

# Changing the Question Changes the Conversation: Qualitative Research Methods, Ethnography, and the Transformation of Engineering Education

**Catherine Becker**

Cornell University/University of Hawaii, Hilo  
473 Hollister/200 West Kawili Street  
Ithaca, NY 14850/Hilo, HI 96720  
cbb59@cornell.edu/beckerc@hawaii.edu

**Rick Evans**

Cornell University  
Ithaca, NY 14850  
rae27@cornell.edu

This research considers the potential of qualitative methods, particularly ethnography, for the transformation of engineering education and research. Students in a communication-intensive course at a top-ranking engineering program in the United States were put into project teams that were assigned to study the culture of engineering education at their institution. Their initial research proposals used quantitative methods and included attempts to achieve researcher objectivity. Students were then required to write autoethnographies of their experiences in regard to the topics they selected. These statements of researcher subjectivity, followed by a process of peer debriefing, resulted in conversations that encouraged the students to explore the ways that their topic and their experiences intersected. Students then revised their proposals to include qualitative methods. While none of the classroom conversations about the teams' initial proposals were about ethical issues related to collaboration, gender, or diversity, the conversations following the revisions of their proposals did.

To tell one story is to silence others...(Kelley, 1997, p. 51).

## Introduction

In a recent article about the ways that research can contribute to the changes needed in engineering education, Watson (2009) stated that in order to “realize systems to educate the engineers of 2020,” we need to change our “daily conversations and negotiations” (citing Seal, 2000, p. 3). There is a solid body of research that explains why the conversation in engineering education needs changing (National Academy of Engineering, 2005) and how we might go about changing it.

In this study, we explored the ways that qualitative research, specifically certain types of ethnographic research, could be used to intervene in the daily conversations and negotiations of engineering students. We assumed that to in order to change the conversation in engineering education and perhaps eventually, in the broader engineering community, we could begin with engineering students. Consequently, we designed an intervention using ethnography as a critical pedagogy to explore the following research questions:

RQ1: Could engaging students in ethnographic research of the organization in which they are participants change their daily conversations and negotiations about engineering education?

RQ2: Would changing the daily conversations and negotiations of engineering students' potentially change engineering education?

We believe that the answers to these questions could also begin to develop a response to the call for a more explicit discussion about qualitative methods in engineering education research (Borrego, Douglas, & Amelink, 2009). Borrego, Douglas & Amelink (2009) state that research questions in Engineering Education should drive the choice of method. However, we wanted to consider the ways that *method* may drive the questions, and subsequently, the conversation.

## Theoretical Framework

The way that theory is used in qualitative studies requires that the theory emerges from that data so that new concepts may be identified. By using methods drawn from various iterations of qualitative research such as grounded theory (Glaser and Strauss, 1967) and ethnography, engineering education researchers have been able to identify the characteristics of creative engineers (Klukken, 1997), a new type of gender bias (McLoughlin, 2005), the requirements for teaching system design in human computer interaction courses (Cunningham and Jones, 2005), describe the culture of an engineering organization (Kunda, 1992), and integrate students' home culture in mathematics lessons (Ensign, 2006), to cite just a few examples. More recently, engineering education researchers have used even qualitative methods to observe the responses of engineering educators to qualitative methods (Borrego, Douglas & Amelink, 2009). Each of these studies has produced new ways of talking about engineering culture, education, and research thereby changing the conversation. According to Evans and Gabriel (2007) awareness, action (which conversation is) and the ability to critique are characteristics necessary for competence when engaging in engineering performances. In this study, we wanted to describe if and how the conversation and subsequently, the performance, would change as teams of student-researchers used ethnography.

