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Educational Strategies for Empowering Women in Science and Technology

Introduction: European Policies Towards Gender in Science and Technology

The present paper has been presented at the conference 'Critical Issues in Science and Technology Studies', and it is based on a research project conducted as a fellow at IAS-STS in 2005–2006. The project aims at investigating women's interest and activism in science and engineering versus teaching science and technology. The current report is a work-in-progress, and should be cited only as a draft. The main issues discussed in the present research report are: 1. European policies towards gender sensitive measures in science and technology 2. Gender differences / gender equality in Europe 3. What do statistics show? 4. Women in science and technology – the Romanian experience; and 5. Case study for a development strategy at the University level – educational measures.

A continuing issue in Europe and in the United States is women's under-representation in science and engineering (Lane 1997; Kohlstedt and Longino 1997; Adelman 1998). Moreover, at a time when technology seems to be playing an ever increasing role in society, a low interest in science, engineering, and technology has been noticed. In Europe, starting from the 90s and more acute in last years, there has been an urgent need to largely increase the number of students in science and technology and more specifically women entering science, engineering, and technology studies, and to support their future careers. As the Lisbon Agenda 2000 seems to indicate, Europe desperately needs more researchers to achieve scientific and technological excellence and to reach the goal of becoming the world's most competitive and dynamic knowledge economy by 2010. As women are currently under-represented in the field of scientific research or in technology, the European Commission is promoting measures specifically aimed at encouraging women to take part in European research. However, the efficiency of these measures located only at the university level is disputable, research or industry's hostile environments being mentioned as key factors affecting the retention rate of women in these fields.

With the growing awareness of the under-representation of women in the scientific community, technology and engineering, there is a real need for new policies and strategies, yet there is a debate about what and how should be proposed or imposed. The discussion topics vary from quantitative objectives like quotas or positive action, such as changing the culture of universities, industry, research and development sectors to even positive discrimination measures. Moreover, it is argued that higher education, government and industry should have an imperative for equal opportunities and female-friendly climate.

For the general research domain, the European Commission settled in 1999 an Expert Group (ETAN 1999) on Women and Science, Science Policies in the European Union, with the main aim of promoting excellence through mainstreaming gender equality. Its priorities have been formulated in the following terms:

- women's participation must be encouraged – supporting research by women;
- research must address women's needs – more research for women should be designed;
- research must be carried out on the gender question itself – research about women should be promoted.

The European Platform for Women Scientists (EPWS 2006) has been launched recently, in order to build a structural link between women scientists and research policy makers. The aim is to introduce a new key strategic actor into the research policy debate by making the voice of women scientists heard, but also linked to education, industry and research and development. At the same time, the platform aims to make women scientists better understand the role they can play in the research policy debate, and the way the can fully benefit from these opportunities by bundling their powers and forces. The aim is also to promote the understanding of the gender issue in science, as well as to promote women scientists from all disciplines. The main characteristics are:

- focus on understanding of the gender issue in science;
- open to any women doing research in any discipline taught at university level;
- especially dedicated to women scientists working in engineering and technology.

Gender Differences versus Gender Equality in Europe

Gender might be defined as a constructed concept referring to the social differences between women and men that are learned and changeable over time, and have wide variations both within and between cultures. How does the issue of perceived gender relate to science and engineering in various cultures in Europe? Is it possible to generalise and to identify patterns which might be applicable for very different contexts? This is obviously a difficult issue, and to differentiate between east and west seems to be as inadequate as making reductions and ignoring the specific culture of various nations within Europe. Nevertheless, in one of the next sections, the Romanian experience in constructing gender and sex roles within the communist period and nowadays will be presented. Some categories in exploring gender differences in life patterns, needs, interests and opportunities are presented bellow as an overview about how relevant these differences are for investigating educational policies of supporting women in science and technology. The following dimensions give an overview of gender differences in relation with gender sensitive measures, and not necessarily with gender equality:

- rights – general human rights and access to justice; legal, political or socio-economic environment, education;
- resources – time, space, information, money, political and economic power, education and training, jobs and career, new technologies, health care, etc;
- participation – target/population groups, decision making;
- norms and values – influencing gender roles, division of labour by gender, attitudes and behaviours of women and men, inequalities in considering masculine and feminine characteristics/patterns.

