On 'Making a Difference': Female Engineers Working in the Environmental Field

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Abstract

The engineering profession is increasingly recognising that engineers need to be educated about environmental sustainability. Many engineering students start with a low level of environmental concern. There has been scant attention given to how best to support those who already have a high level of environmental commitment and who intend to direct their careers accordingly. It is often claimed that women are more likely than men to be attracted to careers where their work is of obvious benefit to society. Some hope that women would bring different values to engineering and would take a more holistic approach to technological design, including considerations of sustainability. However, there is no clear evidence to date that women are changing the practice of engineering. This study seeks to move beyond the debate about whether women will make a difference to engineering and, instead, asks what happens to women who *do* want to make a difference. It draws on in-depth interviews with female engineers who are committed to working in an environmental field. It seeks to understand their experiences and the forces shaping their commitment to making a difference as they progress through the undergraduate engineering program and their early years in the workforce. Finally, it makes recommendations for engineering educators.

Keywords: Engineering education, environmental sustainability, women in engineering.

Introduction

Engineers play a crucial role in environmental sustainability. Traditionally, engineers have treated the earth as a resource for exploitation. In recent years, the quest for environmental sustainability is becoming more important for business and government. There is increasing pressure for engineers to develop cleaner technologies, to reduce resource usage, and to ameliorate environmental damage from past engineering practices.

This study focuses on engineers in Australia. As in other countries, Australian professional engineering bodies are recognising that traditional

engineering education has not adequately prepared engineering graduates for these new demands, and now require that engineering students be educated in environmental sustainability (IEAust 1999). Apart from programs dealing with environmental technologies (such as postgraduate degrees in renewable energy) or environmental remediation (such as environmental engineering), most engineering programs still teach very little about environmental sustainability.

One problem with how environmental sustainability is included in engineering programs is that many engineering students have little interest. Teaching material is therefore aimed at instilling a very basic appreciation of the requirements for sustainability, pitched mainly at the uninterested student. At the other end of the spectrum, however, are those engineering students who are very concerned about the environment and who intend to make environmental sustainability the focus of their careers. Such students are often attracted to environmental engineering. However, some may have entered a traditional engineering program such as mechanical or electrical, often with little initial idea of where they would work, and were subsequently inspired to focus their careers in the environmental field.

The idea for this project came from my experience teaching sustainable energy to mechanical engineering students, and observing how some students were influenced to pursue a career in this field. My main concern is the way in which engineering educators can encourage and better prepare students who hope to pursue a career in an environmentally related field. If properly nurtured, such students may become environmental innovators of the future. They may also help to raise the level of environmental consciousness among their cohort at university and their working colleagues. However, if they find the culture of engineering to be alienating, they may leave to pursue careers where their qualities are valued.

The aim of this study is to understand the experience of engineers who are committed to working in an environmental area and the forces that shape their commitment to 'making a difference' as they progress through the engineering program and their early years in the workforce. To date, this group has received little attention in the literature. Therefore, to gain a better appreciation of their experiences, I have opted for a qualitative approach, drawing on in-depth interviews with fifteen

engineers who are committed to working in an environmental area. For reasons discussed below, I have focused on female engineers.

Women, engineering and environmental sustainability

Since the mid 1970s, Australian engineering schools have been attempting to increase the participation of women, with limited success: currently about 15% of engineering students are female (Engineers Australia 2003). The only engineering discipline where, on average, women are well represented is environmental engineering.

Many efforts to increase women's participation in engineering appeal to arguments about diversity: that including more women should diversify styles within engineering (Engineers Australia WIE 2005). Yet, there is a danger that these efforts implicitly incorporate essentialist thinking (Faulkner 2000) such as the idea that women 'naturally' take a more nurturing approach and thus would design technologies that are more environmentally friendly, more in keeping with the needs of users, etc. Essentialism is problematic because it ignores the historical construction of gender differences and cultural differences in assigning such values (Wajcman 1991). Moreover, many female engineers reject the idea that women have different values to men, as it seems to undermine arguments for women's access based on the idea of equality (Mack 2001).

It is possible to avoid the pitfalls of essentialist explanations while still noting that on average there may exist gender differences in approaches to, say, technological design. For example, Faulkner (2000) cites UK school studies which indicate that boys are more likely to ignore the context and treat design as just a technical task, whereas girls tend to take a more holistic approach and consider how a technology works for the user.