There are a number of types of ethnography, each serving related but slightly different aims. For example, traditional ethnography "attempts to write and inscribe culture" (Denzin 2003: 33). Performance ethnography adds to writing and inscribing, "performing as a method of representation and . . . understanding" (Denzin 2003: 33). Autoethnography "reflexively inserts the researcher's biographical experiences" (Denzin 2003: 33). Critical and reflexive performance ethnography, "dialectically situates the researcher and those he or she studies . . . in a dialogue or exchange" (Denzin 2003: 33). And finally, radical performance ethnography exposes "the ways in which power and ideology shape self, desire, and human consciousness in concrete institutional and interactional sites" (Denzin 2003: 33). All are essentially qualitative. All are a "participatory, collaborative," and even a, "civic" experience in that one *speaks to and with*, rather than *about* some other thing(s) or *for* some other (Denzin 2003: 17). All "emphasize the first-person voice . . . the vulnerability of the observer [and the subject, sometimes one and the same, and] . . . the enactment of meaning" (Bochner and Ellis 2003: 509). They constitute an approach "that . . . blurs the line between researchers and participants, writers and readers, performers and audiences" (Bochner and Ellis 2003: 509). And, all these types of ethnography can be profoundly pedagogical.

Each of these types of ethnography may contribute to changing the conversation in engineering education because each can be used to intervene in the culture of a particular organization and the larger culture within which these conversations take place. Conversations are useful starting point for systemic transformation because they are both influenced by culture, and serve to re-create culture. Furthermore, most scholars of culture agree that culture "is a verb... not a noun, product or static thing" (Denzin, 2003, p. 12). The implication of describing and understanding culture as an action can be seen as a change of the aim of the study of culture – "from cultural invention to intervention" (Conquergood, 1998, p. 31). Consequently, we attempted to use ethnographic methods including interviewing, participant observation, and so on – to intervene in students' conversations in the organization and indeed, the culture of engineering education. We attempted to change their daily conversations and negotiations – and in effect their actions to change the culture of organization that those students' conversations and actions help to create.

## Methodology

During the spring semester of 2009, students were put into project teams and assigned to study the culture of engineering education in the College of Engineering at Cornell University. In spite of being assigned *The Engineer of 2020* (National Academy of Engineering, 2005) and several examples of qualitative research that addressed some the most pressing challenges in engineering education such as the underrepresentation of women and minorities, the need for engineers to function effectively on multidisciplinary teams and deal with ethical issues, all of the teams' initial research proposals avoided all of these issues and avoided using qualitative methods.. All of the teams' original proposals

asked questions that could be answered by *quantitative* methods and included attempts to achieve researcher objectivity. None of their initial proposals asked questions or collected data that would have allowed or enabled them to engage personally in the investigation of the topics they selected..

Following the submission of their initial research proposals, we required the students to write autoethnographies about their experiences in regard to the topics they selected. Autoethnography is a qualitative approach that encourages the observer of a culture to reflect upon their place and performance in the culture (Ellis and Bochner, 2000). Each student was required to write a 3-5 page paper about their personal experience in relation to the topic their team selected. Each student then had ten minutes to discuss their experiences, relate it to theories and concepts from the course, answer questions, and listen to feedback from of their classmates. The students' autoethnographies were used as statements of researcher subjectivity and discussed via a process of peer debriefing. These conversations resulted in thick descriptions of the culture of engineering education that they were immersed in and encouraged the students to explore the ways that their topics and their experiences intersected. Then the students revised their proposals.

We examined the teams' final research project to see how their questions and conversations changed from those that they had when they submitted their initial proposals. In addition, we examined the students' initial and revised research proposals, their autoethnographies, transcripts of class discussions, interviews, the project teams' final research reports and the student's final reflection papers for key concepts (Strauss and Corbin, 1990).

## Findings

We set out to explore the ways that various types of ethnography might contribute to changing the conversation among a group of students in an upper division communication-intensive engineering course. Each of the teams proposed one of following four topics for their research project: Competition/Cooperation, Stress, the Learning-Environment, and Engineering Communication. During the discussions of their autoethnographies, the students' role in the class began to change from the knowledge consumers to knowledge producers, while the instructor's role changed from knowledge producer to information consumer. She spent almost all of the each session transcribing the conversation and acting as time keeper. All eighteen of the students appeared engaged, passionate and highly involved in the conversation. Following the sharing of the autoethnographies, the project teams revised their research proposals. While the *quantitative* research that the students initially proposed using for their final projects did not generate conversations that connected the students personally to the topics of their proposals, the autoethnographies and other *qualitative* research did. The students' conversation transformed from discussing how to get participants in the college of engineering to answer their survey questions to passionate discussions about their experiences related to teams, gender, diversity, and the ability to communicate effectively in engineering.

