Gender and Science Education

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1. Introduction

In 2009 within EU-27 the number of women graduates from tertiary education was about 60% out of the total. There were 145.2 women per 100 men graduating from ISCED 5-6. However the proportion of female graduates varies across the fields of study. For example in 2009 in the broad field of study '*social science, business and law*' female graduates outnumber male graduates in the field being represented with a share of 61.8%. This was not the case with the fields *'science, mathematics and computing'* (EF4*)* and '*engineering, manufacturing and construction'* (EF5*)* where the pattern was reversal. In both fields of study male graduates easy outnumber their female counterparts. In 2009 the proportion of female graduates in the field of '*engineering, manufacturing and construction'* was only 26% on average and in the field of *'science, mathematics and computing'* – about 40%, respectively. These gendered patterns at the tertiary level of education form the so-called 'horizontal segregation' which reflects the fact that the proportion of men and women vary considerably between different fields of study in tertiary education – in all EU-27 countries female students are concentrated in the fields of *'education and training'* and *'humanities and arts'* as well as in the field of '*social science, business and law'* while male students dominate in the fields of *'science, mathematics and computing'* and in '*engineering, manufacturing and construction'*.

We should assess the current state-of-the-arts against the distribution of graduates among the different study fields. In 2009 the tertiary education graduates in the field of '*social science, business and law*' represented **35.6%** of all tertiary student graduates in EU-27. This statistics reflects the existing stable trend for this field of study during the five-year period 2005-2009. At the same time the proportion of tertiary education graduates in the field*'science, mathematics and computing'* was only **9.2%** of all EU-27 graduates and the trend shows a decrease of the proportion from 10.0% in 2005 to 9.2% in 2009. In 2009 the field of '*engineering, manufacturing and construction'* accounted for **12.9%** of all tertiary education graduates. The trend in this field is relatively stable (from 12.7% in 2005 up to 12.9% in 2009).

According to the recent edition of 'She Figure 2009' booklet [1] in the EU-27, 45% of all PhD graduates were women in 2006; they equal or outnumber men in all broad fields of study, except for *science, mathematics and computing* (41%), and *engineering, manufacturing and construction* (25%).

2. Why gender matters in the study fields of 'science, mathematics and computing' and 'engineering, manufacturing and construction'?

Rocard's report [2] threw attention to the fact that during the recent years many studies have highlighted an alarming decline in young people's interest for key science studies and mathematics*.* When looked at from a gender perspective the problem is even worse as, in general, girls are less interested in science education than boys. Raising the female rate enrolment and graduation in SET (Science, engineering and technology) areas of study could:

a. Enlarge the available pool of highly qualified human resources potential in the two areas. In today's global economy, where education and human capital accumulation drive innovation and competitive advantage, increasing graduation rates among female students in '**science, mathematics and computing'** and in '**engineering, manufacturing and construction'** is for many countries the most immediately available opportunity for increasing the output of graduates in these critical areas.

b. Enrich the research in SET areas with a different perspective. There are evidences that patents produced by mixed (female and male) teams of scientists are ranked higher in comparison with those produced by single sex teams of scientists.

c. Elaborate gender-friendly user-driven products and services, e.g. the designers of automobiles' belts should take into account the needs of the pregnant women; the designers of ICT should take into account the specific interests of women in order to elaborate more gender-friendly ICT products and services, etc.

d. Empower women life chances– women graduates from SET areas might have better chance for employability on the labour market keeping in mind the great demand for professionals in these two fields of study and the shortage of supply due to the low demography and declining interest in science education.

e. Enable women for making *informed decisions* in all paths of their lives.

f. Last but not least: foster the emergence of a **critical mass of women** in SET areas, which is of crucial importance for the next generation of students' subject choice of studies. What is more, if there were some kind of **critical mass of women** in SET areas, and especially in the technical disciplines, it would become much easier to recruit more women, since, if there were a lot of female scientists, engineers and technicians, people and the whole society would accustom to women in these professions and to the idea that women could be valued performers in these fields. In this connection it deserves noting that at the beginning of the 20th century men dominated in professions like 'lawyer', 'financier' and 'medical doctor'; indeed in some European countries at the very beginning of the 20th century women were even not admitted to tertiary education in law subjects or if admitted they were not permitted to practice the profession of lawyer. Towards the end of the 20th century the situation was radically changed and the professions of 'lawyer', 'financier' and 'medical doctor' tend to be feminized. Therefore, the lesson learned from the history is that meeting the challenge needs time and effort.

3. Identification of the problem: Why female students do not opt for studies in S&T areas at the tertiary level of education (ISCED 5&6) and related with them career trajectory?

A number of recurrent themes or topics are to be found in the literature on gender and education which deal primarily with educational practice (or what goes on in schools). These are the curriculum (official and hidden), school reading materials, subject preference and choice, motivational and psychological factors of students, school organisation and management, teacher attitudes, assessment, teaching as a profession, co-education and single-sex settings, etc. [3]

In our view the educational system is like a living organism. In order to understand the current state-of-the-arts of segmentation of education by gender at ISCED 5&6 levels of education we must have a close look at what is going in upper secondary education (ISCED 3&4) in terms of **gendered subject choice and performance** by several reasons:

- According to many well documented studies female and male students make a definite choice of the subject of their studies already in 15-16 years old, i.e. during their upper secondary education which in the EU countries (and by definition) is more subject/ disciplinary oriented. Thus the first educational choice for a career trajectory in S&T areas use to be made at the age of 15-16 years old.
- Gender differences in the **subject choice & performance** during the upper secondary education predetermine and cause the gender imbalance in the tertiary education broad fields of study: '**science, mathematics and computing'** and '**engineering, manufacturing and construction'**.