As yet, there is no clear evidence that the entry of women is changing the practice of engineering, such as through greater incorporation of sustainability criteria. The early professional socialisation of engineers may also serve to discourage engineers from doing things differently. But the high proportion of women entering environmental engineering does suggest that more women may be more attracted to a field of

engineering that has a much more 'caring' image. Studies have suggested that women tend to exhibit stronger environmental attitudes and behaviours than men (Zelezny, Chua & Aldrich 2000), and that women give higher priority than men to finding meaningful work, while men tend to prioritise promotional opportunities and job security (Tolbert & Moen 1998). Women may also be more attracted to environmental engineering because it is a new field, and thus easier for women to enter.

This study seeks to move beyond the debate about whether women will make a difference to engineering, and instead asks what happens to those women who *do* want to make a difference, specifically through environmental improvement.

Methodology and selection of participants

The aim of the study was to understand the experiences of female engineers who were strongly committed to working towards environmental improvement. This research is interpretive, in that it seeks to understand the social reality of participants and thus calls for a qualitative approach. It is therefore not possible to generalise from the findings of this study; however, they should be of value to engineering educators who hope to foster more environmentally committed engineers.

Because of the narrow definition of the target group, participants were recruited through my contacts in the environmental and sustainable energy fields. The intention was to identify engineers who were regarded as passionate about working towards environmental improvement, although it is acknowledged that this definition is somewhat subjective. It was not intended to include those who had entered environmental engineering by default, or merely for the career prospects. And in order to avoid imposing too rigid a definition on what was 'environmental work', I included a participant who argued that her environmental values could be applied in more traditional engineering work.

The group size was only fifteen, and thus it is not claimed that the participants fully represent the target group. Instead, participants were chosen with the aim of eliciting a broad range of opinion. Thus I have

included not only environmental engineers (who had studied engineering with the intention of working in the environmental field), but also women who later became inspired to direct their careers in this area. Nine participants were environmental engineers, and six had studied mechanical engineering or related disciplines. For simplicity, the latter group are referred to as 'mechanical engineers'. Three of the environmental engineering participants had commenced engineering as mature-aged students. The participants varied in experience: seven were either about to complete or had quite recently completed their undergraduate studies (although most had undertaken relevant work experience) and the remainder had a range of up to twelve years' experience. Nearly all of the latter group were undertaking or had completed postgraduate study related to their work, a reflection of their high level of commitment. Their past and present workplaces included environmental and energy consultancies, industry associations, private companies, universities and public agencies.

In-depth, semi-structured interviews were conducted and the participants were asked about their experiences in education and the workforce, and to reflect on how their commitment to working in the environmental field had been shaped by these experiences. They were also asked about how engineering education could be tailored to suit people with their interests. The participants' names have been changed to maintain anonymity.

On 'making a difference'

As Elwyn Brooks White once remarked:

> I arise in the morning torn between a desire to improve the world and a desire to enjoy the world. This makes it hard to plan the day.

Most of the participants in this study spoke of 'wanting to make a difference' through environmental work. Of course, a desire to make a difference is not uncommon in working people. The aim of this paper is to explore what such a desire meant for this particular group, and how it

has evolved. And, while the participants indicated a strong desire to work in the environmental area, this was in some cases 'tinged' with a desire for a balanced life and a desire to pursue work that they found intrinsically enjoyable but which may not necessarily be related to environmental improvement.

What is environmental work and how does one make a difference?

What then did the participants regard as environmental work and where did they see that they could make a difference? For some it was in technical design or project management. Others preferred to work in policy and providing strategic advice to industry and government. Some also pursued their environmental interests through voluntary participation in outside organisations, particularly industry groups.

A number of participants, particularly those focusing on non-technical work, saw themselves as taking a much more holistic approach than most of their engineering colleagues. For example, some saw themselves as 'translators' between people from different professions or spheres; others saw they could bring disparate groups together.

Some environmentally concerned engineers who wish to apply their environmental values to their work may have ended up in positions not specifically regarded as 'environmental', by virtue of the job market, their particular skills and other interests. As Linda noted:

> Working in a manufacturing place (…) you can be more environmentally responsible by making sure that your equipment is up to date, well serviced, that you have methods and procedures for making good use of [resources].