The ***Competition/Cooperation Team*** examined issues related to working on engineering projects individually or on teams. Their original proposal suggested sending out a survey gauging the frequency of project team participation in the college and the students' preferences. Their revised study included holding a focus group so that students could speak freely about their experiences and their attitudes regarding collaboration. The focus group was transcribed and analyzed for key themes. The project team identified three themes that they then used to develop survey questions: 1) Students and professors had different preferences for working independently verses working collaboratively; 2) student's struggled to maintain the Academic Code of Integrity while engaging in team projects; and 3) students described a tension between collaboration with peers while competing for grades. The project team then developed new survey questions that attempted to learn more about these concepts among students in the engineering college. Additionally, the project team conducted face to face interviews with five professors who had reputations for being quite different in their policies concerning independent verses collaborative work.

The survey results indicated that there are two major driving factors that encourage students to prefer collaboration: 1) efficiency; 2) learning increases through discussing material with peers. There are three factors that encourage students to prefer to work individually: 1) Fear of violating the Academic

Code of Integrity 2) the belief that course materials are learned more thoroughly when working alone, and, 3) concerns that providing assistance to peers impacts one's academic standing. However, only 4% of the respondents (N=50) indicated that they preferred to work individually. One other conclusion that the students made from their study was, that there is an inherent lack of communication between professors and students regarding the motivation for policies for or against collaboration and that students need more clarity about implications of collaboration in regard to the Academic Code of Integrity and their class standing.

The ***Stress Team*** proposed a follow-up study to a 2005 College Committee on the Evaluation of the Student Experience survey that attempted to gauge engineering student stress as it related to study habits, sleep, health, and coping mechanisms. In the 2005 internal study of the Cornell College of Engineering 48.4% and 62.1% of females reported that the engineering course load was "very" or "extremely" stressful. Additionally, Asian and underrepresented minority students reported significantly higher levels of stress than International and domestic white students (N=938, 35.5% of the number of students in the engineering college).

However, in spite of these results and the questions that they raise that could be illuminated by qualitative research, the project team's initial proposal and revised study did not explore them. Instead the team focused their study on a survey comparing stress levels of engineering students with that of student's in other colleges and used qualitative methods (interviewing) to better understand sources of student stress (curriculum or extra curricular activities). The survey was sent to 500 students with a response rate of 29%. The students did not examine the data set for ethnic differences. They did look at differences across genders and their results indicated that females in other colleges also reported more stress than males and that females reported a lower average score (6 verses 9 on a 10 point scale) for coping with stress. The project team followed the survey with ten face to face follow up interviews to better understand the results of these surveys. What is striking about these results is that the team's interview questions as well as final report ignored the gender differences completely when reporting the results of their study. Rather, they concluded that stress was a function of: 1) age 2) curricular verse extracurricular sources and, 3) different coping abilities; 4) timing of stressful events.

The ***Learning-Environment Team*** set out to study how the environment affects engineering students' efficiency and productivity. The initial proposal was a Quasi-Hawthorne (Mayo, 1949) replication. The team members proposed to observe students studying in environments with varying levels of light and noise. Their revision suggested interviewing one another and ten other engineering students across several eight of the college's majors about their preferred learning environment. They also proposed participant-observations in three different popular engineering study areas. The team reported they were surprised to discover that their main finding was that engineering students displayed territoriality regarding their study areas. The team hypothesised this territoriality was related to the engineering students' need for control. They defend their hypothesis by quoting a critical theory concept discussed in the text, "The macro perspective sees individuals as being molded, controlled, ordered and constrained by society and by social institutions. In contrast, "the micro perspective sees the individual as creating society and its social systems" (Eisenberg and Goodall, 2007, p. 35). The student's report elaborates on this tension between the individual and society:

This dichotomy exists in the engineering world as well...students expressed a need for exclusivity, paralleled with a desire for bonding and a formation of a collective-identity based on their major. Students' sense of belonging is developed within the engineering quad, so often that they admit to preferring that only people from their own major share the facilities. Many reported feeling territorial of their respective engineering buildings and laboratories, which ultimately furthers our notion that students have a basic need for exclusivity and a collective identity. Additionally, our research uncovered the significance of Duffield and its influence on communication and collaboration within the engineering community. This spacious environment brings different engineering majors together within the engineering college community. It is a contrast to the students' constant battle for control and belonging within a constrained environment, from symbols of structure including authoritative professors, one-way information flows, and linear classroom arrangements.