Engineering, technology and science can be considered gendered at least in three ways. First, gendered structures are visible in gender difference in the division of labour and in the work styles of women and men in all these domains. Second, the symbols and images of engineering and science knowledge and practice are gendered through cultural associations between masculinity and technology. And third, individual scientists and engineers have gendered personal and professional identities and experiences (HARDING 1986, FAULKNER 2000).

Central to stereotyping engineering or science is the explanation of cause-effect, a perception that has been called in the literature 'binary thinking' or the 'hard-soft' dualism (FAULKNER 2000). Stereotypical images of science and technology seem to have obvious connotations with the masculine sides of dualisms such as hard – soft, abstract – concrete, people-centred – technology-centred, mind – body, rationality – emotionality.

Engineering study is considered a more gender-segmented field than any of the natural sciences. As Adelman (1998, 61) argues: 'One of the problems in the traditional literature is that the analysis of sex differentials and inequality in scientific careers is grounded in the sociology of academic science, not the practice of engineering'. It is argued that the culture of engineering is more a culture of industry, and then it is reasonable to assume that when the experience of women in industries where they are a distinct minority seeps down to undergraduates, then women's low representation or even migration from engineering programs is not surprising anymore. Women engineering students seem to be more successful in classrooms than in the laboratory (McIlwe and Robinson 1992, cf. ADELMAN 1998), moreover, it is argued (Felder et al. 1995, cf. ADELMAN 1998) that within the small cooperative working groups their work and contributions seem to be undervalued.

Choosing an engineering path might be problematic nowadays in Romania, as statistical data and our interviews showed. Neither women nor men will choose engineering for the right reasons – except maybe those having the right models of what is a real engineer – unless universities can reach out to potential students and society as a whole, with an elaborated and drastically changed portrait of a new culture and practices associated with it. In these conditions this might be the only real reason for attracting more prospective students. Technical studies and careers should be presented and perceived as describing an 'object world' or a 'social world' of engineering (BUCCIARELLI and KUHN 1997), and then it should be clear that women belong to this reality. An important point to consider before looking at the barriers women face in science and engineering disciplines is the argument that women know they are not welcome in these disciplines, and therefore do not pursue a career in where they are not welcomed. This identification between masculinity and technology is seen as the main reason for this lack of interest for engineering professions (FAULKNER 2000).

Jonsson (1999) is exploring sex segregation with regard to choice of type of education, or educational programme. In order to explain this phenomenon, the author is proposing a rational choice model in which sex-specific comparative advantages in different fields of study are in focus. Such relative advantages in sex-typical areas of study are hypothesized to influence educational choices through their effects on the expected probabilities of success in different study programmes. As a conclusion, confirming Jonsson's hypothesis it can be stated that sex segregation depends on the projection of future success for both sexes. Boys seem to be relatively advantaged in male-typical fields of study (like engineering and natural sciences), and vice versa, girls' expectations to be successful will determine their

choices for fields of education and occupations socially constructed as female-friendly.

Of course, encouraging as many students – male and female – as possible to engineering or science fields is a desire for many institutions or national education policies, but it should be accepted that ultimately individuals have to choose their field of interest, and in many regards forcing this issue by positive discrimination might be a problem. It is true that one can encourage, but ultimately individuals have to choose.

As stated already, various measures have been promoted in Europe both at the level of policies and practices. Different scientific projects across Europe are focussing on strategies to overcome low representation of women in some areas like science, technology and engineering.

Analysing only two of these projects: WomEng – Creating Culture of Success for Women Engineers, and ENWISE – Gender Equality in a Wider Europe – Women Scientists in the Central and Eastern European countries and the Baltic States, the empirical section of the present paper is investigating how the envisaged recommendations or policies designed for the academic sphere or universities are received in a specific institution in Eastern Europe, more precisely in Romania.

The first project, WomEng has been designed to compare training degrees in engineering in Europe; analyze professional positions of women engineers; evaluate the process of recruitment of women engineers; and investigate existing innovations which make engineering programs desirable for females. Indeed, it was searching for strategies related to the question 'What should be done for enhancing the number of women in engineering studies and professions?'.

The Envise project addressing mainly the issue of women scientists in the Central and Eastern European countries and the Baltic States was oriented towards identifying existing and relevant statistical data for Eastern Europe and designing recommendations for increasing women's participation in European Community programmes.

