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Extended Abstract

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Gender and Educational Codes in Mechanical Engineering and Materials Science: An Ethnographic Approach

1. CONTEXT:

In Switzerland – as in most Western countries – engineering remains an area of higher education with persistently low levels of female enrollment, although female representation varies significantly along disciplinary lines. The need for an increase in women's participation in these male dominated areas has widely been recognized by now. Yet, in order to achieve change, the emphasis is usually put on the promotion of female students, thereby imposing the burden of degendering on women only. Such an approach, however, fails to aknowledge the gendered character of engineering cultures themselves.
In the last few years, scholars in the field of Science and Technology Studies (STS) have shifted attention away from women and their difficulties in engineering and focused on the analysis of engineering cultures themselves pointing at their gendered characteristics (Faulkner 2000a; 2000b; 2007; Gilbert et al. 2006; Henwood 1998; 2000; Henwood & Miller 2001; Lohan & Faulkner 2004; Mellström 1995; 2004; Paulitz 2006). This strand of research in the field of gender and engineering addresses the way in which practices and identities in engineering cultures are linked to specific forms of masculinity (Connell 1987; Lohan & Faulkner 2004).

2. RESEARCH QUESTIONS:

In this line of thought, my present research focuses on the academic culture of specific engineering disciplines and analyzes their gendered and potentially gendering aspects. The questions investigated are the following: To what extent are social and epistemic practices and identities in engineering disciplines gendered and/or gendering? And how do different disciplinary contexts contribute to the gendering of practices and identities?
The research adopts a comparative approach drawing on ethnographic case studies in two engineering departments at a technical university in Switzerland: Mechanical engineering on the one hand, a discipline with a long-standing tradition that continues to resist feminization; materials science on the other hand, a relatively new discipline that has attracted a rising proportion of women in the last decade. This small contrast within the field of engineering suggests that there might be relevant differences in cultural practices and identities between the two disciplines. Moreover it raises the question of the patterns underlying the practices and identities in each field and the ways these might (or not) be interrelated with patterns of masculinity.
This paper focuses on engineering education as a specific aspect of academic cultures in engineering. In particular, it addresses the way beginners are initiated into their respective subject matter, assuming that key features of the disciplinary culture are enacted and implicitly transmitted in the first hours of the introductory courses.

3. THEORETICAL FRAMEWORK:

The overall frame of the research draws on Bourdieu's theory of the scientific field (Bourdieu 1976) in order to define the structural position of each discipline in the field. The relative autonomy of a discipline depends on its ability to refract demands from outside and varies between different types of disciplines. Historically, namely in the German speaking parts of Europe, engineers had to struggle for the recognition of their field as a scientific discipline and its integration into academy. The institutionalization of engineering disciplines in higher education by the end of the 19th century occurred with reference to a professional field outside science. As a result, up to the present, engineering disciplines maintain a contradictory relation to the scientific field.

With regard to the controversial relation between engineering and science, mechanical engineering is clearly positioned on the engineering pole, with a historically strong link to national machine industry and the concomitant professional field. Its traditional position and boundaries, however, have been threatened by recent developments. Materials science, on the other hand, is clearly positioned closer to the science pole then mechanical engineering; this new discipline, in turn, tends to challenge traditional disciplinary boundaries (Gieryn 1995).

In particular, with regard to the issue of engineering education, I draw on Bernstein's typology of educational codes, namely on his distinction between *collection codes* and *integrated codes* (Bernstein 1975)[1]. Bernstein is interested in the way educational knowledge is transmitted and he assumes that the structure of knowledge transmission regulates the experience and forms the identity of students. In his typology, the *collection code* type of educational knowledge is characterized by a strong classification of knowlegde contents, which implies strong boundary maintainance. This type can be further divided into subtypes which vary in the relative strength of their classification and frame, the major distinction being between specialized and non-specialized collection code. On the other hand, declassification of knowlegde gives rise to the *integrated code* type of educational knowlegde. Integration refers "to the subordination of previously insulated subjects or courses to some relational idea, which blurs the boundaries between the subjects" (op. cit., p. 93).

If we apply this typology of educational codes to the field of higher education, engineering knowledge, in general, must be considered a collection code type of knowledge with strong classification and frame. However, engineering sciences might differ according to the degree of specialization of the knowledge transmitted, or even – when we consider varieties of specialized collection codes – according to the degree of purity of the specialized knowledge; furthermore, engineering sciences might differ in the degree of framing of the pedagogical relationship.

4. METHODOLOGY:

The research is based on ethnographic case studies (Spradley 1979; 1980). This methodology is specially appropriate for the investigation of the implicit dimensions of a particular culture, namely those features taken for granted by insiders. Ethnographic fieldwork was carried out in 2006/07 at two departments of a technical university in Switzerland, mechanical engineering and materials science. It included in-depth-interviews with informants ranging from student to professor as well as participant observation in various informal and institutional settings at the departments. Amongst others, I attended the introductory courses in both disciplines.

