

CRITERIA FOR GENDER INCLUSION

Contributors: Marianne Achiam & Henriette T. Holmegaard

Institutions: University of Copenhagen, UCPH





Summary	4
1. WHAT IS THE PROBLEM?	5
1.1 Why care about the gender balance in science?	5
1.2 Science is gendered	6
1.3 The implied science learner	7
1.4 The conflation of gender with biological sex	8
2. Gender inclusion in science	10
2.1 Existing initiatives	10
2.2 Challenges to promoting gender-inclusion	12
3. Approach to gender in Hypatia	14
3.1 A framework for institutional science education	14
3.2 The societal/cultural level	15
3.3 The institutional level	15
3.4 The interactional level	16
3.5 The individual level	16
4. Criteria for gender inclusion	17
4.1 The individual level	17
The interactional level	19
4.2 The institutional level	20
4.3 The societal/cultural level	22
5. Applying the criteria	23
6. Conclusions	24



Summary

In the coming years, with Europe's knowledge economy developing and new technologies on the rise, skills in science, technology, engineering and mathematics (STEM) will be needed for a broader range of careers than ever before. It is therefore imperative to attract and recruit more youth to STEM study programmes; not just to increase the *numbers* of STEM-trained professionals, but also to increase the *diversity* of STEM-trained professionals.

The present document critically discusses the reasons present-day science education does not attract the required diversity of youth to STEM study programmes. These reasons include the implicit gendering of STEM, which presupposes certain types of learners to the exclusion of others, and the widespread conflation of gender with biological sex, which contributes to creating STEM stereotypes. These mechanisms are at work both in and out of school contexts, and have the effect of excluding a variety of learners from STEM. Clearly, to create and implement science education activities that are inclusive of the full diversity of learners, it is necessary to address these issues.

A number of recent EU projects have focused on the issue of gender and STEM education, and building on these initiatives as well as recent research, we propose a framework to address gender inclusion in STEM activities. This framework encompasses a number of levels (individual, interactional, institutional, and societal/cultural) and guides inquiries into how conditions and constraints at these levels shape STEM activities in various ways to include (or exclude) various types of learners. The framework gives rise to a set of criteria for the analysis the gender inclusiveness of existing STEM education activities, or for the design new, gender-inclusive activities.



1. WHAT IS THE PROBLEM?

Research shows that the way sciences are communicated to youth, in and out of school, is not yet gender inclusive. What is more, young Europeans, both girls and boys, still have very little idea of the variety of careers that are possible in science, technology, engineering, and mathematics (STEM), and the skills that are relevant for those career pathways. In the coming years, with Europe's knowledge economy developing and new technologies on the rise, skills in STEM will be needed for a broader range of careers than ever before.

In most of Europe, female students are no longer characterised as non-traditional students, as an increasing proportion of girls attend higher education in general. However, although in Europe slightly more female than male youth attend higher education, many science and engineering study programmes still struggle to attract female students (OECD, 2015). Only one of three STEM graduates is female; a proportion which has changed very little the past 15 years (EUROSTAT, 2011). Furthermore, within STEM there are large variations in the gender distribution of students across study programmes, and within some sciences female students are still the minority. In particular, the biological and medical sciences have more than 50% female students, whereas women are minorities in physics, computer science, and engineering (European Commission, 2009). It is clear that if more female students pursued a STEM-career, the concerns about how Europe will compete in the global STEM knowledge-economy in the future would be alleviated.

1.1 Why care about the gender balance in science?

There are a number of rationales for striving towards a wider and more diverse recruitment of students in general and female students in particular to attend higher education STEM:

a) An economic rationale

If larger proportions of a student population achieve a higher degree of education, Europe will be better prepared to compete in the global knowledge economy. An example of this rationale is the European call for students to attend particular science and engineering programmes to meet the future demands of the workforce (European-Commission, 2004). Indeed, higher education has become the new star ship in the policy fleet for governments around the world (Olssen & Peters, 2005).

b) A diversity rationale

Higher education must support and welcome a diversity of student experiences, interests and aspirations. One reason is that higher education must reflect and support the diversity of the society as a whole. Another is that a diverse student body fosters the academic, cognitive and social growth of all students (Gurin, Dey, Hurtado, & Gurin, 2002). Finally, from a mere utility perspective, a third reason is that a diverse student population is a platform for developing innovative ideas and being capable of adapting to the rapidly changing society and to diverse purposes and applications (Bøe, 2013).

c) An equity rationale

The premise of European education is that each individual's qualifications are transferred into wage and social position in society. Society acknowledges the hierarchical positions that students gain after education exactly because those positions appear to be equally obtainable by all. The rationale is that the positions students end up acquiring are a result of their individual



effort and interests. Higher education is perceived as a result of a democratic process where everyone has equal possibilities for achieving the benefits they produce (Thomsen, 2008).

d) An empowerment rationale

The knowledge the students gain through higher education enables them to make informed choices about their own lives and the society surrounding them. Higher education gives access to literacy, empowerment and cultural as well economic capital, and as a result, non-traditional students will gain access through higher education to the arenas where decisions are made (Bøe, Henriksen, Lyons, & Schreiner, 2011). Accordingly, empowering students is the outcome of higher education where students can use their capital as well as knowledge to improve their lives as well as the society in general (Shor, 2012).

e) An environmental rationale

Finally, in a global perspective, the environmental threats (e.g. loss of biodiversity or climate change) facing the world today requires a deeper understanding of STEM. In the age of sustainable development all individuals should have the opportunity to contribute to find new sustainable solutions (Sachs, 2015).

It is not sufficient, though, simply to attract young people in general and female students in particular to STEM. It is equally important to ensure that they are included in and retained in their studies, and that their aspirations toward science are supported. There are a number of challenges inherent in these efforts; in the following, we discuss the most pertinent of them.

1.2 Science is gendered

Science has historically been celebrated in Western culture as a rigorous method of producing objective, unbiased truths about the world (Faulkner, 2000; Sinnes & Løken, 2014). However, when women entered the institutions of knowledge in Europe and the US in the 1960s, they were persistently and severely underrepresented in the sciences. This gender gap was thought to be caused by external obstacles to participation in science; thus, it was thought, removing those obstacles would result in equal numbers of women and men pursuing science careers (Allegrini, 2015). The basic assumption in this perspective is that women and men are equal, and thus equally capable of contributing to scientific development. Removing the external barriers to women's participation in science would thus enable women to pursue science careers to the same extent as men (Sinnes & Løken, 2014). Indeed, the numbers of women pursuing degrees in science have increased since the 1970s, as increasing awareness of potentially discriminatory practices has gradually removed social and political barriers to their participation. In other words, the *quantitative* problem has been somewhat alleviated; however, a *qualitative* gender gap in the sciences persists today that cannot be explained in this way (Allegrini, 2015).