Fortunately, Duffield is one place where we can exercise power, rebuild ourselves through collaboration and voice our opinions and have them heard.

### ***The Engineering Communication Team***

The Engineering Communication Team initially set out to study the integration of communication within the curricula of various engineering majors and how this integration affects students' communication abilities and their preparedness for the work force. They initially planned a survey of students and alumni about the technical writing and public speaking skills that they had obtained and how they obtained them. However, after the first face to face interview with a faculty member from the Engineering Communications Program, the team members' revised their questions. Rather than conduct a survey, they decided to interview one another, graduating engineering seniors, and alumni. The team concludes their study as follows:

We learned that many employers and students erroneously believe that communication is a thing, a skill, and that once you learn it you can use it anywhere. Instead, we discovered that communication is not a skill, it's a performance that you can be skilled at if you understand how communication works in a particular context for a particular goal. This idea was amplified by an alumni participant who said:

My education failed miserably in respect to communication. I only acquired the fundamentals of the subject and technical jargon of engineering, but I was not at all prepared to communicate effectively in the workplace. Communication requirements at work go far beyond technical requirements.

Another engineering alumni elaborated, "In every interview I've ever had, I have been asked how I work in groups and handle conflicts." The engineering communication faculty member explained:

In engineering math courses students learn complex formulas not because the specific formula will be necessarily used later, but because the familiarity with the core concepts will allow them to apply their focused mathematical knowledge to diverse problems. It is the same with communication theories that allow students to apply their knowledge to communicate effectively in a diverse world.

### **The Five Concepts**

By analysing the class discussion transcripts, teams' research proposals and reports, autoethnographies and the student's final reflection papers we identified five concepts that can be related to the changing the conversation and negotiations in engineering education.. Qualitative research: 1) provided a voice for multiple perspectives; 2) revealed paradoxes and ironies; 3) encouraged the articulation of new questions; 4) encouraged the performance of new cultural scripts; and, 5) illuminated resistance to alternative perspectives/methods. We conclude this paper by presenting archetypical conversations that illustrate each of these and by discussing implications for engineering education. And while these changes do not correspond neatly with the topics that each team set out to study, we believe that they do represent "discoveries" that had a transformative impact.

#### **1) Qualitative Research Provided a Voice for Multiple Perspectives**

Female Student A: (reading from a transcript): We need a different kind of project team competition. I participated on one of them last year and every time I suggested something, the guys just shot my ideas down, like I didn't know what I was talking about. Then they assigned me all the soft jobs, like making the power points and cleaning the shop. I got really pissed, ya know, they are treating me like I am their bitch, instead of as another engineer. Well ya know, I am nobody's bitch.

Male Student: I feel surprised hearing this. I mean come on, I thought, that sexism thing went out a long time ago. I mean come on, we are all engineers here.

Female Student B: No way, I worked for a large government agency last year. No offense, but most of the engineers and scientists are old white men in their 70s. They called me, “darling,” and “honey” and treated me like I don’t know anything. It was hard to be taken seriously as engineer. Then my supervisor kept telling me that he “liked” me. I kept trying to believe that he was just trying to be nice, but I was uncomfortable all of the time. But I didn’t want to say anything; that would have been even worse. I didn’t want to hurt his feelings; he’s from the old school. It was incredibly stressful and I didn’t know what to do.

## **2) Qualitative Research Reveals Paradoxes and Ironies**

Student: I interviewed this professor who has a reputation for failing students if he finds out that they have collaborated on projects. I wanted to understand why he had this policy.

