SEVENTH FRAMEWORK PROGRAMME

Meta-analysis of gender and science research

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Topic report
Stereotypes and Identity

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Structure

1. Introduction

The topic report on “stereotypes and identity” aims to provide a critical overview of the literature, theory and research carried out on gender and science at the European and national levels. A vast body of international literature has shown that men and women choose different fields of study and professional trajectories. The interplay of many individual, institutional, social and cultural mechanisms across different levels (NAS, 2006; Suter, 2006) has been used to analyse the present (horizontal and vertical) gender segregation in male domains of study and professional careers (Kanter, 1977; Rastetter, 1998; Wetterer, 1999). The goal here is to highlight the main results and gaps of a particular branch of research that has addressed the following research questions:

- Inborn cognitive abilities and the lack of evidence concerning any differences between the sexes in this sense
- Gender stereotypes and career choices in adolescence and the role of the agents of socialization in these processes
- Gender stereotypes in science itself (patterns of persistence and change, the link with the masculinization/feminization of scientific fields, etc.) and their impact on the professional choices of women and men

2. Conceptual framework for “stereotypes and identity”

There are three dominating themes under this multidisciplinary research area. First, even if not the main focus of the studies, there is research that explores the evidence for **differences in inborn cognitive abilities between men and women**. Second, the social construction of gender identity has attracted quite a lot of scientific attention and publications exploring, via **rational choices theory, role modeling and, in particular, gender roles and socialization**, the unequal presence of women and men in science. And third, research has also focused on **the social construction of science** mostly through the analysis of conceptual reflections on the epistemology of science, the hegemonic position of masculinity and its effects on the gendered order within scientific/professional opportunity contexts.

2.1. Inborn cognitive abilities

A branch of the literature deals with the analysis of inborn cognitive sex differences and the way this may influence educational and/or professional choices, to eventually promote gender-differential success in science, engineering and technical fields of study and work.

A bulk of studies have analysed **biologically determined sex-differences in cognitive abilities** and its consequences. Moving away from a *naturalistic and biologically determined point of view*, researchers mainly from Anglo-Saxon countries have explored and measured differences between the sexes in terms of aptitudes and skills. Studies have measured comparisons in mathematical and spatial performance (Geary, Saults, Liu and Hoard, 2000; Halpern, 2000; Gallagher, Levin and Cahalan, 2002; Xie and Shauman, 2003; Gallagher and Kaufman, 2005; Pinker, 2005; Spelke, 2005; Halpern, 2006) and in verbal and written abilities (Weiss, Kemmler, Deisenhammer, Fleischhacker and Delazer, 2003; Levy, Astur and Frick, 2005). They have focused on brain structure and function, hormonal influence on cognitive performance, psychological development in infancy and evolutionary psychology (NAS, 2006) to suggest a biological basis for the differing career outcomes of women and men. To do so they used standardized tests, controlled laboratory experiments, neurobiological techniques and meta-analyses. Along these lines, some studies have probed the existence and explored the nature of cognitive differences between the sexes (Hyde, 2005; Spelke, 2005). The conclusions of the research, however, are rather controversial, as they often highlight (small) statistical age-sex differences while de-emphasizing overlaps between the sexes and superior female performance (Rosenthal, Rosnow and Rubin, 2000).

Through a rather *constructivist approach* most studies show that no scientific experiment has proved the existence of systematic and/or significant biological sex differences in most cognitive functions (NAS, 2006). Gender differences in scientific abilities and mathematical aptitudes may exist. However, this does not indicate that aptitudes may not change or that sex-differential performance in science and engineering can account for the lower representation of women in these fields. In fact, evidence shows that rather than sex differences in cognitive, neurological and biological endowment (often small and in many cases nonexistent), there is an interplay of psychosocial and sociocultural factors (Halpern and Tan, 2001). So, there seems to be wide agreement that the explanation of biologically-determined sex differences in cognitive abilities cannot account for women’s underrepresentation in science-related subjects (technology, engineering, maths and computer studies). In fact, to account for gendered motivations, preferences, interests, decisions and performance, and to gain a better understanding of the differential success of women and men in science and engineering, the focus of the largest body of research has been on exploring biased cultural influences on the social construction of identity. However, as the debate over the possible existence of inborn sex differences in cognitive abilities reemerges regularly, the relevant literature dealing with the nature of biologically-determined sex differences needs to be explored in greater detail.

2.2. Stereotypes and career choices in adolescence

In the early 1990s, theoretical thinking focused on the construction of the gendered world and/or gendered segregation in the social order. Gender is the result of gendered definition processes; it is differently structured throughout the world and through daily interaction. This means that social constructions of separate guidelines/expectations for women and men are developed everywhere and in everyday life.

Gender roles are embodied in a set of stereotypical beliefs or mental models about how women and men should be and how to behave in the different spheres of life. The social construction of gender roles and stereotypes and their permeability change across cultures and over time. Therefore, gender differences in career interests are not fixed but subject to the influence of social forces (Xie, 2006). However, unchallenged gendered stereotypes support the continuity of specific sex roles and occupational gender segregation. The stereotypes are automatic; often we are not aware of them. They are simplifications of reality that serve to reduce the complexity of the world around us and to streamline the decision-making process. There are specific stereotypes (positive and negative) about male and female characteristics and behaviours in society. From infancy and through a lifelong process (primary and secondary socialization) we are socialized into what is “masculine” and “feminine”.

The construction of gender identity, while the result of the interplay of psychosocial and sociocultural factors, is determined by the social construction of gender roles and stereotypical traits and undertakings. The roles and stereotypes traditionally attributed to women and men have diverse effects on girls and women when it comes to enroling and working in science-related fields. However, three main approaches emerge in the analysis of

the gender-biased construction of individual identity in the social context: human capital theories, role modelling and the construction of gender stereotypes.
People adopt **rational decisions** concerning their academic and professional future. The final choices are based on the value they attribute to the different fields of study and areas of work (Eccles, Barber and Jozefowicz, 1999; Wigfield and Eccles, 2000). The value they assign depends on intrinsic motivation (e.g. the importance they attribute to them) and extrinsic motivation (perceived usefulness in achieving their goals and the costs in terms of time/effort). Women and men do not assign the same values to the same tasks and activities. They think and decide differently when it comes to individual benefits. For example, women prefer to work in female-typical jobs because they often have to combine their career with family-related responsibilities. Yet, the explanatory power of this approach to account for horizontal gender segregation is unclear (Xie, 2006).

Role modelling is suggested as one possible mechanism through which social forces affect gender differences in career choice (Bandura, 1986). This perspective argues that individual choices, rather than being rational, are influenced by society at large. Family background and, in particular, the existence of female role models (to identify with) are crucial for the possibility to learn from the experiences of adults working in the labour force (AAUW, 2000; Suter, 2006). Accordingly, female students in engineering and other branches of science often have at least one parent with a professional background in one of these disciplines. For this reason, it is vital that women be exposed, from an early age, to female roles to compensate for the absence of women in technical and science-related contexts. In this regard, there have been pioneering programmes developed by some universities to encourage interest on the part of high school students in technology careers (Margolis and Fisher, 2003; Greusing, 2006). However, the explanatory value of the role modelling approach for investigating mechanisms of horizontal gender segregation is also limited.

By contrast, the perspective of **gender stereotype construction** is more comprehensive. The literature related to gender differences in science does not only deal with inborn cognitive abilities (biologically determined). In fact, differing social pressures seem to have greater influence on the motivations and preferences of boys and girls than their underlying abilities. The main focus of the bulk of the research has been on investigating how the **differential academic performance**, **self-perception of cognitive abilities and educational achievement** of women and men (as a result of the process of socialization, type of school, etc.) are socially determined (Xie and Shauman, 2003).

In this sense, empirical evidence suggests that sex differences in **academic performance** may exist (depending on the nature of the agents of socialization). Yet, in spite of country gaps, there has been a tendency for the differences to diminish. Further, most of the literature focuses on women’s “deficits” (in achievement or self-perceived achievement) to explain the underrepresentation of women. But current empirical evidence collides head on with this hypothesis. Talented girls in maths and science make more diverse choices as regards university studies than equally talented boys. So, even when a gender gap does exist, it can hardly explain gender segregation in higher education. As Xie and Shauman (2003) suggest, differential educational paths cannot be explained on the basis of academic performance in maths or natural sciences: “the gender gap in average mathematics achievement is small and has been declining, although boys remain much more likely than girls to attain high levels of competence. Gender differences in neither average nor high achievement in mathematics can explain young men’s greater likelihood of majoring in science and engineering fields relative to young women” (p. 208).

Considering that systematic and significant biological sex differences in cognitive functions have been rendered moot and that socially conditioned gaps in academic

performance do not account for gender differences in the choice of studies, what are the factors that explain the choice of different educational paths at school, high school and college levels? The present situation of women and men in science-related disciplines and professions results from the interplay of individual, institutional, social and cultural factors. The debate on gendered career choices focuses mainly on the influence of gender stereotypes in the construction of identity through the socialization process (mainly during adolescence), as well as on the self-perception of cognitive abilities, interests and educational achievement. The literature from this perspective explores the influence of gender-related stereotypes (the role of the agents of socialization) on the educational and professional choices of women and men, while debating the mechanisms that may undermine that influence (in particular through institutional education). It also analyses the factors influencing career choices which explain why girls tend to choose science, engineering and technology paths less frequently, while boys opt less often for humanities and social science paths. The aim of this literature is to underline not only the persistence of stereotypes and gender differences in educational paths, but also the changing permeability of this tendency over time.

2.3. Social construction of science

This third topic deals with the analysis of **the mechanisms that articulate the gender-biased construction of science, the persistence of stereotypes and their permeability to change**. The analysis of the social construction of science is mostly carried out through the analysis of conceptual reflections about the epistemology of science, the hegemonic position of masculinity and its effects on the gendered order within the contexts of scientific/professional opportunity. The literature is mainly focused on gender differences in the perception of science/engineering, in the masculine/feminine character attributed to certain disciplines as well as on its influence on educational and professional choices.

Feminist literature has focused on the gendered perception of science. It has been claimed that **mainstream research is neither objective nor value-free**. While some approaches are based on concern for the **marked male dominance in science** (science is “male” science), others deal with the possible **contributions of women to science**: “equality feminism” (Harding, 1986; Keller, 1985 and 1987), “difference feminism” (Rosser, 1990) and “postmodern feminism” (Haraway, 1988 and 1991). Moreover, the gender-biased culture in male-dominated fields, concepts such as “hegemonic masculinity” (Connell, 1987) and “gendered organizations” (Acker, 1990) and its effects on the gender order have also been investigated (Wajcman, 1991). Yet, the old categorization that associates science with male-dominated areas no longer holds (with the exception of engineering and not in all countries). In fact, there has been a ‘revolution’ in several traditionally male-dominated fields of study (such as medicine) in that women have started to enter and even dominate them. Thus, to avoid focusing on continuity, the “fragility” of gender stereotypes in certain science-related professions has been acknowledged.

3. Statistical overview

The statistics on the topic “Stereotypes and Identity” should give an overview of the numbers and percentages of the research topic and its subtopics in the different countries and country groups. This section presents an overview of the statistical distribution of the entries in the “Stereotypes and Identity Database” (GSD). This includes geographic coverage, thematic coverage including institutional sector, scientific field, and life course as well as the methodological approach.

The overall literature on “Stereotypes and Identity” represents more than half of all the entries in the database. This means that of the eight topics in the database, a single one has more entries than all the others combined. The literature dealing with stereotypes and identity in Europe is huge.

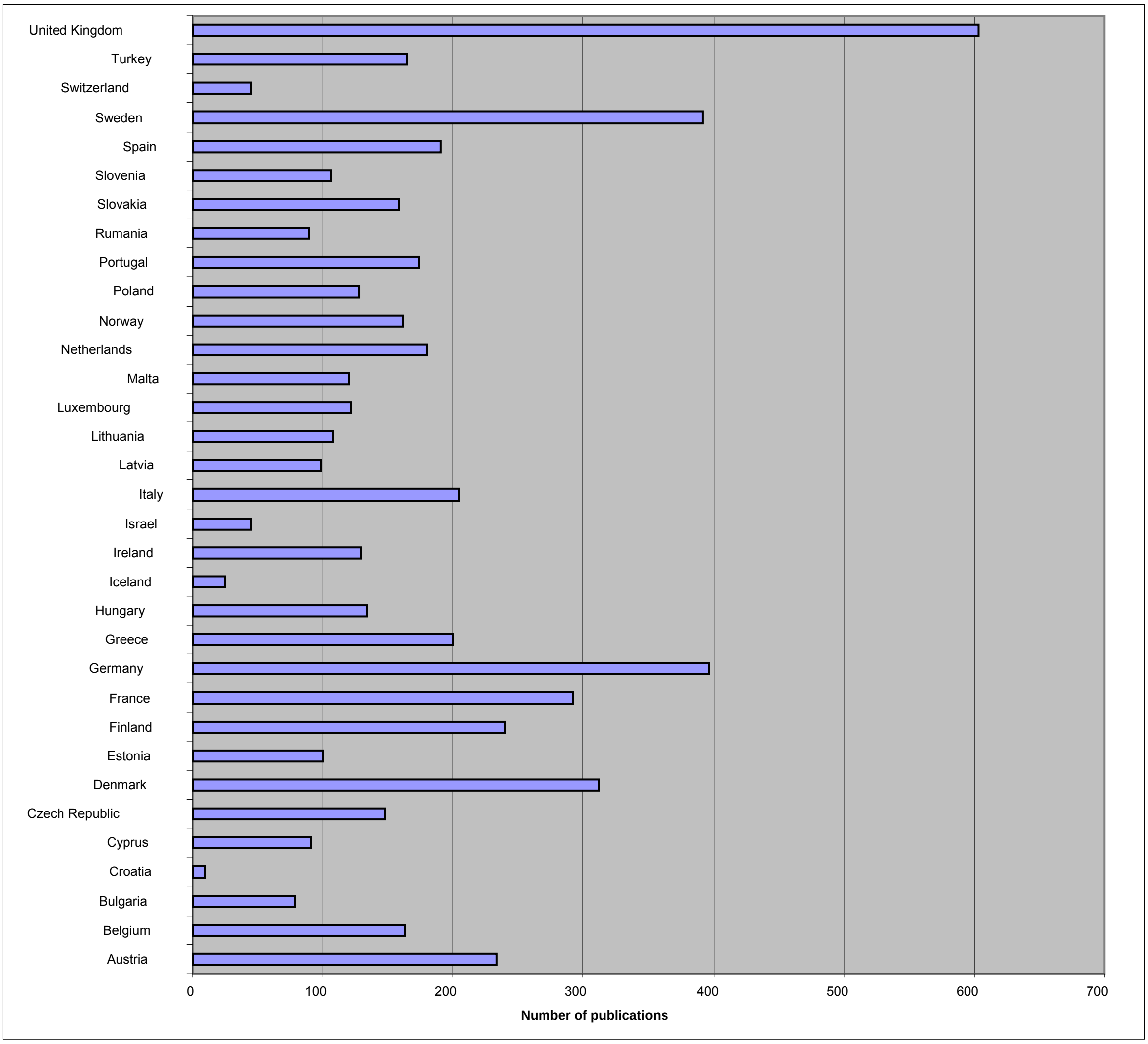
Table 1: Absolute and relative number of SI studies in the database

	N	% all GSD publications
Stereotypes and identity	2458	54.0
Total	4549	100.0

Source: GSD 2010

By looking at the distribution of references, considering geographical coverage, three countries are at the top: Germany, Sweden and the UK. The UK has the most relevant literature in the database, followed by Austria, Denmark, Finland and France. Most Southern countries have fewer entries, and the Eastern European countries are those with the scantest literature on “Stereotypes and Identity”.

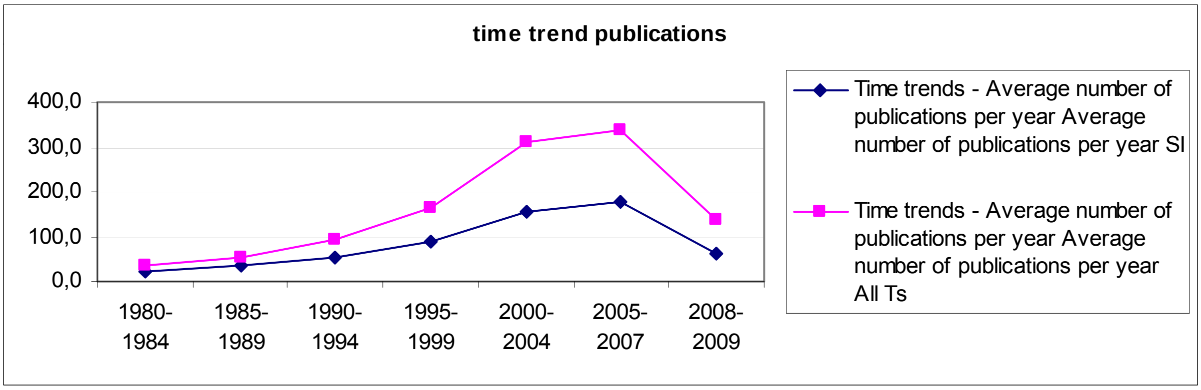
Figure 1: Number of SI publications in all countries (SI publications: total, 2458)



Source: GSD from 2010

The amount of literature has changed over time. The period in which the literature on “Stereotypes and Identity” has been analysed shows that the gender perspective has emerged especially in the last twenty years. Historical studies go back to the 18th century and before, increasing somewhat in number in the 19th and early 20th centuries, and increasing much faster after the Second World War. From the 1970s on, with the beginning of the women’s movement and growing feminist/gender awareness, more literature emerged. The number slowly increased in the 1990s, and doubled between 2000 and 2007. In fact, during the last twenty years “Stereotypes and Identity” (SI) has become a very prominent topic (see figure 2).

Figure 2: Time trends: average number of SI publications (five-year time spans)



Source: GSD from 2010

The subtopics of “Stereotypes and Identity” are distributed very differently across European countries (see table 2). The lowest number of publications in the database was found within the category of “Cognitive Abilities”. By contrast, most publications are related to the “Social Construction of Identity” and, in particular, to the “Social Construction of Science”.

By looking at the numbers of publications in the different country groups, it can be seen that “Cognitive Abilities” has been the most often investigated subtopic in the Southern countries, more than double in comparison to the other country groups. By contrast, Eastern countries have the lowest number in total, a trend repeated for the three subtopics.

Entries for the “Social Construction of Identity” are most often found in the Continental and Southern countries, one third more than in the Nordic and the Anglo-Saxon countries. It would be interesting to compare these results with those of the topic “Policy Towards Gender Equity in Science and Research” because of the likely relationship between research on the causes of gender imbalance and the number of initiatives to promote change, as well as the evaluation of these measures.

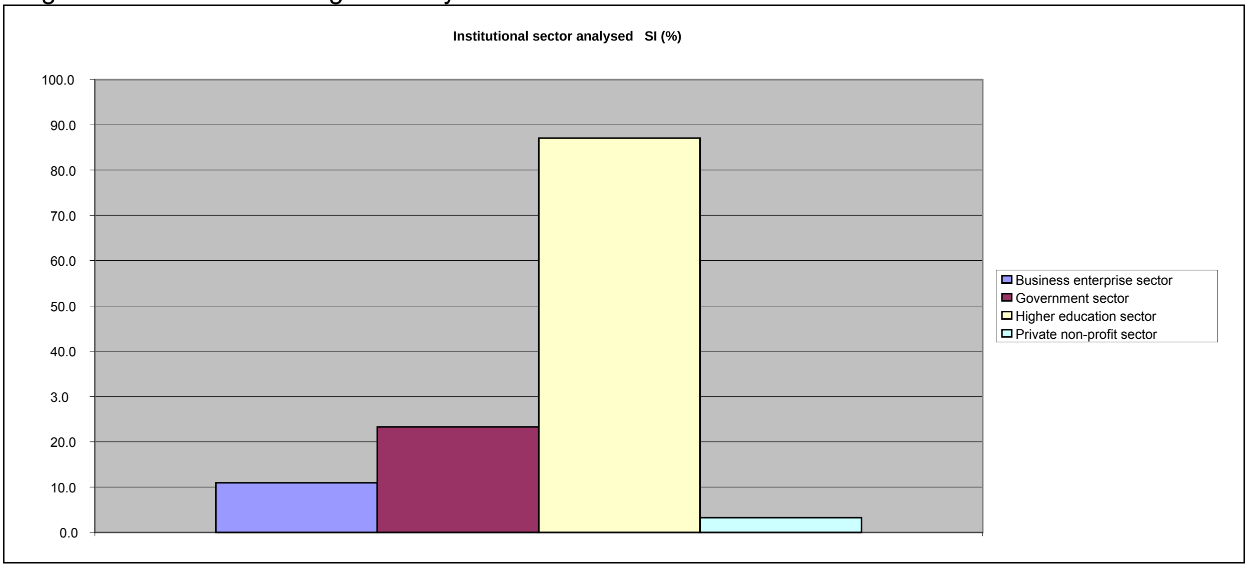
Table 2: Subtopics of SI in country groups

Stereotypes and identity	Nordic countries	Anglo-Saxon countries	Continental countries	Southern countries	Eastern countries
Cognitive abilities	29	41	31	75	24
Social construction of identity	117	111	162	163	53
Social construction of science	316	114	217	135	98

Source: GSD from 2010 adapted

There seems to be a very striking disproportion in the number of publications across sectors over the years (see figure 3). Nearly all studies focus on higher education, which means that university researchers often use their own situation to study “Stereotypes and Identity”. The topic was very seldom investigated in private non-profit organizations, a tendency that can be found in all topics. The number of entries dealing with business and enterprise is also low. So, also from the point of view of policy, more research on private non-profit organizations and enterprises would be welcome in order to know more about the barriers women may encounter (see also the report on science as a labour activity, because of the overlapping of the topics). The topic has also been investigated within the governmental sector, but at a great distance from higher education. It would be important to know what factors lead women to choose this sector less often than higher education, a common trend in many countries.

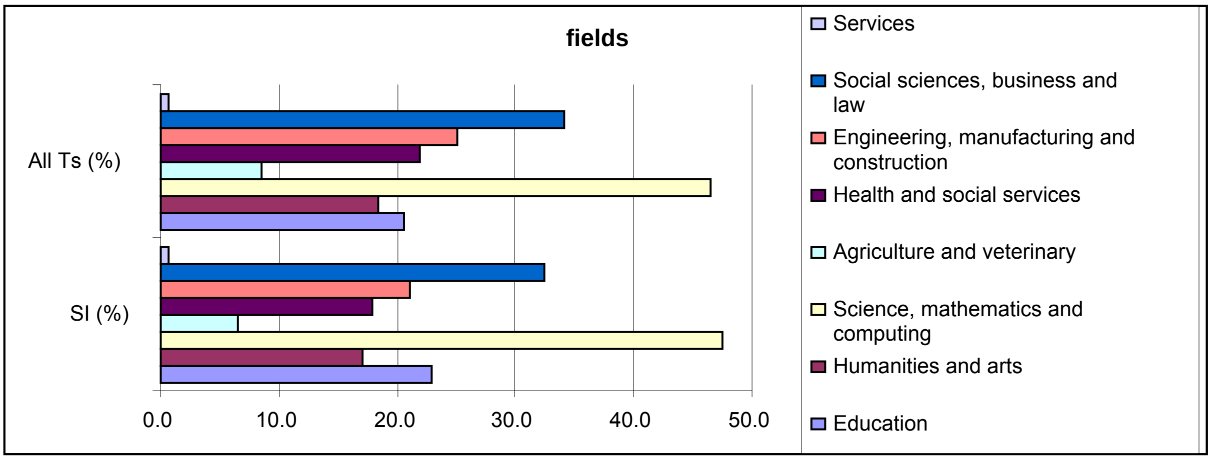
Figure 3: Thematic coverage of SI by institutional sector: from 1980 to 2009



Source GSD from 2010

Comparing the importance of the topic across different study fields, many similarities can be found. Science, mathematics and computing have the highest number of entries; engineering, manufacturing and construction are also common fields of study. On the other hand, "feminine" fields such as services, health and social services and humanities and the arts have been investigated less often. Here often the question of gender balance goes in the opposite direction. For example, why are boys and men underrepresented in these fields? Do they have less cognitive ability and competence in these areas than girls/women? How does the feminine image prevent boys from entering these fields and feeling "at home"?

Figure 4: SI across fields of study

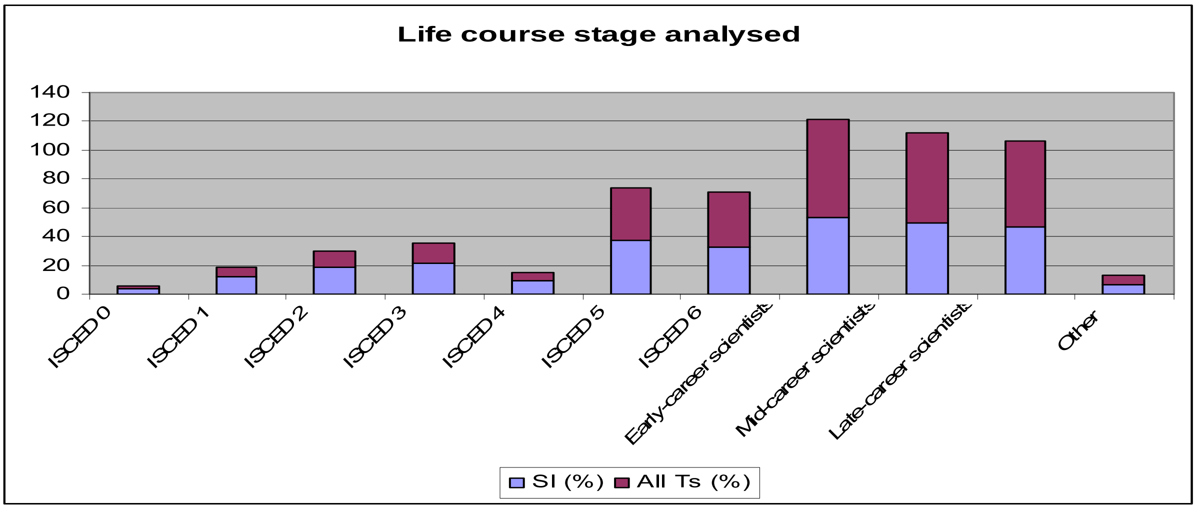


Source: GSD 2010

Fields of study considered to be more "gender balanced", like the social sciences, business and law, have been the focus of a body of the literature (see figure 4). For instance, education and the social sciences have a long tradition of gender research and feminist studies because of their closer relationship to the women's movement.