Getting insight into the reports of these projects, it is obvious that there is still a gap between the western countries and the ex-communist ones. Even though it is not yet acknowledged, there are significant differences not only in numbers but also in mentalities, opportunities or, generally speaking, in socio-economic contexts.

Western countries are constantly proposing measures to increase and support women participation, whereas sometimes in central and eastern Europe two extreme stances might be differentiated: from no concern to this issue of females in science, technology and engineering (due to the high representation and support of women during the communist period) to an exaggerated attitude sometimes blaming the values of democracy that brought major problems in relation with unemployment, wages or socio-economic conditions for women.

The recently launched European platform for women scientists already mentioned seems to have only one female representative from Eastern Europe. It might be only a fact, but meanwhile it seems to be a trend in associating the unproblematic and so called high representation of women in eastern countries as a fact which automatically gives perspective for future and better employment.

The next section is bringing into discussion statistical data illustrating the quantitative differences between east and west.

What Do Statistics Show?

Two different analyses are presented: percentages of women graduates in tertiary education (2001–2003) and proportion of female PhD graduates (2003), using OECED (2006) and European Commission (2006) data.

Figure 1. Evolution of female graduates distributions - ISCED 5A – W Europe

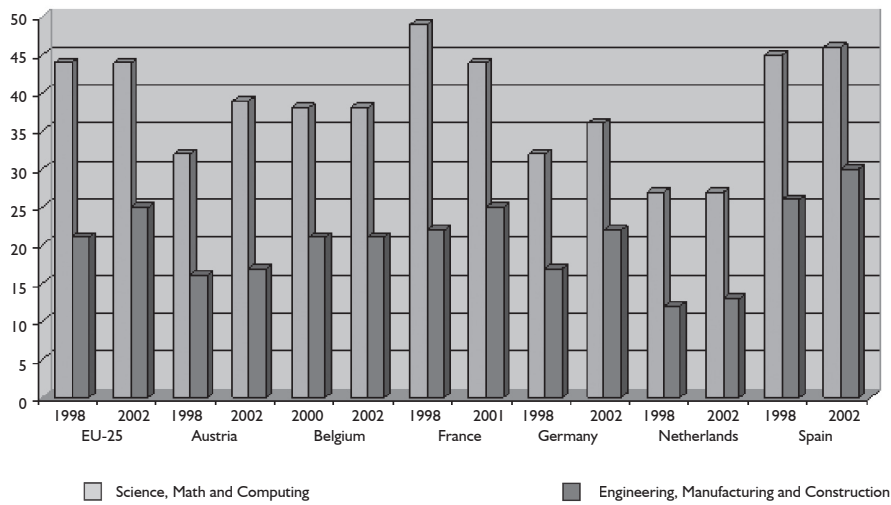


Figure 2. Evolution of female graduates distributions - ISCED 5A – CE Europe

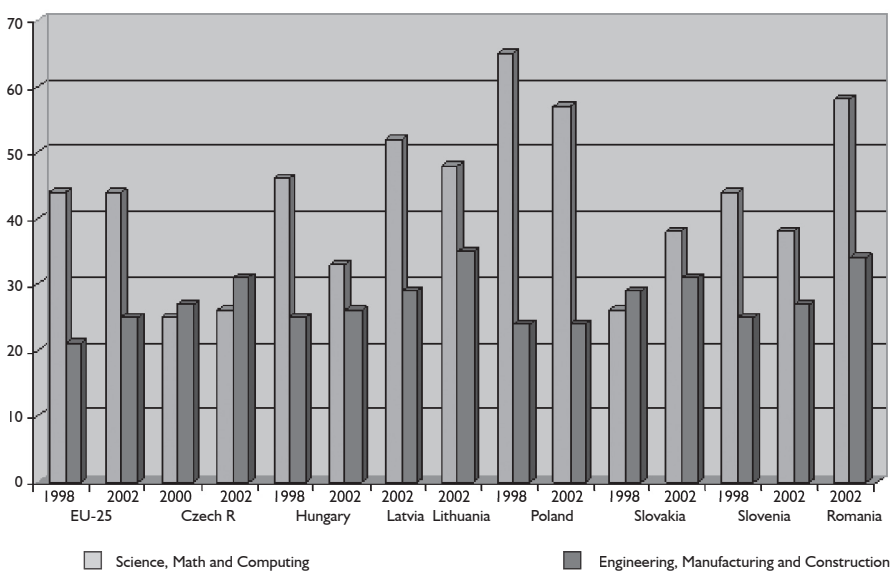


Table 1 presents the percentages of women graduating the tertiary-type A programmes in some countries in Europe (ISCED 5A). These types of education (not necessarily only universities but also post-secondary education institutions) are largely theory-based, and are designed to provide sufficient qualifications for entry to advanced research programmes and professions with high skill requirements (OECED 2006).