Professor: What happened?

Student: Well, I went in there with a set of beliefs about project teams, mainly, that they are good and important for engineering students to participate on.

Professor: And?

Student: When I left his office, after the interview, I did a complete 180. I mean he completely turned me around, now I am going to be reluctant to ever participate in project teams again

Professor: Sounds like your collaboration with that professor changed your perspective on collaboration.

## **3) Qualitative Research Encourages the Articulation of New Questions and Conversations**

Student: I went in all ready to interview this professor [about communication]. I thought I knew what he’d say and I had my list of questions ready.

Professor: What happened?

Student: Well, I asked him the first question and he went off for an hour and half. He never answered any of my questions, and that was fine, cause they really didn’t even make sense anymore.

## **4) Qualitative Research Encourages the Performance of New Cultural Scripts.**

For the first time in my life, I was exposed to the issue of sexual harassment in workplace. When one of my classmate’s described sexual discrimination at her work place, my group members had nothing but fierce condemnation for the incidents. However, I felt apathetic. Years of conditioning via Asian values had made me regard issues of discrimination in the workplace as being a trivial matter that only hindered productivity. I had a similar response when one of my other female class members recounted her experience being harassed at her internship. Most of the women in the class were shocked at the incident. I was shocked as well, but not by the incident per se, but rather by the furious reaction of the class, as such incidents are commonplace in Asia.

I recalled when I was interning for an American company, which had issued a company-wide memo directing all managers to brief their teams on sexual harassment. One of the supervisors summoned his entire team to the meeting room and started the presentation by stating that the memo was issued by the higher-ups in American and that it was relevant only in “liberal America” and that teams in “conservative Asia” functioned differently and would not be held to the same standard. He then put his hand on a female employee’s back, joking that his action was not considered sexual harassment. However, I have started to question this assumption, and the sexual innuendos that are commonly used in Asian and the

practice of referring to some of my female colleagues as “pretty face” rather than their names. I recalled the reading that stated, those who do not “perform their gender correctly are routinely punished.” I realized that absence of complaints does not make it acceptable, and that silence may be a function to remind congruent within one’s culture.

## **5) Qualitative Research Illuminates Resistance to Alternative Perspectives/Methods**

### **Resistance to Considering Gender Discrimination in Engineering**

Professor: I have read studies that indicate that women make an average of .71 dollars for every dollar that men make for doing the same work; in engineering it .80-90.

Male Student 1: Yeah but that’s because some women choose to have children and leave the workforce. There they don’t have as much consistent workplace experience as men.

Male Student 2: I know this isn’t politically correct, but, if you look at it purely from an economic point of view, well, it’s more economically viable to pay women less.

### **Resistance to Considering Issues Related to Underrepresented Minorities in Engineering**

Professor: Have you considered looking at your data for patterns that might differ across ethnicities and/or genders?

Student 1: You really don’t think that there would be any do you?

Professor: Well, I don’t know, but based on the articles we read, it might be worth exploring.

Student 2: We tried to find out if minorities in my company were happy or not. The goal wasn’t really to look at the benefits of diversity; it was about our external image. We never looked to see if the minorities in our organization were being heard or influencing decisions.

Student 1: Oh, diversity, smirity. This university says it celebrates diversity in its mission statement. Ya know, when you come through the gate there is that sign, “Open hearts, open minds.” Open hearts, open minds, give me a break. The mission ends there at the entry way. Once you come in, there isn’t anything being done to foster or celebrate diversity. We all just stay with in our own little groups.

### **Resistance to Class Disparities in Engineering Education**

Student A: Swim team has taught me more leadership skills than any class.

Student B: Swim team? I almost didn’t come to this school because of the swim test. I don’t know to how swim and don’t have time to learn. I am taking 24 credits a semester so I can graduate ASAP. My mom is working at Wal-Mart to support me. Silence. Students shift uncomfortably in their seats.

### **Resistance to Qualitative Research**

In their final reflection papers about what they learned in the course, more than half of the students’ mentioned that at the start of the semester they didn’t believe that they would learn anything from the course or the research project. Eventually all of them changed this opinion; however some struggled with it:

Student: I did the second interview last night, and man, I have to say, well—things didn’t go as I expected.

