Transitions in Learning and Identity In Faculties of Engineering: 
Doctoral Women Engineers’ Perspectives

Abstract
Women face many obstacles in their academic careers but there is a gap in the research with regards to their perceptions of science and engineering education and how participation or non-participation in the culture of engineering affects their identities. Moreover, little research has been conducted with female PhD students especially with regards to the reasons they have continued their studies, and their level of satisfaction with their career and lives. This naturalistic qualitative inquiry was guided by the sociocultural approach and theories of learning and identity. By examining the path of becoming a doctoral woman engineer, this study makes the educational experiences of women intelligible to the general public as well as policy makers. It gives voice to the women engineers whose perspectives are rarely heard in academic settings or mainstream society.

Introduction
Women face many obstacles in their academic careers but there is a gap in the research with regards to their perceptions of science and engineering education and how participation or non-participation in the culture of engineering affects their identities. Moreover, little research has been conducted with female PhD students especially with regards to the reasons they have continued their studies, and their level of satisfaction with their career and lives.

The Canadian Council of Professional Engineers (CCPE: 2000) reports 15 per cent of doctoral students enrolled in engineering to be women. These results have improved in the last decade although the actual numbers are still small. “Programs at the graduate level merit special attention because graduate education is tied, directly and indirectly, to subsequent professional participation and performance in the field (Fox, 1996), and thus the graduate level is a critical stage for programmatic initiatives” (Fox, 1998, p. 201).

In Canadian universities “at the doctoral level, the top three disciplines were chemical, civil, and electrical engineering. All three disciplines registered increases in numbers in 1999 compared to 1998, with electrical showing the largest increase” (Martinson, 2001, p.15). According to the CCPE (2000), the overall total number of doctoral degrees awarded is now at its’ lowest during this last four year period (1996-2000). While the total number of doctoral degrees awarded to women in engineering has increased to 85 in 1999 and a lower number of 72 in 2000. Recruitment and retention programs for women, in Canada and abroad, have attempted to address these disparities at all program levels (Emerson, Williams, & Kieley, 2002; Fox, 2003; Frize, 2002; Gibney, 1998; Male, Lawrance, & Dias, 2002; Rinehart & Watson, 2002; Rosser, 2001; Wood, 2002).
The scope of this paper will address the following research questions: 1) What are the perceptions of doctoral women engineers related to participation and learning in faculties of engineering? 2) How do the female PhD students’ participation or non-participation in engineering affect their identities?

**Method**

This study was guided by the sociocultural approach and theories of learning and identity. Mishler’s (1999) life history narratives were used to examine how sociocultural influences affect doctoral women’s choices to participate in engineering/science. The narratives obtained from two open-ended interviews with seven doctoral women engineers, at various stages in their programs, were the primary source of data. The participants were enrolled in doctoral electrical or mechanical engineering programs at various Canadian universities. Electrical engineering programs vary from university to university and may include traditional areas as well as the newer computers systems programs. In a similar vein, mechanical engineering programs have evolved to include new subdivisions such as biomechanical engineering.

Methodologically, the design adopted is a naturalistic qualitative inquiry using two open-ended interviews with participant verification after the first interview. In this way, the transcripts of the co-constructed narrative were reflected upon to better illustrate the participants’ stories. In addition, the second interview allowed the participants to further elaborate upon the co-constructed stories and perspectives discussed.

More specifically, Mishler’s (1999) case-centered research is an approach with distinctive features that requires individual trajectories of change or transition to be retained through all stages of analysis. “Findings, therefore, do not refer to measures of variables aggregated across groups of individuals but to similarities and differences among intra-individual or intra-case patterns of change” (Mishler, 1999, p.11). The collective voices of my participants were used to, in the end, develop typologies to exemplify both similarity and difference within this unique population. This is supported by Mishler (1999) who posits “rather than suppressing the variability among my respondents in how they achieved their adult identities, this approach retains and respects their differences and addresses them within a comparative framework” (p.11). This attention to studying diversity and change in lives and locating participants within the social and cultural matrix is a “step toward a relational conception of identity that contrasts with a view of identity as immanent or indwelling within a person, stable or consistent, carried into and expressed across situations” (Mishler, 1999, p.16).

The life history narratives, from the participants’ perspectives, help explain how they have come to be doctoral engineering students, what paths they have chosen, and how their relationships influenced these choices.

From this perspective, our identities are defined and expressed through the ways we position ourselves vis-à-vis others along the several dimensions that constitute our networks of relationships. Emphasis shifts from inner
conflicts and their resolutions to the social production of our multiple sub-identities and the dynamics of their relationships. And this, in turn, shifts our attention in theory and research from the assessment of ‘personality’ variables to the study of forms and contexts of discursive genres, such as personal narratives and life stories, within which identities are produced and performed (Mishler, 1999, p.17).