The data shows a comparatively low number of studies focused on primary as well as secondary education (see figure 5). This means that during the research period analysed, early childhood and adolescence have been the object of research less often in spite of the importance of these stages in terms of gendered educational and professional choices. By contrast, the early career of scientists, especially in higher education, is the life stage most often studied.

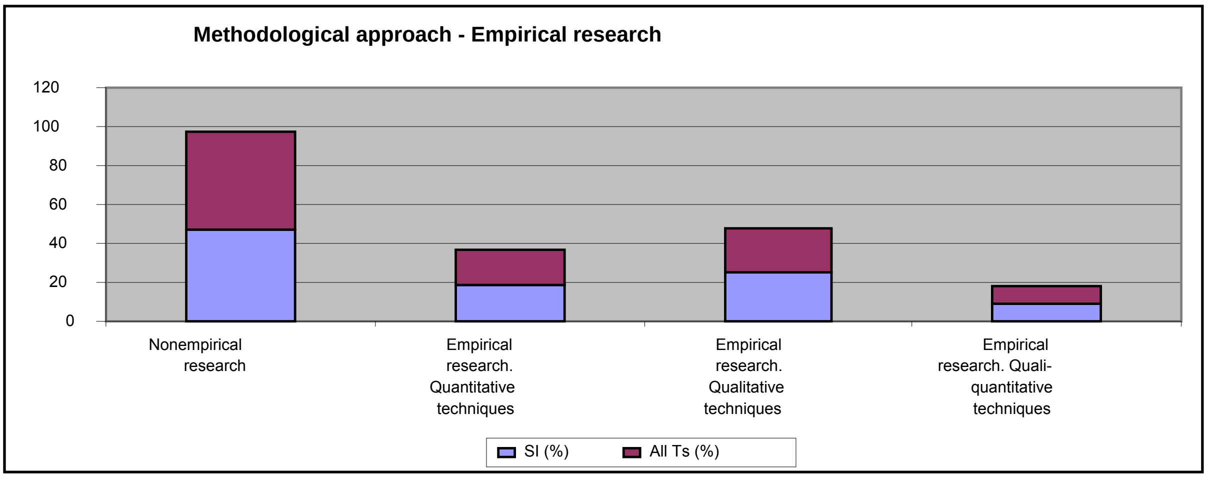
Figure 5: Life course stage analysed



Source: GSD from 2010

Only half of the studies have an empirical approach (see figure 6). The empirical studies focused on "Stereotypes and Identity" have been investigated more often through a qualitative approach. In fact, empirical research using both quantitative and qualitative methods represents only 10% of the database.

Figure 6: Empirical research: methodological approach



Source: GSD from 2010

Half of the approaches are conceptual or focused on the "state of the art". It can be assumed that these are mostly nonempirical studies. Less than half are quantitative or qualitative studies, and a small number refer to compilation of statistics. There is gap in research centred on gender indicators. Half of the quantitative studies use representative samples, less than half micro-data and multivariate analysis, and a very small number are longitudinal studies. Within qualitative studies, the most prominent method of inquiry is the interview, with nearly 60% of the total. Other qualitative instruments, used to a lesser extent in the literature however, are observation, content analysis, case studies and biographical research.

4. Cognitive abilities and academic performance: gender differences?

There is a large body of research devoted to the measurement and explanations of sex differences in **mathematical aptitude, ability and achievement**, because of the crucial role that these play in success in careers in SET (Science, Engineering and Technology) (Shepard and Metzler, 1971; Geary, 1996; Huttenlocher, Levine and Vevea, 1998; Pinker, 2002; Spelke, 2005). The bias associating maleness with mathematics is widespread and pervasive. But, as Banaji (2006) suggests, there is a substantial difference between "perceived/believed" difference and "actual" difference in mathematics performance.

Early evidence focusing on mathematical skills showed well-established gender gaps (Maccoby and Jacklin, 1974). It should be noted, however, that just a few decades ago, this type of research was extremely scarce. For example, Fennema and Hart (1994) have reported that virtually no mathematics education research on gender was published before the mid 1970s. In the 1980s and 1990s gender research gained attention, particularly in Anglo-Saxon countries, and revealed a slight but consistent male advantage in mathematics, as boys tend to outperform girls (Linn and Hyde, 1989). The literature reveals that not only do significant differences in achievement in mathematics and science appear by late adolescence, but also that the gender gap increases with grade level (Ambrose, Levi, and Fennema, 1997). In spite of that, recent investigation has shown conflicting findings. While some studies suggest that gender variations remain static despite innumerable efforts to ameliorate them (Campbell, Verna and O´Connor-Petruso, 2004), other authors have shown a narrowing trend in the gender gap over time (Connolly, Hatchetter and McMaster, 1999; Hyde, Fennema and Lamon, 1990). Additionally, a body of research has found that gender differences in math performance do not really exist in the general population because girls now perform as well as boys on standardized tests (Hyde and Mertz, 2009). Moreover, recent studies show, although not all of them acknowledge it, that gender disparities in education have been changing in favour of girls, both in terms of participation and performance (Jha and Kelleher, 2006).

With respect to differential performance on large-scale mathematics assessments, a generally agreed upon research conclusion is the existence of gender gaps across disciplines and age cohorts (Liu and Wilson, 2009). With a sample involving more than half a million students in forty-one countries, the Trends in International Mathematics and Science Study (TIMSS) is one of the most comprehensive examinations of students' learning of mathematics and science across national boundaries (Mullis et al. 2000). According to Li (2007) the findings of the TIMSS reveal that in most countries males had significantly higher average marks than females in both mathematical literacy and in advanced mathematics in the final years of secondary school. The analysis of the results of the Programme for International Student Assessment (PISA) also shows significant gender gaps in performance across fields of study at the age of fifteen. In all OECD countries, while males show a lower engagement in reading, females reported higher levels of anxiety with respect to mathematics. Additionally, the analysis of the Progress in International Reading Literacy Study (PIRLS) confirms the findings on skill-related gender differences for younger students. For example, girls have better reading skills than boys at the age of nine (Mullis, Martin, Gonzalez and Chrostowski, 2004a and 2004b; Mullis, Martin and Kennedy, 2007).

Box 1. Gender gaps and gender paradigms

There are gender gaps in mathematics achievement in several of the TIMSS countries. The authors examined these gender differences among Asian countries, European countries, and America and analyzed these disparities in terms of the accepted gender paradigms developed to explain the variations. To date theoretical frameworks detailing gender inequity in the hard sciences have essentially been divided between biological factors, socialization factors, and/or a combination of the nature vs nurture theory. Keeves (1972, 1973) examined gender differences in the early IEA studies and concluded (Keeves, 1986) that gender acts as an antecedent for motivation. Sex differences in participation in math and science courses are due to expectancy roles in society to the attitudes inculcated at home and in peer group environments. Other non-TIMSS studies have uncovered large gender gaps especially between high achieving math and science students (Benbow and Stanley, 1983a, 1983b; Page, 1976; Campbell, 2002). These gaps persist despite efforts to eliminate them in Europe and America. Nations are especially concerned about this issue as the development of technical talent is fundamental to both economic and military concerns.

Fuente: Campbell, J. R., Verna, M. and O'Connor-Petruso, S. (2004) Gender paradigms. Paper presented at the IRC-2004 Conference. Lefkosia, Cyprus.

Less attention has been paid to research on the **gender differences in science** achievement of girls and boys than in mathematics. PISA assessments show that science is the field in which overall gender differences are smallest, with a gender gap that is narrower than in reading or mathematics (OECD, 2007). By contrast, other large-scale assessments (e.g. TIMSS) and empirical studies have revealed that gender gaps in science do not seem to be declining over time. Moreover, gender gaps seem to be more pronounced in science than in mathematics, particularly in earth science and physical science (Xie and Shauman, 2003; Li, 2007).

A body of literature has focused on **gender gaps across national contexts and cultures**. Studies in Anglo-Saxon countries have documented that while boys/men tend to excel at quantitative reasoning, spatial ability, problem solving or multiple choice tests, girls/women have an advantage in calculation, untimed and written tests, and tend to have higher grades than males throughout their schooling (Linn and Hyde, 1989; Halpern, 2000). A major focus of research in Nordic European countries, particularly in Denmark and Finland (Kupari, 1986; Töttö, 2000; Hannula et al. 2004; Lauritsen, 2004; Danmarks Evalueringsinstitut, 2005), has also been to explore the topic of gender and mathematics. For example, a central focus of Danish studies is the measuring of differences in school performance between boys and girls using large surveys. While the main conclusion is that sex differences exist, the results also show that the gaps are small and that males and females have different skills (Rasmussen, 2005). Whereas boys are more theoretical and appreciate technological aspects, perform better in physics, in theoretical questions, in constructing experiments and in exercises dealing with mechanics and energy, girls tend to be more problem-orientated in practical questions and appreciate health-related issues, are better at interpreting the results of an experiment, perform better in exercises that take everyday life as the point of departure and are slightly better at questions about temperatures (Lauritsen, 1999). The main conclusion is that gender differences are only found in certain types of mathematical skills. Moreover, in spite of the common trends, the results can vary markedly from one cultural context to another.

Yet, in order to present a nuanced and comprehensive picture of the research literature, it must be acknowledged that stereotypes and gender segregation affect both girls’ and boys’ over/underachievement and representation in certain fields of study and professions. Gender disparity in education is an old phenomenon. However, while traditionally girls have been at a disadvantage and the main focus has been on their “deficits”, new phenomena have emerged: 1) **gender disparities are narrowing** (girl’s underachievement in maths has narrowed in all countries, and in some countries is nil or has been reversed); and 2) **gender disparities in education are turning in favour of girls in terms of participation and performance** (boy’s underachievement in reading remains considerable and their school dropout rate is higher than that of girls).

Cross-national studies reveal that girls’ underachievement in maths has narrowed in all countries and is on the way to disappearing in most (Beaton and Robitaille, 1999). It has been noted that there is greater overlap between the attainment of boys and girls than there is difference (Epstein et al. 1998). In fact, the recent meta-analysis of Else-Quest et al. (2010) provides evidence that in spite of cross-national variability in the gender gap, males and females differ very little in mathematics achievement.

Moreover, according to the OECD (2008), in Nordic European countries girls are (on average) attaining higher marks than boys in all subjects (except physical education). For example, in countries like Finland, girls outperform boys and the gender gap in maths has disappeared (Sapienza et al. 2008). Research in Anglo-Saxon countries, mainly in the UK and the USA, also acknowledges that girls surpass boys in many disciplines (reading, writing, the arts, etc.) and also, from primary through secondary school, earn better grades (HMI, 1999; Sapienza et al. 2008). Additionally, research shows that American girls have higher aspirations than boys, are more engaged in school and more likely to graduate from high school and college (Kafer, 2007).

So, even if from the late 1970s onwards gender issues in education have been associated principally with a focus on the achievements and aspirations of girls (in order to redress the power imbalance), an interest in gender has turned in recent years to concern about the perceived “underachievement” of boys (OECD 2001). Some of the literature acknowledges that the success of boys, measured by examination results, is falling behind that of girls. Recent studies indicate that boys experience more problems in school and they drop out to a higher degree than girls, a problem that appears to be present in many national contexts (Björnsson, 2005; Hegna, 2005; OECD, 2006; Nordahl, 2007).

The debate on boys’ underachievement is not new in Commonwealth countries, such as Australia, New Zealand and the United Kingdom, and in Northern European countries (Jha and Kelleher, 2006). Research in Commonwealth countries suggests that boys do less well than girls in primary and secondary education. They seem to be less conscientious about homework as well as more likely to get into trouble with their teachers, to be suspended or expelled from school, to need special education, to repeat a grade, to leave school without attaining literacy and to drop out of school in general (Kafer, 2007). Similarly, research carried out in Northern European countries reports that boys experience more problems in school and drop out more often than girls (Björnsson, 2005; OECD, 2006; Mastekaasa and Smeby, 2008). So, it has been suggested that it is time to face the facts: **boys, not girls, are falling behind**.

Some studies also suggest that boys' underachievement may be related to their poorer behaviour and their lower motivation. In Scotland, boys' behaviour is demonstrably worse than that of girls, with four times as many secondary school-aged boys than girls facing exclusion from school (SEED, 2006). Similarly, a Belgian study suggests that (some) boys' underachievement is associated with their generally negative attitudes towards school, in particular their less positive relationships with teachers and their poor attitude towards schoolwork. However, the study also shows that at lower academic levels, boys who are the least attentive in the classroom and the least interested in and motivated towards the learning tasks achieve better than predicted results. In this sense, it has been suggested that they are able boys who are particularly "demotivated" (Van de Gaer et al. 2006).

In summary, boys´ representation in certain fields of study and professions is almost nonexistent, their underachievement remains considerable, and their school dropout rate is higher than that of girls. This new situation has been described and explained mainly with reference to several trends: 1) in recent years academic performance has improved at a slower rate for boys than for girls (Biggart, 2000); 2) changes in society and the culture of masculinity, which belittles learning (e.g. feminine values are accepted as being preferable to their male equivalents); 3) structural changes in the economy; 4) the role given to education (Baird, 2001); 5) social, economic and occupational practices (material and cultural resources) (Paterson, 1992); 6) the scarcity of places and facilities in schools and 7) conformity to "masculine" gender identity and the "feminization" of schools (Jha and Kelleher, 2006).

Why have gender issues in education come to be equated with boys' relative underperformance in examinations (and a so-called crisis of masculinity) in recent years in many countries? According to the report of Eurydice, "Gender Differences in Educational Outcomes" (2010), the interest in boys' relative failure is due to many factors, such as public policy interest in examination patterns as the main indicators of effectiveness, concern about juvenile violence and social disorder, concern about family breakdown and male irresponsibility, amongst others. This new focus on the "masculinity crisis", even though generalizations should be avoided -"this does not mean that all boys fail in their education or that all girls achieve good educational results" (Skolverket 2006a: 97) - has been seen as fruitful in its shift of emphasis away from structural factors and onto exploring/challenging the characteristics of masculinity that inhibit boys as learners (Epstein et al. 1998; Pickering, 1997).

In light of these findings, many questions still remain unanswered. **Why do girls/women excel on most long-term memory tests? Why do boys/men have the advantage in tasks with visuospatial components? What are the reasons behind the gender gaps in science and math performance?** Research on gender-related differences in mathematics and science education has been conducted from a variety of perspectives. The literature has attributed differences in the choice of study and career progression to sex differences in biological cognitive abilities, career interests and preferences, gendered institutional policies and practices, bias and discrimination, and societal gender roles and assumptions. Generally, gender segregation in science-related fields has been explained using a combination of these factors. However, a body of controversial literature has focused on theoretical perspectives that revolve around biological/cognitive explanations.

4.1. Biologically determined cognitive abilities

Some studies have centred their attention on whether or not gender differences in achievement in maths and science are due to biological characteristics and individual aptitudes. This research has focused on whether or not women and men are born with different cognitive abilities, and to what extent this may explain gender gaps in science-related fields. So far, research has not proved the existence of inborn cognitive sex differences. There is weak evidence to support the argument that boys'/men's greater proclivity and aptitude towards science, technology and engineering is due to essential cognitive, physical or hormonal differences. But this topic has a long history in the context of education, particularly in Anglo-Saxon countries. As a result, it is *de rigueur* to gather together the arguments in the persistent scientific debate revolving around the so-called biologically determined sex differences in cognitive abilities.

From the GSD it is not possible to identify a large number of studies focusing on the naturalistic and biologically determined differences between the sexes in terms of aptitudes and skills in the field of science. The majority of publications in European countries rarely explore inborn differences in cognitive abilities, and the preference is for a rather constructivist approach (as opposed to naturalistic perspectives). Yet the debate over biologically marked sex differences in cognitive abilities, in the context of gender gaps in school achievement, has persisted in Anglo-Saxon countries (the USA, the UK and Canada), and to a lesser extent in Nordic European and continental countries. The leitmotif of most studies is to determine whether the attainment of educational credentials depends on cognitive abilities. To do so, researchers analyse gender differences in measured achievement in maths and science, and explore the influence of these achievements on attitudes, choice of studies, career aspirations, etc. Most of the research concludes that the innate mathematical abilities of boys/men are not superior to those of girls/women. Furthermore, the causal effects of cognitive abilities on educational credentials are not considered deterministic, but indirect and mediated by the agents of socialization and the environment.

The term *cognoscere* (cognition, "to know") refers to the way people think about or process information (memory, attention, perception, problem solving, language, spatial visualization, etc.). The cognitive perspective deals with the manner in which information is acquired and processed. In this sense, research has focused on comparing male and female cognitive abilities, which have been defined as the "ability to learn and to perform well in classroom work and on achievement tests" (Xie and Shauman, 2003: 15). To do so, behavioural characteristics, visual tasks, verbal and written abilities, spatial performance and science achievement tests have been investigated.

Some of the literature has investigated whether cognitive sex differences in mathematics, reasoning abilities or spatial and verbal skills may result in performance differences on certain test items (Strand, Deary and Smith, 2006). Most studies have focused on **visual tasks and verbal skills.** Women tend to outperform men on tests of perceptual speed, which is the ability to quickly and accurately compare letters, numbers, objects, pictures, etc. They also seem to have more developed language abilities at a much younger age than males (Plummer, 2009), and score higher when it comes to verbal abilities (including earlier language acquisition and conversation, vocabulary, spelling, etc.) and memory (colour naming, listing items, etc.) (Kimura, 1992; Nowell and Hedges, 1998; Kruger, 2001; Weiss, Kemmler, Deisenhammer, Fleischhacker and Delazer, 2003; Halpern, 2004). But even though women excel on tests of verbal memory and verbal fluency, the results are not always significant (Hyde and Linn, 1988).

Some investigations have analysed sex differences in **spatial ability,** a relevant skill in many fields of science and engineering, in order to find any concrete mechanisms that would indicate a gap in cognitive abilities. Early research carried out in Anglo-Saxon countries has found sex differences in specific abilities, from adolescence into adulthood. There is evidence not only of girls' superiority in a variety of **verbal abilities** but also of a male advantage in **quantitative and visuospatial abilities** (Maccoby and Jacklin, 1974). Some studies confirm that males have consistently shown an advantage in spatial perception tasks and tests of visual-spatial ability that involve moving targets, throwing and intercepting projectiles or navigating (Linn and Hyde, 1989; Kimura, 1992; Voyer et al. 1995). This question is, however, complicated because there are many types of spatial ability as well as many tests to measure them. One of the most popular tests to measure individual sex differences in spatial ability is a **mental rotation task,** which involves maintaining and manipulating a visual image in working memory (Halpern, 1997). It has been suggested that males and females draw on different sources of knowledge when confronted with tests questions. Thus, the superior performance of females in biology and earth science has often been attributed to their familiarity with the use of rote memorization and learning skills (Erickson and Farkas, 1987).

Certain **behavioural characteristics** have also been investigated as indicative of sex differences in cognitive abilities. Differences between men and women in attention and perception, which occur at the earliest stages of information processing, may ultimately provide clues to differences in cognitive processing that occur later. But in spite of the evidence of sex gaps in academic achievement and on cognitive ability tests, studies have not shown overall sex differences in **intelligence** (Jensen, 1998) or in the understanding of mathematics (Roivas, 2009a). In fact, differences in intellectual capacities seem to appear in patterns of ability rather than in overall intellectual functioning (Puhan and Hu, 2003).

To explain sex differences in performance, most studies have focused on brain function and structure (Witelson, 1991; Witelson, Glezer and Kigaar, 1995), hormonal influences on cognitive performance (Cohen-Bendahan, Van de Beek and Berenbaum, 2005), psychological development in infancy (Baillargeon, Kotovksy and Needham, 1995; Geary, 1996; Spelke, 2005) and human evolution (Geary, 1998; Baron-Cohen, 2002; Pinker, 2002; Browne, 2002). But the results have rarely been used to suggest that differing career choices and outcomes depend largely on the biological differences between males and females (Benbow and Stanley, 1980 and 1983a; NAS, 2006).

Researchers started to investigate gender gaps in behaviour and abilities in the late 20^{th} century. For example, studies carried out in Anglo-Saxon countries in the decade of the 1970s and 1980s uncovered large gender gaps in mathematics. In the light of the results, Page (1976) suggested biologically-based explanations related to the X and Y chromosomes to understand the differences in mathematics achievement (quoted in Campbell, Verna and O´Connor-Petruso, 2004). In this sense, a branch of research has, since then, explored the origin of the gender gap and developed one of the main controversial paradigms: **"the (genetic) deficit theory"**. This model attributes the perpetuation of unequal academic and occupational outcomes to the "deficiencies" (including genetic and hormonal differences) of disadvantaged groups themselves, in this case girls/women. A body of research has discussed not only whether there are sex differences in brain development and in average performance on cognitive tasks, but also whether such differences account for the discrepancies in science-related fields. The different performance was attributed to **sex differences in brain size** (Hyde and Mertz, 2009). Yet recent studies have demonstrated that even if the male brain is approximately 10% larger, after adjusting for body-size and body-weight ratio, gender differences are not significant.

Although the literature is by no means conclusive, there is also evidence that **neuroanatomic differences (cerebral hemisphere size and symmetry)** contribute to the cognitive functioning of males and females (Weiman, 2004). Many studies have addressed the existence and extent of differences in the wiring and development of certain areas of the brain between boys/men and girls/women (Hyde, 2006; Giedd, 2006; McEwen, 2006). The female brain contains more “grey matter” (implicated in processing), whereas the male brain has more “white matter” (related to the transfer of information from one region of the brain to another). In the same way, “biologistic” research in Sweden affirms the existence of sex differences in brain functions and, as a result, that men and women are suited to different fields of study, trajectories and positions (Hansson and Möller, 2009). Some investigations have suggested that biological explanations can be supported by brain-scan studies, which indicate that men and women use different regions of the brain when performing maths and language tasks (Haier and Harold, 1995). Thus, although sex differences dissolve in adulthood, the use of different brain hemispheres in memorization and learning (right hemisphere dominance in males and the opposite in females), would support the differences in language and spatial cognition.

Focusing on environment-genetic interactions in the brain, other studies reveal that cognitive differences appear to involve differing strategies of information processing rather than different “abilities”. They suggest that sex differences are products of genes, hormones and experiences throughout life (McEwen, 2006). A body of research has explored the **role of hormones in cognitive differences.** Researchers have identified critical periods when the release of sex hormones (e.g. during prenatal development or puberty) contribute to both sex and brain differentiation (Halpern, 2004). Evidence appears to suggest that androgens (e.g. testosterone) do influence certain cognitive abilities, at least for certain spatial tasks. Similarly, Collaer and Hines (1995) conclude that girls exposed to high levels of testosterone *in utero* appear to demonstrate not only better spatial skills than other girls but are also more likely to behave aggressively. More recently, it has been suggested that increases in estrogens during puberty may account for improvements in the reading skills of some adolescent girls with dyslexia (Institute of Medicine, 2001). Yet, Giedd (2006) suggests that while sex hormones (estrogens and testosterone) play a role in brain development, they are not the sole factors driving sex differences in the brain. Therefore, in the light of the findings, firm conclusions about the influence of hormones on cognitive ability, behaviour and learning have not been drawn and new questions emerge: **What is the magnitude of gender differences achievement in math and science? Is there stability in the differences over time? Are there causal connections between gender gaps in achievement and segregation in science-related educational and occupational trajectories? If so, how can they be measured?**

4.2. Limitations of the biological approach

The conventional idea that girls are less mathematically gifted than boys is crumbling under the weight of the data. Since the 1980s, when the technique of meta-analysis (a statistical fusion of the results from many studies) became available, some research has focused on mathematical, verbal and spatial abilities as basic to scientific ability. The findings suggest that widely reported **differences between girls and boys in mathematical performance and science aptitude are too small and inconclusive** (Hedges and Nowell, 1995; Geary, 1996; Gallagher, Levin and Cahalan, 2002; Hyde, 2006; Strand, Deary and Smith, 2006). Similarly, the study of Hyde et al. (2008), based on standardized tests of a sample of more than seven million primary- and secondary-school students in ten states of the USA, indicates that sex differences are statistically irrelevant.

Research investigating gender differences in maths/science aptitude questions the supposed superiority of men and concludes that nowadays **boys and girls have similar levels of ability** (NAS, 2006). Most of the literature has focused on similarities and differences in average scores on different cognitive measures. While females excel at many memory tasks including memory for objects and location, episodic memory, reading literacy or speech fluency, males stand out in visuospatial transformations, especially mental rotation, science achievement and certain mathematics tests. However, according to Hyde and Mertz (2009), most results present much between-sex overlap in cognitive abilities and performance, as girls are now performing as well as boys on standardized tests. Additionally, among the mathematically talented, even if a gender gap is more apparent, it is closing quickly in many countries and is nonexistent in others. In summary, the studies do not show conclusive biological differences between men and women in performance in science and mathematics. Moreover, most research not only concludes that no scientific experiment has ever proved differences between women's and men's cognitive capacities, but also questions the so-called science-based ideological claims of female inferiority as being close to very traditional biological determinism (de Cheveigné and Muscinési, 2009).

Meta-analyses, the analysis of national standardized tests and international comparisons have shown how **the gender gap in math/science performance may increase with age.** Research has demonstrated that sex differences between boys and girls emerge in adolescence (at age ten or twelve), when girls begin to lag behind boys in mathematics (Sagebiel and Dahmen, 2010). A meta-analysis developed by Hyde (1990) did not reveal overall performance differences between males and females, but showed evidence of high-school boys' slighter edge in complex problem-solving (a skill considered highly relevant for science and engineering). In the late 1990s, new studies corroborated these findings by showing **significant gender differences in problem-solving strategies** (Carr, Jessup and Fuller, 1999). Nevertheless, the recent research of Hyde et al. (2008) suggests that in a more equal environment, girls are matching boys even in the most difficult of intellectual tasks. So, considering the results, the abilities that boys and girls exhibit and the skills they possess may come down to differences in sociocultural influences which can help or hinder women in their pursuit of the skills needed to master mathematics and science rather than to differences in their biological endowment (Hyde and Mertz, 2009).