However, she acknowledged the difficulties faced by junior engineers who wish to incorporate environmental sustainability in a traditional engineering position.

> You are expected to do things the way the organisation has done them, and you are not expected to create waves. You are there to do your job (…) If you started

> trying to diversify a little bit, and say you want to spend time improving the sustainability of the [production] line, you would get wrapped over the knuckles, and told: 'you have to make this deadline, don't muck around'.

Even environmental engineers felt constrained in what environmental initiatives they could undertake, particularly if they worked in a consultancy. Nadia noted:

> As an environmental person in a junior position it is the same really. You do what you are told and you might feel like you are achieving something, but it is only what you are being told to do.

Several participants noted that it was difficult to find the right job for them; although most acknowledged that their current job gave them valuable experience. Laura noted:

> You have got to take up the opportunities that come up. It is really hard to find a job that met [my] criteria (…) I still don't know what function to search on job web-guides when I want to find a job that has technical and sustainable elements.

Most of the participants did not regard themselves as radical environmentalists; instead they argued that they could best make a difference by working within the system—not surprising, considering their choice of work. Annette recalled discussing this with environmental activists:

> You need to get into [corporate] positions, even if you don't agree with the politics of the company and what they do. It is the only way you're going to make a real change (…) To me going out and protesting is not going to make any difference (…) Even though you can't make big changes straightaway, you can chip away and make small changes.

Tania, who had once been an environmental activist, recalled her change of thinking:

> Then I thought, no, I've got to make my job my environmental work, and I've got to make it economically. I have got to make environmentalism economically viable. Then everyone will do it.

Experiences of engineering education

Participants had studied either environmental engineering or mechanical engineering (including related disciplines), depending on when they had decided to pursue an environmental career.

Many students enrol in engineering with little understanding of what the profession entails. Rather, it is often a natural progression for students who enjoy mathematics and science at school, who hope for good career prospects and who would rather work with objects than with people. One might expect environmental engineers to differ from the norm, to have chosen the program more deliberately as a pathway into an environmental career. However, this stereotype fits only a small proportion. In his study of environmental engineering graduates from Griffith University, Williams (2000) found that many had entered the program somewhat by default, and only a few were motivated by a strong desire to make a difference to the environment.

The environmental engineering participants in this study were not typical: their decision was more deliberate, and more focused on the 'environmental' than the 'engineering'. Diane's comment reflects this:

> It wasn't engineering as such; it was environmental engineering (…) I didn't really know what it was about. But I was always interested in the environment. So that was a good opportunity for me to link in my career with something that I was and still am passionate about.

Why then did they choose to study engineering rather than another type of environmental program? Most thought engineering would lead to better job prospects. They also regarded engineering as more practical and focused on problem solving. Some had observed that 'solutions' put forward by environmentalists were often dismissed as technically infeasible, and hoped that engineering would provide them with a more factual understanding. The idea that engineers could bring about tangible outcomes was also appealing. Ingrid reflected this:

> It was the idea that you could actually do something practical that would make a difference. Whether it was putting in pollution control equipment, or designing something slightly differently (…) That is what appealed to me.

Most admitted that they had chosen the program with little understanding of what environmental engineers did. Williams (2000) found most aspiring environmental engineers to be more informed about 'green' environmental issues (such as conservation and preservation) than about 'brown' environmental issues (such as pollution and waste management), areas in which most environmental engineers actually work. This was also true of many environmental engineering participants in this study. However, being engineers, most were interested not just in the issues but also in the implementation of solutions. For some this meant engineering design.

Some felt frustrated that they did not learn how to design new 'environmental' technologies, such as renewable energy technologies, within their environmental engineering program. Rachel noted:

> I think there should be a subject on emerging technologies, and technologies that changed the face of the environmental movement.

Some with an interest in designing new technologies felt that their technical skills were lacking and thought that environmental engineering had not covered enough 'engineering'. Some questioned whether they should have studied another discipline of engineering and applied environmental ideas to this. Diane noted:

> A mechanical engineer could be taught to look at the environment impacts of their design (…) Environmental engineers work from the other way around (…) They know what the impacts are, but they don't how to design it.

Nadia, who was also concerned about whether environmental jobs might disappear during an economic downturn, questioned whether she could have been more effective in another field.