The qualitative gender gap consists of pronounced gender imbalances in STEM studies and later careers (Allegrini, 2015). In other words, few STEM study programmes have equal numbers of women and men; most have large majorities of either women or men. This phenomenon has been explained by *essentialism*: The idea that by nature or nurture, girls have developed particular 'feminine' skills and characteristics that preclude them from wanting to engage in sciences such as physics or computer science (Sinnes & Løken, 2014). The status of STEM itself



is not questioned in this perspective (Allegrini, 2015; Sinnes, 2006); instead, initiatives to recruit more women to the male-dominated STEM disciplines have focused on changing girls' dispositions and perceptions in order that they might choose science (Phipps, 2007). Thus, girls are seen as being 'deficient' with respect to science and therefore in need of change (Brotman & Moore, 2008).

The discourses described in the preceding have dominated discussions of women's underrepresentation in science. The problem with these discourses is that they situate science as gender-neutral. However, it is becoming increasingly clear that science, technology, engineering and mathematics are not gender-neutral practices. Rather, STEM can be understood as a set of culturally and historically situated human practices of knowledge and thought (Allegrini, 2015); as such, 'scientific knowledge, like other forms of knowledge, is gendered. Science cannot produce culture-free, gender-neutral knowledge' (Brickhouse, 2001 p. 283). In fact, much of STEM is constructed in terms of the rational, intellectual, and independent; characteristics that are often symbolically connected with masculinity (Due, 2014; Faulkner, 2000; Phipps, 2007). This means that for individuals (boys or girls) who do not identify with such characteristics, a position within STEM is not available to them on the same terms as for individuals who do identify with such characteristics (Due, 2014). This may force those individuals to either reject STEM completely or face 'gender inauthenticity'¹ if they choose to pursue STEM nonetheless (Faulkner, 2000).

It follows from this discussion that efforts to attract more girls to science by reaching an equal balance between the biological sexes is not a viable solution:

It should make us suspicious of attempts to produce a more 'balanced' science simply by increasing the number of women in it (Gilbert & Calvert, 2003 p. 875).

Indeed, a larger percentage of women in science does not necessarily change the way the STEM knowledge-structure is gendered (Sinnes, 2006). In the following sections, we shall discuss in more detail the gendering of science.

1.3 The implied science learner

In spite of its image as being objective and unbiased, the gendering of science has been on-going since its early origins. A number of studies show that gender has influenced the production of scientific knowledge at multiple levels through history (e.g. Lloyd, 1984; Schiebinger, 1989). Instead of transcending sexual differences, the ideals of science have thus effectively helped to establish them (Faulkner, 2000). One of the ways in which the gendering of STEM manifests itself is in the domain of formal education. In higher education, STEM study courses are often structured in a way that reflect a number of explicit or implicit assumptions about what constitutes a standard student, the so-called *implied student* (Ulriksen, 2009). This means that if students are unable to decode these assumptions, or unwilling to comply with them, they risk exclusion from their programme of study. Studies show that in STEM programmes of study, the implied student is usually male (Due, 2014; Hasse, 2002; Ulriksen, 2009):

Women were, and to a great extent are, considered people who are welcome only to the extent they accept the way things have historically been done (Tonso, 1999, p. 346).

¹Gender inauthenticity is used in the sense of a person in some way putting aside or undermining their gender identity in order to participate in a practice (Faulkner, 2000).

The implied student is not just found in higher education settings. The Relevance of Science Education (ROSE) project, which collected data from 40 countries, found significant differences in the foci of science interests between fifteen-year-old girls and boys; furthermore, the foci of interests primarily shared by the girls were found to be largely absent from the secondary school curriculum (Sjøberg & Schreiner, 2010). Again, we find an implied student who is decidedly male.

Implicit suppositions are found outside formal education settings as well. Studies of museums and science centres show that indeed, there may be an *implied visitor*; a visitor whose scientific knowledge, language skills, and financial situation is presumed in ways that exclude a broad range of visitors (Sandell, 1998) and which reinforces the sense among these excluded visitors that museums and science centres are ‘not for them’ (Dawson, 2014). In a similar way as in the examples from the preceding, this implied museum or science centre visitor has in many cases been shown to be male (Dancu, 2010; Heard, Divall, & Johnson, 2000; Wonders, 2005).

There is evidence to show that gendering of science takes place in other types of STEM institutions, as well. For example, the practice of software engineering has a number of built-in *technology/people* dualisms; Faulkner (2000) shows that although these dualisms are not mutually exclusive, the hierarchical valuing of *technology* over *people* in software engineering tends to shift the balance towards masculinity, even though this shift distorts actual practice. Comparable findings have been made in engineering in organisations in different branches of industry, e.g. chemical industry or electronics (Kvande, 1999), and in healthcare science laboratories (Bevan & Learmonth, 2013). Taken together, this could indicate that STEM is strongly gendered in industry and research institutions as well. Although we have not been able to find gender-focused studies of STEM outreach programmes carried out by industry and research institutions, it seems reasonable to assume that if the everyday practices of such organisations are gendered, any outreach activities they carry out would be similarly gendered. We thus hypothesise the presence of an *implied outreach programme participant* who may, in a similar way, be male.

1.4 The conflation of gender with biological sex

The assumption that girls and boys belong to distinct, internally homogeneous groups based on their biological sex ‘creates a stereotype of girls and boys that fits no one in particular’ (Brickhouse, Lowery, & Schultz, 2000, p. 442). Accordingly, the assumption that sex equals gender is increasingly being challenged (Butler, 1993; Gilbert & Calvert, 2003; Henwood, 1998; Phipps, 2007; Rennie, 1998). Rather than the simple translation of biological difference, gender should be approached as a complex category that individuals make themselves recognizable through and *perform* in various ways (Allegrini, 2015; Due, 2014; Sinnes & Løken, 2014). Gender is thus not only culturally embedded, but also performed by the individual. Accordingly, gender should be studied as something individuals *do* rather than something they possess. Individuals adapt to the cultural contexts they participate in, and therefore they do not position themselves in the same way across different arenas. An example of the performance of gender is given by Søndergaard (1996) who describes how some female students downplay their femininity by dressing in neutral clothing in order to emphasise their competence within the ‘hard’, masculine-gendered topics of their study programme. The female students are thus performing a more masculine gender to adapt to the study context.

