

Gender-inclusive Computer Engineering Education: Two Attempts at Curriculum Change*

MINNA SALMINEN-KARLSSON

Department of Technology and Social Change, Linköping University, S-581 83 Linköping, Sweden. E-mail: minsa@tema.liu.se

This study looks at two Swedish attempts at increasing the percentage of women in computer engineering education by changing the curriculum. One of the reforms concentrated on teaching methods and the other on creating a single-sex introductory class for women with a non-science background. The incentives for the reforms, the impact of the different institutional contexts, the role of the leaders as well as the needs and role expectations among the academic staff engaged in the reforms are discussed. The study reflects on the multi-faceted problems in changing a curriculum for the benefit of marginalised groups.

BACKGROUND

IN SWEDEN, like in other Western countries, the dearth of female students in computer engineering education is seen as a problem, and different measures have been taken to increase the percentage of women in these educational programs. Since the beginning of the 1980s there have been different efforts to attract girls to engineering education. Currently, women make up about 30% of the new enrolments to M.Sc. engineering programs, but they are very unevenly distributed. Computer engineering is one of the programs where the percentage of women is the lowest. During the 1990s women have made up 5–11% percent of those receiving M.Sc. degrees in computer engineering [1].

In 1993 the Swedish Council for the Renewal of Undergraduate Education announced a number of grants for those institutions of higher education which had an ambition to change engineering education itself to make it more attractive to women. At that time there was practically no Swedish research on the position of female students on engineering programs, and very little awareness of the international research in the area. Rather, the idea of using pedagogical renewal as a device to attract female students was a way for the National Council to combine two areas where engineering education needed to be improved. During the 1990s there had been several studies of engineering students, both in Scandinavia [2–4] and in the USA [5–7], which showed that there are characteristics in the culture of engineering institutions, in the prevailing teaching methods, as well as the subject matter and the way it is organised to which female students react more negatively than

male students. Such characteristics are, for example, the fragmentation of the subject matter, and the lack of a broad outlook on technology, the competitive atmosphere and individualism, the expected time commitment, and the attitudes of peers and teachers. Thus, the idea of improving the teaching methods to make engineering programs more attractive to female students was not unreasonable. However, the expectation that more gender inclusivity in the program would have direct effects on recruitment could be regarded as optimistic.

Middle University of Technology (pseudonyms are used for both universities in this study) was one of the universities which received grants. At Middle, a new computer engineering program was to be created. The main idea was to use problem-based learning throughout and augment the subject content of the present computer engineering program with more non-technological subjects. The idea of basing an entire engineering program on group work and individual studies and abolishing many of the lectures was very radical.

Parallel to this reform, Northern University of Technology tried another approach, without support from the National Council, by establishing an all-female class for girls who did not have the required science and mathematics background from secondary education. After completing their secondary education and studying the first year of the computer engineering program, which was to be done during two years in an all-female class, these students would be able to continue their studies in the second year of the ordinary computer engineering program. This approach was even more radical than the one at Middle, because single-sex education is practically non-existent in the Swedish educational system, and generally unthinkable for those involved in the system.

* Accepted 15 October 2001.

This article is based on interviews with academic staff engaged in the reform at the two universities. Different members of the staff were interviewed in spring 1995, some months before the start of the new programs, and in the spring of 1996, after their first year of operation. In addition, staff at Middle University of Technology were interviewed in 1993 and their planning meetings observed from December 1993 until August 1995. The interviews were analysed with a modified grounded theory approach, the result of which forms the basis of the article. It is supplemented by results from observations. The concept of reform team or reform group is used to describe those members of the staff who were directly engaged in the overall planning of the reform and who were interviewed for the study. At Middle this group consisted of 10–20 individuals (the number growing during the planning process). At Northern, the group was smaller; about 10 individuals were interviewed. However, the position of the reform team was different at Northern, in that the group was not isolated the same way as at Middle. The whole department to which most group members belonged was indicated by the interviewees as being more or less engaged and is occasionally referred to in the article.

The article starts with a brief presentation of these reforms and the contexts in which they were created. Some features that differed between the reform projects are emphasized: the problems which initiated the reform at each university, and the institutional context in the light of institutional orientation, leadership, knowledge, and role expectations. These features correspond to the model of Becher and Kogan [8] where change in higher education is related to different levels: state authorities and other external agents, the institutional level, the basic unit level and the individual level. Comparing the two reforms I came to the conclusion that there were several factors, on different levels which made it possible to break the generally strong coeducational norm in the reform at Northern, and other factors which steered the Middle reform away from gender issues.