Professor: What happened?

Student: Well I started out asking the questions that we prepared and thinking that I had a pretty good idea of what the answers were going to be....Boy, was I surprised. Her answers weren’t anything like I expected. After that interview our group had to get together and completely revise our questions.

Professor: Did that convince you of the potential of qualitative methods?

Student: No. Nothing short of earth-shattering would ever convince me of that.

## Conclusions

The first research question we set out to answer was: Could engaging students in ethnographic research of the organization in which they are participants in change their daily conversations and negotiations about engineering education? Clearly from the conversation themes we identified above, the answer is yes. However, just because the conversations changed does not mean that they always changed in the ways that we might prefer. For example, consider the inability of the Stress Team to address the results of their research that suggested obvious differences among the stress levels of women and underrepresented minorities. Instead, they focused their discussion of the results of their research on more general stress factors. Still, if we look at the conversations in the class as a whole, we can definitely conclude that the daily conversations and negotiations did change.

In the second research question we asked, “Could changing the daily conversations and negotiations of engineering students’ potentially change engineering education?” While this question cannot as easily be answered yes or no, we do believe that we have learned some valuable lessons from the experiences of our students.

First, in whatever approach we take to researching engineering education and thereby to changing our own daily conversations and negotiations, we know that we must make room for our own and others’ *personal* experience. When the students began listening to themselves, to each other, and to the entire range of their research subjects/participants, they began to recognize that the stories of those experiences” may serve not only as legitimate data, but also as evidence for taking a position on some of our most critical issues. For example, the experiences of the two female engineering students, one in a project team and the other in a government agency, serve to explain why engineering is having trouble attracting and keeping women as engineers. Furthermore, the Asian male engineer described the additional cross-cultural complexity to formulating a response, as he acknowledged through his own experience, culture(s) can exert power to suppress and thereby deny the experience of others.

Second, in whatever approach to research that we take, we know that we need to appreciate the genuine complexities of what we are working so hard to change. The students, for example, began to recognize that organizations have cultures that contain multiple ideologies, systems of values and beliefs that find expression in the practices and daily conversations of the members of those organizations/cultures. And they discovered that sometimes these ideologies are even contradictory. For example, while ABET (Accreditation Board for Engineering and Technology) lists as one of its most important outcomes “an ability to function on multi-disciplinary teams,” professors continue to fail students for collaborating on projects and students avoid opportunities for collaboration and cooperation with their peers for fear that they might violate the Code of Academic Integrity. Or, consider another example, the potential contradiction that exists in the requirement that to graduate from Cornell students must pass a swim test and Cornell’s mission to promote diversity. The policy presumes a certain cultural and class background that is either uninformed about or inconsiderate of other cultures, other classes. Even, the finding that some students were not able to identify practices that reflect a commitment to diversity “once you come in” also suggests the possibility (maybe even the actuality) of a contradictory system of values and practices. Finally, that students articulated possible explanations for contradictions between values and practices – “some women choose to have children and leave the workforce and therefore are less qualified than their male counterparts” or “it’s more economically viable to pay women less” – suggests that addressing conflict between expressed values and actual practices is and will continue to be complex. In order to change our daily conversations and negotiations, we need, like our students, to be able to locate and understand not only these multiple ideologies, practices, and the related complexities that in fact might slow change or actually work against change.

Third, just as our students began to recognize that there are many ways to see, understand, and talk about what is going on around them, we need to invite, indeed open ourselves to new ways of seeing and understanding – new and alternative ways of conducting research. There was a student who



realized the biases inherent in both qualitative and quantitative research and that, in order to hear as well as tell a different story; one might need to employ both ways of seeing and understanding. He wrote:

When my group first started to work on the research project, I can definitely say I was not a believer in qualitative research. As an engineer, I have taken many science and engineering courses, all which emphasize the scientific method and the need for objectivity. I have been told countless times, by teachers and professors alike, that the use of personal pronouns should be avoided in technical reports and paper, and that I should stick to the facts and shy away from injecting my own opinions. Thus, qualitative methods contradicted many of the beliefs I had held about what research should be like. I believed that qualitative research was not research at all, because it relies on opinions and stories of people, rather than numbers and graphs, which cannot lie. My other team members felt the same. However, we decided to include a few open ended questions at the end of our survey and that led to some interesting and surprising results. The thing that helped us understand our topic even more, were the follow up interviews. After doing the project, I realized that quantitative research can be as biased as qualitative research, in that it only tells part of the story.