In summary, to change youths’ access to science in a manner that transcends the ways they perform gender, we must therefore understand how the STEM cultures include specific ways of



doing gender while excluding others (cf. Danielsson, 2011; Hasse, 2008). This entails not only regarding male-dominated sciences and the girls and women within them, but also regarding more feminised sciences and the boys and men in them (Allegrini, 2015).



2. Gender inclusion in science

In the preceding, we have argued that science, technology, engineering, and mathematics are gendered practices, and that in both in-school and out-of-school settings, the way STEM education is gendered often implies a male learner. Further, we have argued that the notion of gender, rather than biological sex, offers a lens to understand the ways in which gendered science education environments include or exclude learners. In the following, we draw on these assertions to briefly review select gender-inclusion initiatives already in existence. We use this review as a primer to discuss the challenges that should be considered when striving for gender inclusion.

2.1 Existing initiatives

The first initiative we discuss here is the EU FP6-funded project GAPP (Gender Awareness Participation Process: Differences in the choices of science careers) that was carried out in 2007-2008 by seven European partners. Its main objective was to develop and test a range of practical activities to help overcome gender differences and create a connection between secondary school students and science and technology (GAPP, 2008).

The perspective on gender in the GAPP project reflects aspects of *equality feminism* and of *difference feminism*. Equality feminists assume that girls and boys are equal in their approach to science, and that obstacles that exist outside of science are the reason girls in fact participate in science to a lesser extent than boys (cf. Sinnes & Løken, 2014). This perspective is evident in some of the initiatives presented by the project group, e.g.

Meeting scientists who are women and sometimes mothers could have an impact on girls who otherwise would not have chosen a career in S&T, thinking that it would not allow them to lead a career and a family/social life at the same time (GAPP, 2008, p. 23).

Difference feminism approaches are also evident in GAPP. In this perspective, women have developed particular characteristics that are perceived as ‘feminine’ or ‘female’, either because of biological differences or gendered society. Difference feminists suggest that these ‘feminine’ characteristics should be recognised and acknowledged (Nash, 2000); in science education contexts, this recognition may be expressed as the development of the science curriculum to accommodate girls (Sinnes & Løken, 2014). The GAPP project group states that:

The ideas that science is only for excellent students and nerds and that research topics are too specific and not related to social aspects are to be demystified; role models are to be used, visiting and interacting with scientists and female scientists in particular [...] (GAPP, 2008, p. 49).

This assertion seems to reflect the notion that girls are essentially different from boys, and to advocate sensitivity and adherence to girls’ special interests in the activities presented by the project. Such an approach is characteristic of difference feminism (Sinnes & Løken, 2014).

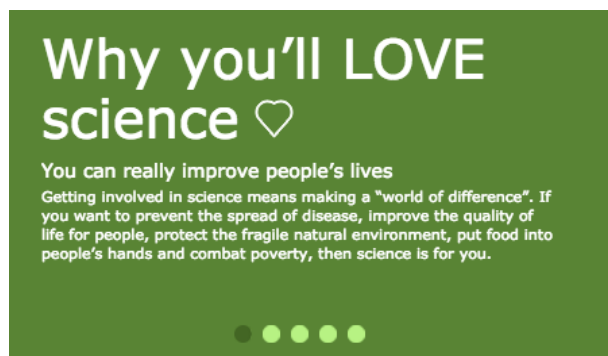
Another example of a project oriented towards gender and science education is TWIST (Towards Women in Science & Technology), which was funded by the European Union (FP7), and carried out by eleven European organisations in 2010-2012. Its aim was to raise awareness about the role and representation of women and men in science through initiatives in science centres and museums (TWIST, n.d.). These initiatives include teacher professional development programmes and classroom activities.



The gender perspective of the TWIST project reflects aspects of difference feminism as well as aspects of *postmodern feminism*. The assertion that ‘girls and boys differ from one another. Not just biologically, but also in the way they learn and behave’ aligns with difference feminism perspectives, and the suggestions that ‘competition could be a good motivator for boys to learn’ while ‘girls may be more motivated when they work together’ seem to be the difference feminism-inspired idea behind many of the activities presented here (TWIST, n.d., p. 27). However, the TWIST project also shows evidence of postmodern feminist approaches, i.e. in approaches that challenge the notion that female and male learners are united, respectively, by biological sex (cf. Sinnes & Løken, 2014). The report states that although there are clear differences between boys and girls, ‘there will always be exceptions. Every child is different. Variations in the way children learn are found not only between the genders, but also within them’ (TWIST, n.d., p. 27).

Finally, the campaign *Science: It's a girl thing!* was launched in 2012 by the EU Commission for Research and Innovation. The campaign is directed towards teenage girls, and attempts to specifically address those girls who would ‘not normally be interested in careers in research’ (<http://science-girl-thing.eu>). The campaign consists of a web site with a number of different features, including profiles of women in science, a quiz (*Discover your inner researcher*), a photo contest, and a fact box. The site links to organisations and events that offer science related information for the target audience, and includes a catalogue of ‘dream jobs’.

Science: It's a girl thing! can be described as an initiative that reflects *difference feminism*. In this perspective, because of biological differences or gendered society, women have developed particular characteristics that are perceived as ‘feminine’ or ‘female’. Difference feminists suggest that these ‘feminine’ characteristics should be recognised and acknowledged (Nash, 2000); in science education contexts, this recognition may be expressed as the development of the science curriculum to accommodate girls the incorporation of ‘female-friendly’ ways of learning (Sinnes & Løken, 2014). There are instances of both approaches in the *Science: It's a girl thing!* campaign. One example is shown in Figure 1. In this image from the campaign web site, science is portrayed as an undertaking that makes a difference by improving lives, counteracting disease, or protecting the environment; all problems that emphasise the ‘feminine’ extremes of the science spectrum (cf. Faulkner, 2000). Furthermore, the phrasing of the title (‘why you’ll love science’) and the symbol of a heart both seem directed towards a certain kind of female learner. Another example is the photo contest with the headline ‘What does science mean to you?’. The emphasis is clearly on the ‘feminine’ and personal end of the spectrum rather than the ‘masculine’ and technological (Allegrini, 2015). In summary, *Science: It's a girl thing!* implies a nurturing, sensitive, and socially-minded learner. One might argue that this emphasis would serve to include a range of boys who identify with these characteristics; however, the title of the project clearly excludes boys.



and

Figure 1. On the *Science: It's a girl thing!* web site, a text box cycles through five messages, all with the headline ‘Why you’ll love science’ ([http://science-girl-](http://science-girl-thing.eu)

2.2 Challenges to promoting gender-inclusion

We found evidence of three approaches to gender equity in the three projects reviewed here: equality feminism (implying *gender-neutral* science education), difference feminism (implying *female-friendly* science education), and postmodern feminism (implying *gender sensitive* science education). We have summed up this result in Table 1.