ENGINEERING EDUCATION IN SWEDEN

A Master's level degree in engineering, with the Swedish title 'civilingenjör', has traditionally carried high status in Sweden. Being a 'civilingenjör' has, to date, meant having a strong background in Mathematics, a solid all-round technical knowledge and specialist knowledge in one of the fields of engineering. In contrast, economics, social science and humanities have a very marginal position in this curriculum, comprising normally 5–10% of the subject matter. Becoming a graduate engineer is supposed to take 4.5 years, but normally takes longer due to the fact that practically nobody goes through without failing examinations at their first try.

The traditional status of a 'civilingenjör' degree

in the Swedish society is mirrored in the fact that fifty percent of the leaders of major industrial companies both in 1930 and in 1980 had this background [9]. However, this state of affairs has changed quite rapidly especially during the 1990s. The technical sector has been augmented (by the state) with hundreds of new study places and a M.Sc. degree in engineering is no longer an unusual achievement. For example, the number of M.Sc. degrees issued in computing and electronics went up from 1600 in 1990 to 2700 in 1999 [10]. Therefore, institutes of technology can no longer choose from an élite of high-school graduates, but have to accept students with average qualifications. A fall in the number of applicants is expected in the future with the diminishing cohorts of young persons with the relevant background, making it increasingly important for the universities to get hold of all available students with the right qualifications. One consequence of this is that, at least in the top leadership, all institutes of technology are interested in recruiting female students.

Status is important in the academic world, and not least among universities of technology. The five universities of technology, which were the only ones until the middle of 1990s, can still be arranged in a status hierarchy, and are to a certain extent constantly competing. While Middle is ranked by its peers somewhere in the upper half of the league, Northern is considered to be at the bottom by most of them.

Incentives from state authorities and market pressures as initiators

According to Becher and Kogan, a university has to answer to external requirements—basically those of state authorities, the potential students and their future employers [8], the latter whom, in the case of engineering education, also represent a powerful professional body as they are M.Sc. engineers themselves.

Johansson suggests that the private sector in Sweden, employing most of the engineering professionals, actually values competencies traditionally regarded as feminine higher than does the public sector (for example higher education) [11]. This could mean that future employers might be inclined to prompt the universities to do something to recruit more women. However, as the decision makers in the bigger industries are graduate engineers themselves, they are wary of changes in the education that are too extensive.

State authorities encourage the recruitment of more women to technical programs—one example being the announcement of grants which initiated the reform at Middle. But this encouragement was mixed up with other interests, such as modernising the education for the benefit of all students, and as the universities were left alone in handling gender issues there was no compelling force or even encouragement to make them the first priority. Thus, the external requirement connected to the

state grant was not powerful enough to really put gender issues on the agenda at Middle.

There are even more direct economic pressures on technical universities due to the decreasing numbers of young people who apply for an increased number of study places, which makes for a risk of more mediocre study results, longer study times and higher dropouts. These market pressures were most important and effective at Northern. The university was located in the sparsely populated northern part of Sweden to give the young people in that part of the country easier access to higher education and to promote the local economy. Because of its location, Northern has not been popular among high-school graduates from other parts of the country and has had recruitment problems throughout its history.

Institutional context and ambivalence

The educational institution, the university of technology itself has a profile, which any reforms have to fit in to. The attitude of the organisational authorities as well as the collegiate is highly decisive for what reform is possible and how much energy and innovation is required of the reformers [8].

The two universities, Middle and Northern, are about the same age, both founded at the beginning of the 1970s. But during the twenty-five years prior to the reform, they had developed differently and constituted quite different contexts for a gender reform initiative. They had different incentives and perceived the risks associated with gender reform in different ways.