In summary, my objective was to obtain thick descriptive data, stories composed by the doctoral women to tell me who they are and who they would like to become.

**Results**

The tensions of participating in social communities contained both ‘affordances’, (that is, positive aspects) and negative instances called ‘constraints’ (Wertsch, 2002). In some instances, participants chose a more neutral position in recounting their experiences. Verbal explanations or ‘texts’ were learned during their participation in the culture of engineering, and then appropriated. The texts or accounts that were considered personally useful for the doctoral engineers were used as a way of making sense of ‘who they are’ or ‘who they are becoming.’ Moreover, not all participants fully appropriated what they learned; in some cases it may not be relevant to ‘who’ they are or the identity they wish to adopt. This is referred to as resistance and is thought to be the opposite of appropriation (Wertsch, 2002).

**Participation and Learning**

The practices that best promoted participation and learning were multi-faceted, that is, both affordances and constraints were intertwined in the same learning setting. Engineering pedagogy was deemed salient when it offered flexibility in the structure of lessons/curriculum, and in the type of projects. The women viewed positive learning strategies as those that were student-centered, practical, and related to real world problems. Other favorable conditions were that of research group collaboration and interdisciplinary perspectives on learning. Participating within the group community was necessary in order for the assignment or the doctoral research to be completed. Some workspaces were more conducive to participation and learning, especially those that were female-dominated. The ‘relational activity’ of women engineers must be valued and more encouraged amongst all the members of the group in order to improve learning.

The constraints associated with participation and learning were first centered on doctoral advisors’ overall treatment of graduate students, that is, putting their research agenda above the welfare of their graduate students, not giving sufficient guidance, using the students’ ideas, not guiding teaching assistants in the running of a course, and taking advantage of their services. Professors were also criticized for their teaching, especially their pedagogical skills and understanding of principles of teaching. They were also criticized for not making themselves available to their graduate students for guidance or feedback. Some participants also perceived the poor teaching of their professors to be
related to lack of effort. Because science and engineering pedagogy is based on a foundation of epistemologically unexamined traditions, the ‘lecture-only pedagogy’ tends to remain the rule. Similarly, if pedagogical changes are implemented, the implementation seldom agrees with the epistemological intentions—perhaps making the learning situation worse. Another constraint recounted by the participants was their experience of negative treatment and exclusion by peers. The complex interplay between similarities and difference impeded learning for the women engineering students relative to their gender and ‘other differences’ in the group. The learning styles, the motivation, and the level of ability of each group member intensified the group dynamic either in a positive or negative way, exemplifying sameness or difference. Moreover, how tasks were assigned within groups was often based on stereotypical sex-roles as well as the women’s perceived level of competence.

**Participation and Identities**

Some of the doctoral women viewed their overall participation in engineering education as positive, others remained more neutral in their descriptions, and yet still other women recounted many negative facets of their treatment that has left them unsure of themselves in relation to their occupational choices. The affordances that some women spoke of were related to having a mentor and role model, and the ways these positive experiences inspired them to influence other women in science and engineering fields.

The notion of being a “real” engineer was a constraint for those women coming to the doctoral program from other disciplines of science. They were reminded through direct statements and behaviors that they had not passed the ‘competence testing’ of the undergraduate program, and therefore could not call themselves engineers. Even for those women who completed a B.Eng., not all identified with the engineering label. Nevertheless, those who came to the doctoral program with a B.Eng. had the ability to choose more freely how they defined themselves. Other doctoral women appropriated the labels given to them that often impeded their expressions of identity. Merging expectations from the culture of engineering with other aspects of their lives and identities can be viewed as a barrier for the women. Doctoral engineers appropriated and resisted societal expectations to fulfill their educational needs on the one hand, and relationships on the other hand. In the academic setting, negotiating the many roles of a doctoral student often collided with the expectations of advisors and male peers. Finally, as an after-thought many participants experienced more personal aspects of their identities, and these complemented or conflicted with their future career goals.

In summary, the stories of participation and learning in engineering programs were ambivalent, since the learning environment was seen in both a positive and negative light. Student-centered learning was enjoyed as a positive aspect of learning, while doctoral advisors were mostly viewed in a negative light. The engineers’ affiliation with the profession of engineering, in both the faculties of engineering and the workplace, was definitely seen as a constraint for the women and other people of ‘difference.’ The women’s participation, and in some cases non-participation, very much affected how they appropriated and resisted labels given to them, as well as how they spoke of themselves. The doctoral participants can be seen as a ‘work under construction’; they are constantly
reinventing their ‘selves’ as there is no single model for becoming a woman doctoral engineer.