Project	Period	Equality feminism	Difference feminism	Postmodern feminism
GAPP	2007-2008			
TWIST	2010-2012			
<i>Science: It's a girl thing!</i>	2012-			

Table 1. The approaches taken to gender equity in three recent EU projects on gender and science education.

As mentioned in section 1.2, there is evidence that societal and cultural conditions represent obstacles to women's participation in science, meaning that equality feminism as exemplified in the project GAPP does have merit. However, research shows that removing external barriers to women's participation does not completely close the gender gap. Thus, additional measures are needed.

The issue of the difference feminism approach of adjusting science subjects to what are thought to be typical girls' interests, as exemplified in the projects GAPP, TWIST, and *Science: It's a girl thing!*, is that it may contribute to the cementation of the stereotypical gender identities the initiative was intended to overcome (cf. Phipps, 2007; Sinnes & Løken, 2014). If science is represented in such a way as to offer women limited, stereotypical ways of being female science participants, those women may be as likely to be alienated by science as if it is represented in a limited, stereotypical male way (Løken, Sjøberg, & Schreiner, 2010). This means that female-friendly approaches to science education give girls the choice of opting out or performing gender in the specific way that is sanctioned by science culture. Either choice serves to maintain, rather than erase, stereotypical gender identities.

The difference feminism argument presented in the TWIST project, namely that biological differences between girls and boys mean that they learn in different ways, is coming under increasing scrutiny. Research shows that the 'essential, hardwired differences' between the two sexes may be a majority opinion rather than a scientific fact (e.g. Choudhury, Nagel, & Slaby, 2009; De Vries, 2004; Grossi, 2008; Ryan, David, & Reynolds, 2004). This means that it cannot be taken for granted that learners have the same preferences and requirements simply because they have the same biological sex. Postmodern feminism reflects this view: In this approach, differences in science engagement among learners of the same sex are at least as important as the differences between the two sexes (cf. Sinnes & Løken, 2014).



The advantage to adopting a postmodern feminist point of view is not only that it seems to address many of the problems inherent in difference feminism approaches, but also that when we address the imbalance in girls' and boys' participation in science from a multifaceted gender point of view, we automatically address a wide range of other variables among learners. This is because science education initiatives that are based on a postmodern feminist point of view would encourage all learners, regardless of their biological sex, to value their own experiences and interests, and reflect on their relevance for science learning. This practice may help establish an increased awareness of all marginalised groups of learners, irrespective of sex (Allegrini, 2015; Sinnes & Løken, 2014).

Furthermore, postmodern feminist approaches address the structural intersection of gender and science (Allegrini, 2015) because they question the association between masculinity, objectivity, and science. In other words, these approaches do not assume that science is objective, rational or dispassionate; they assume that science, like any other human endeavour, is influenced by the social, cultural, and societal context in which it is practiced (Brotman & Moore, 2008). Postmodern feminism thus promotes science education that provides possibilities for learners to enact appropriate gendered (as well as raced and classed) identities (Phipps, 2007). This kind of science education would contribute to challenging the devaluation of femininity as well as broadening normative conceptions of masculinity (cf. Kane, 2006) that may be found in many existing science activities.

Accordingly, Hypatia takes a postmodern feminist approach to gender in which interests, capabilities, personalities and aspirations vary as widely *within* the groups of biological sexes (girls and boys) as they do *between* the groups. In other words, for any given variable, we are as likely to find similarities between a girl and a boy as between two girls or two boys.



3. Approach to gender in Hypatia

In the following, we describe the approaches we take in the project Hypatia to account for gender and promote gender inclusion in the science education activities developed and disseminated in the project. Hypatia specifically targets gender inclusion at several levels: the institutional level, the interactional level, and the individual level. Accordingly, we begin by presenting a framework to guide our understanding of these levels and the interactions between them. Then, we discuss these three levels in turn.

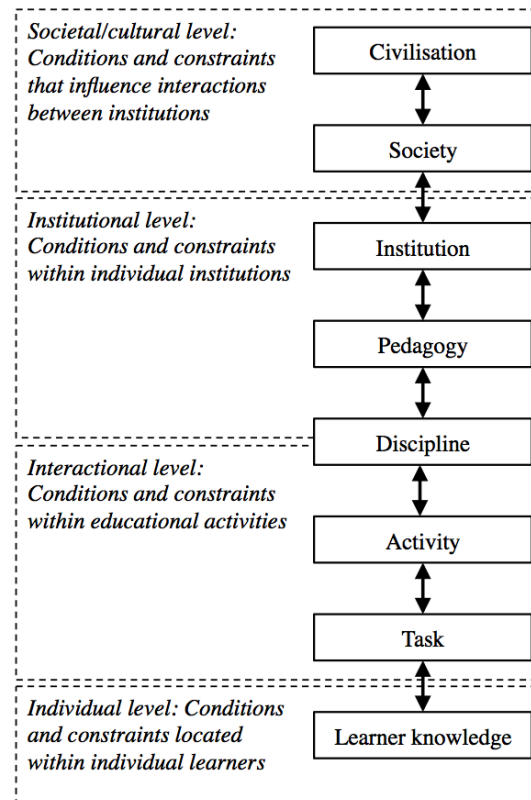
3.1 A framework for institutional science education

The planning and implementation of science education activities within institutions does not take place in a vacuum. Science educators, whether they work in schools, science centres, research institutions, or industry, carry out their planning and implementation work within a complex environment that constrains and conditions their work in a variety of ways. This means that the science education programmes that take place in these settings are the results not only of the careful planning and implementation of the science educators, but also of the various constraints and conditions that influence their work (Achiam & Marandino, 2014). Clearly, the *masculine gendering of science education*, which is our main focus in the present text, can be an unintended outcome of these influences.