Middle has always recruited its students in competition with the older universities, and has managed to grow and acquire a good reputation. Some of the competitive mentality still prevails, and Middle often compares itself with one of the most prestigious universities. Middle had tried different measures to recruit female students in the past, with less than moderate success. Computer engineering was seen as one of the best programs at Middle. The reform would not touch the existing program, but would create a totally new program with basically the same subject matter, but with a totally different pedagogy. The reform group was left on its own most of the time, but when the work had been in progress for a year and a half, the governing board of the university became very critical of the plans. It was not because of the gender issue, but because of the radical pedagogy, which, the board feared, was too 'fluffy' to be able to produce real engineers.

Thus, there were some restricting factors for the Middle reformers in the institutional context: a failure could be perceived as much more serious in the competitive atmosphere, and most of the time there was no knowing how far-reaching reforms the institutional context would approve of. Creating a totally new program instead of reforming the

existing one led to a problem of ambivalence in the institutional context.

Many of the new engineering programs with a high percentage of women have been regarded as having less status than the male-dominated traditional programs. They are regarded as 'soft'. The decision to create an entirely new program also implied that this program would be placed somewhere along the status hierarchy. It was expected that to recruit many women, the program should have 'soft' features, but to stress these soft features would place it far down in the hierarchy. If the new program were to have too feminine an image, it was feared that it would interest neither boys nor girls. The reform group was in a two-fold dilemma: They were to create an educational program which would attract female students, but its planned attractiveness to women should not be evident.

The problem with navigating among several different expectations, many of which are at least partially unknown, is not uncommon in reform work. Goodstein, for example, reports on a university with similar ambivalence as to its image: on the one hand it should have 'an image as a progressive institution whose operations reflected national trend(s)', on the other hand 'too much attention to the concerns of marginal groups might incite backlash and deflect energy away from the school's most pressing goal of improving its national rankings' [12]. It seemed that the Middle team was overly careful because of their ignorance of how far it was possible to go in the context. Actually, the governing board seemed to be more interested in and positive towards recruiting women than the reform team had initially guessed.

Single-sex education

Apart from the problems with student recruitment mentioned above, Northern has a self-image of being a pioneer, and having a better, more student-centred undergraduate education than the old, big universities. The University is also aware of its importance as a regional motor. At the time of the reform Northern had by far the greatest percentage of female students of all the technical universities and presented it as a positive feature to which computer engineering was a negative exception. The culture of the university was relatively open to non-traditional students, as there was a history of innovative recruitment measures, many of them successful. Creating a single-sex class to recruit female students to computer engineering was a radical reform, but also one in a line of such innovations.

The initiative for the reform came from the computer engineering department, and originated from some personal contacts with an institute for vocational training, where qualified computer courses for women only had been held for some time. The original idea was to let women from the training centre continue their studies at the University. This was never realised, but the idea of a single-sex education had been formulated and was

carried out by the department. The governing board of the university was positive to the idea, even if they did not allocate funds for its realisation. Instead, a sum of money was received from the local regional administration, to survey the need for and interest in such a program. For the reform group, these features in the context implied that the need for a greater number of good students was acute, that something other than just improving the program was needed, that there was a breeding ground for innovations, and that female students were seen as a normal and positive feature of the environment.

The institutional context thus was positive to gender reforms, and an ambivalence similar to that at Middle did not arise. However, the idea of single-sex education was so radical that it had to be justified even in this relatively radical context, and actually even in the minds of the reformers themselves. Several of the people involved in the reform stated that they were, strictly speaking, opposed to single-sex education. However, according to the survey the reform group had made, there was some interest in this kind of education among female high-school graduates. So, those reformers who actually did not like the idea accepted the plans as an emergency measure. Once the image of computer engineering education was changed, they said, for example by the women on this program, women would start to come to the ordinary computer engineering program and this measure could be discontinued.

Becher and Kogan point out that universities are often quicker than the central authorities to react to needs from the public and to know what reforms or innovations can be brought about [8]. This certainly seemed to be the case at Northern. The negative attitude towards single-sex education was profound among the state authorities administering the grants. This kind of idea was also seen as practically unthinkable at Middle, and would probably have been unimplementable, even if it would have been recommended from the outside.