Table 1. Percentages of woman graduates, ISCED 5A

Area of study	**Science, Math and Computing**	**Engineering, Manufacturing and Construction**
Country	***Women %***	***Women %***
EU-25 1998	44	21
EU-25 2002	44	25
Austria 1998	32	16
Austria 2002	39	17
Belgium 2000	38	21
Belgium 2002	38	21
Czech Republic 2000	25	27
Czech Republic 2002	26	31
France 1998	49	22
France 2001	44	25
Germany 1998	32	17
Germany 2002	36	22
Hungary 1998	46	25
Hungary 2002	33	26
Latvia 2002	52	29
Lithuania 2002	48	35
Netherlands 1998	27	12
Netherlands 2002	27	13
Poland 1998	65	24
Poland 2002	57	24
Slovakia 1998	26	29
Slovakia 2002	38	31
Slovenia 1998	44	25
Slovenia 2002	38	27
Romania 2002	58	34

Tertiary education – Eurostat Education Statistics (OECED 2006)

The statistical data show that women remain still a minority among western graduates in engineering, manufacturing and constructions; nevertheless, a slight increase of 3% at the EU (25) has been noticed. Comparing with Western Europe (*Figure 1.*), the

data representing the situation in the East (*Figure 2.*) show better circumstances; the percentage of women are higher, and there is also a trend to increase these percentages of female graduates at the ISCED 5A level.

While all of these indicate a continued positive trend overall, the situation is that women remain underrepresented in science, technology and engineering jobs or especially in leading positions (European Commission 2006).

Table 2. Proportion of female PhD graduates in 2003

Area of study	**Science, Math and Computing**	**Engineering, Manufacturing and Construction**
Country	***Women %***	***Women %***
EU-25	34	27
Austria	25	24
Belgium	25	17
Czech Republic	30	31
France	33	29
France	44	25
Germany	27	18
Hungary	34	27
Latvia	67	38
Lithuania	64	29
Netherlands	40	18
Slovakia	47	28
Slovenia	34	32
Romania (2002)	58	39

Source: Based on Eurostat Education Statistics (European Commission 2006)

An interesting perspective is represented by female PhD student rates. As we show in *Table 2.*, there are again differences, but the situation seems to have improved at least in the fields of Engineering, Manufacturing and Constructions.

Women in Science and Technology – The Romanian Experience

During the communist period and in almost all the states assuming such an ideology, including Romania, it has been stated as a priority to get women into technical higher education, and later on employ them in technical professions as engineers or researchers. In terms of quantity (as a quota) it has been successful, but what about quality, like advancement policies, payment and prestige, or with how much effort and what kind of support?

More or less, the so called 'eastern communist mentality' regarding women's involvement not only in science or technology but as full employees can be described

in a context where everything was an imperative, by inculcated values that women are able to succeed, so they should be given the chance. Support has also been offered to women (childcare facilities and sometimes flexible study or work schedules) but still, women were responsible for the household. Women in western societies have been, and maybe still be underrepresented in science and technology for the major reason that only few women were given the training or opportunity, and also because there has not been an urge to pursue such a career, or just to be the second breadwinner in a family. This invoked a society that has not empowered women in the west, while in the east to be a woman employed has been perceived as an urge and, in science and technology, a real demand.

When speaking about differences, some dilemmas should be discussed, not necessarily comparing east vs. west: more important is the process of understanding the cultural differences and thus the mentality and socio-economic characteristics in the east and, more accurately, connecting the two different periods: communism and transition, and evoking their impact on society. The two questions we pose in the present discussion which will be illustrated with the specific features of the Romanian reality are: 1. Are there any stereotypical images of Eastern European women? and 2. Are the women in these contexts aware of their position, existing gender differences, or gender sensitive issues in their societies? An eloquent picture of contradictions and paradoxes is expressed using the antithesis between the apparent independence and professional activities of women and the relatively conservative gender patterns which are still dominating the Romanian mentality. These are relevant when considering the everyday struggles of women in science and technology, not only in Romania, but we should be aware of the specific meanings of concepts like representation, involvement, activism, shared responsibilities or even feminism in post-communist contexts; they have not the same meanings, and sometimes these differences are not very well known in western societies.