> Project management for example is an area [that] has a huge influence over how projects are carried out. If you do something like that and just apply environmental values and environmental knowledge to what you are doing, you can probably make more of a difference than somebody coming from an environmental angle who is just trying to make a little difference.

This suggests that students who are passionate about the environment may be drawn to environmental engineering rather than to other disciplines, where they could develop greater skills to design new technologies.

Participants with an interest in policy were of a different mindset. Helga argued:

> I think environmental professionals have more in common with other environmental professions than they necessarily do with other engineers (...) And a lot of the projects that environmental people are involved in rely for their success on integrating the whole framework (…) So you've got to put all those together rather than actually design a solution.

The engineering profession frequently expounds the importance of fostering creativity in engineering design. However, participants who regarded themselves as quite creative felt frustrated by their experiences. Rachel, whose previous work was in a creative field, expressed her concern thus:

> There just is no creative outlet at all. Design is maths. I got the shock of my life when I went into Design 1 and they started teaching us maths, like I wanted to draw something or create something (…) Design [should be about] sitting down and coming up with an alternative process or thinking about things in a different way.

She felt that it was not until her final year design project, where she was given a free rein, that she could be truly creative. Lucy thought that the assessment system discouraged students from putting forward creative but non-traditional solutions:

> It is very much a handed down discipline and people do things in engineering now because that is how they have been taught (…) I really didn't get the feeling that we were encouraged to think that much outside the square (…) My assignments were sometimes a little bit more off the wall, and sometimes I get good marks for them and sometimes I [wouldn't].

Some participants working in policy or cultural change expressed frustration that engineering programs did not adequately deal with the context for sustainable technology. Tania thought that engineering did not 'teach them how if fits into the bigger picture'. Engineering calculations, she suggested,

were 'the easy bit'. The political and financial obstacles to implementing sustainable systems were the main problem. Susan felt frustrated that non-technical subjects were 'watered down'. She subsequently undertook post-graduate study to supplement her understanding in these areas.

> We really loved those focuses on areas outside of engineering, but at the same time they were watered down and done fairly poorly because we were engineers. I think people assumed that it needed not to be too difficult. But the fact is that a lot of people that have left the degree have gone into (…) all sorts of areas (…) The type of people that go into the degree aren't just engineers.

The mechanical engineers in this study were different in that none had started the program with the intention of working in an environmental area. Most spoke of encountering an inspirational person, perhaps a guest lecturer or work colleague, or of having their interest sparked by doing an environmental subject during their studies. Some spoke of being shown a path, a way they could apply their environmental interest in the workplace. Nicola recalled a guest lecturer who:

> talked to our class about renewables, and that's when I thought that's really what I wanted to do (…) And you kind of thought, it would be feasible to be able to get a job in that area.

Laura was inspired by her first supervisor, who was very enthusiastic about renewable energy.

> [H]e really showed me that you could work in the field and apply yourself to make a difference (…) I decided then that I really wanted to have some belief about what I was working on.

Some thought that their programs were too geared towards training engineers for a particular industry, and reacted against this. Anita regarded her engineering program as 'anti-environmental' because of its strong focus on the fossil fuel industry. Her rejection of this led to an interest in sustainable energy. She questioned why her program had portrayed a negative image of sustainability rather than 'as a challenge that needs some innovation and something to get excited about'.

Some participants reported being inspired by environmentally related subjects in their program. Margaret, who objected to the strong automotive focus in her degree, was inspired to pursue a career in sustainable energy after fortuitously enrolling in a renewable energy elective. But she felt it came too late in the program. She thought that students were not being sufficiently exposed to growth areas such as energy management and ecologically sustainable design:

> I feel like mechanical engineering is very sort of tunnel visioned, it's just cars, cars, cars. I think that if there was a little bit more education, people would come into this area a bit more. I guess if there was just a little bit [like] renewables, [in] first and second year.

Nicola, who studied subjects in the Arts faculty as well as engineering, keenly felt the difference between the two approaches: not only did Arts subjects emphasise the human side, but they also explored the complexity and 'greyness' of issues, rather than treating them as black and white. This comparison led her to think about how she could apply engineering in a socially useful way.

> It used to make me a bit angry that engineering was so tunnel vision, and not really thinking if their work was benefiting society in any way (…) [Renewable energy] was the only thing I thought I could be able to throw myself into that and (…) be able to justify it.