Thus, there were differences in the institutional contexts which made a reform that would have been impossible at Middle possible to realise at Northern. These differences can be related to Becher and Kogan's statement that reforms are often easier to make in smaller universities with little prestige. Departments in less advantageous positions respond to new societal values and market demands faster and accept greater reforms more easily than more prestigious departments, which can afford to overlook influences from the educational market environment as long as they maintain their academic credibility. Middle is not an old institution, but it does have a respected position and, especially in the area of computer engineering, a self-image as a top institution. Northern as a university was more oriented towards the society outside the sphere of higher education than was Middle. The orientation towards different reference groups gave rise to

different conditions of gender reform at these two institutions. At Northern, which co-operated with vocational training institutions and regional authorities, recruiting women into computer engineering was not such a double-edged issue as it was at Middle which had mainly the other technical universities in mind.

LEADERSHIP AND WORK IN THE REFORM TEAM

To effect change in a prevailing curriculum, the basic unit is the most important actor, according to Becher and Kogan [8]. Normally 'basic unit' designates a department, but in this case it refers to the two reform teams. The basic unit is operating in the context of institutional norms, peer group norms and wider social, economic and cultural values.

The relation of the reform to the institutional context was different at the two institutions. For the computer engineering department at Northern, the reform, if it were to succeed, was both positive and relevant. There were already many female students at the university and the university saw the percentage of women as a key part of its profile. In this context, efforts to recruit more women to computer engineering, where they were few, signified striving for normality. In contrast, at Middle the scarcity of women in computer engineering was seen as deplorable, but not alarming. Because the earlier efforts to recruit women had delivered meagre results, the team members were not sure that this reform would deliver much either.

For a reform project itself, leadership is crucial. Some functions appeared as especially important for a leader in a project of this nature, which is aiming to change the gender composition in a male-dominated educational program. The leader should legitimise the work (which is easily perceived as controversial), the leader should keep the gender issue on the agenda and inspire the team in a task that is often conceived of as problematic. To this end, the leader needs to have legitimacy of some kind, have an interest in gender issues, and some basic knowledge in the area of gender and technology. A reform which is to promote a special group always has political implications at an institution, which means that it has to be negotiated in the institutional context. Thus, it is also essential that the leader of a gender reform is sensitive to the local institutional context to know just how far the limits of gender equality can be pushed.

The dean of computer engineering at Middle could be characterised as a symbolic leader. The project proposal was written by him alone and based on his vision of another kind of pedagogy in engineering education. He personally recruited the project group. His vision was the basis of the reform work, and the work of the group amounted

to concretising it: turning it into something applicable. The group was thus guided by a common vision and became very consensus-oriented, not least because the leader had a tendency to reconcile differing opinions as far as possible.

All reformers need to get some basic knowledge about gender issues as a point of departure, and the knowledge of the leader is crucial in introducing a language and a style in which these issues can be discussed and in emphasising the existence and importance of a knowledge base, which can be used for the task. The Middle leader was interested in gender issues, but not very knowledgeable. The project plan explained why the new kind of pedagogy would be attractive to female students, but the basis of the vision was pedagogical renewal. Consequently, gender issues were not taken up in the group to any notable extent. When gender issues were brought up (normally by a female group member), the discussion soon turned to other issues. Jordan and Yeomans point out that for a leader it is often too optimistic to explain the importance and benefits of a certain reform and trust the team to share the values and act on basis of them [13]. That is what happened at Middle—even if the gender aspect of the vision of the leader was accepted by the team, it was not made a basis for action.

At Northern, two leaders were appointed, one with knowledge about gender issues and one for legitimation. One of the initiators was the female dean of the Mathematics Department, who had done some research of her own about gender and engineering education. She remained as one leader of the project throughout the process. But when the reform project became reality, another leader was sought, and a newly appointed male professor of computer engineering was engaged. He was interested enough in the aim of recruiting female students and could provide the project with legitimacy, which would have been difficult for a female leader to achieve. Before accepting the task, he also initiated discussions about the idea in the whole department, looking for different opinions. It was only when he perceived that there was a common acceptance of the 'experiment' that he officially got involved in the work.

The reform group at Northern was quite small. The reform was not a vision to be firstly discussed and then concretised, and the group was more practically oriented. There were some major tasks to be done, but nothing as thorough as at Middle. The value of the idea had to be examined, which was done by going out and asking high-school students. The two introductory years were tailored by mixing the courses of the existing introductory year and the first year of the computer engineering program, creating a new introductory course and leaving some free space for the female students to fill themselves. The teachers who were to be involved were informed of the possibility and desirability of adjusting their courses to a new student group, and several of them decided to try

minor innovations. Recruitment brochures were sent out and the local press was informed. Male students were informed of the new group, and common gatherings and a mentoring system were planned to help the women find their way at the university. As the recruitment of female students was the only aim of the project, there were no competing issues (such as a radical change of some other aspect of the program) on the agenda.