This paper is based on two field vignettes involving a close reading of the settings and the sequences of the first course lectures. In particular, explicit and implicit messages conveyed

[1] This distinction is based on the concepts of classification – which refers to contents – and frame – which refers to the pedagogical relationship.

to the newcomers in the course of the lecture are examined. The specific pedagogical features of each engineering class are elaborated following the principles of grounded theory (Glaser & Strauss 1967). They are discussed in the light of Bernstein's concepts, thereby pointing at the differences found between mechanical engineering and materials science and elaborating on their gendered implications.

5. FINDINGS AND CONCLUSIONS:

Prominent features displayed in the vignette on the introductory course in mechanics can be summarized as follows: (1) The course is very strictly organized, thereby implicitly enacting and reinforcing lines of professional status and hierarchy in the field. (2) The professor emphasizes performance and discipline as crucial factors for success: this is done through the reference to military hierarchy in a quote from da Vinci and by explicitly enjoining beginners to follow instructions and observe discipline. (3) The body of knowledge to be transmitted to students is presumed to be fixed, it has clear external and internal boundaries and seems unquestionable. Moreover, there is a clear cut between everyday knowledge and scientific knowledge. (4) Students are not in a position to shape the teaching relation; they experience themselves as absolute ignorants and the setting of the course leaves no space for active appropriation of the topic.

The analysis suggests that typical features of the mechanical engineering class include

- a high degree of classification of contents, i.e., a high degree of boundary maintenance between contents and a strong hierarchisation of contents;
- a strong frame of the pedagogical relationship, leaving students with low control over the selection, organization, and pacing of the knowledge transmitted.

These features point to the importance of boundary maintenance in the discipline and to a strong sense of membership in the professional community. Subordination to hierarchy and strict discipline turn out to constitute crucial aspects of the process of cultural affiliation into mechanical engineering. I will argue that these features inhibit the development of a more gender inclusive culture in the field.

In contrast, the following features displayed in the vignette on the introductory course in materials science can be highlighted: (1) The professor of materials talks to his audience trying to establish a kind of dialogue with his students. He is not stressing hierarchy, but rather encouraging beginners to speak. (2) The pronoun "we" is often used, when refering to the community of materials scientists. This "we" invites beginners to participate in the exciting enterprise of materials science, addressing them as potential insiders of the professional community. (3) The aim of this sequence is to familiarize beginners with some principles of scientific procedure and with the specific approach to the topic of materials science, rather then to introduce them to a fixed body of knowlegde. (4) There is no sharp cut between everyday knowledge and educational knowledge in this introduction, the professor trying to tie in with the everyday knowledge of the beginners.

My findings suggest that typical features of the materials science course include

- a higher degree of integration of contents, students being familiarized with scientific principles and main disciplinary questions right from the beginning;
- a weaker frame of the pedagogical relationship, giving students the opportunity to get involved into the train of thought of the teacher.

These features point to a higher degree of openness in the field of materials science, rooted in the blurred boundaries of an interdisciplinary context. I will argue that this type of culture is open to social diversity and thus more likely to attract women.

To conclude: To what extent are the educational practices found in these two engineering fields gendered or having a gendering effect?

The features of the educational code in mechanical engineering (as opposed to materials science) point to strong boundary maintenance in the discipline. Accordingly, newcomers are exposed to ambivalent processes of inclusion and exclusion from the very beginning. These processes have a gendered dimension indeed, although this is not explicitly stated. Clearly, in the process of cultural affiliation into mechanical engineering, subordination to hierarchy and discipline are crucial elements and their military connotation is taken for granted. The type of treatment beginners are subjected to in the process of becoming a member of the community of mechanical engineers, recalls processes of initiation into masculinity. These specific features of the educational culture in mechanical engineering can be traced back to the early history of the discipline, as has been shown by Boel Berner for Sweden (Berner 1997), Catherine Marry for France (Marry 2004) or Karin Zachmann for Germany (Zachmann 2004). My findings suggest that the persistence of these features inhibit the development of a more gender inclusive culture in the field.
On the other hand, the weaker classification and frame of the educational code in materials science point to a higher degree of openness in the field. The bridging of disciplinary boundaries and the concommitant emphasis on procedures allow for connectivity to the interests that motivated students to select this field of study. In the process of cultural affiliation into materials science, newcomers are acknowledged as potential members of the community. Accordingly, they soon have the opportunity to meet doctoral students and to get a first picture of research in their future field. The educational culture of this relatively new field, with its hybrid scientific identity, seems not to have a clearly gendered subtext for the time being; it is more inclusive and open to social diversity, thus more likely to attract women (see also Gilbert 2009).