Despite their concerns, most did not regret studying engineering. Although some of the participants work mainly in policy, they believe that an engineering degree benefited their work significantly and perhaps gave them an edge. For example, Laura argued that as an engineer she could have valuable input to policy, particularly because there were few people in policy with a technical background.

Experiences shaping their environmental commitment

Many participants spoke of how they moved from an idealist to a more realist position because of their experiences in the workforce, and through

working with colleagues who were less enthusiastic about the environment. Margaret was initially surprised that some of her colleagues were cynical about the prospects for renewable energy.

> It's made me a bit more practical (…) I really believe in renewable energy and I'd really like to get into that industry, but it's taken some of the sheen off (…) I'm not as gung ho about ideas and I need to hear more about them before I can become excited.

Some participants spoke of become more aware of the economic constraints on environmental technologies, and recognised that the market place needed to be transformed. Ingrid noted that she became a lot more cynical, as she came to understand the politics of environmental regulation.

> That the right thing isn't necessarily what gets done. And there isn't even a common understanding of what the right thing is to do, in some cases. I have seen examples of environmental regulation just being purely about political point-scoring and not linked to severity of the problems, and that has really put me off, I guess jaded me.

Helga, a senior environmental manager, reflected on this phenomenon:

> I characterise most environmental professionals as idealists in part but cynics in practice, because they have got to have some optimism or they wouldn't just continue to bump their head against a brick wall, because it is difficult to get environmental improvement implemented.

For many, their experiences in the workplace demonstrated that environmental problems were not so easily remedied. Engineering programs, which focus mainly on technical solutions, may not adequately address the wider institutional barriers to sustainability. Nadia remarked:

> I think I have learned a lot about how complex the issues usually are, there is usually not a straightforward answer, it's usually quite complex (…) When I started studying, everything was black and white, but now there is usually all these shades of grey in between and there are lots of reasons why these things are the way they are.

Some spoke of becoming more aware of the need for trade-offs. Sonya remarked:

> Well I have always been aware of the social and economic impacts and how there is a fine balance between environment, economic and social sitting together and I have come to the realisation that you can't always have the best for all of those categories.

With their focus on technical solutions, engineers may be far less aware of the difficulties of achieving cultural change. Ingrid spoke of coming to the realisation that:

> You can't get people to change by just pointing out to them that what they are doing is causing a whole lot of problems. It doesn't work that way. You have to become a lot more tolerant of alternative viewpoints.

Nadia, who had previously worked in cultural change, had found this type of work very frustrating because of the lack of tangible outcomes. She has since moved into a technical position.

> I really wanted to knuckle down into something with numbers and do (…) something with outcomes and answers, rather than other than grappling with these big fuzzy issues (…) They are really big, (…) complex issues and I don't really feel qualified to work in that area.

Most hoped to see evidence of outcomes. Susan, whose work had included cultural change in a traditional industry noted:

> You work in an organisation and you do internal improvements, and you can measure the change, you know that you've done something good. Like contract procurement, you can measure how many toilet rolls are from sustainable sources. But how do you measure the change in people's attitudes?

It was also suggested that achieving tangible, measurable outcomes was crucial for convincing management (often traditional engineers) to endorse further environmental initiatives.

Nearly half of the participants worked for consultancies; indeed engineering consulting is where many if not most environmental and sustainable energy engineers work. One participant, of senior rank, reported that

she could make a valuable contribution in consulting because she had control. However, a number of the junior participants felt quite frustrated: while acknowledging that they were gaining valuable experience, they felt that they were unable to effect change. Many were adamant that they wanted to see concrete, tangible change as a result of their efforts. Sonya noted:

> I am a bit disenchanted by (…) the amount of government money being wasted on studies (…) I don't I feel as if my job is actually doing anything or changing anything.

Nicola's experience has partly deflated her attitude that engineers can make a difference.

> We just respond to policy and business opportunities and that kind of thing. We are not really shaping the future in any way.

Some were concerned that working in consultancy meant that at times they might have to compromise their values, because they work for clients who are not necessarily environmentally conscious.