Group work and self-confidence as simple solutions

Several aspects in engineering education are problematic for female students, in all three areas of subject matter, teaching methods and the prevailing culture. Each of the two reforms addressed predominantly one of these. At Middle teaching methods were the issue; and at Northern the reform aimed to combat women's intimidation by the culture of computer engineering education. The concentration on only one of the relevant areas means that even if the reforms were radical in the sense that they introduced something previously unthinkable (the single-sex class at Northern and new teaching methods at Middle) they did not profoundly change engineering education for the benefit of women.

The main idea at Middle was that women are sociable and like working in groups. This coincided with the pedagogical basis for the new program: problem-based learning, where study groups are a fundamental learning device. Once during the observed planning meetings, the idea that male students might get to dominate in mixed groups was brought up by a female team member, but it was not followed further. In the interviews, a couple of the female team members brought up girls' experience of group work as something where girls got to do most of the work and discipline the boys, but they did not bring it up in the meetings.

The inclusion of more non-technical subject matter was seen as important for both male and female students to make them into modern engineers, and it was expected that this subject matter would be attractive to women. However, the program was to give as much technical knowledge as the existing computer engineering program. The leader's vision included increasing the length of the program to make room for the non-technical subject matter. The team had one representative for these subjects, and her suggestions were accepted without discussion. However, after one year's planning work it became clear that it was not possible to lengthen the program, and the need and the amount of non-technical subject matter came under discussion. In the end it was decreased considerably—even if there still was more of it than in the ordinary computer engineering program. The explicit rules and implicit traditions about what a M.Sc. engineer has to know greatly limited the possibilities for change.

The main idea behind the Northern reform had its point of departure in the culture of computer engineering. The basic assumption of the reformers

at Northern was that girls are deterred from computer engineering studies because of the image they have, correct to a certain extent, of male computer engineering students as computer nerds, who like to show off with their knowledge. To address this problem, the reform would create a reserve for the female students, where they could acquire basic computer knowledge without any interference from the male students, and where the teachers could help to boost their self-confidence so that they would not be put down by these men after two years when they would start studying together.

Female reformers and team expertise

Any basic unit consists of individual faculty members who realise role expectations and private goals in their daily work [8]. The private goals of the reformers were different at the two institutions, as were role expectations in the reform teams.

At Northern there was a recognised need for change of the recruitment pattern, as well as the gender balance of the program. The difficulty of recruiting academically qualified students was affecting most of the teachers in their work and was experienced as a main obstacle to a rewarding life as a teacher. The teachers' private goals had to do with getting better students to improve the academic standards and preferably getting more female students in order to improve the program's reputation at the institution. By contrast, the main problem for the reformers at Middle was the rigid university structure, which, as they saw it, prevented them from practising good teaching. The private goals of the reformers were related to the satisfaction of making a major reform in pedagogical terms. For many the goal of recruiting female students was of minor importance.

The institutional contexts, leadership styles and aims of the reforms also created different conditions for the female members of the different reform groups. At Middle, half of the reform group consisted of women, which was something that the leader was proud of and which he presented as a guarantee that women's perspectives were integrated in the work. However, the token mechanisms which are in action at many male-dominated organisations [14] restricted the possibilities for the female reformers to advocate female students' interests.

Differentiation of female engineering students and the stereotyping culture

At Middle the female reformers regarded themselves as not quite ordinary women, and were regarded so even by their male colleagues. This was well in accordance with the common idea that those few women who choose to study computer engineering are somehow different from the great majority of women. The female reformers felt that as they belonged to the minority which came to engineering education and enjoyed it anyway, they could not really expect to know the needs and

wishes of the other kind of women—those who needed an educational reform in order to be attracted to the education. The female reformers had learned their role as 'one of the boys' to the extent that they saw an abyss between themselves and 'ordinary' young girls, not because of age, but because of their interests.