The multiple transitions and negotiations involved in undergraduate and graduate programs of engineering, and the variety of contextual learning environments inherent in each, make it impossible to generalize specific best practices. Moreover, because of the low number of women in doctoral mechanical and electrical engineering programs in Canada, it was essential to keep their identifying information confidential. After the Montreal Massacre (1989), identification of women engineers has been given careful consideration. A compromise was reached in displaying the data that encompassed similarities and differences of doctoral women’s transitions across the public school system, undergraduate, masters, and doctoral programs of engineering.

**Composite Sketches: Becoming**

From the narrative life histories of my participants (that is, the story of how they have come to be doctoral women in engineering) three composite sketches were developed to illustrate their experiences. Although there are probably other routes, these three were based on similarities and differences reported by the doctoral participants. These combinations of individual identities also help to preserve confidentiality; yet still it allows for a ‘picture’ of who these women have become. The following sketches of doctoral engineering women describe in point form the Optimistic, Conflicted, and Reconciled identities of the participants.

- **Optimistic**
  - Whatever choices made in school/career, were supported by her parents
  - Somehow, her science interest was nurtured in school and at home
  - Younger participants
  - Completed engineering programs consecutively
  - Has little or no work experience
  - Have in past or are currently dating engineers
  - Have had positive experiences with mentors

- **Conflicted**
  - Choice of interests and schools not supported by both or either parents
  - Gender/sex differences felt
  - Considered leaving engineering or not sure how to find a work environment that suits her
  - Negative experiences in engineering program, academia, and/or industry
  - Difficulty with dating relationships somehow related to engineering/PhD culture
Reconciled
- Supportive parents but neither are engineers (mothers were housewives, fathers were professionals)
- Special schools or programs
- Recognized or experienced negative treatment in industry
- Academia may be the only place to pursue their type of research
- Settled/committed personal life
- Significant others are engineers or a related occupation

Conclusion
This study has provided a preliminary account of the relationship between choice of engineering education, and the retention and success of women in the profession as influenced by deeply interrelated multiple factors, such as (a) the nature of the participation and learning opportunities, namely the pedagogical practices and ‘inclusionary’ measures adopted by faculties of engineering, and (b) the identities performed, namely their ability to adapt and become who they needed to be to get the job done.

Recommendations
Since engineering education was the focus of this study, recommendations for change will begin here. Faculties should examine epistemologically how science is constructed and taught, and how a change in this view can assist professors to teach in ways to encourage learning and participation, especially for engineering students of ‘difference.’ Since professors’ teaching was viewed as a hindrance, offering workshops as part of their teaching workload to pedagogically improve content, delivery, and evaluation of courses would be a starting point on the continuum of change. Appointing a committed working group of professors to investigate a holistic student-centered program, such as mechanical engineering at the University of Sherbrooke, is another salient recommendation. An important consideration when designing courses and lessons for the classroom is not to use ‘binary logic’ or simply use a ‘taxonomy of difference,’ that is, insert a cultural component into the current curriculum that isolates the ‘essences’ of various culture. This insertion could misrepresent foreign cultures and reinforce stereotypes, constructing students of ‘difference’ as ‘Other’ (Guest, 2002).

More specifically for faculties of engineering, structural barriers and policy procedures need to be examined. The doctoral women perceived their advisors as a barrier to their timely and successful progression through the PhD program. Doctoral candidates positive relationships with their advisors is of paramount importance (Cooper & Stevens, 2002; Crude, 2001; Fox, 2000; Wood, 2003). Faculties of engineering need to develop explicit expectations as to what constitutes adequate PhD research, dissertations, and doctoral experiences. In other words, faculties need to mandate explicitly the preparation of doctoral candidates. This could minimally include listing basic criteria needed to complete the PhD, specific timelines for student-progression along the PhD continuum,
and ways to encourage and assist with conference presentations and publication of articles. Moreover, advisors should receive training from the faculty/university on how to ‘become’ an advisor. Areas to be addressed are guidance strategies, examining and improving interactional styles, how to train RA and TAs, and examining the perceptions of the role of advisors, that is, challenging the new advisors’ previous beliefs and assumptions. Graduate exit surveys could be employed, similar to current teaching evaluations, to help shed some insight on what the advisors are doing well and what needs improvement. As Rosser (1998) has suggested, multi-perspective approaches to increasing enrolment and retention of women in engineering are more effective and in keeping with addressing notions of ‘difference’ in engineering populations.

References