Some research suggests explanations involving some balance between physical gender differences and socialization forces to understand gender differences in SET domains (Campbell, Verna and O´Connor-Petruso, 2004). A first theoretical framework, the so-called **"males exhibit greater variability",** shows that more males are found at the extreme ends of the normal curve on many traits (Feingold, 1992; Hedges and Nowell, 1995). International data on cognitive tasks show consistent sex differences. Some differences favour males and others females. **The question posed by some researchers is to what extent there are too few women with the highest levels of ability to be scientists and engineers.** As early as the 19th century, it was suggested that variability in intellectual abilities is greater among male than females (Ellis, 1894). As males are more likely to be represented at both tail-ends of a normal distribution, they are both the lowest and the highest performers. This finding suggests that within-gender differences are greater than between-gender differences. This is a crucial finding because if extremely high achievement is a strong predictor of participation and success in science-related fields, the underrepresentation of women amongst the top achievers may explain gender differences in SET domains. In a nutshell, gender gaps may be attributed to the fact that males exhibit more variability than females.

However, according to Xie and Shauman (2003), **gender gaps do not seem to be wide enough to explain differences between males and females** in science education and trajectories in SET. Moreover, some research has suggested that if the main reason behind the lack of women amongst the most talented in maths is due to greater male variability or aptitude, this should apply to all populations regardless of ethnicity or nationality. Analyses of PISA and TIMSS have shown that fifteen-year-old girls matched or outnumbered their male peers in the top tiers in countries like Iceland, the Netherlands and the UK (Hyde, 2006;

Hyde and Mertz, 2009). Thus, as the international comparisons have shown, the argument of male variability cannot explain the differences between males and females in SET.

A second theoretical framework, known as **“the combination of nature and nurture”** (Campbell, Verna and O´Connor-Petruso, 2004), suggests that while genes (nature) would account for no more than 50% of variance for most traits, the other 50% can be attributed to family and environmental factors (nurture) (Plomin, 1997). For example, even if there are gender gaps in spatial abilities, it is not clear whether such differences can be attributed to biological or social causes (Linn and Petersen, 1985). The existence, the causes and the consequences of gender gaps in mathematics achievement related to differences in spatial ability are controversial, as recent research has shown that spatial skills can be trained (Boersma, Hamlin and Sorby, 2005). The fact that males and females can improve in any cognitive area (Halpern, 2006) means that the skills they possess are more likely to be attributable to differences in training rather than to innate ability (Hyde and Mertz, 2009). Accordingly, there is weak evidence to support the explanation that the greater male proclivity and aptitude for and selection of science is due to sex bias in cognitive abilities determined by biological, physical, hormonal and neurological elements.

Halpern (2006) proposes a **biopsychosocial conceptualization** of the issue to replace the nature/nurture dichotomy. Sex differences are less common than similarities. When differences are acknowledged, studies are keener to suggest that they are embedded in the environment. Yet the author suggests that it is necessary to assume that nature and nurture are not independent variables and do not merely interact. Halpern explains the need to replace the dichotomy by a model that is biopsychosocial. Nature and nurture are inextricably intertwined and cannot be separated. Thus, a reciprocal relationship among many types of variables needs to be recognized: experience alters the biological underpinnings of behaviour, which in turn influences the types of experiences people have. As a result, gender disparities are a question of intelligence and of the relationship among cognitive abilities, academic achievement, career choice and gender.

Box 2. Biopsychosocial contributions to cognitive performance

Females and males are both similar and different in their cognitive performance. There is no evidence to support claims for a smarter sex. Males and females have different average scores on different cognitive measures; some show an advantage for females and others show an advantage for males. Females are achieving at higher rates in school at all levels and in all subjects, including subjects in which they obtain lower scores on aptitude/ability tests (e.g. advanced mathematics). Although there is much overlap in the female and male distributions, on average, females excel on many memory tasks including memory for objects and location, episodic memory, reading literacy, speech fluency, and writing. Males excel at visuospatial transformations, especially mental rotation, science achievement, mathematics tests that are not tied to a specified curriculum (possibly due to use of novel visuospatial representations and transformations), and males are more variable on many cognitive tests. A biopsychosocial model that recognizes the reciprocal relationships among many types of variables is used as an explanatory framework.

Source: Halpern, D.F. (2006) Biopsychosocial contributions to cognitive performance. Paper presented at the National Academies Convocation on Maximizing the Success of Women in Science and Engineering: Biological, Social, and Organizational Components of Success, held December 9 in Washington, DC.

Furthermore, there are **limited data** proving the existence of statistically significant sex differences in most cognitive functions (Hyde, 2005). Biological essentialism and biological determinism, which explain the subordination of women on the basis of "nature", have developed mainly through the results of medical research (Hansson and Möller, 2009). Moreover, the gender neutrality of the tests has been questioned, as educational experts have argued that rather than research these are measuring investigations (Jensen, 2009).

Beside the fact that sex differences tend to be rather small in mathematical performance and science aptitude, there are also certain **methodological limitations** to the empirical evidence concerning the extent/existence of gender gaps. The size of the gap is strongly dependent on **the nature of the study sample**. Most studies use controlled laboratory experiments and only a minority have examined large samples. For example, it has been argued that very few studies completed in countries such as the UK have met the methodological criteria of large and nationally representative samples (Deary et al. 2003).

The results of meta-analyses are not coincident with regard to the **magnitude of sex differences** (Hegarty and Sims, 1994; Voyer, Voyer and Bryden, 1995). This body of research has mainly dealt with measurements that show sex differences in average cognitive abilities and performance, in mathematics or science, in high school or college (Xie and Shauman, 2003; Hyde, 2005; Spelke, 2005). Often experimental results are based on group averages and no one is average (Halpern, 2006). As a consequence, the differences or similarities found between women and men depend largely on the tests and measurements used. In this sense, it has been argued that the magnitude is relative and depends on what and how it is measured; as Halpern (1989) says: "what you see depends on where you look".

Box 3. Intelligence and gender: The sexism of scientific interpretations of cognitive skills

Since the 1960s, psychologists have tried to explore sex differences in intelligence more systematically, referring mainly to a special trend of men on optical perception of space and in mathematics and of women in language. The "supposed" intellectual differentiations between women and men have been used as an explanation of the occupational segregation by sex. This book explores scientific ideas and discussions around cognitive sex differences and the political and social use of these ideas. Some studies referred to explanations of sex differences on the basis of the different intellectual skills between men and women. According to the author, the different scientific interpretations of cognitive sex differences, are not evidence-based and have serious theoretical and methodological problems. The author blames the idea of physical cognitive differences and specific professional trends. The criticism also includes the definition and the structure of gender and intelligence, the history and political use of psychometrics, the history and sociology of occupational segregation by sex, as well as the efforts to attribute cognitive abilities to biological phenomenon, such as genes, hormones and the functional organization of the brain. The differences in intelligence between sexes are only small deviations to the mean values. The hypothesis that women are more linguistically skilled is problematic, as it is not clear what linguistic skill means and the observed differences are very small. Social bias and the effect of environmental factors are also explained.

Source: Kati, D. (1990) Intelligence and Gender: the sexism of scientific interpretations of cognitive skills. Odysseus, Athens.

In spite of the gender approach, most studies focus on women and science. **Research aiming to understanding the underrepresentation of men in the arts, humanities and social sciences is almost nonexistent**. Additionally, considering cross-national differences in mathematical performance, **results have not been consistently replicated in different countries** and, as a result, are not conclusive. In this sense, a comprehensive review with the accumulated data and methodologies should be developed.

The majority of the literature suggests that there is some gender gap in mathematics at primary, secondary and graduate levels. The debate over the gender gap in maths revolves around aspects such as the origin of the gap, the magnitude, whether or not it is narrowing, the causes of the gap and its effects as men and women choose their careers, and possible ways to eliminate the divide. Yet the agreement or disagreement with the existence of a gender gap in these fields has a lot to do with when the researchers originally conducted the investigations. **Research conducted in the area of the gender divide in mathematics before the 1990s suggests that the divide exists and is very large. However, since the late 1980s, research has pointed to the idea that the gender gap in average mathematical performance is not only small but has been declining over time** (Hyde, Fennema and Lammon, 1990; Dunlap, 2002; Xie and Shauman, 2003).

On the basis of their synthesis of the research on gender differences in science, Linn and Hyde (1989) concluded that differences in verbal and spatial ability are diminishing. Increasing evidence indicates that young females and males are equally talented and interested in the field of mathematics, and that the sex gap no longer exists at high school and college levels (Suter, 2006). Additionally, some studies suggest that the gap is narrowing as girls' achievement equals, or even surpasses, that of boys (NAS, 2006). According to Xie and Shauman (2003) "there is disagreement about the magnitude of the differences, the timing of their emergence, and their stability over time… about the practical significance of the math and science achievement differentials" (p.35). More recently, neither the existence nor the magnitude of sex gaps has been clearly demonstrated (Gallagher and Kaufman, 2005). In summary, **as the sex gap has narrowed in the last decades and gender disparities in education seem to be turning in favour of girls (in terms of participation and performance), there do not seem to be differences in performance for the biological and cognitive theories to explain**.

Box 4. Math achievement: Gender gaps?

- Male students tend to surpass females on science and math achievement tests, but only in certain types of skills
- Differences slightly favour females prior to adolescence, whereas males outperform though high school across all grade levels
- Sex differences in average performance are significant but small in comparison to differences within each gender group
- Males are more dispersed in the high and low ends of the achievement spectrum, and women are underrepresented amongst the top achievers
- Gender differences in average mathematics achievement and in high level mathematics achievement do not explain gender differences in majoring or degree attainment in science
- The magnitude of the gap in science achievement do not seem to be declining over time

Fuente: Xie, Y. and Shauman, K. A. (2003) Women in Science: Career Processes and Outcomes. Cambridge, MA: Harvard University Press.

Educational outcomes are influenced by certain individual characteristics like intelligence, aptitudes or career aspirations. Xie and Shauman (2003) suggest that while attainment of academic credentials depends on cognitive ability, the causal effects are not deterministic. To trace gender differences throughout the career process of becoming a scientist/engineer, the authors adopted a life-course approach in order to be able to recognize interactive effects (across multiple domains in a life, such as education, family and work), individual variations and the cumulative nature of these effects. The magnitude/stability of gender gaps in standardized maths and science achievement tests at different points of the educational trajectory (from the seventh to the twelfth grade) from the early 1970s to the early 1990s is examined. The authors also explore the causal connections between gender gaps in maths attainment and gender gaps in the science and engineering career choices and professional aspirations explored. They conclude that, considering the inconsistency of the data, neither the sex gaps in high-school attainment nor the fact that fewer women than men score in the upper tail of the maths achievement distributions offer satisfactory explanations of why fewer women than men major in SET fields.

Women are graduating in very high numbers with degrees in science fields, so women obviously have the innate ability to do science. But women are not graduating in equal numbers as men in all fields. Given that the conclusions of the literature focusing on inborn abilities are rather ambiguous and that there is no conclusive evidence that one sex is more intelligent than the other (Halpern, 2006), it cannot be stated that men are more biologically advantaged than women in learning and performing in mathematics and science-related fields. By contrast, research investigating gender differences in scientific aptitude suggests that boys and girls have similar levels of ability. Moreover, the evidence proves neither the causality of the relationship between brain functioning and maths achievement nor the biological basis for such differences (Xie and Shauman, 2003).

Nonetheless, the debate about inborn cognitive differences between the sexes is not completely closed, at least among policy-makers. An example is the controversy surrounding the statement made by the president of Harvard, Laurence Summers. In early 2005 Summers suggested that the fact that women have less innate ability in maths than men might be one reason for the fact that fewer women succeed in science and maths careers. He offered three reasons to explain the underrepresentation of women in science. First, women want to have children and, as a result, they are unable to work the 80-hour weeks that would make them competitive with their male peers. Second, the innate differences between men and women lead men to outperform women at the top end of science and maths tests in late high school years. Thus, "innate ability", "natural ability" or genetics are more important than social factors. Finally, discrimination discourages women from pursuing science and engineering. The comments have been widely refuted by many researchers (Bombardieri, 2006). Some defend the gender stratification hypothesis, which maintains that gender differences are closely related to cultural variations in opportunity structures for girls and women (Else-Quest et al. 2010). Others point to specific domains of gender equity responsible for gender gaps in maths. In summary, the debate over the roles of nature and nurture in human development has been, once again, reopened: **Are scientists the products of their inherited genetic gender code or are they shaped by the gender-biased environments in which they live? Biology or culture?** (Sapienza et al. 2008).

While researchers do not know why there are gender gaps, most agree with the following statement: “Cognitive ability is a prerequisite for success in any field, but success depends on much more” (Halpern, 2004:139). As a result, even if biological and evolutionary interpretations continue to abound (Feingold, 1992; Archer and Mehdikhani, 2003), current research provides evidence of the impact of environmental and sociocultural factors on the development/nurturing of mathematical skills (Hyde and Linn, 2006) and the understanding of gaps in career choices and professional trajectories.

5. Gender stereotypes, identity and career choices

Researchers agree that sex differences in cognitive and neurological functions due to genetics (inborn talent and abilities) do not account for differing gender outcomes in academic and professional SET fields. The lack of consensus regarding the origin of cognitive sex differences has led researchers to delve into other potential causes for gender differences. As Xie (2006b) summarizes, “we have a temptation to try to find a single, simple explanation. There are two tendencies in finding simplistic explanations. Some scholars claim that everything is biology. Others claim that everything is discrimination. I think we should give up the naive idea that there is a single explanation” (p.67).

As there do not seem to be simple answers to the question, a considerable body of research has focused on **social, cultural and environmental factors** to explain boys’ and girls’ career choices and performance in SET. Thus, several factors have been documented by the literature, aimed at a better understanding of the gender gap: the role of students’ attitudes (Karp, 1998), self-efficacy and self-confidence (Bong, 1999; Sanders and Peterson, 1999), parental involvement (Ma, 1999), teacher attention (Sadker, 1999), textbook content (Parker, 1999) or, among other things, the knowledge of future careers (Lightbody and Durndell, 1996; Rohrer and Welsh, 1998; Li, 2007). According to this approach, the interaction between psychosocial and sociocultural factors is the key to understanding the differential career choices of girls and boys. Therefore, this branch of the literature has explored the role of gendered stereotypes and the pressure and influences of the agents of socialization in the process of the construction of gender identity.

5.1. The “critical filter” hypothesis

Investigations have argued that **students’ interest and ability in SET fields in college depends largely on their experiences and achievement in maths and science during their middle- and high-school education**. A body of research claims that boys and girls have different expectations of themselves within the classroom (Tschumy, 1995). Sadker and Sadker (1994) suggest that adolescent girls feel that they cannot be bright and popular at the same time. In this sense, it is suggested that young females are unaware of this so-called “first career move”, yet the fact that they give up advanced maths classes can prevent later careers in maths, science and technology.

Studies in Finland confirm the decreasing number of female students in long mathematics courses (Kupari, 1986). Males not only tend to choose the longest mathematics courses in school but they also tend to succeed more than females (Töttö, 2000). According to the **pipeline perspective**, performance in domains relevant to success in science-related fields explains the gender gap SET. Yet, given the varying nature of the gender gap in course participation (changes over time and across disciplines), the results of testing this “differential course-taking hypothesis” have been ambiguous (Xie and Shauman, 2003).

Some studies suggest that gender disparities in post-secondary educational trajectories may have originated years earlier. Thus, **cumulative sex differences over time may have an effect on career success** (Rosenthal, Rosnow and Rubin, 2000). Research evidence indicates that the persistent gender gap identified in mathematics and science, as well as the emerging gender disparities in technology, is complicated by other factors such as socioeconomic differences (Sammons, 1995) or inequalities of region and race (Li, 2007). Rural schools lag behind in technology because of the economic disadvantages of the community (Li and Willing, 2002). As a result, (male and female) students from rural areas are at a higher risk of “leaking out” of the science and mathematics pipeline because of the scarcity of available resources and poor visibility (Schoenfeld, 2002).

The pipeline is constructed in distinct segments corresponding to educational stages, and women are described as “leaking” from the pipeline. Yet, while the underrepresentation of women in technology and science is often attributed to a shortage of women "in the pipeline", many authors have suggested that the metaphor is simplistic. In spite of the fact that career paths take a variety of forms, the pipeline metaphor implies a one-way flow without interruptions (Cohoon and Aspray 2006). Thus, the metaphor neglects systemic approaches that may lead to greater understanding and more fruitful approaches to intervention. An alternative to the pipeline, which constructs the world in terms of stages and flows, is to focus on the layers (societal, occupational and organizational) of cultural contexts. Attention can then given to assumptions, values, norms and expectations (across national contexts), concerning the appropriate role of women and men (Ridgeway and Correll 2004).

The limitations of the pipeline perspective, as well as those of the approach that presents participation in maths and science courses in high school as a key filter for entry and achievement in SET higher education, were also noted by Xie and Shauman (2003). Their book *Women and Science* reviews previous literature and presents empirical results with the aim of addressing the following questions: **Are there causal connections between gender gaps in achievement and segregation in science-related educational and occupational trajectories? If so, how can they be measured?** They conclude that gender gaps in maths ability are not very effective in predicting achievement in science-related studies and professional success in SET careers. This finding has been supported by more recent research, which shows that many women with mathematical talent pursue non-scientific studies and careers (Gallagher and Kaufman, 2005; Xie, 2006).

In the 1960s, scientific (feminist) literature increasingly turned its attention to the position of women in mathematics and science. Much of the research has attempted to explain the low participation and achievement of women by their deficient spatial ability and other cognitive disadvantages, viewed by many as due to innate biological factors. This first wave of research into gender differences also looked at the belief that mathematics and science are male domains and only people with "aptitudes" can do mathematics. Other factors explored were women's "deficits" and achievement-based or self-perceived disabling beliefs among female students. A body of the literature on gender socialization focuses on "deficits", which are often seen as the reason for girls and boys hesitating to choose certain disciplines for their degree. The aim is (for example in the case of those studies focusing on girls) to compensate for the so-called deficits (in technical socialization) or to motivate them to appreciate technical competences (Roloff, 1990; Wächter, 1999; Sagebiel, 2003 and 2005). Yet overall, these programmes have not been particularly effective: "on the whole they are one-off, "stand alone" measures and are unable to change the wider cultural context in which they are located. Yet while such initiatives are to be welcomed, they need to be part of a broader strategic approach" (European Commission, 2000: 63).

In the early 1970s, research turned away from the assumption that innate biological factors dictate gender differences in participation and achievement. There is no physical or intellectual barrier to the participation of women in mathematics, science or technology, but rather social and cultural barriers (such as the stereotyped sex-role identifications, the differential treatment by parents or the "chilly climate" for females in the classroom) which are an integral part of the social order. Current empirical evidence suggests that talented girls in maths and science make more diverse choices as regards university studies than equally talented boys. So, **even if there is a (narrowing) gender gap in secondary education, this cannot explain gender segregation in higher education**.

As a result, the "critical filter" hypothesis, which suggests that participation and achievement in maths and science coursework is essential for entry into SET career trajectories, has been rejected. The fact that the lower presence of women in scientific and technical studies is not justified by their performance in related areas (mathematics, physics, technology, etc.) is a key finding which challenges part of the established discourse. But then **what are the**

factors that explain gender differences in career choices and professional trajectories? Why do females continue to choose technical careers much less than males? Why do males not choose arts and humanities as much as females? In this sense, Xie and Shauman (2003) have suggested that "segregation is likely the combined result of a gender gap in Science/Engineering (S/E) interests, in the level of support and encouragement of S/E interests, and in the likelihood of acting on one's S/E interest" (p.58).

5.2. Gender stereotypes and gender roles

Some researchers claim that society continues to contribute to gender stereotyping (Schwartz and Hanson, 1992; Bauer, 1999; Sanders and Peterson, 1999). Society transmits gender roles and shapes opportunities and expectations for both genders. Some approaches assume that gender stereotypes are formed during the socialization process, whereas others suggest a lifelong process of production and reproduction of gender roles (Jacobs, 1995). From a very early age, children are bombarded by stereotypes. Parents and peers transmit simplistic labels and deep-rooted messages that say what a feminine woman and a masculine man should be like. Moreover, the stereotypes introduced in the family and social environment are often reinforced by images in the mass media as well as widespread education practices.

Through the socialization process different role models are assigned to women and men according to what is traditionally attributed to each sex. The set of physical qualities and psychological characteristics that a society assigns to men and women is what we call gender stereotypes. **Gender stereotyping establishes a dichotomy between the feminine and the masculine** and so the defining characteristics of what is distinctively feminine and masculine are antagonistic. Often, the masculine is identified with competitiveness, aggressiveness and independence; men are interested in technical issues, have analytical competences and professional ambition, are orientated towards control and domination, and prioritize the achievement of goals over the emotional (agency and instrumentality). By contrast, the stereotype of the feminine revolves around the belief that women care for the welfare of others, are interested in affective interpersonal relationships and are child-friendly, are able to express their emotions, are sensitive and empathetic and are identified with submission and passivity.

Women are linked to fewer socially appreciated terms: intuition, nature, private, subjectivity, passivity, dependency, subordination or domesticity. Men are associated with valued terms such as reason, public, objectivity, independence, authority or power. Consequently, this **binary and reductionist categorization** (masculine is associated with the positive and feminine with the negative) reflects a sex-based hierarchy and asymmetry (men are established as the measure and cannon of all things), and explains the androcentric character of our culture. This kind of approach contributes to essentializing and homogenizing the characteristics attributed to girls and boys. By appealing to a form of "social" or "educational" essentialism, skills and learning abilities are organized around dichotomous categories, some associated with boys and others with girls. The consequence is the creation and reinforcement of gender stereotypes among students, teachers and families (Mendick, 2005).

While women tend to be attributed **expressive-communal traits**, men are associated with **agentive-instrumental features** (Eagly and Steffen, 1984). Instrumental features are used to define the prototype of a person who works in the world of computers and technology. Thus, men are associated with qualities that suggest the ability to be assertive and competitive and with a fascination for technology (Arnold and Faulkner, 1985). Expressive-communal traits (tendency to express emotions, social abilities, etc.), which define the role of women, are not attributed to professions related to technology. In fact, engineers or computer scientists are portrayed as intelligent and creative, but lacking in social skills (impractical, living outside of reality, lonely and *freakies*) (Margolis and Fisher, 2003). This dualistic notion of gender reinforces traditional gender stereotypes that associate men with technical skills and women with social skills. We tend to think that women not only feel less attracted to science, engineering and maths courses and to technology-related professions, but that they are also less qualified than men (to whom technical skills are attributed). As a result, some scientific and technical fields of research are traditionally regarded as incompatible with being a woman and with typical female attributes.

Besides associating each sex with a number of features, **stereotypes shape behaviour and gender roles**, while constituting the basis for a system of values and beliefs on which we build our identities as men and women. According to Suter (2006), gender stereotypes are "deep-rooted perceptions of male and female characteristics which support the continuity of specific gender roles and occupational segregation" (p.98). As a result of its **descriptive and prescriptive character**, gender stereotypes inform not only they way women and men are, but also the way they are supposed to be.

Thus, together with sex differences in perceived qualities, a socially shared set of expectations about gender behaviour is created. Gender roles and stereotypes also imply a set of expectations from observing what people do (descriptive norm) and what is expected that people should do (prescriptive norm). The prototype of men and women (on the bases of cognitive skills, personality, roles and physical appearance) is described. In turn, prescriptive standards serve to determine how men and women are expected to behave socially, in accordance with the prevalent image and avoiding deviant behaviour. In fact, those individuals who do not act according to the rules may be punished. For example, calling women who study computer science or engineering "tomboys" or "unfeminine" would be a form of social sanction, activated if there is an incongruity with the feminine gender role (Sainz and González, 2008). Hence, many girls end up choosing studies and professional trajectories consistent with the skills associated with female gender roles (social sciences and humanities) and consistent with social conventions. They disregard science, technology and engineering as an alternative for academic and professional development as they do not "fit" within the feminine gender role they are expected to play in our society. The consequence: this whole set of sex-differentiated stereotypes perpetuates the existing roles and behaviours expected of women while undervaluing their true potential.

Distinct from the rational choice and role model approaches is one that argues that **the perspective of the construction of gender stereotypes is more comprehensive** (Xie and Shauman, 2003). This body of literature focuses on differing social pressures that have greater influence on the motivations and preferences of boys and girls when choosing their careers than their underlying abilities do. The main focus of the bulk of the research has been on investigating how differential academic performance, self-perception of cognitive abilities and educational achievement of women and men (as a result of the process of socialization, type of school, etc.) are socially determined.

Stereotypes are shared social beliefs, values and norms which reflect the roles assigned to men and women. They are the product of particular historical, cultural and social contexts. So, in spite of the similarities, the discussions about masculine and feminine "nature" vary over time and across national contexts. While a study conducted in thirty countries found broad cross-cultural agreement on the nature of gender stereotypes, differences between countries were associated with religious beliefs and the value system related to work (Williams and Best, 1990). Some studies have also found significant differences in the intensity of the stereotypical gender roles depending on age, sex or habitat (Li, 2007). Additionally, the weight of stereotypes has been confirmed by a recent study, 'Culture, Gender and Math' (2008), an analysis of PISA results which suggests that gender gaps in maths scores disappear in countries with a more gender-equal culture. Thus, while the sex difference is highest in Turkey, it disappears in Norway and Sweden and is reversed in Iceland.

As a consequence, around the perspective of the construction of gender stereotypes arises an important point of debate which underlines **the social construction of gendered stereotypes and their permeability to change over time**. Gender is the result of gendered definition processes, differently structured throughout the world in daily interaction. This means that social constructions of separate worlds for women and men are developed everywhere and reinforced in everyday life. In this regard, it has been pointed out that while fields such as engineering and ICT remain male dominated, women's representation in many areas previously dominated by men, such as medicine, has increased in recent decades. Therefore, **gender differences in career interests are not fixed but subject to the influence of social forces** (Xie, 2006). **Yet, many questions still remain unanswered: Are there gender differences in terms of expectations for success in maths? Do boys and girls differ in their self-esteem and confidence in their ability in science? Is self-perception of competence gendered?**

5.3. Interests, confidence and self-perception of competence: impact on career choices

Interest and confidence are positive determinants of participation and achievement. Xie (2006) suggests the possibility that gender differences in science are driven by gender differences in career interests. Furthermore, research has shown that girls lag behind boys in **level of interest, expectations for success and confidence in their ability** in maths and science (Eccles, 1989). Some studies have focused on the expectations of students, analysing boys' and girls´ different perceptions of their performance in SET areas. A striking finding is that, in spite of the fact that gender performance differences are not significant, girls tend to: 1) underestimate their abilities in maths and science (Vendramin et al. 2003); 2) have lower expectations regarding their intellectual potential (Pearl et al. 1990) and 3) be less confident and less positive about their academic performance in maths (Zappert and Stansbury, 1985).

Box 5: Gender differences in confidence?