At the same time the women had to work in keeping up their positions as 'one of the boys'. This meant that it was risky to bring out one's femininity, for example by talking about gender issues. Actually, the one female group member at Middle, who was genuinely interested in making a female-friendly education and took it upon herself to remind others about gender in the meetings, felt quite awkward after a time. Thus, the women adopted the strategy of participating in the work the same way as the men: representing their subjects or departments, but not their gender. Their existence did not guarantee that gender issues were taken into account, but it provided the male reformers with an excuse to ignore them.

The reform group at Middle did not engage external experts with knowledge in gender and technology or gender and higher education. They seemed to be unaware of the fact that such research existed. One seminar on gender issues was arranged during the one and a half years that the planning work took place, but most of the reform group did not attend. Like practically all university staff, the reformers had reached their positions because of their theoretical knowledge of their discipline [15]. Most of them had a similar education to their students, that is, almost solely technical and natural science studies. Women's studies lie on the social sciences side of the divide, and are generally unknown to the staff at technical universities. If they do have an interest in the area, they might acquire some knowledge in popular form, for example from their daily newspaper. However, in the media, women's studies are often represented as a political, rather than a scientific domain. It is therefore not surprising that the team members generally were not aware of the extent of research which would have been relevant to their efforts.

The stereotype of women in technical education being different from other women was not rooted at Northern. When talking about female students, the Northern reformers talked about the variation among female students and did not agree that women choosing technical education were somehow different from other women. The teachers at Northern had more experience of female students because most of them had taught classes with many women in them. This probably affected their self-image as well—the female reformers at Northern did not refer to themselves in terms which would separate them from 'normal' women. In addition the task itself, concentrating on computer culture, made it easier for the women at Northern to use their own experience. While the task of the female reformers at Middle was to

figure out what an unknown group of students would like to have from their education, for the women at Northern it was enough to reflect on and talk about how they themselves had experienced the culture and male dominance of engineering education. It was not crucial whether they were different from the students that were to come; the issue was about the culture they had met at the university and could report on. The basic idea of the reform was that there was something wrong with this culture, from a gender perspective, and it made it relevant for the female reformers to discuss their own experiences, even with colleagues.

In addition, the Northern approach made it easier for the male reformers to engage in discussions about gender. There was only one aim: getting more high-quality students, and there was one method, which at least officially was accepted by the majority of the staff at the department: preventing the male students and the computer culture in general from intimidating the female students. To talk about female students and gender issues was not strange, as the project was a possible solution to the problem, which was shared by all in their daily work. When discussions about gender became relevant even for male teachers, it made it easier for the female teachers to talk from a position as women—talking about gender in this context did not totally exclude oneself from being ‘one of the boys’. This opportunity for both male and female reformers to engage in gender issues is probably one of the reasons why the gender seminars which were arranged at Northern attracted many members of the staff.

CONCLUSIONS

Both reforms managed to recruit more women than computer engineering education in general. The program at Northern has had an enrolment of 20–26 students each year and the Middle program has recruited 9–16 women each year, which is 25–45% of the total new enrolment. While the numbers may seem low, they should be compared to the ordinary enrolment in computer engineering programs, which generally amounts to around 5–10 women (or less than 10% of the new enrolment) in M.Sc. programs.

The outcomes of the reforms can be related to the basic problems which initiated them. Middle is an example of how societal concerns of gender equality can be used in the service of financing and initiating a reform which was basically to solve a different problem: that of stagnated teaching methods. Northern is an example of how general recruitment problems make favourable conditions for recruiting female students. Both universities solved their problems at least to some extent. As to increasing the number of female students in computer engineering education, the Northern approach can be said to have been more successful.

It was also the more radical of the two, with respect to gender, as it introduced something that had never been heard of among technical universities in Sweden. (The pedagogical reform at Middle was quite as radical, in the area of teaching methods, but not with respect to gender.)

While state initiatives such as that at Middle, or the overall equality rhetoric may stimulate efforts to recruit female students, it seems that there has to be a coincidence of several factors (the ones at Northern being one possible mix) for more radical ways to be explored. If lack of female students is not experienced as the most important problem, state initiatives cannot automatically be expected to result in gender inclusive programs, even if they involve substantial financial incentives. It may be only when female students are necessary, in one way or another, for the survival of a program that substantial changes can be expected for their benefit. This means also that certain models are not transferable, even if they seem effective in fulfilling the aim of recruiting female students. There has been some interest in the reform at Northern from the part of some other universities (not only in Sweden, but in Denmark and Norway as well), but none of them has implemented such a reform to the full. Most often there still seem to be institutional aspects which make such a deviation from the normal nominally coeducational—though practically almost all-male—track based on secondary school science background an impossible idea.