The constraints and conditions that influence science education efforts may be *explicit*, such as for example a clearly formulated mission statement of a science centre that defines the range of possible activities, but the constraints may also be *implicit*, such as for example an established ‘way of doing things’ that remains tacit among educators but still strongly conditions the way they design education programmes. This means that in the planning of science education activities, it is important to be aware of these constraints and conditions. Some of them may originate or manifest themselves at levels that are beyond the immediate control of science educators (cf. Artigue & Winsløw, 2010); in these cases, it is important to *acknowledge* that these conditions exist in order to control the degree to which they influence the science education activities. Other conditions and constraints may originate or manifest themselves at levels that are within the control of science educators; in these cases, knowing that the conditions exist can help the educators *counteract* or *remedy* them. In the present case, of course, it is of particular importance to be aware of, and monitor, the constraints and conditions that influence the ways in which gender is implied in our science education activities. To this end, we may use the framework of levels of co-determination (Figure 2).

The framework of levels of co-determination illustrates how the planning and implementation of activities within an institution is subject to influences that may originate and manifest themselves at various levels inside and outside the institution (Achiam & Marandino, 2014). There is often a strong dialectic relationship between the levels, meaning that particular constraints and conditions cannot always be unambiguously attributed to specific levels. However, the framework should simply be thought of as an analytical tool to guide our reflections about designing and implementing science education activities; whether we can pinpoint the precise origins of the phenomena we observe is a secondary concern.

Figure 2. The constraints and conditions that influence planning and implementing science education activities in institutions originate and manifest themselves at different levels. The *societal* level includes conditions that originate outside the institution, i.e. that come from the society surrounding the institution, and even the civilisation in which it exists. The *institutional* level includes the institution itself as well as its chosen institutional pedagogy. Discipline denotes the conditions that come from the scientific discipline being disseminated, while the *interactional* level includes conditions that originate where specific activities are being realised. Finally, the *individual* level refers to the origin or manifestation of conditions that are related to the learner's knowledge. Modified from Achiam and Marandino (2014).



3.2 The societal/cultural level

At the societal/cultural level, we find conditions and constraints that originate outside the institution. For example, many museums and science centres are dependent on government subsidies; these subsidies are often given on the condition that the institutions and their activities align with the conditions set out by the government or ministry in question. The science education activities carried out by schools are strongly influenced by e.g. curriculum authors, typically located at the ministerial level. And the science education activities carried out by industrial actors could conceivably be shaped by corporate social responsibility (CSR) issues that play out at the intersection between the levels of society and institution. **These conditions and constraints are typically located at levels beyond the control of individual science educators.**

3.3 The institutional level

At the institutional levels of the hierarchy, we find the conditions and constraints that originate within the particular institution in question. The type of institution will often have a defining influence on the kinds of activities undertaken; e.g. an industrial institution might offer education programmes with the ultimate aim of recruiting workers for its future work force, while a science activity in school might be developed with the ultimate aim of furthering students' learning progression within a specific curriculum area. **These conditions and constraints are often, but not always, located beyond the control of institutional science educators.**

'Discipline' describes a branch of knowledge unified by a common epistemology and ontology, e.g. physics or biology. In institutions, scientific disciplines may be more or less explicitly present. In any case, conditions and constraints at the level of discipline are those that pertain to the

nature of the particular branch or branches of science as it is *realised* in the institutional context. Discipline is located between the institutional level and the interactional level (see Figure 2), because the overarching discipline is often determined by the type of institution (e.g. experimental sciences in a science centre) while the specific aspects of the discipline that are chosen for dissemination are usually determined at the interactional level (e.g. constructing a potato gun). **The constraints and conditions that originate and manifest themselves at the level of the discipline are often negotiable by institutional science educators.**

3.4 The interactional level

The specific ways in which an institution organises and presents learners with scientific activities strongly influence the ways in which learners participate. For example, an activity arranged in the form of a science café affords certain types of interactions between participants (e.g. conversation, discussion) but constrains others, just as an activity arranged in the form of a laboratory experiment allows some actions between participants (e.g. shared hands-on activities, experimentally comparing variables) and prohibits others. In other words, the specific format of the interaction that is designed by the institution influences the way science is disseminated within it. **The constraints and conditions that originate and manifest themselves at this level are typically under the control of institutional science educators.**

3.5 The individual level

The individual level refers to the constraints and conditions that originate or manifest themselves in relation to the learners' individual knowledge, values, experiences, etc. For instance, we can imagine how a learner with a strong sense of empathy may prefer group work, while a learner with a strong capacity for acting might find individual tasks attractive. These preferences strongly co-determine the ways in which the individual learner can participate in the education activity, **and should therefore be considered and addressed by the institutional science educator.**

In summary, the framework of levels of co-determination may be used to identify the constraints and conditions that affect the development and implementation of science education activities in institutions. In particular, we can use the framework to structure the *gender inclusion aspects* of developing and implementing science education activities. In other words, do the constraints and conditions that originate and manifest themselves at various levels imply a certain kind of learner in the resulting science education activities? In the following sections, we describe how this inquiry can take place.

4. Criteria for gender inclusion

In the following, we describe criteria on how to assess the gender inclusiveness of science education activities. We use the discussions presented in the previous sections of this document to structure these criteria. We begin by presenting criteria for gender inclusion at the individual level, and progress through the interactional, institutional, and societal/cultural levels. It is important to note that there are large differences between the cultures and institutions addressed by these criteria; thus the criteria should always be considered from the point of view of the specific activity in question, the institution in which it takes place, and the culture surrounding that institution.

4.1 The individual level

Girls and boys internalise norms and become gendered at the individual level. This process is ongoing, and is influenced by explicit socialisation and modelling among other things (Risman & Davis, 2013). This means that when girls and boys encounter science education activities, they already have well-established gender identities. To avoid feeding into the sense that the science activities they encounter are for certain kinds of learners and not for others, it is important to avoid building essentialist presumptions into the activities.

The aim of the Hypatia project is to encourage more girls to participate in STEM. However, in the following we refer to girls and boys collectively as ‘learners’ to include the variety of ways of *doing* gender, i.e. *being* a girl (or a boy) in science. The following criteria may be used to assess the gender inclusiveness of planned and/or implemented science education activities at the individual level:

What relevant prior knowledge do learners have?	<i>Ensure that the activity takes a point of departure in what learners already know about the scientific subject matter, acknowledging that different learners have different kinds of prior knowledge that may be relevant in different ways.</i>	<i>For example, the topic ‘dinosaurs’ may be relatable for some learners due to their prior knowledge about archaeology while it might be relatable for others due to their interest in mass extinctions.</i>
What scientific interests do learners have?	<i>Ensure that the activity allows for or requires several different trajectories of inquiry that correspond to different ways of being interested in the subject</i>	<i>For example, an activity may have a technological trajectory, a socio-scientific trajectory, and an ethical trajectory.</i>
	<i>Ensure that the activity gives equal consideration to specific details of the activity and the bigger picture.</i>	<i>For example, some learners may be interested in the overarching implications of science, whereas others may be interested in the technological details of science.</i>
	<i>Challenge learners to depart from their preferred interests and widen their engagement in science (many children have gender stereotypic interests; it is our responsibility as educators to</i>	<i>In many cases, learners may be supported to move out of their comfort zone to pursue new interests</i>



challenge those).