Maybe the changed daily conversations and negotiations of our students can change engineering education – but only if we are able to listen to them.

## References

- Borrego, M., Douglas, E.P. & Amelink, C.T. (2009). Quantitative, qualitative, and mixed research methods in engineering education. *Journal of Engineering Education* 98, (1): 53-66.
- Cunningham, S. and Jones, M. (2005). Autoethnography: a tool for practice and education. Proceedings of the 6<sup>th</sup> ACM SIGCHI New Zealand chapter's international conference on Computer-human interaction: making CHI natural. Auckland, New Zealand: *ACM International Conference Proceeding Series* 94: 1-8.
- Eisenberg, E. and Goodall, H.L. (2007). *Organizational Communication: Balancing Creativity and Constraint*, 5<sup>th</sup> Ed. Boston: Bedford/St. Martins.
- Ellis, C. and Bochner, A. P. (2000). Autoethnography, personal narrative, reflexivity: Researcher as subject, in Denzin, N. and Lincoln, Y. (Eds.) *The handbook of qualitative research*. Thousand Oaks, CA: Sage: 733-768.
- Ensign, J. (2006). Helping teachers use student's home culture in mathematics lessons. In Rodriguez, A. & Kitchner, R. (Eds). *Preparing Prospective Mathematics and Science Teachers to Teach for Diversity: Promising Strategies for Transformative Action*. New Jersey: Lawrence Erlbaum Associates.
- Evans, R. and Gabriel, J. (2007). "Performing engineering: How the performance metaphor for engineering can transform communications teaching and learning." Paper presented at the 37th ASEE/IEEE Frontiers in Education Conference.
- Freire, P. (1970). *Pedagogy of the Oppressed*. New York: Continuum Press.
- Glaser, B. G., & Strauss, A. L. (1967). *The Discovery of Grounded Theory: Strategies for Qualitative Research*. New York: Aldine Publishing Company.
- Kelley, U.A. (1997). *Schooling Desire*. Routledge: New York.
- Klukken, P.G., Parsons, J.R., Columbus, P.J. (1997). The creative experience in engineering practice: Implications for engineering education. *Journal of Engineering Education* 86 (2): 133-38.
- Kunda, G. (1992). *Engineering Culture*. Philadelphia: Temple University Press.
- Mayo, E. (1949). *Hawthorne and the Western Electric Company, The Social Problems of an Industrial Civilisation*, Routledge: New York.
- McLoughlin, L.A. 2005. Spotlighting: Emergent gender bias in undergraduate engineering education. *Journal of Engineering Education* 84 (2): 373-381.
- National Academy of Engineering (2005). *The Engineering of 2020*. Washington, D.C.: National Academies Press.
- Seal (2000). Culture and complexity: New insights on organizational change. *Organizations and People* 7 (2): 2-9.
- Strauss, A., & Corbin, J. (1990). *Basics of Qualitative Research: Grounded Theory, Procedures and Techniques*. Newbury Park, Ca: Sage Publications
- Watson K. (2009). Change in engineering education: Where does research fit? *Journal of Engineering Education* 98 (1): 3-4.

## **Copyright statement**

Copyright © 2009 Authors listed on page 1: The authors assign to the REES organisers and educational non-profit institutions a non-exclusive licence to use this document for personal use and in courses of instruction provided that the article is used in full and this copyright statement is reproduced. The authors also grant a non-exclusive licence to REES to publish this document in full on the World Wide Web (prime sites and mirrors) on CD-ROM and in printed form within the REES 2009 conference proceedings. Any other usage is prohibited without the express permission of the authors.