This study examines possible interaction effects of gender and region (urban vs. rural) on student beliefs about women in math and science, their attitudes towards math and science, and their confidence in the use of technology. A secondary purpose of this study is to examine possible differences in confidence of using technology between high school students who consider math-related or science-related careers and those who do not. The data collected from an anonymous survey of 450 secondary students were analyzed. The results showed interaction effects of gender and region on student beliefs and attitudes. First, the gender differences in students' beliefs about women in math and science changes significantly depending on the location of the school. Second, when region was considered, significant effects on students' choice of mathematics- and science-related careers were identified. Urban students, regardless of their gender, were more likely to consider careers related requiring knowledge of science or mathematics than rural students.

Source: Li, Q. (2007) "Mathematics, Science, and Technology in Secondary Schools: Do Gender and Region Make a Difference?" in Canadian Journal of Learning and Technology, Volume 33 (1), Winter.

Though the origin of these gender differences is unknown, it has been argued that they are subject to the influence of social forces. A body of the literature has focused on how gender stereotypes can influence female choices over time, reducing their **confidence in their abilities** and their interest in SET to the point of eventually turning them away from science as an occupation. Some studies show that even if girls have the same cognitive abilities as boys to understand and do mathematics, the social construction of identity leads them to give the subject up and to lose their confidence and interest in the field (de Cheveigné and Muscinési, 2009). An explanation for the gender gap in confidence is the strong gender stereotype that boys are better at maths.

Moreover, a recurring theme in Anglo-Saxon countries is the effect that the mathematics gender gap has on girls and their **self-esteem and self-confidence**. A lack of confidence manifests itself in many ways, such as course avoidance, choosing traditional female collegiate courses and careers, or not applying to college at all (Dunlap, 2002). High self-esteem is directly connected to academic achievement and career goals. But a gap in self-esteem separates boys and girls as they enter adolescence, about the same time the gender gap in mathematics appears (Sadker and Sadker, 1994; Sanders, 1997). Therefore, there seems to be a correlation between students' confidence in maths (self-esteem), academic achievement and dropout rates (Karp and Shakeshaft, 1997).

Many girls with academic qualifications in maths or technology similar to those of their male peers feel less competent. The **perception of competence** is closely tied to the construction of self. Thus the more positive our perception of our own skills in any domain, the better our self-concept. Therefore, if girls feel they have less ability in maths, computer science or technology, the concept they have of themselves in those fields will be poorer (Sainz and González, 2008). Moreover, it has been suggested that women tend to attribute their success in mathematics and technology to external causes (luck or effort); by contrast, men attribute the successes to internal causes (skills) (Dickhäuser and Stiensmeier-Pelster, 2002). Technical careers require a high level of competence in mathematics, physics, technical drawing or computers. Consequently, the fact that girls perceive themselves as less skilled than boys leads them to be less likely to choose those subjects (Eccles, 1983; Bandura, 1999; Hannover and Kessels, 2004). In this sense, according to Wajcman (1991) "the absence of technical confidence or competence does indeed become part of feminine gender identity" (p.155), resulting in the construction of gender differences and the marginalization of women in technology-related fields".

It has been claimed that gender role stereotypes influence not only how girls see themselves (AAUW, 1999), but also their school performance. Moreover, **not only can gender stereotypes lower confidence** (and, as a result, lead some women to develop less interest in pursuing science-related careers)**, but it can also increase the gender differential results** (leading to poorer test performance) (NAS, 2006). The study of Gallagher and Kaufman (2005), 'Gender Differences in Mathematics', shows that maths tests not only measure different skills and talents, but also the expectations for the test. The strong stereotype of the superiority of males' performance may influence the confidence of females and affect their performance on maths tests. The misconception that women are inferior in maths skills is so widespread in Western societies that the mere fact of reminding a woman of her sex can significantly reduce her score on a test. Even asking students something as seemingly innocuous as writing their sex before the test had negative effects on girls' results. Girls have to fight against the stereotype of their "ineptness" in mathematics, which implies an added psychological burden. Furthermore, when students are aware of the stereotype, this not only lowers the girls' scores, but also raises the boys'. Stereotypes and gender roles cause **future expectations** to be determined more by socially prescribed models than by individual aims or abilities. Thus, the fact that historically the profile of females has not been considered suited to SET has not only been detrimental to the consolidation and affirmation of women in science but also justifies their absence from this field.

Besides the perceptions of boys' and girls' confidence in their own talent and abilities, it has been suggested that the nature of the environment in which the maths and science tests take place is a key element in understanding the current gender gaps in SET. The recent study of Niederle and Vesterlund (2009) suggests that test scores may not only reflect the individual's ability, but also the way individuals respond to the **competitive test-taking environment.** The response to competition seems to differ for men and women. In fact, as gender performance is different in a competitive and in a non-competitive setting, women tend to fail to perform well in competitions (Gneezy, Niederle and Rustichini, 2003; Niederle and Vesterlund, 2007). Some of the literature has explored why males outperform females on high stakes tests, even though females achieve equal or higher grades than males in school. Research attributes the gender divide to the fact that boys take more high school mathematics classes than girls, as well as to the approach of boys and girls to the tests. While girls perform better on tests that are not timed and that consist of essay questions, boys outperform on multiple-choice and **"beat-the-clock pressure cooker"** timed tests (Sadker and Sadker, 1994).

If there are no inborn cognitive differences between men and women, why do they perform differently on some speeded tests of mathematical and scientific reasoning? Gender roles and stereotypes influence not only women's and men's motivations, professional interests and attitudes towards science and technology, but also **the perception of their own talents and abilities**. Considering that there are no differences between the sexes in capacity for science, research in social psychology explains differences in performance in high-stakes, speeded tests of mathematical aptitude and scientific reasoning on the basis of girls' awareness of the negative stereotypes of women in science. The findings show that the activation of negative stereotypes can have a detrimental effect on girls' performance in academic science and engineering. A body of the literature has suggested the existence of the ***stereotype threat*** (Steele and Aronson, 1995) in women, which constitutes evidence against the hypothesis of inborn differences in cognitive abilities (e.g. men are biologically predisposed to higher achievement in mathematics) (McGlone and Aronson, 2006).

The *stereotype threat*, which refers to the "experience of being in a situation where one faces judgment based on societal stereotypes about one's group" (Spencer et al. 1999), is a barrier that limits women's performance and expectations in science-related fields. It is a mechanism with great influence on attitudes and behaviours that women show regarding the areas traditionally considered masculine (Steele, 1997). This threat arises from existing stereotypes about different minority groups, such as the women enroled in technical fields, where their presence is low and surrounded by gendered stereotypes. The fact that there are stereotypes about the supposed lack of capability of women in technology means that those stereotypes become a threat and contribute to the fact that women end up acting in such a way that they confirm them. That is, the "pressure" of the expectations about the inability of women in technology leads women to end up obtaining results according to those expectations and, as a result, below their true potential. The negative effect of the *stereotype threat* affects women's motivations, professional interests and attitudes as well as performance in the fields of science and technology.

Women experiencing the *stereotype threat* encounter an additional source of anxiety while performing a task, which can cause them to underperform (Steele, 1997; Spencer et al. 1999). Girls and boys tend to perform equally well with less demanding mathematical material, but when given high-pressure tests with highly demanding problems, if gender stereotypes are made salient, or if they are told that there are sex differences in performance on these tests, sex differences do emerge (Quinn and Spencer, 2001; Davies et al. 2002). Thus, when presented with a particularly hard test in a subject where males are thought to excel, both men and women may fear failure, but women also fear confirming the negative stereotype. Moreover, the **negative effect of the *stereotype threat*** on women is not limited to performance in maths; it also affects their interests in academic and vocational domains (e.g. engineering) (Schmader 2002). Additionally, findings show that women's ability to negotiate is undermined by the *stereotype threat* (Kray et al. 2001). Taken together, the activation of negative stereotypes can have a detrimental effect on women's interests, performance and expectations in domains relevant to success in academic science and engineering (NAS, 2006).

5.4. Gendered cultural norms: social value and expectations of success

An extremely important factor in determining academic success is **motivation** (Gottfried, 1983; Adelman and Taylor, 1986). Motivation can be intrinsic (participation in an activity purely out of curiosity) or extrinsic (participation in an activity purely for the sake of attaining a reward or for avoiding punishment) (Woolfolk and Hoy, 1990). Numerous research studies suggest that intrinsic motivation or, more specifically, academic intrinsic motivation is the key factor to higher academic achievement. The reason: the intrinsically motivated student is more likely to retain the concepts learned and to feel confident about dealing with unfamiliar learning situations (Gottfried, 1983). Yet there are clear sex differences in motivation and attitudes towards science, an aspect that may explain the divide in selecting studies related to mathematical skills (Hannula et al. 2004). For example, the analysis of the Danish results of the ROSE international study, centred on the interests and opinions of students about studying rather than on their competences, revealed that science fails to capture female students' interest and motivation. Girls tend to find studying science more difficult and reject the possibility of a future career related to science and technology (Lauritsen, 2004).

Academic motivations and professional interests appear to be more influenced by the different social pressures on boys and girls than by their underlying abilities. **Motivations** are built around gender roles (Eagly and Steffen, 1984; Eagly, 1987; Eccles, Barber and Josefowicz, 1999). When girls and boys begin to consider possible adult careers, differential **interests** are detected. In this sense, boys prefer occupations related to achievement, while girls choose those from which they can reinforce the social dimension traditionally linked to women. Furthermore, students have an image of the student “type” enrolled in certain courses of study. The less the image of the typical student enrolled in such courses conforms to the one that students have of themselves, the lower the probability of choosing these courses (Hannover and Kessels, 2004). For example, it is important for teenage girls to distance themselves from the *nerd* or *hacker* stereotypes and emphasize their own preferences for communication and social contact. This confirms the idea that girls are more motivated to pursue academic studies and professional trajectories consistent with female gender roles (Eccles, Barber and Jozefowicz, 1999).

Do males and females differ in their views about the relevance of taking mathematics and science for their future professional trajectory? While female college students are interested in working with and assisting people, their male counterparts opt for making a lot of money as a career goal. Recent research reveals that boys most value professional tasks related to achievement and career advancement. By contrast, girls appreciate more professional activities that do not jeopardize their personal life and that allow them to stay in touch with other people and even to help others (Eagly, 1987, Eagly and Steffen, 1982; Eccles, Frome, Suk Yoon, Freedman-Doan and Jacobs, 2000). Suter (2006), who investigated the motives behind the choice of study in Swiss universities, suggests that young men and women are equally talented and interested in the field of mathematics, but while males make the choice on the basis of career prospects, females are also motivated by social and political commitments.

Studies have shown that as children progress through school and begin to consider possible adult careers, the **ambitions** of boys and girls begin to diverge. Girls tend to show more interest in languages, literature, music, and drama than equally bright boys, who are likelier to focus on physical science and mathematics and history (Eccles, 1994). Accordingly, females pursue fields of study such as the humanities, social sciences, biology and health sciences, while males prefer “hard” fields such as physical science and engineering. As already mentioned, it should be acknowledged that there has been a “revolution” in several fields of study, with women entering traditionally male-dominated fields. Perhaps the most striking case is medicine, while amongst those that choose ICT professions, boys prefer “hard technological professions” and girls tend to opt for “soft technological professions” (Zarrett and Malanchuk, 2005). Most of the data showing those preferences date from the 1970s and 1980s, but more recent work finds the same tendencies among students in the 21st century (NAS, 2006).

Furthermore, **attitudes** towards science and technology are also influenced by gender roles and stereotypical traits. Women tend to show more negative attitudes than men towards technological tools (e.g. computers) (Shashaani, 1994). One of the possible causes of this negative attitude is related to women’s greater anxiety about technology (Dickhäuser and Stiensmeier-Pelster, 2002). However, while many studies refer to conflicts between female identity construction and social constructions of science in explaining the perpetuation of this field as a male domain, others demonstrate how technical habits, attitudes and interests, for example of new engineering students, show considerable variety across genders (Wolffram and Winker, 2005).

Other studies have found little difference between college men’s and women’s attitudes towards mathematics, but have confirmed the lower likelihood that women would pursue science-related career goals (Hyde et al. 1990). The recent report entitled ‘Who Likes

Science and Why? Individual, Family and Teacher Effects' (2006), which investigated the relationship between **scientific achievement and students' attitudes towards science**, corroborates previous results and concludes that gender is a determining factor in planning for a science-related career: although female students held more positive attitudes towards science, more boys intended to use science in further studies or careers.

The career trajectory chosen (or to be chosen) in secondary school seems then related to the interest that adolescents show in relation to their future profession (Xie, 2006). Research related to **expectations** reflects the fact that young women are less likely to be interested in pursuing a SET major in college (Xie and Shauman, 2003). Accordingly, it has been shown that girls and boys believe that maths and science are more useful for the future goals of young men (Hyde et al. 1990). Further, recent research developed by Li (2007) concludes that more males than females internationally reported that doing well in science was important to getting the desired job.

Do women and men have different expectations when it comes to professional trajectories? Are the self-perceptions of future success in engineering and ICT professions determinant when it comes to making the choice of studies? If so, is there a causal connection between personal costs, work-family balance and gendered choices? Is the choice of studies marked by psychological as well as social factors? It has been suggested that career choice and trajectory involve a set of traits, including abilities, interests, personality variables, opportunities and, among other things, the knowledge of available career options (Eccles, 1982; Eccles, Kaczala and Meece, 1982; NAS, 2006). There are **two main theoretical frameworks** that aim to shed further light on the unequal representation of men and women in SET by focusing their attention on the process of individual career choices: the "theory of work adjustment" and the "Eccles paradigm" (Campbell, Verna and O´Connor-Petruso, 2004).

Some research suggests that one of the factors that impede the progress of women is their own expectations about professional careers. Jackson, Gardner and Sullivan (1992) have analyzed the different aspects that come into play and contribute to this situation. First, women are aware of the social reality. They know women still earn less and that it is more difficult for them to find a job in certain professions and to reach managerial positions. Therefore, they accept low wages and give less importance to professional development. Secondly, women expect to have more time to be able to deal with family responsibilities, and this may prevent them from reaching the top in their professional careers.

Firstly, the "theory of work adjustment", also known as the "balance between development and a nurturing job environment" (Campbell, Verna and O´Connor-Petruso, 2004), suggests that there is a correspondence between each individual's abilities, interests and preferences, and the degree to which a job permits the nurturing of these personal qualities (satisfaction). Rational choice and human capital approaches suggest that women and men decide differently when it comes to individual benefits. In this respect, some studies have shown that achieving work-family balance is more difficult for women than for men (Cinamon and Rich, 2002).

Choosing a demanding career, running the household and childrearing may be a salient issue for girls. The "**theory of role specialization within the family"** (Becker, 1973, 1974 and 1991) suggests that, following the traditional pattern, women tend to specialize in household chores and childcare and men more in the labour market. Although women have been incorporated into working life, they know there is not an equal division of household chores or childcare between men and women. They are aware of the social and family pressures they will have to face if they choose certain professions. Accordingly, researchers of the so-called "human capital theory" predict that whereas men pursue jobs with a rising trajectory, women work in jobs that have flat growth over the life-cycle and that have little or no penalty for withdrawal due to family-related responsibilities (Polachek, 1979). This anticipation of conflict between family and work roles among females, according to Lubinski, Benbow and Morelock (2000), is undoubtedly associated with poorer working conditions as well as limited job satisfaction and career growth (quoted in Campbell, Verna and O'Connor-Petruso, 2004).

Girls anticipate the difficulties they may encounter in their professional lives if they choose a SET-related career. Some studies have suggested that more adolescent girls than boys consider science to be a difficult subject (Adamuti-Trache, 2006), a fact that may have a strong impact on their performance in a particular subject area. As a result, while technical studies require many hours of dedication and often the renunciation of a personal life, careers in social sciences and humanities are perceived as easier to reconcile with their private life. The heavy human capital investment and anticipated time demands of SET occupations may lower the interest of "rational" girls (Suter, 2006). Thus, women should have a preference for professions that enable them to combine professional and family careers and for professions which permit career breaks (such as education, psychology, or medicine). Yet the empirical validity of this theory of gender segregation by occupations has been debated (Xie, 2006).

Secondly, the "Eccles paradigm" (Eccles, 1982, 1984 and 1989; Eccles, Adler and Meece, 1984; Eccles and Harold, 1991; Eccles et al. 1993 and 1999; Eccles, Barber, Updegraff and O´Brien, 1995) is also known as the "expectancy value theory**"**, probably one of the most comprehensive theoretical approaches even if its explanatory power to explain horizontal gender segregation has been questioned (Xie, 2006). The social value attributed to the profession is a key element when it comes to choosing a field of study. Both men and women are aware of the greater difficulty of engineering and technology studies. But women may perceive that, once they have graduated, their inclusion in an engineering or ICT company may be more difficult to achieve and even that they would be equally valued if they chose a less demanding career. While the personal costs of choosing a career related to science and SET may not be worth it for women, if men perceive that the social value attributed to being an engineer is higher, they may be willing to face the costs of greater effort.

Fishbein and Ajzen (1975) developed a classic expectancy-value theory, the "**theory of reasoned action"**. They propose that people engage in certain behaviours after a deliberative process in which all the available information associated to the likelihood of achieving what they want is considered. The deliberative process determines a more or less positive attitude towards certain behaviour (such as a career choice). Yet, besides the attitude towards the behaviour, the theory of reasoned action suggests that the intention of the person is determined by an external factor: the subjective social norm, the pressure that the person perceives from the social environment to engage in, or not to engage in, such conduct.

Years later, Fishbein and Ajzen (1988) provided a new idea associated with the relationship between attitudes and behaviour through the "**theory of planned action"**: the behavioural intention is marked not only by the attitudes and the subjective norm, but also by the self-perception of competence and the expectation of not finding obstacles to achievement. The predictor of behaviour is the intention of realizing it, which depends not only on the individual orientation towards action (attitudes), but also on the immediate social environment and the perceived control over the achievements. This could be the case of girls or women who forgo choosing a specific career or competing for a job, as they anticipate they will have to face many barriers and obstacles (quoted in Campbell, Verna and O'Connor-Petruso, 2004).

The theoretical model of Eccles focuses on differences in choices determined by gendered cultural norms. The “expectancy-value” model links the attitudes towards a given behaviour (intention or desire to perform an action) with expectations of success and the individual value attributed to the options. The choice of a person depends, among other factors, on two types of beliefs: the prospects for success and the importance and value given to each of the possible options. In summary, people do not undertake a challenge unless they value it and have some expectation of success; the perceptions are shaped by the cultural milieu, individual short-term and long-term goals, aptitudes and self-concept of ability.

Eccles adds a specific vision for the analysis of choice specifically related to achievements associated with the choice of career and/or profession in connection with sex (Eccles, Barber and Jozefowicz, 1999). In investigating what factors influence adolescents’ choice of courses and careers, Eccles (1994) found that **students value what they think they will learn in a course and that is heavily influenced by their intended career.** It is assumed that people choose freely, according to their intellectual abilities, personal interests and aspirations. Yet many occupations are highly gender-segregated. This makes it more likely that girls will not imagine themselves in SET careers and therefore they will not value mathematics or physics courses as much as boys do.

Eccles’s model defines a close **relationship between external factors (social structures and culture) and internal or psychological factors (expectations, self-concept, identity and values)**. The key variables playing a role are: the differential socialization of girls and boys on the part of mothers, parents and teachers; gender stereotyped beliefs and the self-concept that the person has in relation to the characteristics required for the performance of the task (expectations of success, short- and long-term goals associated with identity and psychological needs, feminine and masculine self-concept and the potential cost of investing time in a given activity).

According to Eccles, **differential socialization**, which promotes a hierarchy of different values and interests amongst men and women, **can explain why there are differences in career choice**. Expectations of success and the value attributed to the task, key variables in explaining individual choices, are affected by the impact of gender roles and representations, which shape the personal and social identity of each individual. If the person grows up in an environment that enhances independence and flexibility of roles and provides varied models of women and men, free choice will be promoted. Thus, in addition to personal experiences, identity is marked by cultural beliefs and stereotypes (characteristics of the family, school, friends and the mass media) as well as by “societal” stereotypes.

5.5. Gender-related factors: agents of socialization

Given the lack of results supporting the explanations that rely on sex-related biological abilities or involving some balance between physical sex differences and socialization forces, a review of the main theoretical frameworks concludes that the unequal representation of men and women in SET is largely the result of socialization factors (Campbell, Verna and O´Connor-Petruso, 2004). The socialization process involves the internalization of the social world in the context of a particular social structure. This process accompanies us throughout life, but it is during primary socialization that children internalize the world filtered through the eyes of close adults (parents and family). Yet socialization is not limited to childhood, as the process continues with the intervention of other key agents of socialization.

The main theoretical feminist perspectives and political debates of the 1980s have focused on the female socialization process and thereby on dichotomous stereotypes in the construction of gender differences. Gender stereotypes are acquired through learning and communication processes. Sociocultural factors as well as factors related to the individual’s environment are involved in these processes. Socialization agents play a key role in perpetuating gender stereotypes (Leaper and Friedman, 2007). **Family (parents), school (teachers), peer groups and the mass media** help to define the appropriate pattern of behaviour for men and women. As a result, the gendered choice of different academic paths is explained by the nature of the socialization process (Eccles 1983; Eccles, Frome, Suk Doon, Freeman-Doan and Jacobs, 2000). The construction of masculinity and the identification of SET as a masculine domain are still influenced by the transmission of gender stereotypes acquired through the socialization process. As a result, in the same way that most women do not choose science-related degree courses and trajectories, men are not likely to choose women’s fields.

5.5.1. Family

The family influences boys’ and girls’ educational choices and paths. This occurs not only through explicit decisions, but also in subtle ways, through the transmission of parents’ expectations and career choices. **The approach of the “micro-inequities and macro-inequities”** emphasizes that there are many psychosocial variables, reinforced by social agents, in which gender inequities occur (Campbell, Verna and O´Connor-Petruso, 2004). For example, some micro-inequities arise when parents emphasize "masculine" behaviour for their sons and "feminine" behaviour for their daughters. Parents want their sons to exhibit masculine ways of acting and their daughters to be "lady-like". Women and men develop different cultures of gender as a result of differential socialization based on a **dichotomy between what is feminine and what is masculine**. Cultural representations of the feminine often focus on the area of maternity, relationships and caring for others. By contrast, representations of masculinity are associated with the production of financially valued goods and hierarchical power. Given the importance of the family in society, it seems reasonable to think that it plays an important role in gender segregation across fields.

Young girls and boys try to fit into the socially constructed models of masculinity and femininity, but their decisions are also likely to be influenced by the expectations of their family. As a result, girls and boys tend to choose their educational paths according to the assigned **social roles**. Accordingly, jobs traditionally considered masculine may be refused by adolescent girls, as they are opposed to the feminine image of sensuality and seduction (Vendramin et al. 2003). Moreover, as it may be harder to combine family and work in some fields than in others, the choice may be made on the basis of the need to reconcile personal and family life with professional spheres (Duru-Bellat, 2005). Eventually, according to Campbell and Beaudry (1998), these **subtle micro-inequities accumulate over time** to produce observable gender stereotypes and gender gaps across fields (quoted in Campbell, Verna and O'Connor-Petruso, 2004).

Parental perceptions, beliefs and attitudes, for example when it comes to the estimation of school abilities, influence children’s development and interests, and may ultimately help to explain gender gaps in science. During childhood, in line with gender stereotypes, parents not only tend to encourage sex differences in behaviour and experience by treating boys and girls differently, but also by **estimating their abilities differently** (Jacobs and Eccles, 1992; NAS, 2006). From early childhood education, parents expect girls to be better at language skills and boys at maths, despite the absence of any gender difference in actual grades or test scores (Gutbezahl, 1995; Halpern, 2006). Research has found that parents of daughters are more likely to believe that their child is not interested in science or that science is difficult for their child than parents of sons (Ford et al. 2006). Furthermore, the differentiated gender success is often explained on the basis of “innate” abilities in the case of sons and “effort to compensate lack of skills” in the case of daughters (Duru-Bellat, 2005).

A body of literature has, however, found **differences in the estimation of abilities on the part of fathers and mothers**. Some studies suggest that fathers tend to have a less traditional orientation of gender roles than mothers and that they are more likely to encourage girls to get involved in activities that are not traditionally associated with women (McHale, Shanahan, Upedegraff, Crotuer and Booth, 2004). Yet Eccles and Jacobs (1986) have demonstrated that the relationship is particularly strong with respect to mothers' perception of the difficulty of science for their child and the self-efficacy and interest of the child in the subject. Mothers' beliefs in particular about the abilities of their sons and daughters have a notable influence on their children's educational attitudes (quoted in in Campbell, Verna and O´Connor-Petruso, 2004). Furthermore, Jacobs (1991) found that mothers who endorsed a male-maths stereotype underestimated their daughters' ability in maths. More recent research supports this finding (Halpern, 2006; Tenenbaum and Leaper, 2003).

Parental behaviour towards boy and girls may differ, a fact that can explain gender-related differences in achievement in SET. Throughout the school years, many parents respond differently to their sons and daughters. Parents generally engage more with and show more encouragement to their sons than to their daughters when it comes to entertainment and leisure related to mechanical skills, maths and technology. As a result: 1) they tend to discourage girls from studying for careers related to mathematics and technology at an early age and 2) they further reinforce the capabilities of their male children in science-related subjects, while promoting the abilities of their daughters in areas linked to the female gender role. This causes girls to feel that they have a lower level of proficiency in mathematics and technology than boys, which translates into a poorer self-concept and low expectations of success in these subjects (Bandura, 1999).

Further, **negative gender stereotyping** of abilities can strongly influence children's conceptions of what they can achieve (Steele, 1997; Eccles, Frome, Suk Yoon, Freedman-Doan and Jacobs, 2000) and their future career choices (Eccles, Barber, and Jozefowicz, 1999). Yet the results are not conclusive. For some authors the effects are mixed (Lytton and Romney, 1991). By contrast, other studies conclude that parents' interest and engagement in science and mathematics predicts the grades that children earn later on in school (Jacobs and Eccles, 1992), in that such treatment can powerfully affect children's own identity and influence their view of their own talents. In this sense, children's self-evaluation of academic competence appears to be more strongly related to their parents' appraisals of their academic ability than to their academic performance.

Besides parental attitudes, beliefs and perceptions, parents may also inadvertently influence their child's lack of interest in science by **responding differently to sons and daughters**. Some research has found that parents: 1) are more likely to explain scientific concepts to sons than to daughters (Crowley et al. 2001); 2) use sex-differential language (e.g. parents tend to use less cognitively-demanding language with daughters) (Tenenbaum and Leaper, 2003) and 3) more often buy science materials (computers, books, games, etc.) for boys than for girls (Simpkins, Davis-Kean and Eccles, 2005). As a result, girls may be less likely to develop self-confidence or an interest in science.