The OECD's Programme for International Student Assessment (PISA) explores the educational performance and attitudes of 15-year-old girls and boys. It is running every three year. The OECD's PISA tests of 15-year-olds - *PISA 2006: science competencies for tomorrow's world* [4] and especially *PISA 2009: Assessment Framework. Key competencies in reading, mathematics and science* [5] show that in the majority of OECD countries girls and boys perform equally in science domain assessment, i.e. the assessment of *scientific literacy*.

The OECD report: *Equally prepared for life? How 15-year-old boys and girls perform in school* [6] review the knowledge gained about gender related issues from PISA 2000 and PISA 2003 when reading and mathematics respectively were the major domains of assessment, with attention also paid to the relationship between student performance and student attitudes and consider in more detail the results from the PISA 2006 survey, when science was the major assessment domain, considering also student attitudes to science and the environment.

The Eurydice study *Gender Differences in Educational Outcomes: Study on the Measures Taken and the Current Situation in Europe* provides a review of the research literature on gender and education and summarises the main findings from international performance surveys on gender differences in education. It states that:

'PISA 2006 also reported that overall gender differences were the smallest in science when compared to reading and mathematics. …on average there was no gender gap [in science domain of assessment] in most countries. Females had higher results in Bulgaria, Greece, Latvia, Lithuania, Slovenia and Turkey, while males scored higher in Denmark, Luxembourg, the Netherlands and the United Kingdom (England). However, despite performing equally as well as boys in most countries, girls tend to have lower self-concept than males in science i.e., on average, girls had lower levels of belief in their scientific abilities than boys in all European countries. Boys also had higher self-efficacy, i.e. a higher level of confidence in tackling specific scientific tasks in all countries, except Austria, Poland and Portugal. As PISA 2006 focused on science, it reported other interesting issues. On average females were stronger in *identifying scientific issues*, while males were stronger at *explaining phenomena scientifically'.*

Main finding of section 3:

The origin of the problem with the female low participation rates in tertiary education S&T programmes is identified with the **gendered subject choice & performance** during upper secondary education (ISCED 3&4). Therefore the problem should be redefined as: *Why do girls and young women of 15-16-years old not identify with mathematics, science and technology subjects and related careers, despite the fact that they perform equally in science domain of assessment?*

We claim that gender inequalities still remain in European education systems in terms of subject preferences and performance, and in qualitative aspects of the education and training experience.

4. Examination of reasons behind the problem: findings from several on-going and completed research-oriented large-scale international projects as well as from several EU, UNESCO and UN reports

In this section we review and consider findings of the following large-scale research projects:

ROSE project: The Relevance of Science Education [7]; **IRIS project:** Interests & Recruitment in Science. Factors influencing recruitment, retention and gender equity in science, technology and mathematics higher education; **HELENA project:** Higher Education Leading to ENgineering And scientific careers; **WOMENG:** Creating Cultures of Success for Women Engineers[8]; **PRAGES project** : Practising Gender Equality in Science[9]; **IFAC project:** Information for a Choice. Empowering Young Women through Learning for Technical Professions and Science Career[10]. For example the IFAC project focuses on two significant reasons for lower female enrolment rates in SET:

- There are pre-existing societal gender stereotypes reflected within the educational system that prevent young women from studies in SET.
- There is a lack of accurate information on career options provided by sources like media, school etc. on the field of SET, which negatively influences possibilities of choice.

Main findings of section 4:

The reason behind the identified problem is complex and multi-faceted. It is built on accumulation of different causal factors. The review of the research (past and current) as well as the examination of identified reports addressing the issue provides strong evidence about the underlying factors that affect the observed gendered subject choices of students.These influential factors which form the gendered perception of subjects and the careers and which appears to be decisive in framing girls'choices could be classified into three groups as follows:

- Gender stereotypes which operate at different levels like: society, family, education's institutions, media and which are sustained and reproduced (consciously or unconsciously) by different actors, e.g. parents, school, peers (schoolmates), etc. In particular in educational system and process (at all levels of education) science gender stereotypes are sustained and reproduced through the gendered nature of school reading materials and textbooks (mainly in primary and secondary schools), trough the uncritically designed websites (of higher education and research institutions), through teachers' attitudes in the teaching process and in many other verbal and not-verbal (images) ways. The consequences of gender stereotyping are low self-esteem and low confidence. Traditional stereotypes are the biggest challenge for gender equality in education
- The absence of female scientists/engineers role models, professional counseling and guidance, mentoring programmes, etc. at the level of upper secondary education. There are few, if any role models in positions of leadership in S&T areas of study.
- An outdated pedagogy in terms of the way science is taught in schools and the irrelevance of science curriculum to students' interest, in particular to girls' interests.

What kind of science curriculum might attract girls' interest in the subject?

- If it includes social elements and discuss the relevance of the subject to society, i.e. its *social relevance*, for example the benefits of S&T for society;
- If it shows the human dimension of science's endeavor. A historical review of some great debates in science and scientific discoveries reveals a kind of *personal relevance* – instead of the stereotyped 'abstract, cold and depersonalized' image of science appears a more human image of science, which is full of passion, struggle for recognition and other human qualities. Therefore if science curriculum includes a bit of history of science illuminating what is going behind the 'scene of science' it might attract students' interest in the subject;
- If it is cross-disciplinary and multidisciplinary (especially at the tertiary level of education).

5. General conclusion

Traditional stereotypes and the way science is taught (at all levels of education) remain the biggest challenge for gender equality in education, in particular for women under-representation in S&T studies.

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