What previous experience do learners have with science?	<i>Avoid presenting learners with strongly gendered activities that may contribute to the internalisation of ‘female’ or ‘male’ identities.</i>	<i>For example, competitive activity is a widespread approach to engaging learners in out-of-school contexts. This, however, may not support the participation of all types of learners. Instead, present learners with science activities that include its various facets, e.g. interpreting and discussing data, having diverging points of view, arguing one’s perspective, reaching agreement (or not), understanding wider implications, etc.</i>
	<i>Ensure that the diversity of science is represented to the largest extent possible in the activity.</i>	<i>For example, doing science is often portrayed as one, fixed ‘scientific method’: Construct a hypothesis, do an experiment, analyse data, draw a conclusion. However, every instance of doing science has its own individual sequence and trajectory of inquiry.</i>
What previous experience does the learner have with the type of institution?	<i>Acknowledge that individual learners may have experienced gender exclusion in some types of institutions.</i>	<i>For example, research shows that during museum visits, parents explain science more often to boys than to girls. This may affect learners’ willingness to participate in the education activity.</i>
	<i>Encourage all learners to participate to an equal extent, and set high expectations for all learners.</i>	<i>For example, some learners may hesitate to engage while others may speak before they think. It is important for educators to encompass these differences.</i>
How does the learner’s sense of self or identity relate to the activity?	<i>Ensure the activity can encompass a variety of different ways of engaging.</i>	<i>For example, some learners might be more comfortable with plenary discussions, others with group work.</i>

Considering these criteria in the development or implementation of science education activities will help ensure a more gender-inclusive approach to *individual* science learners. It is possible for an activity to be both gender inclusive and not be aligned with all the criteria listed here; however, the closer the alignment, the more the activity will support the participation of both girls and boys in STEM activities.



The interactional level

Gender is produced at the interactional level across multiple situations in our everyday life. Even in novel situations where there is no reason to expect male privilege to emerge, it often does (Risman & Davis, 2013). Furthermore, research shows that how the social demands of a situation can change how motivated girls and boys are to perform well (Hausmann *et al.* 2009). For these reasons, there is a particular challenge in constructing science education situations that promote gender equality. From the outset, it is important to expect all participants to have equally valuable contributions to make to the task performances.

This means that it is important to have considered, *a priori*, the ways in which the interactions between the participants may inadvertently create and reproduce inequality. These ways may include ‘othering’ (e.g. by having lower expectations for certain participants) or the adaption of a subordinate role (e.g. trading one’s status as an equitable group member for acceptance into the group).

Does the activity require different capabilities in a balanced way?	<i>Ensure that the activity has a balanced approach to participants’ learning preferences, i.e. includes thinking tasks, motor skill tasks, and value-related tasks.</i>	<i>For example, carrying out an experiment might require primarily motor skills while assessing the ethical implications of a scientific finding might require primarily the ability to assess value arguments.</i>
What kind of interaction does the activity require?	<i>Ensure a suitable variation of different interaction forms.</i>	<i>For example individual work, group work, or dyad interactions</i>
	<i>Ensure that the different roles required by the activity have equal status, or that the roles rotate between participants, to counteract instances of othering or subordination.</i>	<i>For example, if the activity requires learners to take on experimenter, managerial, of secretarial tasks, ensure that learners take turns carrying out these tasks.</i>
What scientific role models do the learners encounter?	<i>Ensure that the involved science educators and scientists reflect a variety of personalities. Girls and boys are most inspired by role models they feel psychologically similar to. Otherwise, the standards set by the other person become a contrast that girls and boys may react against.</i>	<i>For example, ‘career dating’ activities often involve meeting scientists. Here, it is important to present the learners with a variety of personalities, genders, and career pathways, not just ‘star scientists’.</i>

Consideration of these issues will help ensure a more gender-balanced approach to the *interactions* between science learners, and between educator and learners, in science education activities.



4.2 The institutional level

Institutions routinely embed gender meanings in their ideologies, the distribution of resources, and the way they organise their practices (Risman & Davis, 2013). These meanings may become tacit institutional logics, which are difficult for individual educators to observe and act upon. However, being aware of the potential gendering of these logics and practices and making that gendering explicit can help educators counteract or circumvent them.



What is the institution's core aim and profile, and how does this set the scene for the activity?

Be explicit about the socio-scientific role of the institution (research, industry, education) when addressing learners, and about how this shapes the science education activities in question.

For example, a science centre's mission statement that reads 'We aspire to stimulate curiosity and inspire science learning in everyone by creating fun, hands-on experiences' sets the scene for particular ways of doing science that may exclude some kinds of learners.

Ensure the best possible alignment between the institution's stated aim and the activity's opportunities for gender inclusion.

For example, are there ways to interpret the stated aims of 'fun' and 'hands-on' (see above example) in activities that include a greater diversity of learners?

How does the institution approach science, and how is this reflected in the institutional pedagogy?

Acknowledge that different pedagogical approaches appeal to learners in different ways.

For example, the discovery pedagogy of some science centres may appeal to extrovert personalities who enjoy experimentation and risk-taking, whereas the more positivist pedagogical approach taken by some museums may appeal to more introvert personalities who enjoy observing and reflecting.

Does the institution focus on a specific scientific discipline, and is it represented in specific ways in the institution?

Ensure that a balanced approach to the discipline is taken.

For example, it is easy to classify physics as 'hard' and biology as 'soft'; yet all scientific disciplines have built-in dualisms such as hard vs. soft. Science education activities that encompass these dualisms, rather than embracing one extreme, are inclusive to a broader range of learners.

Ensure that the variety of ways of conducting research within the scientific discipline are represented in the activity.

For example, biology requires both descriptive activities (drawing or classifying) and experimental activities (laboratory testing).

What kind of engagement does the space support?

Ensure that the physical learning environment support the planned activities.

Exhibitions, laboratories, discovery spaces and reading spaces support different types of activity. For example, many exhibits have one seat, which prompts individual activity. To promote group work, the affordances of the physical space are important.