In understanding the Romanian context, we will locate the analysis in two periods: the communist era between 1945 and 1989, and the transition period of more than 15 years and the so-called 'wild capitalism'. There are a few steps and phases which should be pictured as indicating the legacy of the communist past, namely the low industrial development before 1945; the great emphasis of transforming society when all people, regardless of sex and race, were considered equal politically, economically and socially. All those capable of working in the paid labour market should work, and women explicitly should work in order to pursue the aim of social transformation, which was active participation of all on the labour market. The aim of industrialization was providing workers with better living standards, building industrial colossi as well as small industrial enterprises which not always were profitable, providing free education and the possibility/obligation to take a designed job/position associated with future rewards (getting on the lists for obtaining an apartment or buying a car). Of course, there have been significant privileges for people belonging to the communist nomenclature, including those in research and industry having not only access to Eastern publications/ conferences/ stages, but also to Western research arena.

The shift of the transition brought the emergence of new contradictory statuses and roles for all people, and sometimes women had more difficulties to assume the adaptation for these transformations. Rebuilding the democratic system, and reshaping the values

and norms have also been difficult tasks for the Romanian society. Transition to market oriented economies created sometimes unexpected problems for people who were not prepared for assuming active roles, relying as before, only on state support. These problems are mainly connected to no stable jobs, competition, unemployment, and as consequences various phenomena occurred: poverty, aging, decreasing fertility rate, brain drain. There have been and still are problems in reshaping institutions; the 'institutional vacuum' should be addressed, and it requires radical attitudes, responsibilities and skills having to be learned. Of course, there have been proposed policies like promoting equal opportunities, anti-discrimination measures and so on; nevertheless, their effects are still expected. One can ask the question of how the reality for women has changed during the transition period. Two levels should be mentioned here: changes regarding the roles of women as paid workers/mothers (reshaping the career-family balance), and new opportunities for women as social, civil and political actors.

There are no uniform paths regarding these two aspects, and unfortunately there still is no coherent public mainstream discourse in terms of gender impact, and former attitudes and mentalities dominate at the societal level.

Method and Data

The present paper is reporting, as an exploratory study, the partial results of the qualitative data analysis in relation with the changing organizational culture of one University in Romania towards a more sensitive environment for empowering women in science, technology and engineering. The main focus was on two types of directions:

- Engineering faculties: 1. Electrotechnics and Informatics; 2. Energetic Engineering; 3. Management and Technological Engineering;
- Natural sciences: 1. Mathematics and Computing; 2. Physics; 3. Chemistry.

Having in mind the theoretical considerations about science and technology at EU level and in the literature, like 'the research agenda' for 'making gender stick to engineers' (Faulkner 2000, 109–111) and extended to science and technology as well; and the results of the two already mentioned projects WomEng and Enwise, we proposed a research design to investigate how valid the measures and directions of these studies are for a specific higher education institution.

The following methods have been proposed:

1. Interviews with 10 respondents employed at the university: 2 in high administrative positions (one male and one female professor); 4 female engineers (1 assistant professor, 1 junior lecturer, 1 senior lecturer and 1 professor) and 4 female students (2 from natural sciences and 2 from engineering).
2. Two focus group interviews with women: the first one gathering 6 academics (2 assistants, 2 lecturers and 2 professors), and the second one consisting of 8 students.

The interviews have been oriented towards the following dimensions:

1. Women and science, technology and engineering at the national and European level;
2. University policy regarding gender issues;
3. Institutional development.

Specific issues also discussed were recruitment policies, career chances for graduates, adjusting education fields and labour market, teacher training strategies and the partnership between schools – university – industry – research.

The focus groups have been organised as follows: in advance, the participants received a two-page document about the major findings of the two mentioned projects, in relation, of course, with the university.

The structure of discourse, both in interviews and focus groups, reveals not very different patterns with respect to equal opportunities for male/female students or academic staff. The major problem mentioned by almost all interviewees located at the industry or research domains was that the labour market seems to be weak and unable to absorb trained labour force, and is especially inflexible towards women.