However, increasing the percentage of women enrolling in computer engineering does not automatically solve the problems of the male hegemony of the education. In the official Swedish rhetoric, the lack of women in computer engineering is seen as a problem, not only because there is a shortage of men, but also because women are seen as carrying different values which, if they have a chance to affect the development, will make the industry better, too. It means that apart from enrolling in computer engineering, female students should also be given opportunities to make their special contributions. Even though both Middle and Northern managed to recruit many women, it can be questioned whether they managed to do very much about the general male dominance of computer engineering.

In spite of the differences, both reforms were basically quite similar in this aspect: through a reform more women were recruited, but the program, especially with regard to the subject matter, remained essentially the same. At Northern, it was because there was no ambition to make major changes to it, whereas at Middle it was because it was impossible for the reformers and the teachers to think in radically new ways. Changing teaching methods or attempting to change the culture of computer engineering were probably steps in the right direction, but without profound changes also in subject matter, computer

engineering education will remain much the same. Both the state initiative at Middle and the market pressures at Northern resulted in programs, which

still are, if not enticing women to an unchanged education, just helping women to adapt to a traditionally masculine education.

REFERENCES

1. SOU 2000:58, *Jämställdhet och IT: delbetänkande från Jämit—Jämställdhetsrådet för transporter och IT*, Fritzes, Stockholm (2000).
2. Vivian A.L. Berg, *Firkanter og rundinger, Kjömskonstruktioner blant kvinnelige dataingeniørstudenter ved NTNU*, Trondheim: Norges teknisk-naturvetenskapelige universitet (1999).
3. Bente Rasmussen and Tove Håpnes, Excluding women from the technologies of the future? A case study of the culture of computer science, *Futures*, **10**, pp. 1107–1119 (1991).
4. Agneta G. Göransson, *Kvinnor och män i civilingenjörsutbildning*, CTH Informationssekretariatet, Göteborg (1995).
5. Vivian Anderson, How engineering education shortchanges women, *J. Women and Minorities in Science and Engineering*, **2**, pp. 99–121 (1994).
6. Karen L. Tonso, Student learning and gender, *J. Eng. Educ.*, **2**, pp. 143–150 (1996).
7. Elaine Seymour and Nancy Hewitt, *Talking about Leaving: Why Undergraduates Leave the Sciences*, Westview Press, Boulder, Co. (1997).
8. Tony Becher and Maurice Kogan, *Process and Structure in Higher Education*, Routledge, London (1992).
9. Boel Berner, Engineering identity and economic change, *Engineers in Swedish Society 1850–1990*, Polhem, **2**, (1992), pp. 131–160.
10. Jämställdhet och IT: en kartläggning, *SOU 200:31*, Fritzes, Stockholm (2000).
11. Ulla Johansson, Den offentliga sektorns paradoxala maskuliniseringstendenser, in (E. Sundin, ed.), *Om makt och kön. I spåren av offentliga organisationers omvandling*, SOU 1997:83. Fritzes, Stockholm (1997).
12. Lynne Goodstein, The failure of curriculum transformation at a major public university: when 'diversity' equals 'variety', *NWSA Journal*, **1**, p. 87. (1994).
13. Steven Jordan and David Yeomans, Whither independent learning? The politics of curricular and pedagogical change in a polytechnic department, *Studies in Higher Education*, **3**, pp. 291–308 (1991).
14. Rosabeth Moss Kanter, *Men and Women of the Corporation*, Basic Books, New York (1993).
15. Sue Lewis, Including gender in higher education science and engineering courses, *GASAT 7 International Conference, Canada 1993 Contributions*, pp. 662–669 (1993).

Minna Salminen-Karlsson, Assistant professor at the Department of Technology and Social Change at Linköping University, Sweden. Minna Salminen-Karlsson received her Ph.D. in Educational Studies in 1999, for her work on 'Bringing Women into Computer Engineering'. Since 2000 she is associated to the Department of Technology and Social Change doing ethnographical research on knowledge creation and gender relations in Swedish software companies.