Even if educators cannot change or affect the institutional practices, they can in some cases work around those practices to create gender inclusive activities. Therefore, considering to what



extent the institution is gendered in specific, non-inclusive ways will contribute to creating better conditions for gender-inclusive science education activities.

4.3 The societal/cultural level

Finally, gender identity is shaped and influenced by the culture and society which institutions, educators, and learners are immersed in. These conditions are difficult or even impossible for educators to change, but by being aware of them, we may help offset or counteract their effects.

How do public interest and ideas set the scene for the activity?

Acknowledge that science may be represented in certain gendered ways in the public sphere. If taking a point of departure in these public representations (to spark interest in activity), consider how to support multiple ways of participating in the activity, beyond those publicly recognized.

For example, a popular Danish television programme for children presents two male youngsters who carry out engineering inspired activities that often involve high speed and explosives. A science centre might attract visitors with references to the programme. However the science transmitted by using the programme as a platform for learning risks excluding certain kinds of learners.

What are the stakeholders' interests and how does that interact with the activity?

Consider the way gender is implicitly or explicitly conceptualised by stakeholders (ministries, politicians, funding organisations, interest groups etc.) and the potential effects of this conceptualisation on the activity.

For example, the campaign Science: It's a girl thing! exemplifies how a certain conceptualisation of gender within the EU has a significant, defining effect on the content and activities on the web page.

What are the cultural constraints for the activity?

Consider what is included in the definition of 'science' in national cultural context, and what is excluded. Assess whether employing a broader conception of 'science' in the activity could support the inclusion of a broader range of learners

For example, in Italy, a background in the classical languages is considered to be a valid qualification for studying physics. This is in contrast to Denmark, where physics students are required to have a background in math. The consequence of this is that many more girls enter the physics study programme in Italy than in Denmark.

Consideration of the degree to which any specific culture and society influences the science education activities in question are necessarily more abstract than considerations at the other levels; however, it is clear that modern culture and societies (understood as nations) have gendered structures (Risman & Davis, 2013) that inadvertently affect attempt to promote gender inclusion. The more we are aware of these structures, the better we can alleviate their effects.

5. Applying the criteria

As outlined in the Hypatia document of work, the gender inclusion criteria will be employed by the five museum partners to refine selected sets of good practices into workable modules.

To support the partners in assessing to what extent the criteria have been met, and whether there is further potential for gender inclusiveness in the modules, UCPH will provide feedback to the partners. This support will be given in the following way:

- Each of the five museum partners may submit a text to UCPH that describes how the sets of good practices have been refined into workable gender inclusive modules using the criteria, as well as their detailed reflections about this process.
- UCPH will provide feedback by Skype call (30-60 minutes) to each of the five museum partners, discussing with them the decisions described in their submitted texts and, to the extent possible, providing additional ideas and reflections on the potential for further gender inclusion adjustments in the modules.
- Consideration and implementation of these further adjustments will be carried out at the discretion of each museum partner.



6. Conclusions

The present document takes a point of departure in the latest research on gender and STEM education to address the important issue of how to create STEM education activities that are gender-inclusive. A significant outcome of this work is the observation that there is not one easy way to do this; to cite the TWIST project, *one size does not fit all*. Exclusion mechanisms function in a variety of ways, in a variety of contexts and at a variety of levels. Accordingly, to create and implement STEM activities that are inclusive for a wide diversity of learners, it is crucial that we question ourselves as STEM educators, our institutions as places of STEM learning, and our national cultures as the contexts within which STEM is embodied: Are we, implicitly or explicitly, implying certain types of learners? And if so, how can we broaden the scope of our activities to encompass the diversity of potential STEM learners required in the Europe of the future? The criteria for gender inclusion presented in this document are intended as a foundation for this undertaking.



References

- Achiam, M., & Marandino, M. (2014). A framework for understanding the conditions of science representation and dissemination in museums. *Museum Management and Curatorship*, 29(1), 66-82.
- Allegrini, A. (2015). Gender, STEM studies and educational choices. Insights from feminist perspectives. In E. K. Henriksen, J. Dillon, & J. Ryder (Eds.), *Understanding student participation and choice in science and technology education* (pp. 43-59). Dordrecht: Springer.
- Artigue, M., & Winsløw, C. (2010). International comparative studies on mathematics education: A viewpoint from the anthropological theory of didactics. *Recherches en Didactique des Mathématiques*, 30(1), 47-82.
- Bevan, V., & Learmonth, M. (2013). 'I wouldn't say it's sexism, except that ... It's all these little subtle things': Healthcare scientists' accounts of gender in healthcare science laboratories. *Social Studies of Science*, 43(1), 136-158.
- Brickhouse, N. W. (2001). Embodying science: A feminist perspective on learning. *Journal of Research in Science Teaching*, 38(3), 282-295.
- Brickhouse, N. W., Lowery, P., & Schultz, K. (2000). What kind of a girl does science? The construction of school science identities. *Journal of Research in Science Teaching*, 37(5), 441-458.
- Brotman, J. S., & Moore, F. M. (2008). Girls and science: A review of four themes in the science education literature. *Journal of Research in Science Teaching*, 45(9), 971-1002. doi:10.1002/tea.20241
- Butler, J. (1993). *Bodies that matter. On the discursive limits of "sex"*. New York: Routledge.
- Bøe, M. V. (2013). What's in it for me? Norwegian students' choices of post-compulsory science in an expectancy-value perspective. *Nordic Studies in Science Education*, 9(1), 95.
- Bøe, M. V., Henriksen, E. K., Lyons, T., & Schreiner, C. (2011). Participation in science and technology: young people's achievement - related choices in late - modern societies. *Studies in Science Education*, 47(1), 37-72. doi:10.1080/03057267.2011.549621
- Choudhury, S., Nagel, S. K., & Slaby, J. (2009). Critical neuroscience: Linking neuroscience and society through critical practice. *BioSocieties*, 4(1), 61-77.
- Crowley, K., Callanan, M. A., Tenenbaum, H. R., & Allen, E. (2001). Parents explain more often to boys than to girls during shared scientific thinking. *Psychological Science*, 12(3), 258-261.
- Dancu, T. N. (2010). *Designing exhibits for gender equality*. (Ph.D. Doctoral dissertation), Portland State University.
- Danielsson, A. T. (2011). Exploring woman university physics 'doing gender' and 'doing physics'. *Gender and Education*, 24(1), 25-39. doi:10.1080/09540253.2011.565040



Dawson, E. (2014). “Not Designed for Us” : How Science Museums and Science Centers Socially Exclude Low-Income, Minority Ethnic Groups. *Science Education*, 98(6), 981-1008.