National and European policies related to gender issues: the gender mainstreaming or gender watch system is unknown to 90% of respondents. As people stated, there are not enough opportunities for gaining information on or getting in research projects (especially on gender policies) at the European level, and for the national competition this issue is still not very important.

'Students benefit forms apply <no discrimination> policy' as an academic staff member declares; no examples of problems regarding any gender related issue were possible to be revealed in focus groups or interviews. In science, more and more students are female (60–70%), as they are preparing for possible teaching careers, and chances for a future job in research and development or industry for these graduates are rather low. The real problem in natural sciences like physics or chemistry is that not enough students are interested in such careers anymore. In engineering faculties the situation is better: they have more prospective students, but the female ones represent around 35–40% in some faculties, while in some specialisations like Robotics or Technology of Machine Building or Engine Engineering their proportion is very low (0–10%).

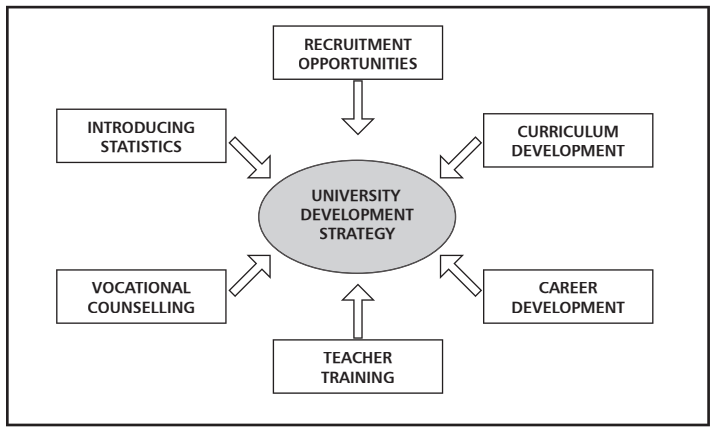
As students argued, the curriculum is not differentiated or gender sensitive, but still optional social subjects like marketing, law, communication theory, sociology or the teacher training module, are followed by more female students from engineering and technology faculties. The female students are keen to have the possibility to study gender related subjects, having yet no opportunity to enrol in such courses. As academic staff declared, there are no specialists dealing with this gender – technology – society issue at the university, but it might be an interesting direction for research.

As a conclusion, the main themes which can be summarized are related to:

- Research – more opportunities for research projects;
- Teaching – gender sensitive curriculum;
- Employment – more career counselling and more chances on the labour market;
- University culture – developing a strategy for a sensitive environment.

It has been agreed that an initiative group on gender issues should be set up on a voluntary basis, and following the research study, a strategy should be followed. Fig. 4 presents the main areas of intervention. These dimensions will be elaborated in the future, and will be part of the final scientific report.

Figure 4. Planned strategies for university development in relation with gender issue



Conclusions and Reflections

Recent developments in the European area – related with democratization, citizenship, employment and equal opportunities – made participation and activism both in education and at the workplace an important area of research. Western European countries, as well as Eastern post-socialist nations are complaining of the low representation of women in some areas like science, technology and politics. Across Europe, various measures are focusing on encouraging women in science and technology, and sometimes the differences between east and west are not considered. The prevalent research topics and expected impacts of these measures have been investigated as a departure point in the present paper. In the theoretical section, various models in investigating the study and career path of women in science and technology are presented (Adelman 1998; Jonsson 1999, Faulkner 2000). To illustrate different patterns between east and west, quantitative analyses based on the ISCED (International Standard Classification of Education) database are presented showing differences on female students' representation in science and engineering at the university level. The relevance of some interesting results of the European project 'WomEng' (Creating Culture of Success for Women Engineering) is investigated in relation with the Romanian situation in this field, in the context of dissemination and valorisation. Based on qualitative methods, interviews and focus groups, several educational strategies for enforcing and empowering women, students and teaching staff are presented, contextualised for a university in the Romanian socio-economic context. Study and work in engineering and natural sciences shows not so highly gender-segmented fields at the level of higher education, but later in their professional career there are more barriers for women entering these fields. The issue of diversity and gender sensitive policy in education and employment is not about engineering and/or science only; not about women only and not to be solved by women only.

That's why a strategy – at least in the university context – should follow the following dimensions: statistic data in reporting gender related issues; improving recruitment opportunities; curriculum development; vocational counselling; career development and teacher training.

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