Some studies suggest that parents hold **“gender differentiated” views about their children**. The attitudes of parents who held a gender stereotype not only affected their own assessment of their child's abilities but also influenced how their child assessed his or her own abilities as well as performance (Schwartz and Hanson, 1992; Tiedemann, 2000). Parents (and, more generally, the family) may not only have different levels of interest and engagement in science, mathematics or engineering, but they may also respond differently to their sons and daughters as they study these subjects. Other studies go further and suggest that many adults believe that boys have an innate mathematical ability and, as a result, both parents and teachers tend to **underestimate the intelligence levels of girls** (Sadker and Sadker, 1994). These influences "teach" girls to underestimate their own mathematical abilities. As a result, research suggests that parents should be "educated" to avoid the reproduction of gender stereotypes, promote higher self-esteem and self-confidence, and encourage girls to study, persevere and excel in maths and science (Tschumy, 1995; Karp and Shakeshaft, 1997; Sadker, 1999).

Family influences are important in two different stages: 1) in the construction of early identity, particularly during adolescence and 2) in the decision to choose a course of study ("science" or "arts"). Parents are the primary socialization agents and their beliefs influence their children's decisions (whether to enrol in college or what to choose as a major). Some of the literature suggests that parental attitudes and expectations of their children may be related to their own **level of education** (Xie and Shauman, 2003). Highly educated parents are more likely to expect their children to go to college and to be able to afford the expenses involved. Further, they may contribute to enhancing their children's scientific skills, an aspect that may have an effect on the participation, achievement and persistence of women in SET. Moreover, social forces affect gender differences in career choice through **role modelling** (Bandura, 1986; Xie and Shauman, 1997). According to Xie (2006), role modelling means that young people learn from the experiences of adults who are actually working in the labour force. This perspective argues that even if individuals' decisions may seem rational (*rational choice theory*), they are bounded by the social structure and a sex-linked process. The socialization process, which links sex and gender, occurs when men and women are valued, rewarded or punished for different behaviours, interests or expression of emotions, but also through the observation of **different models**.

Parents act as role models for their sons and daughters. Thus, young males and female tend to make educational and occupational choices emulating same-sex adult experiences. In this sense, the e**xistence of female role models (to identify with) in the family** is crucial (AAUW, 2000; Suter, 2006). Some studies suggest that the presence of someone in the family who has undertaken scientific-technical studies has a great impact on the fact that girls choose this type of study (Håpnes and Rasmussen, 2000). The research shows evidence of the enormous importance of the existence and/or absence of female role models in disciplines or scientific fields traditionally portrayed as masculine in understanding boys' and girls' divergent roads.

According to Chodorow (1978), girls tend not to separate from their mothers as early or completely as boys. She argues that the construction of gender identity is related to the attachment that girls and boys feel for their parents--in particular, the attachment they feel towards their mothers, as mothers are the figures that play (or at least used to play) a dominant role during the early years of socialization. Yet the process of breaking away takes place differently for boys than for girls. Boys experience a more radical break with the mother. Their masculinity is built in opposition to the mother/femininity. Thus, they often lack abilities to relate with others and share their feelings ("male inexpressivity"), while developing more analytical ways of looking at the world. By contrast, girls tend to remain close to their mothers (continue hugging, kissing and imitating) and this may explain the fact that women tend to be more characterized by emotional sensitivity and compassion. As girls develop their identity in close relationship to their mothers, it is not surprising that those with mothers who are housewives will be less likely to choose a male stereotyped science-related degree course (in conflict with dominant female images). Thus, research findings have shown that the mothers of women engineers are often engaged in the professional sphere.

Girls seem less likely to be exposed to positive role models or to be encouraged by parents or teachers to pursue S/E studies (Xie and Shauman, 2003). Suter (2006) suggests that the encouragement of the family is an important social resource, as female students in engineering and other branches of science often have at least one parent with a professional background in one of these disciplines. This finding points up the importance of having a supportive network as well as a female/male role model within the family. However, the explanatory value of the role modelling approach, when it comes to investigating mechanisms of horizontal gender segregation, is limited.

Some researchers also agree that besides educational achievement, the **socioeconomic status of the family of origin** is a strong educational predictor (Education Sector, 2006). Having resources at home, such as having a computer and being able to use it, may significantly influence the development of skills and attitudes in maths and science. Furthermore**,** according to Sáinz (2007), social class plays a major role in interpreting gender differences in attitudes towards SET. Girls of lower social status express a more positive vision of the computer and information technology. This may be a result of the fact that they grant a greater instrumental role to the computer, as they perceive it as an opportunity for upward mobility as well as of the fact that young girls have an exaggerated idea of its utility because of the limited access they have to it. Deaux and Major (1987) analyse the effect of the salience of gender stereotypes with regard to attitudes towards computers and information technology in different contexts. They conclude that having a computer at home does not guarantee that girls show more positive attitudes towards ICT, an aspect that could be due to the lower level of bonding of girls with the computer and their instrumental conception of it. Accordingly, Xie and Shauman (2003) point out that in spite of the strong association between the family's socioeconomic status (parental income) and maths/science achievement, this variable is unlikely to explain gender differences independently of the sex of the children.

Finally, according to the meta-analysis developed by Leaper et al. (1998), the effect sizes of the influence of the parents on gender beliefs began to weaken after the mid-1980s, as a result of the **diminishing weight of gender stereotyping,** made apparent by the similar performance of boys and girls in high school and college in SET, as well as girls' current academic success (NAS, 2006). However, it has been demonstrated that the "nature" of the family (traditional versus egalitarian families) may be very influential in determining the nature of the children's socialization process as well as the choice of studies.

Some research shows that children living in **households characterized by gender equality** tend to make less stereotyped classifications of occupations and that girls from such families more often want to pursue non-traditional careers (Weisner and Wilson-Mitchell, 1990). In relation to gender roles, girls tend to express a stronger interest in mathematics (Jacobs and Eccles, 1992; NAS, 2006), while obtaining better results in secondary school, especially in maths and science (Updegraff, McHale and Crouter, 1996). Further, in more egalitarian families, aware of the lower expectations for girls, parents try to adjust their attitudes, aspirations and behaviour (Jacobs and Eccles, 1992) accordingly. By contrast, more traditional environments are more likely to hold the belief that boys find science easier and more interesting than girls do and when it comes to SET disciplines, parents not only encourage but also expect better achievement and greater persistence from boys (Eccles and Jacobs, 1986). This suggests that gender equality, mainly in the family and in the educational context, can mean an opportunity to reduce gender gaps and to encourage boys and girls to choose their professions freely. Thus, new questions emerge: What is the role of the school during the process of socialization? Does the educational system (through its teaching approaches, formal and informal communication styles, lack of female role models, etc.) reinforce and reproduce gender stereotypes? If so, what measures have been implemented in order to avoid a gender-biased education?

5.5.2. School

Besides individual and family influences, the foundations for career development are also subject to influence from other institutions and agents of socialization. While during the process of primary socialization the influence of the family is absolute, the reference of the family loses weight as other actors and institutions gain more importance during adolescence. Throughout the process of secondary socialization, when more general values are attained, boys and girls choose subjects of study (in accordance with desirable gender characteristics) under the influence of new agents of socialization: the school system, peer groups and the mass media. The school is a crucial institution in terms of personal and social development and the construction of gender identity. It has been suggested that school-level influences affect not only differences in achievement in maths and science tests but also in career orientation. In fact, the **school exerts influence through diverse channels**: “the availability of courses, sporting facilities, and extracurricular activities; the quality of teaching, teacher’s expectations, and guidance; the availability and orientation of guidance counselors and the characteristics of the student’s peers” (Xie and Shauman, 2003: 8).

Many researchers agree that cultural norms and ideologies influence students’ choice of certain subjects. When asked about their interests, adolescent boys express preference for learning about planes, cars, atom bombs, nuclear power plants or electricity, while girls prefer learning about rainbows, healthy eating or animal communication (Jones et al. 2000). Sax (2009) states that “boys don't want to study poetry and art because they think those are girls' subjects. Girls don't want to study computer science or engineering because they're boys' subjects” (quoted in Plummer, 2009). It has been suggested that the reason girls do not continue in maths and science-related subjects is related to the fact that they do not like those subjects or they do not see it as an integral part of their lives (Schwartz and Hanson, 1992; Sadker and Sadker, 1994). Sex differences in career aspirations reflect how men and women perceive different opportunity contexts. It has been argued that young women choose SET fields to a lesser extent than young men because they do not perceive SET (a perception reinforced by the agents of socialization) as being within their realm of opportunity (Xie and Shauman, 2003).

As career aspirations reflect students’ perceptions of their appropriateness and attainability transmitted by the school, the school climate and teachers (teaching style, expectations towards students, attitudes, degree of encouragement offered, etc.) help to explain why more boys are inclined to pursue mathematics or engineering degrees, whereas women are more likely to choose education or nursing degrees. Some of the literature suggests that the educational system reinforces traditional gender stereotypes, insofar as **it reflects the social structure of the larger society**, and has a fundamental effect on the reproduction of behaviours adjusted to the socially accepted construction of masculinity and femininity. According to Wajcman (1991): “in modern societies it is the education system, in conjunction with other social institutions, which helps to perpetuate gender inequalities from generation to generation” (p.151). At school, teachers and academic advisers have considerable influence on the academic choices of children and adolescents. But the school is an institution with substantial masculine orientation and, as such, tends to reproduce the existing social status quo. Classmates, teachers and their stereotypes strongly influence children’s conceptions of what they can achieve (Steele, 1997; NAS, 2006). In this sense, rather than intellectual ability, success is determined by the gender-specific roles that boys and girls take on in school.

Education is a significant social area where gender segregation and the **reproduction of gender stereotypes are generated**. Young people are influenced by a torrent of messages to conform to a variety of career and professional expectations. However, research has found that young people, despite believing in equality between the sexes, still opt for traditionally male and female subjects at school (Aksu, 2005). Some authors conclude that schools contribute to reproducing the dominant culture and the problem of gender stereotypes (Schwartz and Hanson, 1992; Bauer, 1999; Wiest, 2001).

In the literature that seeks to explain why girls choose science-related studies to a lesser extent than boys, there is a line of research that examines **the pedagogies, teaching styles and classroom interactions between teachers and students**. It has been suggested that "one of the more important reasons explaining the gaps between sexes is the **teachers' stereotyped attitudes** towards the girls and boys in the classrooms. These can be described as sexist attitudes, although the teachers themselves are usually not aware of such reactions" (Ben Zvi-Mayer, Hertz-Lazarovitz and Safir, 1990; Aksu, 2005). Teachers use gender stereotypes as they make assumptions about members of their own or the opposite sex. For example, male and female teachers live in a social context and therefore assume that some disciplines are more feminine than others (Vendramin et al. 2003); as a result, girls may be advised against taking advanced maths and science-related courses. Further, some researchers have shown that teachers believe that boys are better at maths and that girls get better grades, despite the fact that both boys and girls obtain equal grades in mathematics examinations (Sadker and Sadker, 1994). Teachers participate in the consolidation of existing gender stereotypes and the activation of "self-fulfilling prophecies" (Sainz and González, 2008). Thus, teachers' expectations with regard to their students become reality as girls are often discouraged from enroling in courses and study programmes that run counter to gender stereotypes (Hackett, 1999).

Research from Anglo-Saxon and Northern European countries has suggested that there is a link between a child's progress in certain areas of the curriculum and his/her learning style (Riding and Douglas, 1993; Carrington and Tymms, 2005). In their review of gender and science, Linn and Hyde (1989) conclude that **informal as well as formal learning approaches and experiences** are key determinants for gender differences in science. Swedish studies which investigated how to get women to study mathematics in further education also discussed the way learning is approached and how female engineering students experience their learning situation (Roivas, 2009b). However, the view that suggests that educational achievement is influenced by the connection between the teacher's approaches and the learner's preferred styles is not supported by some Anglo-Saxon research (Carrington and Tymms, 2005).

Research also shows gender differences in **communication styles in the classroom**. Myers et al. (2007) suggest that the "hidden curriculum" transmits messages that often reinforce sex stereotyping and the dominance of boys regarding the school space. While boys tend to speak more spontaneously in class, formulate their answers as they speak and dominate class discussions, girls tend to choose their words carefully, reflecting on the question and constructing an answer before they speak (Hall and Sadler, 1982). Additionally, Wajcman (1991) suggests that mainly as a result of the "hidden curriculum", it is believed that a "mathematical mind" is non-feminine and that maths are connected with computing. So, interested girls have to fight for computers against boys' computer time (an experience that continues into tertiary education) and end up internalizing the belief that boys possess something they lack. Girls "live difference as inferiority" (p. 152), and stereotypes of male competence and female distance (and marginalization) from technology are recreated. Similarly, more recent research has found that even if boys and girls have apparently the same access to computers and technology in the classroom, boys tend to show more control over the “machines”, while girls ask for permission to use computers and do not use them on their own. In summary, some studies suggest that different classroom pressures may have more influence on the motivations and preferences of boys and girls than their underlying abilities.

A recurring theme regarding the cause of the possible gender divide in mathematics relates to the **type of classroom instruction boys and girls receive in primary school, high school and college**. In spite of the fact that gender bias in the interaction between the teacher and students was found in all subject areas, the greatest bias was found in the maths and science classrooms (AAUW, 1999). The effects of gender stereotypes and gender inequality can easily be observed in almost all of the classroom situations. On the basis of their stereotyped expectations, whether consciously or unconsciously, teachers often treat girls and boys differently (Gutbezahl, 1995). In spite of the limitations, some research provides empirical evidence that boys received more **attention**, **challenging interaction and constructive feedback from teachers** than girls did (AAUWW, 1992; Sadker and Sadker, 1994; Smith, 1996). Other authors have gone further and suggest that while boys are encouraged to participate, are given more eye contact and longer wait times, girls are the “invisible members of classrooms” (Schwartz and Hanson, 1992; Sadker and Sadker, 1994; Matthews et al. 1998; Bauer, 1999). Some research has also identified inequalities in classroom instruction. Boys are called on more often, interact more with the teacher, are asked complex, higher order and open-ended questions more often, are called on to use abstract reasoning more often, and tend to dominate the classroom. The conclusion: unbalanced gendered instruction works to the detriment of the maths and science performance of female students (Karp and Shakeshaft, 1997; Sadker, 1999).

Box 6: Mathematics and gender. A reconstruction of the background of didactic research and the micro- ethnographic analysis of interaction in classes

Jungwirth’s dissertation consists of two parts. In Part I the background in which the research on women and maths is based on is described. The background analysis indicates that target of research is the equality of women and men with respect to maths, with men's relation to maths being considered as norm. The aim of the research is to find out the causes for phenomena not corresponding with this target: the fewer participation of women in maths and their partly existing minor performance in maths. In Part II the study about gender-specific modifications of the structures of interaction in the maths classroom is presented. The aim is to find out the rate of frequency according to gender. The present study, on the other hand, analyzes the actions in their relationship to context and process. The data involved in the study are audio and video recordings of 38 lessons together in 11 classes of Austrian grammar schools. In addition to the observation of the lessons there were interviews with the teachers concerned about the acting of the girls and the boys in their classes and their aims in teaching maths. My analysis confirms the findings saying that maths lessons are organized mainly on the basis of conversations of following the tripartite scheme: question of the teacher - answer of the students - appraisal of the answer by the teacher. All act so that this basic pattern emerges. Yet there are sequences arranged differently according to the gender of participating students. This means that teacher and girls, respectively teacher and boys, modify interaction in a specific way by using specific methods of acting. Girls and boys use of different participation methods is considered as an expression of girls and boys different framing of the knowledge constitution. Their different frameworks are explained by the assumption of a girl- and boy- specific socio-linguistic subculture.

Source: Jungwirth, H. (1991) Mathematik und Geschlecht. Rekonstruktion des Hintergrundes der didaktischen Forschung und mikroethnographische Analyse unterrichtlicher Interaktion. University of Linz, Linz.

The negative influence of teachers and academic advisors, the male-biased technology curriculum, together with the **small number of women teachers who serve as role models** to younger students are arguments also used to explain the segregation of women in science and engineering within the school environment (Ayalon, 2003). The shortage of women among SET teachers leads to a **lack of female role models** who may serve as references for younger girls when it comes to career and employment choices. The absence of positive role models of women in SET seems to be one of the main explanations for females’ career choices. The stereotype than boys are more suited to maths is re-enforced by the fact that the number of male teachers in maths courses is often higher than the number of female teachers.

Moreover, gender stereotypes are made more salient in environments where the **presence of women is the exception** (Deaux and Major, 1987). At the university, women who study in a polytechnic school become more visible than those studying in faculties where women are the overwhelming majority. For Guimond and Roussel (2001), the decision to enrol in studies related to mathematics or science is less frequent in the case of women because of the salience of male stereotype in these areas, which largely determines the way women assess their own abilities as inferior to men’s. This appears to activate a set of attitudes and behaviours on the part of the girls, their teachers and their fellow students, which contribute to the reproduction of specific gender roles in those contexts. In this sense, many girls end up choosing specialties closer to the female gender role within science-related fields. Additionally, most current scientists, engineers, and mathematicians are male and the typical characteristics of “success” more likely resemble those of male rather than of female students. This may deter some young women from viewing SET careers as appropriate.

There is much discussion in today’s schools concerning the gender gap between boys and girls in the area of mathematics and science. Some research questions the existence of the gap, while stressing that girls have caught up with boys and that gender differences have narrowed over time. By contrast, other researchers maintain that the gap persists over time and across disciplines. In this regard, there is much debate about the causes of the gender divide and what should be done to eliminate it. While some researchers blame the family and the mass media for perpetuating gender stereotypes that encourage boys to excel in science, a body of the literature has claimed that unequal classroom instruction, biased instructors and social pressures in junior high and high school have caused the gender gap (Dunlap, 2002). It is interesting to note how the debate over the causes of the problem opens the door to the **debate on possible solutions and measures** to be implemented in the school system.

Gender stereotypes are created and maintained in the classroom. Gendered socialization and experiences cause boys and girls to choose differently and to be interested in different fields. The “why” and the “what can be done about it” have been the object of debate mainly in Anglo-Saxon, Nordic and Continental countries. According to the report ‘Gender Differences in Career Choices: Why Girls Don’t Like Science’ (CCL, 2007), if cultural and environmental factors, rather than biological predispositions, account for the gender gap in science, young girls’ disengagement with science can be prevented and their natural interests fostered. Thus, several steps have been suggested to foster girls’ interest in science as well as a number of programmes to encourage girls to pursue studies and careers in science and engineering. The main conclusions suggest that much effort is needed, at multiple levels of our society, to ensure that males and females are free to develop their talents and to pursue the careers best suited to their own personal interests and desires.

Some of the suggestions made by researchers for combatting a mathematics gender divide in the classroom are simple and not too difficult to implement. Teachers should **improve the way they conduct the classrooms** (e.g. reduce speed and give students more wait time) (Karp and Shakeshaft, 1997; Bauer, 1999), **provide balanced instruction** (e.g. provide equal opportunities for boys and girls while respecting their differences), **change their teaching methods** (e.g. help girls to see how maths fit into their lives as well as female student’s with special needs) (Schwartz and Hanson, 1992; Karp and Shakeshaft, 1997; Roivas, 2009b), **send positive messages** to build students’ confidence (Bauer, 1999), **use cooperative learning** groups rather than competitive ones (Schwartz and Hanson, 1992; Bauer, 1999), **provide positive role models** in the areas of maths and science (Karp and Shakeshaft, 1997) and, among other things, **provide teachers with more education** in the area of gender inequities in mathematics and science (Levi, 2000). Most of the debate, however, has been centred on aspects related to: 1) roles models; 2) single-sex classes; and 3) pedagogic and learning environments and instruction in gender equality for teachers.

The scarcity of women role models in maths and science courses in primary and secondary education may lead girls to believe that they do not belong in such careers. Research has suggested that during the middle-school years, girls start to lose confidence and self-esteem in their abilities to learn maths and science (Dreves and Jovanovic, 1998). For example, a recent investigation shows that, in spite of the lack of significant gender gaps in the grades attained, girls report a poorer self-concept with respect to their abilities in physics than boys do (Kessels, 2005).

Box 7: Role models, school improvement and gender gaps

A number of countries are running role model recruitment drives under the assumption that like is good for like: ethnic minority teachers should teach ethnic minority children, women should teach girls, and so on. The empirical basis for this would appear to be case study and personal reflection. This paper will examine quantitative data to test the hypothesis that male teachers produce more positive attitudes amongst boys and female teachers amongst girls. Using data from the Performance Indicators in Primary Schools (PIPS) Project, information from 413 separate classes for 11 year olds were examined. 113 were taught by males and 300 by females. All the pupils completed questionnaires that were designed to measure attitude to school, reading, mathematics and science. In addition, background data on those pupils were collected, including cognitive measures, attainment scores, ability measures and home background measures. The data were examined to look at attitudes using multilevel models controlling for background factors. The analysis concentrated on interaction effects between the gender of the teacher and the gender of the pupil and the results gave little support for those who advocate recruitment drives with role models in mind.

Source: Carrington, B. and Tymms, P. (2005) "Role models, school improvement and the 'gender gap' Do men bring out the best in boys and women the best in girls?" Paper presented to the EARLI 2005 Conference, University of Nicosia.

In this regard, some studies have suggested that it is essential to change classroom instruction and **provide positive female role models.** It has been argued that the fact that girls have knowledge about important women in a field traditionally associated with men, such as mathematics, engineering or computer science, may: 1) help to eliminate the belief that women are intellectually inferior to men in these domains and 2) help talented girls to reinforce their self-concept with respect to their ability in these fields (Marx and Roman, 2002). As a result, this body of literature defends the need to expose girls from an early age to female role models through pioneering programmes to encourage the interest of high school students in SET careers (Dunlap, 2002; Margolis and Fisher, 2003; Greusing, 2006). Other studies have, nonetheless, **examined and questioned the role model argument.** In addressing the question of the importance of same gender role models, certain research draws attention to the limitations of this hypothesis, especially in relation to its claims regarding the benefits of matching teachers and learners by gender. Research carried out in Northern European countries that attempted to investigate the widespread acceptance of the view that the gender gap in achievement stems from the shortage of male role models in schools, concludes that high school students attach relatively little importance to the teacher's gender (Carrington and Tymms, 2005). In fact, rather than gender, students value more the teachers´ capacity to impose discipline in the classroom in a friendly, sensitive and impartial way.

Empirical and longitudinal research in Anglo-Saxon countries has also concluded that matching teachers and students by gender (or race or ethnicity) in school has little effect on educational achievement. However, the conclusions suggest that "gender matching" does influence teachers' subjective evaluations of students (Ehrenberg, Goldhaber and Brewer, 1995; Cizek, 1995; Carrington and Tymms, 2005). Research carried out in English primary schools has found no empirical evidence to support that gender matching affects students' performance. Accounting for the methodological limitations of the study, Carrington and Tymms (2005) conclude that there is no empirical proof to suggest that male teachers enhance the educational performance of boys and that, conversely, female teachers enhance the educational performance of girls. They did find, however, that both boys and girls taught by women are more inclined to show positive attitudes towards school than children taught by men. Nevertheless, studies recognize the need not only to make teaching a more inclusive profession but also to increase the availability of role models to break down enduring gender stereotypes (Mulholland and Hansen, 2003). Further, some studies have also attempted to assess the limited impact of gender-based role models in the university setting. The findings provide only limited support for the role model hypothesis, as the performance of students is not consistently or significantly affected by the gender of the teacher (Butler and Christiansen, 2003).

On the basis of the unfounded belief that females are inferior in mathematical ability, young girls may be led to underperform on mathematics examinations (*stereotype threat*). Moreover, classroom dynamics may result in a failure to identify and adequately nurture mathematically gifted girls. As a result, more radical steps, such as the need to promote **single-sex (maths and science) classes**, have been defended as a way to allow female students to excel and diminish the gender divide.

Box 8: Doing gender' or 'undoing gender': *Monoeducation* against horizontal segregation

As a *quasi 'paradox intervention'* (Teubner, 1997; Wetterer, 1996) *mono-education* of female students hypothetically can deconstruct gender differences. Instead of those differences between female students are allowed to become visible. Promoters of *mono-education* of women especially in male dominated degree courses argue that, because of the negative effects of heterosexual environments on female students' self-confidence they should be taught in single sex contexts. Several studies have shown that women engineers come over representatively out of girls' schools (Janshen and Rudolph, 1987). And, because of the crucial self-confidence for a career in a male dominated world, one can expect that mono-educational possibilities could help to overcome the inner and outer barriers.

There is a different political agenda in European partner countries on the estimation of mono-education. In Germany in the course of feminist research and discussion about co-education since the middle of the 1990th several so called mono-educational models were installed in engineering degree courses in universities of applied sciences in Germany (Gransee and Knapp, 2003; Metz-Goeckel, Schalzhaf-Larsen and Belinszki, 2000). In several European projects like INDECS) (Sagebiel, 2005) and Womeng) (Sagebiel and Dahmen, 2006) some of those models were included for European comparison. Against institutionalisation of mono-educational elements and more against women's universities principle prejudices of universities representatives at management level seem to be the most prominent barrier.

In France and UK there seems to exist no actual positive discussion of mono-education. In France for example the last elite women institution for higher education in engineering was just closed and transferred in a co-educational school. In UK situation seems similar to those of France as they closed more and more women's colleges arguing that from outside these colleges have been seen as less qualitative, with less money and equipments. At the same time in non European countries like the US or South Korea women colleges are flourishing. So the main contra argument of self-stigmatising by separated educational rooms for women does not fit in every culture and nation.

Source: Sagebiel, F. (2005) Attracting Women for Engineering. Interdisciplinary of Engineering Degree Courses in Mono-Educational versus Co-Educational Settings in Germany. In: Maione, Valeria (Ed.): Gender Equality in Higher Education. Miscellanea Third European Conference Genoa, 13.-16.04.2003, Milano 2005, S. 294-318.

