineering approaches.*

5.2 Teaching for Thinking and Better Learning

Transforming the curriculum to be inclusive of a diversity of values mans that we try to give people opportunities to bring out their strengths and to show that their response to a particular situation can be right for them and the job in hand.

In fact, these initiatives are really just good teaching practice: in their guide for considering gender in teaching practice, Nightingale and Sohler [13] offer suggestions about increasing involvement between the students and teachers, avoiding long lectures, improving facilitation skills, allowing for different learning styles, encouraging collaboration, and making the subjects relevant to real life.

Caroline has developed a new integrated first year course which incorporates environmental, social, and ethical issues and has published a teacher's guide book for others to implement her ideas [14].

Cynthia has integrated a variety of reflective writing tasks into 1st, 2nd and 4th year engineering subjects to encourage students to recognise their own values and opinions, and to consider what has influenced these points of view, and what influence they have on the students' decisions within engineering.

Our approaches to assessment also provide opportunities for a diverse range of student learning styles. We use small groups, discussions, role plays, open book exams, negotiated assessment regimes, learning contracts, and so on.

We are both strongly interested in understanding and improving opportunities for student learning. We believe the best we can do for our students is to role model our values by encouraging questioning, balance and connection, and to help them learn how to express themselves and to think for themselves. This is the essence of life long learning. The initiatives mentioned above are examples of our attempts to cater for a diversity of values and learning styles.

6. SUMMARY

In this paper, we have, as engineering academics, explored our own struggles with engineering and our responses to engineering, and the way in which those responses eventually led us to realise the importance of bringing our selves and our values into the way in which we practise engineering. We have given examples of the way in which this has changed our practice, and of how we attempt to foster this explicit expression of 'being me' in our students, and we have validated our experiences and approaches by drawing links with other studies. We offer our learning as a potential role model for others.

7. EPILOGUE

The process of writing this paper proved to be a useful learning experience for us both in appreciating diversity - Caroline had written some text about values which did not feel comfortable to Cynthia, and when Cynthia tried to draft the paper, the result felt decidedly

uncomfortable for Caroline. So we revisited our reason for doing this, thought about our implicit assumptions, laughed at the irony of co-writing a paper on diversity and then trying to force the two of us into the same model, and happily restructured the paper.

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