For participants working in more traditional companies, the need for support from colleagues was vital. Trying to 'make a difference' is difficult enough, but doing it alone makes it even more so. Some spoke of being in positions where they were isolated and environmental work was not well regarded, and they quickly left. On the other hand, being part of a supportive like-minded team made all the difference. Susan, who worked in a traditional engineering firm, reported:

> In my immediate group was a very surprisingly environmentally conscious and motivated and driven group of environmental specialists, who really wanted to make a difference (…) And we really supported each other strongly. And because of that team (…) we did achieve a lot.

But it was not only the workplace that was shaping their commitment. The two participants with young children spoke of how the time demands of children had changed their thinking: they realised that environmentally friendly behaviour must be made much easier for people. Travel was another factor which raised cultural differences about environmental problems.

Rachel recalled how a visit to a developing country knocked some of the naiveté out of her. Although the country faced massive environmental problems, she saw how people in poverty were much more focused on more immediate matters of survival:

> There is no understanding of environmental issues there. They think you're talking about the landscape.

For others, however, travel strengthened their commitment, as it more clearly demonstrated the severity of environmental problems in developing countries.

Conclusions and recommendations

What lessons then can engineering educators draw from this study?

Many engineering students commencing study with little idea of what engineers do. Thus their time at university is often the first stage in deciding how they want to direct their career in the engineering profession. Even those who have chosen environmental engineering still have little initial understanding of this discipline. Given sufficient exposure to the idea, some engineering students will opt to direct their career towards environmental sustainability.

This suggests that it is not adequate merely to expose students to ideas about environmental sustainability at an elementary level. While all engineers need to have an appreciation of this, there will be some that could be inspired to take these issues much further. Several of the mechanical engineers in this study spoke of a chance event that inspired them and showed them that they could pursue an environmentally related career. Such events should not be left to chance. Opportunities for developing this interest need to be spread throughout the course.

The question of how sustainability issues should be incorporated into traditional engineering programs is of concern to engineering educators: should it be covered comprehensively within its own subjects or should it be integrated throughout the program. The latter is intended to demonstrate that sustainability is important in all aspects of engineering, but risks a more superficial treatment. Most participants thought sustainability

could be integrated into most subjects. However, subjects dealing solely with sustainability are more likely to be taught by someone enthusiastic about the topic. Given the importance of role models in inspiring students, there is a role for such approaches.

Participants emphasised that they were concerned about wanting to see tangible outcomes from their work. This, along with their sense of deflation when they struck the harsh realities of the workplace, suggests that students would benefit from undertaking realistic but achievable projects, which focus not only on technical design, but also on the context. Engineering programs also tend to treat problems as black and white, which does not help student develop skills in critical analysis. Some participants noted that it was not until they entered the workforce or postgraduate study that they learned not to take information at face value.

The next stage of this project will be to focus on mechanical engineering programs and to analyse the effectiveness of educational opportunities related to sustainable energy—how students can be attracted to such opportunities, and what experiences may influence their career choice.

References

Engineers Australia (2003), *The Engineering Profession: A Statistical Overview 2003*, Barton: Engineers Australia.

Engineers Australia, Women in Engineering (2005), *Women in Engineering*, viewed 4 June 2005, http://www.ieaust.org.au/about_us/sig/wie/publications.html.

Faulkner, Wendy (2000), 'The power and the pleasure? A research agenda for "making gender stick" to engineers', *Science, Technology, & Human Values* 25 (1): 87–119.

IEAust=Institution of Engineers Australia (1999), *Manual for the Accreditation of Professional Engineering Programs*, Barton: IEAust.

Mack, Margaret (2001), 'What difference has feminism made to engineering in the twentieth century?', in Angela Crager, Elizabeth Lunbeck, and Londa Schiebinger (Eds.), *Feminism in Twentieth-Century Science, Technology and Medicine*, Chicago: University of Chicago Press.

Tolbert, Margaret and Phyllis Moen (1998), 'Men's and women's definitions of "good" jobs', *Work and Occupations* 25 (2): 168–194.

Wajcman, Judy (1991), *Feminism Confronts Technology*, Cambridge: Polity.

Williams, Philip (2000), 'Environmental engineering: towards the new engineer', Ph.D. Thesis, Griffith University.

Zelezny, Lynnette, Pho-Pheng Chua, and Christina Aldrich (2000), 'Elaborating on gender differences in environmentalism', *Journal of Social Issues* 56 (3): 443–457.