There is much debate amongst researchers today about the value and possible **benefits of single-sex education** (Dunlap, 2002). Single-sex classes were pioneered in the late 1980s in Denmark as a means of providing space for girls and improving their self-confidence (Kruse, 1992). The advocates of single-sex schools argue that they allow girls and boys greater freedom to choose subjects not associated with their gender. By contrast, the conservative argument is that such classes would allow boys and girls to be inducted into the prescribed social roles. Many claim that they would benefit girls' self-esteem and stimulate their interest in mathematics/science classes (Tschumy, 1995; Streitmatter, 1999). Among the reasons for the success girls achieve in single-gender schools, Sadker and Sadker (1994) suggest the availability of female role models as well as the fact that girls are more actively involved in the learning process than in coeducational programmes. Single-sex groups enable girls to feel freer to answer questions and to participate more in lessons, and boys to work harder without worrying about their own 'image' as a learner (Younger and Warrington, 2007). As a result, single-sex education can improve motivation, behaviour and achievement (SEED, 2006).

Box 9: 'Doing gender' or 'undoing gender': *Interdisciplinarity* against horizontal segregation

The focus of *interdisciplinary* in transforming engineering degree courses for attracting more women students goes along with gender segregation in choices of degree courses. Statistics have shown that gender segregation exists nearly everywhere in Europe, with women prevalent in language and cultural studies, and men prevalent in science and even more so in engineering studies.

If the non-technical contents meet the interests of female students interdisciplinarity would allow them to study engineering in greater contexts and so broaden their horizon of technology, and by this way the gender gap in engineering can be decreased. With technological sociology, psychology of group dynamics and conflicts, technology politics and ethics, cultural and gender studies for example students develop the potential to analyse and solve complex problems with a wider horizon and by this way hopefully encouraging students to cross their 'disciplines' borders and work co-operatively. On the other hand those non-technical elements and soft skills e.g. in communication and languages, are traditionally female fields of interest, competence and choice. While these contents are more complementary e.g. social and gender studies can include a critical potential for technology. Gender studies are necessary to see the social dimensions of gender problems which otherwise would have been individualised, like 'women have the choice to engage in profession or in family', the normal argumentation of students in the beginning of learning about gender. So the impact of interdisciplinarity in this way could be a critique of technology pointing to social and gender bias.

The attracting factor for women and a new group of men is only one but increase of efficiency of new production for new groups of people is another factor. In quickly changing global society professionals and engineers have always to learn new contents to fit their jobs and male careers. So it can be argued that *life long learning* is necessary, and in every European research program it is not casually a catchword, which means that it has to be reflected on in every research project. To put in non-technical contents in degree courses means to put some technical knowledge in later life phases to learn, if necessary. It means, more radically to change the image of engineering and thereby successfully decrease the gender segregation on the long run. Life long learning as necessary element of professional career includes at the same time more chances for women, because short breaks in career to fill gaps of knowledge will be normal, independent of gender. It is no special issue for women, but all professionals are expected to engage in further education

Source: Sagebiel, F. (2005) Attracting Women for Engineering. Interdisciplinary of Engineering Degree Courses in Mono-Educational versus Co-Educational Settings in Germany. In: Maione, Valeria (Ed.): Gender Equality in Higher Education. Miscellanea Third European Conference Genoa, 13.-16.04.2003, Milano 2005, S. 294-318.

Opponents of single-sex education suggest that, despite some success stories, no conclusive evidence has documented higher achievement for girls in single-sex classes and colleges than in coeducational institutions (Smith, 1996; Sanders and Peterson, 1999; AAUW, 2002). Many critics claim that single-sex classrooms are unfair, in terms of all students’ needs being taken into account. Some research concludes that segregated schools, or even segregated classes, are not effective because in single-sex classes girls tend to receive a “watered-down” version of the material (Lee, 1997). Furthermore, while single-sex education may allow for greater subject choice, it has been suggested that such environments are unable to eliminate the impact of wider society (Skelton and Francis, 2009).

Looking at both sides of the debate concerning separate-sex schools or single-sex classes in the private sector and internationally, Dunlap (2002) studied single-sex mathematics classes as a possible solution to the mathematics gender divide. Her findings reveal that single-sex maths classes may be the answer because girls feel that not having boys in class helps them to learn better--they are more confident and less distracted, and as a result obtain better grades. However, the author has some reservations about implementing a single-sex maths classroom; even in same-sex classrooms, she argues, there are potential biases that favour boys. For this reason, the author encourages more extensive research in this area.

Research conducted in Anglo-Saxon countries in the 1970s and 1980s aimed to explain the poorer academic performance of girls in mathematics (Boaler, 2002). The explanatory factors of gender-related differential academic performance can be classified into two theoretical perspectives: 1) a perspective that assumes that girls do not "fit" well and should “masculinize” themselves in order to adapt better and 2) a perspective that emphasizes the need to transform the contexts of learning in order to make them more inclusive of girls (Caprile, 2009).

The “chilly” classroom environment can lead gifted girls to drop out of maths and science courses in favour of friendlier subjects. Several studies focus on **the learning environments** associated with the scarce participation of women in scientific and technology-related studies. This approach analyses the nature of the transmission of knowledge of disciplines such as mathematics or science in compulsory education. Research developed in Northern European countries suggests that there is a problem of didactics in mathematics and science, insofar as they are perceived as “cold and distant” disciplines that lack space for creative thinking. In this sense, special support measures are recommended to change attitudes, curriculum and educational methods, while promoting positive role models for girls and paying more attention to female students' special needs (Roivas, 2009).

A body of the literature focuses on pedagogy and teaching styles that foster greater motivation for girls towards mathematics and technologies. These studies have focused on forms of cooperation and specific applications of knowledge. For example, some studies suggest that if at an early age girls have more contact with computers and learn with simple programming languages and applications, ICT and technological programming would stop being an area “reserved” for males and would improve females’ self-concept of their ability in ICT (Dickhäuser and Stiensmeier-Pelster, 2003; Zarrett and Malanchuk, 2005). On the other hand, as Mendick (2005) has suggested, approaches committed to creating more feminized teaching styles feed into the dichotomous stereotypes according to which girls and boys are “suited” to different subject.

Other studies emphasize the **need to bring the gender perspective to bear** in the study of the transmission of knowledge with respect to power relations and the different forms of inequality. Boaler (2002) suggests that it is necessary to understand gender as a theoretical analytical tool (not linked to fix characteristics attributed to girls and boys). Thus, gender should be understood as a process of negotiation which emerges in certain situations and in different ways, depending on the context (family, school, etc.). To bring the gender perspective to bear means understanding gender as a form of legitimizing and constructing inequalities that cannot be separated from other forms of inequality (social class, ethnicity, etc.). Accordingly, rather than "feminizing" the channels of transmission of knowledge, the proposal is to introduce more inclusive pedagogies and learning environments in order to overcome the power relations in the classroom (Paechter, 2003).

The main focus in research and theory has been on the differences between men and women. The concept of "doing gender" makes it possible to observe, analyse and change performance/behaviour in everyday interactions. Further, the polarization between engineering/nonengineering must be avoided. Research work on gender and engineering has to address the interactions between gender identity, symbols and structures and thus try to destabilize the equation of masculinity and engineering (Haraway 1985; Faulkner 2000a and 2000b). "Doing masculinity" in the educational and professional spheres needs to be analysed more seriously.

Finally, other investigations emphasize the need to **improve instruction for faculty members and councilors** as to how to combat gender inequity in the classroom. For example, policy recommendations recently suggested by Hyde (2006) include the following: 1) a spatial learning curriculum should be instituted in primary and secondary schools; 2) colleges of engineering should have a spatial skills training programme for entering students; 3) four years of maths and four years of science should be required in high school, or at least for university admission; 4) the mathematics curriculum needs more emphasis on real problem solving, and 5) teachers and high school guidance counselors need to be educated about the findings on gender similarities in mathematics performance; otherwise, teachers will believe the stereotypes about girls' inferiority in mathematics that pervade our culture and those expectations will be conveyed to the students. Yet some questions still remain unanswered: Are there "outside-of-school" experiences that influence the choice of educational paths? What is the role of friends and peer groups? And what about the influence of leisure activities when it comes to choosing (or not choosing) technical subjects?

5.5.3. Peer groups and leisure

Throughout adolescence, boys and girls strive for a gender identity according to gender roles, as this will facilitate their being socially accepted by other teens and by the people around them. **Friends and peer groups** are the main reference point for teenagers. The opinion and the attitude of the group are particularly pertinent in adolescent behaviour and play an important role in the choice of leisure activities, as well as the choice of educational path and academic activities. In general, youth culture is not favourable to technical subjects (seen as more difficult) (Sainz and González, 2008) and this perception may be decisive when it comes to choosing the field of study, first at school and later at university.

In spite of formal equality, the scarce presence of women in scientific environments and technical studies and the fact that men are a minority in the arts and in health sciences underscores the persistence of gender bias in the socialization process. During their leisure time (peers, media, games, etc.) children and teenagers are also influenced by gender-related stereotypes which may predispose them to make certain career choices and not others. From a sociological perspective, gender gaps in performance might also be the result of different **"outside-of-school" experiences** of males and females. Such differences in experiences and activities might in turn lead to differences in the motivation to seek knowledge about science, which in turn will lead to performance differences in different content areas of science. Horizontal segregation may be partly explained by the transmission of stereotyped values and expectations by the family, but also by close friends, which discourage girls and boys from following certain academic and professional careers because they may be at odds with the femininity of women (Bandura, 1999) or the masculinity of men.

During adolescence, male and female social spaces function as separated areas in which feminine and masculine stereotypes are reinforced. Some studies suggest that girls are more sensitive than boys to the **perception of social acceptance** and that it is particularly important for them to be accepted in the group (Håpnes and Rasmussen, 2000). The peer-culture and the opinion of friends influence the choice of studies, leading to the selection of those studies understood as "normal" and that facilitate continuity in the group.

Moreover, studies have found that students, particularly girls, feel that social pressures have an impact on their achievement, and in this sense an even stronger influence on girls than parents and family are their peers (Bryan, 1997). Related to this is the notion that **“females camouflage talent”** (Campbell, Verna and O´Connor-Petruso, 2004), based on the hypothesis that while during preschool and primary school years gifted females are encouraged to develop their talents, during early adolescence and adulthood many gifted females learn to camouflage them in an effort to gain acceptance by other females and by males, for dating and marriage. As a result, their career development is limited (Kerr, 1994).

Societal expectations for men and women result in different kinds of expectations in the early socialization of boys and girls which, besides being influenced by peer-groups, are reinforced by appropriate role models from real life in **textbooks and in the media**. Some studies have also focused on the manner in which the sexes are portrayed in textbooks and have found that men appear more often and in a wider set of roles than women (Nilsen, 1975; Środa and Rutkowska, 2007). The role models used emphasize that males and females are involved in different leisure time activities. Further, Johnson and Murphy (1984) have suggested that such a division of activities might also lead males and females to be motivated to perform better in different subject areas. However, most of the roles represented by male and female figures in the media do not support educational attainment as an important aspect in life.

The construction of youth identities through leisure not only occurs with peers but also through **games and the new technologies**. Even if there are no remarkable differences between girls and boys in terms of their skills and attitudes, choice of subjects and careers is gendered. According to the research of Hanula et al. (2004) in Finland, a factor explaining this divide is the world of games. Boys' games are more physical, vigorous and competitive than girls'. Boys and men are more object-orientated and girls and women more socially-orientated. In the fields related to mathematics, there is less need for social contacts. Also, boys' orientation to games, in which different kinds of quantities, measuring and spatial action is typical, leads to different orientations in mathematics. More recent research carried out in order to understand why girls and boys differ in maths and science performance has also suggested that boys tend to engage in play that is more movement-orientated and therefore grow up in more spatially complex environments (which gives them an advantage in maths and science) (Niederle and Vesterlund, 2009).

Parents and peers play a key role in the adolescents’ choice of academic and professional careers (Eccles, Frome, Suk Yoon, Freedman-Doan and Jacobs, 2000; Zarrett and Malanchuk, 2005), as well as their preferences for certain leisure activities (Simpkins, Davis-Kean and Eccles, 2005). The mass media and ICT are nowadays just two of the most powerful channels of socialization. The importance of these instruments lies not only in the content they transmit, but also in the new ways of establishing relationships, transmitting information and communicating.

Nowadays young people use ICTs as tools to develop themselves as gendered subjects and even to position themselves as such (Enochsson, 2005; Heemskerk, Brink, Volman and Dam, 2005; Tønnessen, 2007). However, as the academic and vocational preferences of boys and girls are in line with gender roles, the subjects that teenagers most enjoy and those in which they show themselves most competent confirm the stereotyped distribution of academic domains (Eccles, Frome, Suk Yoon, Freedman-Doan and Jacobs, 2000; Guimond and Roussel, 2000; Marsh, Trautwein, Lüdtke, Köller and Baumert, 2005). Thus, the gender system and social gender roles channel women into more feminine careers and professions and distance them from SET and ICT educational and career patterns (Margolis, 2003; Vekiri, 2008).

Adolescents have grown up with ICT. The information revolution and the new technologies have been fundamental in the construction of the identity of the "Net generation". As Presnky (2001) suggests, they are "digital natives", in opposition to the "digital immigrants". It is not surprising, then, that those teenagers who are interested in technology and feel competent in the subject show more positive attitudes towards ICT and use the new technologies (e.g. computers) more frequently (Sáinz, 2007).

In addition, video games are an important source of motivation to become involved in computers and technology (Vendramin et al. 2003). Recent studies suggest that the gender digital divide is almost nonexistent in younger cohorts, as their technological skills and digital abilities are very similar, and that computers are even more popular amongst girls than amongst boys (Håpnes and Rasmussen, 2000). Other studies, however, suggest that very often interest in computers and technologies is presented as negative when associated with girls and positive when associated with boys. Moreover, girls tend to associate computers with boys, as they want to present themselves as "feminine" and boys as "masculine" (Vendramin et al. 2003). The different socialization of boys and girls is also made evident by video games. The supply of video games is stereotyped, reflecting reality and at the same time contributing to its reproduction. Video games have been largely designed by men and for boys/men. Since games have not only largely been marketed to a male audience, but are also bought by fathers for their sons, according to the OECD report 'Return to Gender: Gender, ICT and Education' (2008), it is not surprising that more boys play video games than girls. As a result, it seems difficult to separate "preference" from historical patterns of access, which are strongly gendered.

5.5.4. Mass Media

Throughout childhood and into adolescence, children develop specific views about gender roles according to the society in which they live. Gender roles are socially constructed and vary according to the culture and over the course of people's lives. Most of the behaviour associated with gender is learned rather than innate. Yet children not only learn about gender roles from their parents, teachers and peers, but also from media sources. Do the mass media present traditional gender stereotypes? If so, do they have an impact on the attitudes, behaviours and, possibly, on girls'/women's and boys'/men's choice of studies?

According to the **"gender schema theory",** children have a tendency and readiness to process the information they receive based on gender or sex-linked associations that are part of their gender schemas. Additionally, the "s**ocial cognitive theory"** (Bandura, 1986) provides an explanation for how children learn specific attitudes and behaviours from the images and characters they encounter in the media. Adolescents learn gender stereotypes from media sources which, in turn, influence their attitudes and behaviours. According to Bandura (1969), children learn these specific attitudes and behaviours through repeated observations (“identificatory learning”) of both actual models in their social environments (parents and teachers) and symbolic models (images and characters they encounter in the media). So we learn to be male or female, and the mass media contribute to making such roles seem “natural”.

During identity formation, adolescents develop “possible selves” (Ruvolo and Markus, 1992) that represent who they may (or not) become. They develop a gender-role identity, learning how to interact with members of the opposite sex and select an occupation (Faber, Brown and McLeod, 1979). Thus, media models can shape their conceptions of self and become an important source of influence (Signorelli, 1997). In fact, as suggested by Steinke (2005), before children reach adolescence, when most begin to develop individual identities and prepare for future roles, they are likely to have seen countless media images that emphasize gender qualities and urge conformity to traditional stereotypes.

Box 10: Media representations of women scientists

In this paper the authors explore the representations of female scientists in Finnish print media. The media representations of women scientists are explored by analysing 94 person interviews in Finnish newspapers and magazines published between January 1997 and August 2002. Although the article does not focus on analysing youth relevant media concerning their representation of women scientists, in their introduction both authors refer to the stereotyping of scientist and researchers, which starts already at a young age and already includes a gendered perspective (reference here are the SAS-study and the draw-a-scientist test). Important is to remember that young people mainly don’t have first hand knowledge about professions in science and research, which underlines the role of media as agent for producing, maintaining or challenging the stereotypes of scientists.

In the discussion section the authors summarize their results, determining that women scientists in the analysed person interviews were overall depict “in a fairly multi-faceted and varied way”, but disciplinary fields of the interviewees “followed traditional gender patterns” as the majority of the female scientists and researchers came from the humanities. Women with immigrant or ethnic minority backgrounds were not represented at all. Five labels of interviews could be identified: as ‘Top Researchers’, ‘Multi-talents’, ‘Pioneers’, ‘New PhDs’ or ‘Experts’

Source: Husu, Liisa and Taino, Liisa (2004) ‘Representation of women scientists in Finnish printed media: top researchers, multi-talents and experts’. In: Jan-Ola Ostman et al. (eds.): Proceedings of the Conference on Language, Politeness and Gender: The Pragmatic Roots, Helsinki, September 2-5. University of Helsinki.

The mass media, in particular television, perpetuate traditional gender stereotypes in that they reflect dominant social values. Though not as strongly as in earlier years, the portrayal of both men and women on TV (adverts, programmes, soap operas, films, etc.) is largely traditional and stereotyped. While the majority of women on TV are restricted to a few roles, male roles are far more extensive and more exciting (they are more often portrayed in employment, tend to have a higher status and are less likely to be shown in the home). This serves to promote a polarization of gender roles. Viewers are often invited to identify with male characters and to objectify females, a mode of viewing called “the male gaze”, and the media reflect the current distribution of power and the dominant values. As a result, although images of women in the media have improved in recent years, many researchers examining media content have documented stereotypical images that reinforce traditional conceptions of femininity and masculinity (Signorelli, 1997), a fact that may limit adolescents’ visions of "possible selves" (Ruvolo and Markus 1992).

The media are a powerful agent for transmitting gender roles and pervasive stereotypes. In general, people exposed to stereotypical information have higher scores on sexism scales than those exposed to neutral information (Ward and Caruthers, 2001). Some researchers suggest that during the middle and high school years, interest in science declines (American Association of University Women, 2000; George, 2000). During adolescence, when girls and boys show awareness of gender roles and the media become influential sources of information, is when they first seem to lose interest in these subject areas. For this reason, it has been suggested that there is a connection between cultural representations of gender and the gender gap (Steinke, 2005).

Research indicates that the media (in particular TV) is a major source of information about scientists for middle school-aged children. It has been found that girls and young women develop gender schemas that lead them to label certain high-status professions (technology, scientists, engineering) as masculine and, as a result, to restrict their professional aspirations (Kelly, 1978; Steinke, 2005). Images of male and females interactions reinforce traditional social and cultural assumptions about the role of women in science through overt and subtle forms of stereotyping.

In advertising campaigns, movies and TV programmes women are not usually portrayed as using technology or occupying prominent positions within the ICT field. A study examining gender stereotyping in the mass-media portrayals of male and female scientists on television programmes likely to be viewed by middle school-aged children (dramas, cartoons, situation comedies and scientific educational programmes) concludes: 1) male scientist characters are more prevalent than female scientist characters; and 2) while male scientists show masculine attributes (independence and dominance), female scientists are portrayed with feminine attributes (dependence, caring, and a romantic nature) (Steinke et al. 2008). Further, research on middle school-aged children found that boys who indicated the media were very important had more negative attitudes towards women in science. The findings are important not only because this may affect girls' behaviour, but also because it may affect their adult views (Steinke et al. 2007)

As a result of the sex-biased image of science in the media and the characteristics attributed to the "ideal" scientists, SET-related professions are more likely to be perceived as more "appropriate" for male than for female students. This would explain the different educational choices that lead to segregation in education and finally in the labour market. Yet while some studies have documented negative effects of media images of scientists on children's attitudes towards science, others have noted the positive effects of these images. The media are inevitably socializing children into traditional stereotypical roles because of the prevalence of such images on TV and the importance ascribed to them by children (Sharpe, 1976). But the media also offer a wide range of potential role models, both positive and negative. As a result, while there is little doubt that the media present largely traditional gender images, the evidence of the impact of such images on gender attitudes and behaviour is not conclusive.

5.5.5. Socialization and gender identity

Self-concept is a set of beliefs and feelings that each person has about herself/himself. It covers many aspects that have to do with skills and abilities, physical appearance and personality, professional interests and leisure, individual ideology, etc. The self-concept is acquired through interaction with others, mainly through comparison with others and as a result of the feedback received in relation to our image. As a result, family, teachers, peers and media are crucial for the acquisition of our self-concept.

Gender identity helps to explain the persistence of social pressures that influence our behaviour in accordance with the predominant gender roles. In this connection, several studies suggest that girls and boys place greater value on those activities that "fit" with their gender role (Eagly and Karau, 2002). If girls have a self-concept of ability in relation to computers and technology that is lower than that of boys, this is probably related to their weaker positive attitudes, emotional attachment and use. Yet research has also concluded that the self-concept of ability in relation to ICT can be used to predict attitudes towards computers and technology as well as the intention to follow studies and carry out work connected with the new technologies (Sáinz, 2007).

Hughes (2001) has suggested that the "scientific identity" is related to the choice of scientific and technical paths, and therefore to educational trajectory. Choosing between scientific and technical paths and other trajectories is part of the process of building one's personal identity, of recognizing a system of values, norms and expectations. From this perspective, the construction of gender identity during adolescence has significant weight in the construction of a scientific-technical identity. As a result, the construction of gender identity cannot be separated from the construction of scientific and technological identity. Given that that the process of choosing an educational path is part of the process of identity construction, the agents of socialization are key elements in the processes of construction of the identity of teenagers and youth. In each conceptual "domain" emerge identity forms linked to the other spaces which interact with each other. In summary, the construction of gender identity is not a linear process, but a contradictory and conflictive one through which traditional gender roles are assimilated or transgressed and gender identity is negotiated in multiple and varied contexts (Caprile, 2009).

Several studies in line with this theoretical approach have analysed the gender gaps in scientific fields such as mathematics, engineering and ICT (Arnold and Faulkner, 1985; Faulkner, 2000a and 2000b; Miller 2004; Sutter, 2006). Men and women internalize certain beliefs about being male or female. Maths, physics or engineering are perceived as typically masculine subjects, while psychology, education and medicine are often presented as feminine areas. According to this approach, the fascination for science is an attribute assigned to men, while being a woman is strongly connected with a certain fear of technological skills. Most scientific and technical fields of research are traditionally regarded as contradictory to typical female attributes and to being a woman. Accordingly, men and women tend to choose a type of occupation that "matches" the social representation of masculinity/femininity. In summary, gendered choices are associated with typical male and female stereotyped characteristics.

The perspective of the female/male socialization process, or gendered socialization, was used in the 1980s to explain the small number of women in engineering (Bilden, 1991). In early childhood girls are held back from playing with tins and machines. Years later, when girls are anxious to adapt to the female image and to be included within their reference group, they separate themselves from fields of study portrayed as masculine and associated with male roles (natural sciences, maths, technology and engineering). By contrast, boys are taught to develop abilities more associated with science and technology ("tinkering", assembling and disassembling electronic machinery, etc.). They learn to enjoy experimenting with and repairing machine parts, while separating themselves from the disciplines associated with femininity (humanities, social sciences, etc.).

If the **"theory of role congruence"** (Eagly and Karau, 2002) is applied to women studying or working in SET, there emerges an incongruity between the feminine gender role assigned to women and the professional role that they assume and play. In this sense, feminist research on technology suggests that female identity construction conflicts with existing identity and the construction of engineering. This inconsistency leads to the activation of certain stereotypes in people in the environment, leading to negative reactions towards those women whose behaviour does not conform to the social role traditionally allocated to them. Accordingly, women's activities are devalued in relation to that of their male peers because of the perceived gap between the community characteristics that are presumed to be developed by women (to be consistent with their gender role) and the agent-instrumental characteristics of men.

Moreover, women who succeed in traditionally male areas not only face more difficulties than their male peers and need to make greater efforts to achieve the same objectives, but also need to demonstrate that they are equally qualified to occupy the same job (Fassinger, 2001). However, when women fail to conform to their gender role requirements, they suffer certain consequences, as their behaviour is often criticized and rejected. Those women whose behaviour is seen as outside of the "appropriate" role for self-categorization are punished for it (Fiske, 2006). Further, as girls and boys hold negative stereotypes of girls who like or do well in science, investing in subjects perceived as "masculine" domains may threaten a girl's feminine identity (less feminine, less attractive, less popular, etc.) (Xie and Shauman, 2003). By contrast, it has been empirically proved that men who work in "feminized" fields taken advantage of it (Fassinger, 2001). In this connection, some studies have investigated patterns of behaviour that differentiate men who choose a traditional female role (e.g. kindergarten teachers or nurses) from those who choose traditionally male roles (Loughrey, 2007).

The configuration of gender identity is a complex phenomenon, constructed in accordance with individual predispositions and the influences of the agents of socialization. Traditionally, biological differences have been used to explain social differences between women and men. Today, by contrast, research concurs that differential socialization leads individuals to adapt their identity and behaviour to social expectations. According to the interaction theory, people construct their social realities and identities, shaped by rules of social life, cultural expectations, workplace norms and laws. Thus, women and men build up their identities by constructing themselves and responding to social definitions; girls and boys build theirs by learning to adapt to what they think is the prevalent female/male appearance and behaviour and to avoid deviating from those images. Many girls rule out choosing SET careers because these do not fit the feminine gender identity and the role that women are supposed to play in society. Accordingly, they follow academic and professional trajectories consistent with their gender identity, such as psychology, education or nursing. In these professions it is assumed, according to social conventions, that they can develop the "feminine" skills (sensitivity, support, empathy, etc.). This, in turn, means that women's needs and potential are undervalued in SET areas.

After exploring the role of gender stereotypes and career choices in adolescence and focusing on the role of the agents of socialization in these processes, it is still necessary to answer the following questions: Are the perceptions of science gendered? And what about the "way" of doing science? What is the magnitude of women's contributions to science? Does the hegemonic position of masculinity in science have an impact on career choices? What is the influence of gender stereotypes in science on the professional choices of women and men? Moreover, are gender stereotypes changing in certain subjects (medicine, nursing, etc.)?

6. Gender stereotypes in science: impact on career choices

The mechanisms that articulate the gender-biased construction of science, together with the persistence of stereotypes and their permeability to change, are presented in this section. The literature deals with gender differences in the perception of science, which are discussed with respect to issues such as conceptual reflections on the epistemology of (objective) science, the hegemonic position of masculinity and the nature of women’s contribution to science. Other studies are related to the masculine/feminine character attributed to certain disciplines, exploring the influence and impact on educational and professional choices. The nature of academic culture as well as the (gendered) way of “doing” science is explored. Moreover, the “fragility” of gender stereotypes in certain disciplines is also acknowledged in view of the changes that have been taking place, as women enter traditionally male-dominated fields (e.g. medicine) and men female-dominated fields (e.g. nursing).