De Vries, G. J. (2004). Sex differences in adult and developing brains: Compensation, compensation, compensation. *Endocrinology*, 145(3), 1063-1068.

Due, K. (2014). Who is the competent physics student? A study of students’ positions and social interaction in small-group discussions. *Cultural Studies of Science Education*, 9(2), 441-459.

European Commission. (2009). *She figures. Statistics and indicators on gender equality in science*. Luxembourg: Publications Office of the European Union.

European Commission. (2004). *Increasing human resources for science and technology in Europe. Europe needs more scientists*. Luxembourg: Office for Official Publications of the European Communities.

EUROSTAT. (2011). Education statistics. Retrieved from [http://ec.europa.eu/eurostat/statistics-explained/index.php/Education_statistics - Graduation_in_maths.2C_science_or_engineering](http://ec.europa.eu/eurostat/statistics-explained/index.php/Education_statistics_-_Graduation_in_maths.2C_science_or_engineering)

Faulkner, W. (2000). Dualisms, hierarchies and gender in engineering. *Social Studies of Science*, 30(5), 759-792.

GAPP. (2008). *Bringing young people closer to science and technology professions. A gender perspective in a practical handbook*. Naples: Fondazione IDIS.

Gilbert, J., & Calvert, S. (2003). Challenging accepted wisdom: Looking at the gender and science education question through a different lens. *International Journal of Science Education*, 25(7), 861-878.

Grossi, G. (2008). Science or belief? Bias in sex differences research. In C. Badaloni, A. Drace, O. Gia, C. Levorato, & F. Videtto (Eds.), *Underrepresentation of women in science and technology* (pp. 93-106). Padova: Cleup.

Gurin, P., Dey, E., Hurtado, S., & Gurin, G. (2002). Diversity and higher education: Theory and impact on educational outcomes. *Harvard Educational Review*, 72(3), 330-367.

Hasse, C. (2002). Gender diversity in play with physics: The problem of premises for participation in activities. *Mind, Culture, and Activity*, 9(4), 250-269.

Hasse, C. (2008). Learning and transition in a culture of playfull physicists. *European Journal of Psychology of Education*, 23(2), 149-165.

Hausmann, M., Schoofs, D., Rosenthal, H. E. S., & Jordan, K. (2009). Interactive effects of sex hormones and gender stereotypes on cognitive sex differences—A psychobiosocial approach. *Psychoneuroendocrinology*, 34(3), 389-401.

Heard, P. F., Divall, S. A., & Johnson, S. D. (2000). Can 'ears-on' help hands-on science learning for girls and boys? *International Journal of Science Education*, 22(11), 1133-1146.

Henwood, F. (1998). Engineering difference: Discourses on gender, sexuality and work in a college of technology. *Gender and Education*, 10, 35-49.



Kane, E. W. (2006). "No way my boys are going to be like that!": Parents' responses to children's gender nonconformity. *Gender & Society*, 20(2), 149-176.

Kvande, E. (1999). 'In the Belly of the Beast': Constructing femininities in engineering organizations. *European Journal of Women's Studies*, 6(3), 305-328.

Lloyd, G. (1984). *The man of reason. 'Male' and 'female' in Western philosophy*. London: Methuen.

Løken, M., Sjøberg, S., & Schreiner, C. (2010). *Who's that girl? Why girls choose science - in their own words*. Paper presented at the XIV IOSTE Symposium, Socio-cultural and human values in science and technology education, Bled, Slovenia.

Mussweiler, T., Rüter, K., & Epstude, K. (2004). The ups and downs of social comparison: Mechanisms of assimilation and contrast. *Journal of Personality and Social Psychology*, 87(6), 832-844.

Nash, K. (2000). Equality and difference. In L. Code (Ed.), *Encyclopedia of feminist theories* (pp. 174-176). London: Routledge.

OECD. (2015). Education and employment – what are the gender differences? *Education Indicators in Focus*, 30, 1-4.

Olssen, M., & Peters, M. A. (2005). Neoliberalism, higher education and the knowledge economy: from the free market to knowledge capitalism. *Journal of Education Policy*, 20(3), 313-345.

Phipps, A. (2007). Re-inscribing gender binaries: Deconstructing the dominant discourse around women's equality in science, engineering, and technology. *Sociological Review*, 55(4), 768-787

Rennie, L. J. (1998). Gender equity: Toward clarification and a research direction for science teacher education. *Journal of Research in Science Teaching*, 35(8), 951-961.

Risman, B. J., & Davis, G. (2013). From sex roles to gender structure. *Current Sociology*.

Ryan, M. K., David, B., & Reynolds, K. J. (2004). Who cares? The effect of gender and context on the self and moral reasoning. *Psychology of Women Quarterly*, 28(3), 246-255.

Sachs, W. *Planet dialectics. Explorations in environment and development*. London: Zed Books

Sandell, R. (1998). Museums as agents of social inclusion. *Museum Management and Curatorship*, 17(4), 401-418.

Schiebinger, L. (1989). *The mind has no sex? Women at the origin of modern science*. London: Harvard University Press.

Shor, I. (2012). *Empowering education: Critical teaching for social change*: University of Chicago Press.

Sinnes, A. T. (2006). Three approaches to gender equity in science education. *NORDINA*, 2(1), 72-83.



Sinnes, A. T., & Løken, M. (2014). Gendered education in a gendered world: looking beyond cosmetic solutions to the gender gap in science. *Cultural Studies of Science Education*, 9(2), 343-364.

Sjøberg, S., & Schreiner, C. (2010). *The ROSE project. An overview and key findings*. Oslo: University of Oslo.

Søndergaard, D. M. (1996). *Tegnet på kroppen. [The sign on the body]*. Copenhagen: Museum Tusulanums Forlag.

Thomsen, J. P. (2008). *Social differentiering og kulturel praksis på danske universitetsuddannelser*. (Doctoral dissertation), Roskilde Universitetscenter, Roskilde, Denmark.

Tonso, K. L. (1999). Engineering gender - gendering engineering: A cultural model for belonging. *Journal of women and minorities in science and engineering*, 5, 365-404.

TWIST. (n.d.). *One size fits all? Enhancing gender awareness in teaching*. Amsterdam: NEMO.

Ulriksen, L. (2009). The implied student. *Studies in Higher Education*, 34(5), 517-532.

Wonders, K. (2005). Hunting narratives of the Age of Empire: A gender reading of their iconography. *Environment and History*, 11(3), 269-291.