The ethnographic analysis presented in this paper supports the idea of gendered cultural characteristics in engineering disciplines; moreover, it confirms the diversity of educational cultures in engineering. In particular, the findings suggest that processes of masculinity construction are inscribed in the educational code of mechanical engineering, having an inclusive effect on (some) men, and accordingly an excluding effect on (most) women. As a consequence, more gender equality in engineering education will only be achieved by a process of degendering educational codes and institutional practices in the field of higher education.

6. RECOMMENDATIONS:

The findings of this research suggest that, in order to degender educational practices and to be more socially inclusive, teaching in engineering sciences, particularly in the introductory courses, should be reworked in order

- to enhance active participation of students in the learning process and
- to encourage reflexivity on the procedures of scientific research and the construction of disciplinary knowledge.

7. ACKNOWLEDGEMENTS:

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8. REFERENCES CITED:

Berner, Boel (1997): Explaining Exclusion: Women and Swedish Engineering Education from the 1890s to the 1920s. *History and Technology*, 14, 7-29.

Bernstein, Basil (1975): On the classification and framing of educational knowledge. In: Bernstein, B., *Class, Codes and Control. Volume 3: Towards a Theory of Educational Transmissions*. London, Boston: Routledge & Kegan Paul, 85-115.

Bourdieu, Pierre (1976): Le champ scientifique. *Actes de la recherche en sciences sociales*, 2/3, 88-104.

Connell, Robert W. (1987): *Gender and Power*. Cambridge: Polity.

Faulkner, Wendy (2000a): Dualisms, Hierarchies and Gender in Engineering. *Social Studies of Science*, 30:(5), 759-792.

Faulkner, Wendy (2000b): The Power *and* the Pleasure? A Research Agenda for 'Making Gender Stick' to Engineers. *Science, Technology & Human Values*, 25:(1), 87-119.

Faulkner, Wendy (2007): 'Nuts and bolts and people': Gender-troubled engineering identities. *Social Studies of Science*, 37:(3), 331-356.

Gieryn, Thomas F. (1995): Boundaries of Science. In: Jasanoff, S., G. E. Markle, J. C. Petersen & T. Pinch (Eds.), *Handbook of Science and Technology Studies*. Thousand Oaks, London, New Delhi: SAGE, 393-443.

Gilbert, Anne-Françoise (2009): Disciplinary cultures in mechanical engineering and materials science: gendered/gendering practices? *Equal Opportunities International*, (in print).

Gilbert, Anne-Françoise, Fabienne Crettaz von Roten & Elvita Alvarez (2006): Le poids des cultures disciplinaires sur le choix d'une formation supérieure technique ou scientifique: une perspective genre. *Revue suisse de sociologie*, 32:(1), 121-141.

Glaser, Barney G. & Anselm L. Strauss (1967): *The Discovery of Grounded Theory - Strategies for Qualitative Research*. Chicago: Aldine.

Henwood, Flis (1998): Engineering Difference: discourses on gender, sexuality and work in a college of technology. *Gender and Education*, 10:(1), 35-49.

Henwood, Flis (2000): From the Woman Question in Technology to the Technology Question in Feminism. Rethinking Gender Equality in IT Education. *The European Journal of Women's Studies*, 7, 209-227.

Henwood, Flis & Katrina Miller (2001): Boxed in or Coming out? On the Treatment of Science, Technology and Gender in Educational Research. *Gender and Education*, 13:(3), 237-242.

Lohan, Maria & Wendy Faulkner (2004): Masculinities and Technologies. Some Introductory Remarks. *Men and Masculinities*, 6:(4), 319-329.

Marry, Catherine (2004): *Une révolution respectueuse: Les femmes ingénieurs*. Paris: Bélin.

Mellström, Ulf (1995): *Engineering Lives: Technology, Time and Space in a Male-Centred World*. Linköping: Linköping Studies in Arts and Science 128.

Mellström, Ulf (2004): Machines and Masculine Subjectivity. Technology as an Integral Part of Men's Life Experiences. *Men and Masculinities*, 6:(4), 368-382.

Paulitz, Tanja (2006): Geschlechterforschung und Technikwissenschaften: Konstruktionen von Wissen in Fachkulturen des Ingenieurbereichs. *Zeitschrift für Frauenforschung & Geschlechterstudien*, 24:(4), 23-42.

Spradley, James P. (1979): *The Ethnographic Interview*. New York: Holt, Rinehart & Winston.

Spradley, James P. (1980): *Participant Observation*. New York: Holt, Rinehart & Winston.

Zachmann, Karin (2004): *Mobilisierung der Frauen. Technik, Geschlecht und Kalter Krieg in der DDR*. Frankfurt/M: Campus.