6.1. Gender differences in the perception of science

Over 40 years ago, Rossi (1965) addressed the question of the absence of women pursuing academic careers in science, by asking ‘Why So Few? Women in Science, Technology, Engineering, and Mathematics’. Early work in this field tackled issues relating to the (masculinist) character and the gendered images of science, concluding that science is associated with masculine roles and values. The interest of feminists has been mainly in the conceptualization of women’s exclusion from the scientific world, as well as in the influence of early educational processes (e.g. sex-role stereotyping in the content of the curriculum), and in the apparently greater attractiveness of certain areas of science in comparison to others (Thomas, 1990).

The nature, image and agenda of science, in particular its epistemological content in terms of objectivity and reality, have also been the object of ongoing critical discussion in an effort to explain women’s exclusion (Rossiter, 1982; Harding, 1987; Fox-Keller, 1996). Since the 1990s, while specific measures have been put in place to address the problem in many countries, research has continued to focus on women in science. Today, given the pervasiveness of the phenomenon internationally, “why so few?” is still a question to be posed. Arguably, **women have moved from exclusion to segregation** (Osborn et al. 2000) within the culture of science, defined as the “ecclesiastical academy” (Noble, 1992). Noble argues that Western science has promoted a homosocial and misogynous culture. In this atmosphere, women have been “not merely marginalized but anathematized; allegedly, they face not only discrimination but dread” on the basis of clericalism and the fear of women’s power to “pollute sciences” (Ibid. xiv). Furthermore, Noble suggests that the professionalization of science in the 19^{th} and 20^{th} centuries is an essential aspect of what he regards as the enduring patriarchal system and the difficulties of access to the scientific profession that women face.

As a consequence, an important starting point for much of early feminist research is a critique pointing out that mainstream **research is not as objective and free of values as traditionally assumed**. In this sense, the approach is based on the consideration that male dominance in science is really deep-rooted. Science has been developed on the basis of male values and references. **Science is not universal--it is “male science”** and therefore can only produce masculine scientific content.

Another body of literature deals with questions related to **what women can contribute to science**. The focus is on whether women can change science and to what extent they can bring a “caring rationality” into the “hard” sciences. The social construction of science is related to epistemological questions of constructing science from the gender perspective or how the gender system affects the formation and construction of science. In this regard, Sinnes (2006) identifies three approaches to gender equity in science education, which represent different understandings of why women are underrepresented in science and what they can contribute to it.

Box 11: Can there be a feminist science?

This paper explores a number of recent proposals regarding "feminist science" and rejects a content-based approach in favour of a process-based approach to characterizing feminist science. Philosophy of science can yield models of scientific reasoning that illuminate the interaction between cultural values and ideology and scientific inquiry. While we can use these models to expose masculine and other forms of bias, we can also use them to defend the introduction of assumptions grounded in feminist political values. Our sciences are being harnessed to the making of money and the waging of war. The possibility of alternate understandings of the natural world is irrelevant to a culture driven by those interests. To do feminist science we must change the social and political context in which science is done. So can there be a feminist science? If this means is it, in principle, possible to do science as a feminist? The answer must be yes. If this means can we in practice do science as feminists? The answer must be not until we change present conditions.

Source: Longino, H. E. (2005) “Can There Be a Feminist Science?” in Kontext, vol. 4, n. 1-2.

A first approach, so-called **“equality feminism”,** suggests that females produce the same scientific knowledge as males. As girls and boys are equal in their engagement in science education, women have been kept away from science because of political and social forces external to science (Howes, 2002). So, far from condemning scientific knowledge as being inherently masculine, from this perspective the critiques are centred on unfair employment practices within science (Harding, 1986; Keller, 1985 and 1987). If women enjoy equal opportunities, society will also benefit, as there will be more women contributing to the development of scientific knowledge. As a result, while the impact of the researcher’s gender on research priorities may be acknowledged, science itself would not be affected; scientific knowledge is considered to be objective and value-free.

The **“difference feminism”** approach suggests that girls and boys are different in their engagement in science education. Either by nature and/or through nurture, women have developed what society refers to as “feminine” characteristics (Nash, 2000). If it has been argued that males and females are equal in their approach to science, this is due to: 1) the “patriarchal masquerade of neutrality” (Franklin, 2000); and 2) the higher value attributed to the characteristics associated with masculinity (Tong, 2000). According to this perspective, scientific knowledge is influenced by the gendered identity of the researcher. Historically, the development of science has ignored the contribution of women and, as a result, scientific knowledge and production is markedly “masculine” (Rosser, 1990; Harding, 1998). Furthermore, some authors have argued that women’s qualities are superior to men’s (Gillingan, 1982) and others claim that a feminine science would be more socially responsible and democratic (Rosser, 1990; Shiva, 2001). They point out that a gender perspective not only makes women, women’s situation and their contributions visible, but can also produce new knowledge through new theories and new areas of focus. In summary, it is suggested that women may change traditional scientific paradigms and structures.

Finally, a third approach focuses on the fact that differences in science engagement among students of the same sex are as important as the differences between boys and girls. **“Postmodern feminism”** challenges homogeneity and, unlike previous approaches, suggests that all women cannot be treated alike. Haraway (1988 and 1991) warns against a totally relativist view of science, while suggesting that neither men nor women are in a position to describe the world on any other’s behalf. In this way, the reason to recruit women into science would not be to produce better knowledge, but to hear different approaches to science.

6.2. Masculine/feminine nature of disciplines

Since the last decade of the 20th century, key international and European organizations have become more concerned with the persistence of gender segregation and inequalities in academic science. UNESCO and the European Commission have included the gender gap in academia on their official policy agendas and produced several reports (European Commission, 1999 and 2001; UNESCO, 1999; Osborn et al. 2000; Ress, 2002). Additionally, in the USA, Canada, Australia and virtually all EU countries, specific policy measures (e.g. the provision of special chairs for women) have been implemented in order to address the issue (Ellemers et al. 2004; Chesterman, 2004). However, the ETAN Expert Working Group on Women and Science has claimed that the exclusion of women from science persists (Osborn et al. 2000), and no consensus has yet been achieved about the reasons behind women’s minority status.

Cross-national research on women’s position in science has acknowledged that gender acts as a negative factor for women in scientific careers (Stolte-Heiskanen, 1991; Tripp-Knowles, 1995; Osborn et al. 2000; Zimmer and Laubenthal, 2000). Lower productivity among women and differential devotion to work commitments, mainly as a result of dual responsibilities at home and at work, have been suggested as plausible causes of women scientists’ lower promotion rates (Cole, 1979; Etkowitz et al. 1992). However, not only has this hypothesis produced contradictory results, it has also long been contested (Chusmir, 1986; Harding, 1986 and 1991; Delamont, 1989; Rose, 1994). On the other hand, stereotypes may result in biased judgments, even in the absence of objective gender differences (e.g. women display less commitment or they are less suitable for academic work). The study of Ellemers et al. (2004) concentrates on possible reasons for the persistent underrepresentation of women in science in Dutch and Italian academia, considering the enduring factors identified in the literature over time, and concludes that this is due to differential commitment to career and to gender stereotypes. Thus, stereotyping women can be seen as putting women at a disadvantage, and as greatly affecting their career opportunities within science.

In her book ‘Women and Scientific Employment’, Glover (2000) combines an analysis of secondary data and a theoretical discussion to address the question of women’s status in scientific education and employment. After making a plea for examining different scientific disciplines separately, the author focuses on physics and explores the feminization rates in the UK, France and the USA. Glover differentiates between quantitative and vertical/hierarchical feminization, and argues that both act independently, because encouraging women to enter the sciences as students has only a weak connection with their retention and advancement in scientific careers after graduation. In this context, it should be noted that it has been (and still is) popularly assumed that an increase in the pool of qualified women graduates will automatically lead to an increase in women academics. This demographic argument has been suggested as an explanation for the lower proportion of women across science/technology disciplines in the past (Sutherland, 1993), and an increase in women in scientific careers is expected to take place spontaneously and automatically in a matter of years after an increase in the number of women students. This assumption, that quantitative feminization in science will be followed by hierarchical feminization, has already been criticized as overly optimistic (Pérez-Sedeño, 2001). In fact, although the percentage of female students has been increasing over the last decades, this has not been reflected across countries in subsequent changes at the top of the academic pyramids.

Most explanations of sex-segregation in science have tended to focus either on the individual level (e.g. deficit theory perspectives would suggest women lack confidence in their ability to become scientists) or on the alleged characteristics of science (e.g. its male-dominated culture). Stolte-Heiskanen (1991) investigated the obstacles to women's access to senior positions in science in 12 European countries. Among the six general gendered patterns identified, it was concluded that the more the field embodies power, the less woman-friendly the community is. Further, taken-for-granted assumptions about subject areas (e.g. that science is a good thing in itself) (Millet, 1983), and about gender may be instrumental in maintaining male dominance and segregation in scientific communities.

The definition of science is not straightforward. While investigating gender and academic subjects in UK academia, Thomas (1990) distinguished between arts and science. She maintained that it has become a cliché to rate the former as lower (progressive and feminine) than the latter (conservative and masculine). Moreover, Rose (1998) suggested that it is inappropriate to distinguish between natural and social sciences on the grounds that all organized and systematic knowledge can be regarded as scientific. But, for the purposes of this analysis, it is useful to acknowledge the differential social meanings associated with the different disciplinary fields. Foucault's concept of disciplines may be helpful in understanding women's exclusion from the sciences. Disciplines are claimed by Foucault (1980) to be practices that create and reproduce power/knowledge relations in order to sustain and transform particular interests. Furthermore, meanings are said to arise from everyday discourses, and scientific disciplines, far from being neutral constructions (Knights and Richards, 2003), are designed to "shape and control behaviour" (Townley, 1994). As a result, even if academic disciplines are not intentionally created to control behaviour, it is likely that they may have different gender systems (Vázquez, 2006).

According to Bond (2000), academic culture is "the single most important factor" in creating a difficult environment for women. The comparative study (the USA, the UK and Canada) of Becher and Trowler (2001) suggests that academics are segregated into separate cultures, what they call "tribes", and separate disciplinary knowledge bases, their "territories". Their study then supports the idea that academic subjects are not value-free phenomena, but distinctive cultures and social constructs with their own perceptions and interpretations determined by historic, sociopolitical circumstances. Their finding could be related to the so-called "sex role spillover", which refers to the "carryover into the workplace of gender-based roles that are usually irrelevant or inappropriate to the work setting" (Gutek and Cohen, 1992:133). Men have traditionally dominated the pure and applied natural sciences, and this field has assumed the typical characteristics of occupations characterized by job-segregation along gender lines. By contrast, women have tended to cluster in humanities and social sciences, and as a result, a binary discursive "soft"/"hard" science distinction has emerged (Knights and Richards, 2003).

Academe is usually conceived of as divided into disciplines or fields of study which constitute branches of knowledge. Several reasons have been presented to explain the fact that students, men and women, may or may not be attracted to specific disciplines (Thomas, 1990; Pérez-Sedeño, 1996; Bezrogov and Ivanchenko, 2003). Most studies and initiatives of women in higher education at national and European levels have essentially focused on gendered career paths specifically within the field of science (Harding, 1986; Lie and O'Leary, 1990; Rose, 1998; Osborn et al. 2000; Glover, 2000; García de León, 2003). While the emphasis has been on questions relating to women's access to scientific fields and the gendered way of "doing" science, the significant segregation within the social sciences and the humanities has too often been overlooked (Vázquez, 2006).

Bagilhole and Goode (1997) suggested the possibility that discipline segregation along gendered lines may create two different cultures, one unresponsive to women and gender concerns in general and the other more receptive to them. While science/technology fields are said to be characterized by their practices of following strict and rigorous scientific standards for hypothesis formulation and testing, the “soft” sciences (in English, not usually considered sciences at all) typically take a much more informal methodological approach.

It has been suggested that engineering, as a field associated with masculinity, can be seen as gendered, considering its division of labour, its working styles and its symbols and images (Sagebiel, 2003). Moreover, as previously noted by Harding (1986), the gendered nature of engineering may be attributed to the personal and professional identities of individual engineers and institutionalized elements such as male fraternities that may, consciously and/or unconsciously, define and reproduce the exclusion of women (McLean et al. 1996). Furthermore, science/technology fields often not only place academics in isolated laboratories, but also may become discriminatory domains with regard to women (Spender and Podmore, 1987). Yet, even if it can be suggested that it is the particularly masculinist domain of engineering and science that hinders academic women, the reality may not be so straightforward.

Earlier research has tended to focus on prejudices against academic women within particularly male-dominated academic fields (e.g. physics and engineering) to explain variations in success (Dahms, 1999; Bagilhole et al. 2000; Etkowitz et al. 2000; Zuckerman 2001). By contrast, disciplines such as languages, humanities and social sciences (particularly psychology, history and education), as well as certain new scientifically-orientated fields such as health sciences, have been considered female-friendly (Bain and Cummings, 2000).

The literature exploring the images associated with science and scientists has documented stereotypic portrayals. Students perceive scientists as predominantly (white) males with glasses, lab coats and facial hair (Barman, 1997). Further, while biology is viewed by pre-college female students as a caring branch of science, physics tends to be associated with war and destruction (Jones, 1990). **Have these differences influenced students’ perceptions of science? And their career choices?** The data indicate that they do. However, over time, significant changes have taken place. For instance, the old dichotomy between arts and humanities (female-dominated) and science (male-dominated) no longer seems to hold (with the exception of engineering and ICT).

Several studies have described sweeping changes in the gender system. For example, it has been noted that gender disparities in terms of subject choice and career destination have decreased in some countries: 1) for (some) middle-class students (e.g. those attending fee-paying schools) (Arnot et al. 1999) and 2) among girls and boys attending single-sex schools (where there seems to be less pressure to conform to sex stereotypes) (Skelton and Francis, 2009). Furthermore, focusing on gifted girls, some researchers suggest that sociocultural changes occurring over the past three decades have gradually resulted in some changes in women's attitudes towards career choices (Leung, Conoley and Scheel, 1994). Furthermore, the top career choices for gifted early-adolescent males and females seem to be identical (Reis, Callahan and Goldsmith, 1996). These changing trends, shown but not always acknowledged in all recent literature, reveal the ‘fragility’ of gender stereotypes when it comes to certain disciplines and professions. For example, while engineering and ICT continue to be male-dominated areas, medicine is now gender-balanced in many countries and is even female-dominated in others, and nursing is becoming an increasingly masculinized field.

Women and medicine

The first women who attended universities in many of the countries of Europe and America did so to become doctors, and only later chose other careers. Yet from the establishment of universities in the 13th century until the late 19th century, when women first began to study and practice medicine, members of the profession were exclusively men. There were active policies of exclusion of women from medical practice as well as segregation in other work spaces not configured as "suitable" for them. Looking back over the past 150 years, women have made tremendous advances within the medical profession. Despite the persistence of horizontal and vertical segregation, there are, internationally, increasing numbers of women entering medicine. Medicine has gradually become a feminine profession. Thus some research has revisited the role of women in medicine over the years as well as the changing gender stereotypes surrounding this profession.

Professions are created and practiced by people, either men or women. Yet gender is determinant in career opportunities. The power relations, hierarchy and authority within a profession depend on whether there is a tradition of male or female practice, the current levels of feminization and the status of men and women (Ortiz-Gómez et al. 2004). Throughout history, different health professions have been building professional identities (masculine or feminine). The achievement of this identity is based on the selection of the members of the professional group on the basis of their gender as well as on the incorporation of gender values into healthcare. There has been an active and historically changing process by which values and behaviours (masculine and feminine) transform the profession and the medical specialities (e.g. the diagnosis and empathic treatment area, introduced in the 1920s, was defined as more "feminine", intuitive and less scientific). The interest in the construction of "gendered" professional identities in health has led to studies investigating dominant female identities in certain specialties. Research has also focused on the processes by which male identities are shaped in medicine, dentistry and surgery, while historically functioning as a way of increasing the prestige of the activity (Ortiz-Gómez and Bernuzzi Sant'Anna, 2007).

It seems that in the near future the health professions will be largely in the hands of women, even if there are important differences in feminization between specialities and countries. This would be an unprecedented situation in an employment sector in which women's dominance was limited to midwives and nurses only fifty years ago. It has been argued that the increasing feminization of the medical profession will transform medical practice, especially within the European public health care systems. Some studies have discussed the implications of the increasing numbers of women in the medical profession. It has been presented as a sign of decline in pay, a decrease in medical care coverage (women generally prefer shorter working hours and spend more time with each patient), but also as the possibility to offer more humane, personalized and comprehensive care (Ortiz-Gómez, Teresa, 2007). For example, the research carried out by Kilminster et al. (2007) delineates some of the effects of gender on the culture, practice and organization of medicine, while recognizing the need to develop more sophisticated research designs to explore the structural, economic, historical and social contexts that interact to produce medical culture.

Men and nursing

Literature in recent years has documented how the proportion of women in male-dominated professions has been steadily increasing (Fassinger, 1990; O'Brien and Fassinger, 1993; Rainey and Borders, 1997). However, little has been written about the variables that might influence men to enter gender-atypical fields of study (such as nursing, librarianship, elementary school teaching and social work) (Chusmir, 1990; Hayes, 1989; Jome and Tokar, 1998; Lemkau, 1984; Tokar and Jome, 1998; Lease, 2003).

Whereas women who choose to enter male-dominated occupations are generally viewed as making a positive career move (Hayes, 1986), the same perceptions do not hold true for men who enter female-dominated occupations--they may, for example, face lower status and financial rewards, and even find their abilities, masculinity or sexual orientation questioned (Chusmir, 1990; Hayes, 1986 and 1989). Indeed, some research suggests that there is a stigma associated to men in these professions, not considered “real” jobs for men (Williams, 1992).

Some Anglo-Saxon studies suggest that girls are not only interested in a significantly greater number of careers, but also show greater gender-role flexibility in their career aspirations. By contrast, boys aspire to careers significantly higher in the level of prestige and of the education required for them than girls (Mendez et al. 2002). Other researchers report that, mainly as a result of the continuous devaluation of activities performed by women, 1) women have more incentives to enter male jobs and 2) men have little incentive to embark on typically “female” studies and professions. Similarly, it appears from the literature that the increased similarity in the career aspirations of gifted boys and girls is attributable to girls becoming more interested in male-dominated occupations, rather than vice versa (Leung, Conoley and Scheel, 1994). Consistent with these findings, it has been noted that there is greater pressure on boys than on girls to adhere to traditional gender-role stereotyped behaviour (Massad, 1981).

Box 12: Just how male are male nurses..?

The aim of the present research study was to elucidate, quantitatively, the gender role perceptions of male nurses in Ireland. Caring, women and the female gender role are all historically and fiercely synonymous. However, not all carers are women. For instance, male nurses also assume caring roles. What we do not know is how these men actually relate to their own gender role. Is it possible that because of their immersion in a stereotypically caring career they actually occupy the female gender role? A quantitative non-experimental descriptive design was adopted. Short-form Bem sex role inventory was mailed to a random sample of 250 male registered general nurses in Ireland to ascertain whether they perceived themselves to occupy the male or female gender role. One hundred and four men completed the inventory. Overall, the sample identified with more female than male gender norms. Specifically, 78 respondents identified themselves as adhering to more female gender role norms than male gender role norms, whereas 21 respondents identified more strongly with male gender role norms. Five respondents identified equally with both gender roles. This study quantitatively elucidates the gender perceptions of male nurses in Ireland for the first time. Adherence to the female gender role may be an important prerequisite to caring. If this is true, then this study supports the notion that many male nurses occupy this gender role. However, adoption of facets of the female gender role may not be unique to male nurses. Many men may occupy this role and perhaps resultantly be attracted to or well-suited to caring careers. Attracting such men may help in solving the recruitment and retention issues that surround caring careers.

Source: Loughrey, M. 2007, 'Just how male are male nurses..?' Journal of Clinical Nursing, vol. 17, no. 10, pp. 1327-1334.

Men, masculinity and health were analysed by feminists in the decade of the 1990s. Gender identity and behaviour are formed not only through socialization but are also constructed within larger contextual institutional processes. Nursing is perceived to be a feminine occupation and therefore is devalued in (patriarchal) society, particularly in relation to medicine. In contrast with perceived male qualities such as strength and dominance, nursing is stereotyped as having the traits of caring, nurturing and submission. As a result, male nurses build their identity outside of the expected masculine role. They are a small, but increasing, minority. They are, according to Kanter (1977), tokens: people who differ from the majority of the group members in ascribed characteristics such as sex or race, which carry with them a set of assumptions about culture, status, and behaviour.

The depiction of male nurses has perpetuated negative stereotypes. According to Neighbours (1999), male nurses are socially disadvantaged but in different ways than female nurses. Four “role traps” and stereotypes of male nurses are identified: the “ladder-climber” (male nurses are viewed as ambitious), the “troublemaker” (male nurses do not put up with degrading comments and treatment from male doctors), the “he-man” (they are expected to do all the heavy lifting) and the “homosexual” (male nurses exhibit “feminine” traits, such as empathy and caring).

More recently, Burton and Misener (2007), in their work ‘Are You Man Enough to Be a Nurse?”, have created a typology of all the stereotypes: 1) the “physician wanna-be” or “failed medical school applicant” (the general stereotype presents nursing as passive and unintelligent work); 2) the “gay/effeminate” (the general stereotype is that men who choose nursing must be both gays and effeminate); 3) the “misfit” (the general stereotype is that men in nursing do not fit into mainstream male occupations); and 4) the “womanizer” (the general stereotype suggests that heterosexual men choose nursing for sexual exploits and conquest, or as a means to advance professionally).

Women and ICT

There are studies and careers traditionally chosen by men and rejected by women, and the other way around. Indeed, in some historically male-dominated areas (for example, technology careers such as computer engineering and telecommunications), the female presence in most western countries has either remained stable or has been declining and it is very rare to find women interested in professions related to new technologies. The predominance of men in activities related to technology is seen as **a sexist expression of an "androcentric" science**. Technology is designed by and for men and so women have only a minor role to play in the design, development and use of ICT. It should be stated, however, that women are a heterogeneous group, and while their reality is different from men’s, it also very diverse. As noted by Marcelle (2000), the diffusion of ICT is not gender-neutral and its effects vary depending on the origin of the women and their social class, race, access to education and training, age and social status. Therefore, while some women's groups have access to these tools, others are excluded.

Some research has explored **why women are less attracted or relate less well to the technologies** than men, and concludes that the key lies in the **social learning of certain expectations and stereotypes**. For example, research carried out by the Technology Children's Center (MIT) reached, among others, the following conclusions: men see technology as a source of power and women as a means to establish a connection; men focus on the machine and women on the social function of technology-- technology is an end in itself for men and a means to an end for women.

According to Wajcman (2006), technology is in a broad sense part of what we are. But **technologies are not neutral** from the point of view of gender. For example, they are classified according to a gender-based ranking: the brown goods and white goods (Schwartz, 1983). The first have been traditionally associated with men and the second with women. The "second order technologies" (appliances rather than domestic technologies), are tools that have mainly served to improve women’s quality of life.

Women have joined the technological revolution in the early 21st century. But there are still various gender divides (Castaño, 2008). An increasing number of experts wonder **why women are more reluctant than men in terms of ICT appropriation**. Research in the 1980s and early 1990s talked about **masculine technophilia and feminine technophobia**. Currently, values traditionally attributed to science and technologies continue to be associated with men and with masculinity (objectivity, rationality, etc.). Unlike women, men have had direct contact with technologies since childhood (Alemany, 1992). Several investigations show the persistence of an equation between masculinity and technology (Cockburn, 1983 and 1985; Hacker, 1989; Wajcman, 1991; Faulkner, 2000 and 2001; Lohan and Faulkner, 2004); and men are often presented as being “in love” with technologies. **As a result, technology is presented and perceived as masculine.**

Valian’s work (1998) illustrates how perceptions of gender differences, as well as existing norms in an organizational context, shape individuals’ perceptions of competence and success. As a result, when the preponderance of men/women is observed in certain professional roles, we naturally assume that men/women are better at those “masculine”/“feminine” careers. For example, some studies reveal perceptions that women are better suited to the “soft” side of ICT (such as user relationships, understanding and communication) (Kuhn and Rayman 2007; Nielsen, von Hellens, Beekhuyzen and Trauth, 2003). Further, although these skills are alleged to be critical to IT, they are valued less when women exhibit them because they are “natural” for them and not an achievement. The implication is that women are insecure and less technically “savvy”, traits which do not allow them to overcome barriers to better career paths.

According to the ‘Global Gender Gap Report’ (2007), there is empirical evidence to suggest the continuance of male domination in the field of technology. Men use computers and the Internet more than women, while reporting more experience and positive attitudes towards computer-related activities. But some research suggests that children’s preferences and patterns of ICT use, influenced by gendered socialization processes, might contribute to future gendered educational and career patterns. The ICT gender gap is also reflected among young people (Faulkner, 2007). In all of the OECD countries, there appear to be differences in boys' and girls' attitudes (engagement, self-esteem and motivation) towards ICT. Boys are more motivated to learn digital skills, have a more positive attitude towards computers, have wider computer experience and report more interest and positive attitudes to computer-related activities than girls (OECD, 2007). These differences have often been interpreted as a possible explanation for why girls do not choose computing studies or become ICT professionals.

Moreover, organizations are not gender neutral (Acker 2006; Ferguson 1984; Wajcman, 1998) and culture and climate have been identified as crucial to the recruitment and retention of women. In this sense, "chilly" is a term that has been used to describe unfriendly climates for academic women (Chilly Collective 1995). The ICT workplace is “chilly”: extended work schedules, promotion of individual technology innovation, double standard with regard to the behaviors required for success (Gherardi 1995), etc. The research literature suggests that organizational culture and climate can significantly affect women's participation and employment outcomes. Thus, features of the male-dominated ICT subculture would be perceived as distinctly inhospitable to many women (Faulkner 2007). Moreover, Wright (1996) argues that the “engineering culture” of ICT work has an adverse impact on the participation and progress of women, because a culture that develops in a male-dominated environment is necessarily one in which males have the advantage. In fact, the perception that various elements of ICT culture are male-orientated (gaming software, hacker fraternities, etc.), adds to the perception that ICT organizational contexts are unfriendly towards women.

A variety of strategies (such as mentoring, role models or recruiting) have been proposed for rectifying the underrepresentation of women (Catalyst, 2003). Cultures are inherently resistant to change and so effective interventions are needed in order to reshape the values and assumptions of their members and to facilitate a cultural transformation; however, as research has pointed out, adequate monitoring (Doherty and Manfredi 2006) and resistance (Vázquez and Elston, 2006) are needed as well.

6.3. Educational and professional choices

An early concern of feminist research was the different subject and career paths that girls and boys take. A national curriculum which allows little subject choice tends to reduce the gender gap in subject choice and attainment (Arnot et al., 1999), but when choice is allowed, boys and girls opt for gender-stereotyped subjects and career choices. The different choices of men and women are associated with typical male and female stereotyped characteristics (Suter, 2006). Insofar as science is associated with male rather than female stereotypes, science-related subject areas and professions tend not to be a woman's first choice.

Moving beyond traditional organizational thought, theories of **gendered organizational culture** are concerned with deconstructing the ways in which organizations serve to maintain the gendered status quo (Kanter, 1977; Acker, 1990; Connell, 1995). From this perspective, researchers focus on the ways in which organizations help to influence and shape societal understandings of gender, masculinities/femininities and sex-role expectations. Gender is a socially constructed distinction between masculine and feminine (Goode, 1995). Acker (1990 and 1992) produced an analysis of gendered organizations in which she argued that men and women are active agents who "do" gender in the course of their everyday work lives. As gender is created and recreated in organizations, the term "gendered processes" has been used to refer to the ways in which "advantage and disadvantage, exploitation and control, action and emotion, meaning and identity, are patterned through and in terms of a distinction between male and female, masculine and feminine" (Acker, 1990:146).

Box 13: Gendered organizations

In spite of feminist recognition that hierarchical organizations are an important location of male dominance, most feminists writing about organizations assume that organizational structure is gender neutral. This article argues that organizational structure is not gender neutral; on the contrary, assumptions about gender underlie the documents and contracts used to construct organizations and to provide the commonsense ground for theorizing about them. Their gendered nature is partly masked through obscuring the embodied nature of work Abstract jobs and hierarchies, common concepts in organizational thinking assume a disembodied and universal worker. This worker is actually a man; men's bodies, sexuality, and relationships to procreation and paid work are subsumed in the image of the worker. Images of men's bodies and masculinity pervade organizational processes, marginalizing women and contributing to the maintenance of gender segregation in organizations. The positing of gender-neutral and disembodied organizational structures and work relations is part of the larger strategy of control in industrial capitalist societies, which, at least partly, are built upon a deeply embedded substructure of gender difference.

Source: Acker, Joan (1990) "Hierarchies, Jobs, Bodies: A Theory of Gendered Organizations", in Gender and Society, Vol. 4, No. 2 (June), pp. 139-158.

Thus, within the workplace, masculinities and femininities are created and reinforced through the values and beliefs of both the individuals within the institution and the institution itself. In summary, far from gender-neutral entities, organizations are gendered sites which reflect larger society. Much of the literature concentrates on the negative impacts of traditional masculinity on women’s experience, yet it is becoming increasingly evident that these practices also have adverse implications for many men. For example, sex-role stereotyping within work organizations restricts their ability to become actively involved in the private sphere (LaRossa, 1988).

The research literature focuses on the masculine atmosphere in science and its effects on the gender order. Studies in European and non-European countries have shown that what drives women away from science, technology and engineering is not the “hard” nature of science or women’s deficits in abstract thinking, but the prevalent climate of exclusion which constructs an atmosphere of “dominant masculinity”. In the construction of gender and the reproduction of male power in science, the concept of traditional hegemonic masculinity is central (Connell, 1987). Hegemonic masculinity is “the configuration of gender practice which embodies the currently accepted answer to the problem of the legitimacy of patriarchy, which guarantees (or is taken to guarantee) the dominant position of men and the subordination of women” (Connell, 1995: 77). The social construction of the definition of science is male bias. The image of hegemonic masculinity in science is transferred through polarized gender stereotypes which connect initiative, strength, rationality and autonomy with men, while women are constructed as inferior (Wajcman, 1991).Women and men who differ from the hegemonic form of masculinity are both devalued (Döge, 2002).

The culture of organizations is based on stereotypical gender roles and the image of the “ideal manager” or a “normal employee” tends to be male-biased (Bischoff, 2005). Thus, working styles, professional identities and the shared culture are gendered (Faulkner, 2000a and 2000b). Thus, elements of dominant masculinity such as male homosocial networks help to construct and reproduce male identity, power, and privilege through the accumulation of resources relevant to career success (Rastetter, 1998). The lower status of women in educational and professional organizations, together with their minority status, hinders their access to the unacknowledged and implicit patriarchal support system (Morley, 1999; Bagilhole and Goode, 2001; Husu, 2001). Exclusionary processes and feelings of being excluded from informal male networks could be a source of deep insecurity with a negative influence on the self-confidence that is vital to career success, especially in male-dominated fields of study and professional life. Women feel excluded and marginalized, are disadvantaged by negative perceptions about their abilities and commitment (Roberts and Ayre, 2002), feel more dissatisfied with their professional lives and careers and their career opportunities are reduced (Wilz, 2004).

Recent qualitative (Erlemann, 2002; Bagilhole et al. 2005) and quantitative studies (Roberts and Ayre, 2002; Haffner, Könekamp and Krais, 2006) show that traditional masculine definitions of engineering determine the organizational culture and restrict women’s feelings of belonging. Thus, women engineers do not feel comfortable because of the rough climate (e.g. in the construction industry) (Bagilhole, 2005), and they leave this professional field because of traditional masculinist culture (Erlemann, 2002). In summary, the fact that traditional scientific environments are constructed according to a masculine organizational culture leads to women’s “invisibility”, not only because of their absence (as staff and students) but also in terms of the recognition of their contribution to the history of science.

Girls tend to anticipate the difficulties they will encounter in their professional lives if they choose a technical career. They realize that science-related studies will require more dedication and the renunciation of their personal life. By contrast, careers in social sciences and humanities, which in fact may involve more competition and poorer working conditions (Brynin, 2006), are assumed to be more consistent with a personal life (Cinamon and Rich, 2002). It is believed that women should prioritize family rather than professional responsibilities. According to the "*social role theory"* (Eagly, 1987), gender differences in behaviour are the result of the distribution of gender roles and the social division of labour. Thus, women are associated with the domain of reproduction (reproduction and care), while men are associated with the public domain. Women who want to be mothers and professionals will face more difficulties in achieving work-family balance (Cinamon and Rich, 2002). In this regard, jobs and professions related to science, computers and technical courses will require more effort and dedication and will make it even more difficult for women to reconcile the work and the private spheres. The fact that many women feel that students will have to invest and work harder than men in these areas to achieve the same results may serve as an argument to explain why there are fewer women in science and technology.

Boys and girls are embedded in their culture and are shaped by it. As long as the culture maintains traditional gender roles and images of science (e.g. ideas that science is more appropriate for boys than for girls), it very likely that adolescents will take those values and attitudes with them to school and college. As Jones, Howe and Rua (2000) recently suggested: "To continue the status quo without transforming the culture is to condemn girls to remaining on the sidelines of science".

7. Summary and Conclusions

In the structure of the meta-analysis, stereotypes and identity are seen as one explanatory factor for horizontal and vertical segregation, dealing with the analysis of the gender bias in structural social dynamics that are reproduced in scientific work. The topic refers to the gender-biased construction of cognitive abilities and identity with regard to science. The ETAN report's (Osborn et al, 2000) "concern was that excellence of science in Europe was being compromised by patronage, institutional discrimination and old-fashioned approaches to human resource management" (p.12). Two main theoretical perspectives could be differentiated: the human capital theory sees the unequal careers of women and men as the result of their unequal investment in human capital. In this line of thinking, it is stated that women make the rational choice to invest less in human capital than men because they are aware that in the future they will have to split their time between family and domestic responsibilities and their professional working life. The second theory sees the unequal treatment of both genders as the reason for the low number of women in science and research. During the career there are different selection and evaluation processes which appear to be gender-biased.

7.1. Summary of the report

Stereotypes are shared social beliefs, values and norms which reflect the roles assigned to men and women. They are the product of particular historical, cultural and social contexts. Generally, stereotypes are simplifications of reality that serve to reduce the complexity of the world around us and to streamline the decision-making process. Gender stereotypes that influence identity as well as science can be seen as very persistent effective deterring factors. The three subtopics focus on barriers at different levels and in different disciplines. In the subtopic of "inborn cognitive abilities" biological and psychological differences--from brain size to standardized psychological tests, controlled laboratory experiments, neurobiological techniques and meta-analyses--are used to explain the different outcomes in science. Even though the interplay of psychosocial and sociocultural factors is mentioned in most of the literature, again and again in the literature the differential success of women and men in science and engineering is put down to women's inferior abilities in maths and science. There is, then, a bulk of research analysing biologically determined sex differences in cognitive abilities and their consequences. This seems astonishing from an empirical point of view, as the evidence of the gender gap in performance in maths and science in most of the studies is very thin. In some countries the gap has vanished and in others, such as the Nordic countries, the situation has reversed. Moreover, the gender gap in performance in language, where most of the studies found differences that were not favourable to boys, has been less often investigated and certainly not dramatized in connection with gender segregation in professional careers. Blaming the different biology of men and women follows a very traditional biological determinism, as de Cheveigné and Muscinési (2009) have pointed out.

In summary, within-gender differences are greater than between-gender differences, as Carol Hagemann-White found in her comprehensive literature review of 1988, in which she tested her zero hypothesis that there are no between-gender differences. What is most important is that gender gaps do not seem to be wide enough to explain the differences between males and females in science education and SET trajectories. One must look to the social determinants of performance and decisions about gender segregated careers as well as to the methodologies with which research results are produced. Even though cognitive abilities are a prerequisite for a successful career in any field, they are not the whole story. The "critical filter" hypothesis together with the "pipeline model" can thus be rejected.

A broad theoretical perspective is connected with the lifelong process of socialization. This perspective comes together with gender construction processes. The central basis for gender roles in societies is, on the one hand, individual learning processes and on the other hand, social structural processes based on two-gender hierarchically structured societies. Reality, from a sociological point of view, is not only structured by individuals, groups, organizations and societies, but also by powerful definition and construction activities. In looking at gender roles, then, such powerful definition processes need to be taken into account. One central definition is the binary and reductionist categorization (masculine is associated with the positive and feminine with the negative) that reflects a sex-based hierarchy and asymmetry (men are established as the measure and cannon of all things). This dualistic notion of gender reinforces traditional gender stereotypes that associate men with technical skills and women with social skills. The dichotomy between the feminine and the masculine establishes gender stereotyping, gender roles and, based on these, a gendered division of labour. In this binary thinking, women are responsible for reproductive and men for productive work in society. In gender stereotypes, this binary thinking is always activated.

Self-confidence and self-esteem are influenced by gender stereotypes and stereotypes about women's perceptions of their lower competence in maths influence their construction of self. The more positive our perception of our own skills in any domain, then, the better our self-concept. The misconception that women are inferior in maths skills is so widespread in Western societies that the mere fact of reminding a woman of her sex can significantly reduce her score on a test. The fact that girls perceive that they have poorer skills in maths and science than boys leads them to be less likely to choose those subjects. The activation of negative stereotypes can have a detrimental effect on women's interests, performance and expectations in domains relevant to success in academic science and engineering (NAS, 2006).

Motivation can be intrinsic (participation in an activity purely out of interest), or extrinsic, (participation in an activity purely for the sake of attaining a reward or avoiding punishment). The international Relevance of Science Education (ROSE) study, which focuses on the interests of students and their opinions about learning rather than on their competences, has revealed that science fails to capture female students' interest or to motivate them. The motives behind the choice of study can have considerable influence. While males make their choices on the basis of career prospects, females are also motivated by social and political commitments, even though young men and women are equally talented and interested in the field of mathematics. While many studies refer to the conflicts between the construction of a female identity and the social constructions of science to explain the perpetuation of this field as a male domain, others demonstrate how technical habits, attitudes and interests, for example of new engineering students, show a wide variety across gender (Wolffram and Winker, 2005).

Identity is marked by cultural beliefs and stereotypes (characteristics of the family, school, friends and the mass media) as well as by "societal" stereotypes. The key variables playing a role are the differential socialization on the part of mothers, parents and teachers depending on the sex of the child, gender-stereotyped beliefs and the individual's self-concept in relation to the characteristics required for the performance of the task (expectations of success, short- and long-term goals associated with one's identity and psychological needs, feminine and masculine self-concept and the potential cost of investing time in a given activity).

There are numerous individual findings about the differential and comprehensive influence of socialization agents, such as the family, school, peer group and the mass media. Parents hold "gender-differentiated" views about their children and tend to engage more with and show more encouragement to their sons than to their daughters when it comes to entertainment and leisure related to mechanical skills, maths and technology. As a result: 1) they tend to discourage girls at an early age from studying careers related to mathematics and technology and 2) they further reinforce the capabilities of their male children in science-related subjects, while promoting the abilities of their daughters in areas linked to the female gender role. Thus, parents tend to underestimate the intelligence levels of girls and teachers do the same.

Teachers have stereotyped attitudes towards the girls and boys in the classrooms although they themselves are usually unaware of their gender-biased reactions. In this way, teachers' expectations of their students become reality, as girls are often discouraged from enroling in courses and studies that run counter to gender stereotypes. While gender bias in the interaction between the teacher and students was found in all subject areas, the greatest bias was found in the maths and science classrooms. The "hidden curriculum" transmits messages that often reinforce sex stereotyping and the dominance of boys regarding the school space. Boys and girls taught by women are more inclined to show positive attitudes towards school than children taught by men. Research developed in Northern European countries suggests that there is a problem of didactics in mathematics and science, in that they are presented as "cold and distant" disciplines that lack space for creative thinking. Recommendations are to change attitudes, curriculum and educational methods, while promoting positive role models for girls and paying more attention to female students' special needs (Roivas, 2009). Single-sex maths and science classes for girls as well as language classes for boys that would reduce the importance of gender stereotypes and roles could help to further the performance of both genders, but there are several prejudices that act against single-sex teaching. The alternative to changing the educational culture in schools so that pedagogies and the learning environment can be made more inclusive and the power relations in the classroom can be overcome is difficult to put into practice because of the complex interconnections. There are, then, two theoretical approaches to the issue of gender-related differential academic performance: 1) a perspective that assumes that girls do not "fit" in well and should "masculinize" themselves in order to adapt better and 2) a perspective that emphasizes the need to transform the contexts of learning in order to make it more inclusive of girls (Caprile, 2009).

The fact that friends and peer groups, as the main reference groups for teenagers, do not look favourably on technical subjects (perceived as more difficult) can have a greater influence on girls because they are more sensitive than boys to the perception of social acceptance - it is particularly important for them to be accepted in the group (Håpnes and Rasmussen, 2000). This again increases the effectiveness of gender stereotypes in determining study and career choices.

The mass media and ICT are nowadays among the most powerful socialization channels and therefore the media play an important part in transmitting gender roles and the culture’s pervasive stereotypes. Television in particular perpetuates traditional gender stereotypes insofar as it reflects dominant social values. Boys' games are more physical, vigorous and competitive than girls'. The character of the male scientist is more prevalent than that of the female scientist and while male scientists show masculine attributes (independence and dominance), female scientist are portrayed with feminine attributes (dependence, caring, and a romantic nature) (Steinke et al. 2008).

The idea of gendered socialization has been used since the 1980s to explain the small number of women in engineering. According to the interaction theory, people construct their social realities and identities. SET careers do not fit the feminine gender identity and the role that women are supposed to play in society (Sagebiel 2005). In summary, the construction of gender identity is not a linear process, but contradictory and conflictive, through which traditional gender roles are assimilated or transgressed, and gender identity is negotiated in multiple and varied contexts (Caprile, 2009).

Gender stereotypes in science help to perpetuate the gender-segregated educational and career choices of men and women. Feminism has found science to be a gender-biased institution that is not at all neutral. Three approaches to gender equity exist in science education: equality feminism, difference feminism, and postmodern feminism (Haraway 1988 and 1991), the latter arguing that all women cannot be treated alike.

Disciplines are claimed by Foucault (1980) to be practices that create and reproduce power/knowledge relations in order to sustain and transform particular interests. The more the field embodies power, the less woman-friendly the community is. The old dichotomy between arts and humanities (female-dominated) and science (male-dominated) no longer seems to hold (with the exception of engineering and ICT). The ICT workplace is “chilly”: extended work schedules, promotion of individual technology innovation, double standard with regard to the behaviors required for success (Gherardi 1995), etc.). In all of the OECD countries, there appear to be differences in boys' and girls' attitudes (engagement, self-esteem and motivation) towards ICT. Boys are more motivated to learn digital skills, have a more positive attitude towards computers, have wider computer experience and report more interest and positive attitudes towards computer-related activities than girls (OECD, 2007). While engineering and ICT continue to be male-dominated areas, medicine is now gender-balanced in many countries and even female-dominated in others, and nursing has become an increasingly masculinized field. The significant segregation existing within the social sciences and the humanities has too often been overlooked (Vázquez, 2006).

What is the outcome for educational and professional choices? The image of hegemonic masculinity in science is transmitted through polarized gender stereotypes which connect initiative, strength, rationality and autonomy with men, while women are constructed as inferior (Wajcman, 1991). In the construction of gender and the reproduction of male power in science, the concept of traditional hegemonic masculinity is central (Connell, 1987); this is promoted by male homosocial networks which help to construct and reproduce male identity, power and privilege through the accumulation of resources relevant to career success (Rastetter, 1998).

7.2. Gaps

Most of studies about stereotypes and their role in segregation focus on the way women’s educational and professional choices, rather than men’s, are reduced by them. There is therefore a need for more studies on men’s limited choices. The subtopic ‘cognitive abilities’ has been investigated mostly from the psychosocial point of view and this has produced a plethora of studies, especially in Anglo-American countries; there is room now for more of a focus on sociological studies on the mechanisms of perpetuation of gendered cultures in education, career and the scientific profession.

The many contradictory findings regarding stereotypes, especially with regard to cognitive abilities, show that there is a need to control possible gender bias in the methods used to obtain the results. There seems to be a lack of critical methodological research on this issue. The use of cohort methodology, in which the development of stereotypes and reactions to them could be observed from childhood to adolescence, is also lacking.

Gaps by Country groups
Overall gender equality in science is a new issue in **Eastern countries**. More research is needed on cognitive abilities, gender differences in educational achievement and choice of study; there is also a need for conceptual reflections on the epistemology of science from the gender and power perspective – this last with the exception of three countries, the Czech Republic, Croatia and Slovenia. Even in the Czech Republic, however, where the theoretical background of gender issues is strong, gaps are created by the preponderance of rather descriptive studies with a predominance of qualitative studies. A special common issue for Eastern European countries on which studies are lacking could be research on the changes in gender stereotypes in science that took place in the transition from the socialist era to that of democracy.

The gaps in **Anglo-Saxon countries** seem more sophisticated. Given the sizable number of studies on the subtopic of ‘cognitive abilities’ and their shortcomings, more research is needed to look at the ways in which gender bias is being perpetuated and how it influences the choice of studies and profession. Following Cole et al. (1994), the following areas should be studied more under the gender perspective: access to curriculum, course design, teachers’ attitudes and teaching styles, language, assessment issues, and the role of technology in teaching. Evaluation of the potential of a gender mainstreaming policy to counter negative hegemonic discourses and practices could be part of this work. This should be included in the recommendations in the report on ‘Policy towards Gender Equity in Science and Research’.

While there is a growing body of literature on gendered pedagogy, a systematic examination of gender-aware teaching both in terms of subject content and single-sex classrooms is needed to identify why and how this can further benefit girls and boys. A closer examination of the interplay between individuals’ pleasure in science gained though interests, experiences and performance and their attitudes to science should be undertaken, both for girls and boys at school and for women and men studying at university. Research should help to reduce the lag between popular notions of scientific workplaces and their contemporary reality to raise the level of understanding among pupils, parents, careers advisors and teachers about the range, content and remuneration of scientific occupations. Within the subtopic of ‘construction of identity’, the acceptance of stereotypes on the part of pupils, students and employees and the adoption of gender-appropriate identities should be studied for different age cohorts and from the perspective of ethnicity and socioeconomic group. Within the subtopic of ‘construction of science’, theoretical and empirical research is needed to elucidate further the ways in which binary dualisms, expressed through stereotypes, operate in different scientific disciplines. The insights provided by Faulkner (2000a and 200b) and others in the field of engineering could be replicated in other fields.

In the **Nordic countries** the subtopic of ‘cognitive abilities’ has not been clearly defined and expressed as an important research target and studies on this issue are exiguous. Globally, the problem of getting women to study mathematics and technical sciences has not been solved in the Nordic countries. Furthermore, there is no homogeneous research situation on the topic ‘stereotypes and identity’ in these countries. The Nordic country group report blames especially women’s and gender studies in the Nordic countries, which should have done more empirical studies in other scientific disciplines outside the social sciences, medicine and technology studies. The acceptance of women’s and gender studies has not led to any large-scale changes in male-dominated hierarchies and practices in science and the university system.

The difference in research situations is reflected, for example, in the different number of empirical studies in Denmark in comparison to Finland and Iceland. The research in Finland is conceptual and motivated only by feminist thinking--not by empirical research findings or by other alternative epistemological orientations (apart from a few empirical dissertations outside the mainstream). In recent years, studies of men and masculinity have begun to appear. The position of men’s studies is weak; it was developed to add a perspective to the social relations between men and women and to highlight the position of men. It is remarkable that research focusing exclusively on boys and men is practically nonexistent in Denmark, Sweden and Iceland, although men constitute half of the population. Only two Danish entries deal with the man’s view of gender identity in the labour market.

Research on the subtopic of the ‘social construction of science’ has documented how gendered values or perceptions have consequences for research theories and interests, as well as findings. The report claims that there has not been a “revolution in science”, despite the strong influence of feminism in social sciences and the strength of epistemological thinking in women’s studies in Finland, Norway and Sweden. In mathematics and other natural sciences--which continue to have an aura of objectivity and thus also of gender neutrality--there seems to be a stronger resistance towards this kind of gender question. Generally, research on stereotypes and identity has focused only on academia and the school system. Advanced quantitative methodologies, like longitudinal studies, are lacking, for example in studies on the reasons for different educational choices between the sexes.

In the **Southern countries** the social science correspondents of all the countries concurred that there are wide gaps in the studies on ‘stereotypes and identity’ at the national level, notwithstanding the presence of important findings at the supranational level. Particularly, there seems to be a lack of a comprehensive and coherent framework of analysis of the issues. The subtopic ‘cognitive abilities’ and differences between men and women are underdeveloped, for example, in Portugal, Spain, Greece and Israel.

There is not sufficient empirical research on several important issues, such as the dynamics that allow some individuals to overcome traditional stereotypes and choose professional fields dominated by the “other” gender. Most of the efforts and interventions aim to change girls’ choices and not both girls’ and boys’ choices of traditionally "masculine” and “feminine” educational and professional fields. Israel’s mandatory military service for females provides scholars with a privileged observatory of how women adopt the soldier identity, traditionally associated almost exclusively with the masculine. Another research possibility in connection with this field could be to study career choices and self-perception among religious versus secular women, in which much quantitative work has been done, and the role of military service in gender inequality and stereotyping. In spite of the abundance of studies on education concerned with stereotypes or gender and the attitudes of students and teacher candidates towards science in Turkey, not all include a thorough gender analysis in terms of focusing on epistemological concerns. A lack which Southern countries have in common with other country groups is that the studies do not present alternative or innovative methods towards the deconstruction of gender stereotypes; pedagogical approaches and the teaching material still have not really changed and the results of the studies have not been fully exploited.

Overall, the **Continental countries** have focused very much on stereotypes and identity to explain horizontal and vertical segregation. Within the subtopic of 'cognitive abilities' research has concentrated on school education. Cognitive abilities have been reflected in the context of gender gaps in school achievement (Austria), often in connection with the subject of mathematics (Belgium), where women's giftedness has been discussed (Germany) or explored from a naturalistic point of view (France). In Switzerland the different abilities of boys and girls, women and men, have been the subject of studies. In summary, no report has shown gaps in research on cognitive abilities. From the social constructional perspective, there have been studies on what tasks and abilities are perceived as more masculine and feminine. Differences in relation to learning styles, preferences and the abilities of male and female students have been investigated (Netherlands). Especially in Austria and Germany, measures to promote girls and women in non-traditional professions have led to the question of how and when girls and boys develop gender-specific interests and competences. The basis for the research was the gender-specific socialization aspects in combination with gendered self-concepts (France, Germany). This was studied in schools and higher education.

The largest numbers of studies focused on the low representation of women in science and engineering degree courses and/or professional fields. Girls' and boys' gendered choices of fields of study and profession were found to be connected with stereotypes and the social construction of identity. There have been studies on attempts to change gender stereotypes and the association of professions or specific fields with typical male and female characteristics (engineering, especially) by creating role models and the influence of society at large (mainly the role of the family/parents) has been reflected in these (Belgium). Another debate took place on coeducation and its gendered effects on school success, as Germany expanded on so-called models of single-sex degree courses in traditional men's fields of study and degree courses. The social construction of science has not been consistently investigated in France, but has become more popular over the last years in other continental countries. It started with more epistemological studies in the 1980s, when the neutrality of science and its potential for discrimination became a focus. The hegemonic position of masculinity and the impact and consequences of this masculine culture on the social construction of science became an issue in several continental countries.

One common gap in all the continental countries is the translation of research results into measures to change the factors responsible for the reproduction of gender stereotypes. Moreover, individual countries focus on different gaps. Thus, the Austrian report mentions the lack of explicit studies on gender stereotypes and especially on the role of the family in socialization. The Belgian report mentions no research on the first levels of education and the mechanisms of the reproduction of gender stereotypes. It states as well that research on the culture of universities and other institutional areas that support stereotypes could be gone into in greater depth. The report from France calls for the development of strong empirical research, particularly on the social construction of science. The German report notes the lack of a critical review of the data gathered and of the methodologies. The report from the Netherlands points to questions of why the structural and cultural barriers that female academics come up against in academic selection and evaluation are there to begin with--who benefits from them and who maintains them? Further questions concerning when and how stereotypical images may actually affect appointment decisions have not yet been addressed. Furthermore, the studies have mainly been carried out in experimental settings and do not deal with daily situations. In view of Switzerland's research situation, studies in an international context would be welcome; more research on the social construction of humanities, health sciences and other scientific fields, in which men are heavily underrepresented, would be particularly important.

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