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Gendered education in a gendered world: looking beyond cosmetic solutions to the gender gap in science

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Abstract Young people in countries considered to be at the forefront of gender equity still tend to choose very traditional science subjects and careers. This is particularly the case in science, technology, engineering and mathematics subjects (STEM), which are largely male dominated. This article uses feminist critiques of science and science education to explore the underlying gendered assumptions of a research project aiming to contribute to improving recruitment, retention and gender equity patterns in STEM educations and careers. Much research has been carried out to understand this gender gap phenomenon as well as to suggest measures to reduce its occurrence. A significant portion of this research has focused on detecting the typical "female" and "male" interest in science and has consequently suggested that adjustments be made to science education to cater for these interests. This article argues that adjusting science subjects to match perceived typical girls' and boys' interests risks being ineffective, as it contributes to the imposition of stereotyped gender identity formation thereby also imposing the gender differences that these adjustments were intended to overcome. This article also argues that different ways of addressing gender issues in science education themselves reflects different notions of gender and science. Thus in order to reduce gender inequities in science these implicit notions of gender and science have to be made explicit. The article begins with an overview of the current situation regarding gender equity in some so- called gender equal countries. We then present three perspectives from feminist critiques of science on how gender can be seen to impact on science and science education. Thereafter we analyze recommendations from a contemporary research project to explore which of these perspectives is most prevalent.

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I denne artikkelen bruker vi ulike perspektiver fra feministisk kritikk av naturvitenskapen til å analysere hvilke syn på kjønn som kommer til uttrykk i et av de største Norske prosjektene rettet mot å øke rekrutteringen, spesielt av jenter, til realfag.

Norge har i flere år på rad blitt vurdert som ett av verdens mest likestilte land (Hausman, Tyson and Zahidi 2010). Likevel har Norge ett av de mest kjønnsdelte arbeidsmarkedene i verden (EU 2009). Spesielt innenfor realfaglige yrker ser man store kjønnsforskjeller. Selv om mer enn 60 prosent av studentene ved norske universiteter nå er jenter, forblir jentene en minoritet innen for fag som fysikk, IT, teknologi og ingeniørfag (Kunnskapstdepartementet 2010). Det samme mønsteret kan ses i andre land som også skårer høyt på likestillingsstatistikker slik som USA (American Association of University Women 2010) og Storbritania (Phipps 2008). Mens valg av fag til en viss grad tidligere korresponderte med jenter og gutters prestasjoner i disse fagene, er dette ikke lenger tilfellet. Resultater fra både TIMSS (Onstad og Grønmo 2009) og PISA (Kjærnslie og Roe 2010) visere en stor nedgang i kjønnsforskjeller i realfagene.

Flere prosjekter blitt initiert for å forstå og komme med forslag til hvordan man kan øke likestillingen i realfagene. Det største norske prosjektet med denne målsetningen er prosjektet Vilje-con-valg (på engelsk Lily). Lily har spurt første års studenter ved universiteter og høyskoler i Norge om hva som har gjort at har valgt –eller latt vær å velge realfaglige studier. Basert på dette har anbefalinger blitt laget til hva som er viktig for å øke rekrutteringen –spesielt av jenter til realfagene.

Denne artikkelen tar utgangspunkt i at alle prosjekter som jobber med kjønn og realfag reflekterer visse perspektiver på hvordan kjønn påvirker deltakelse i realfag. I artikkelen gjør vi bruk av et teoretisk rammeverk basert på feministisk kritikk av naturvitenskapen for å analysere hvilke syn på kjønn som kommer til uttrykk gjennom Vilje-Con-Valg. I vår analyse av hovedrapporten fra Vilje-Con-Valg publisert i Kimen (REF) finner vi tre underliggende perspektiver på kjønn: 1. At kvinner og menn har ulike verdier, 2. At jenter ønsker å bekrefte sin feminine identitet gjennom sitt yrkesvalg og 3. At kvinnelige rollemodeller er viktig for å rekruttere flere jenter til realfagene. I følge våre analyser er dette perspektiver som vi også finner igjen i et forkskjellsfeministisk tankegods. Her fokuseres det også på ulikhetene mellom menn og kvinner og på hvordan kvinner kan bidra med andre, ofte kvalitativt bedre, perspektiver på forskningen. Men der forskjellsfeminismen, representert ved blant annet Sandra Harding, går videre ved å rette en kritikk mot de kjønnede og ofte undertrykkende praksisen i vitenskapen, kommer ingen slik kritikk til uttrykk gjennom Vilje-con-valg. I stedet for å anbefale en endring av vitenskapen, retter anbefalingene fra Vilje-con-valg seg mer i mot hvordan vitenskapen skal *presenteres* for jentene for å imøtekomme deres femininitet.

Artikkelen retter spørsmålet om en endring av realfagenes image er nok for å øke likestillingen i disse fagene eller om en mer dyptpløyende endring av de kjønnede praksisene innen for disse feltene er påkrevd. Artikkelen stiller også spørsmålet om man i forsøket på å endre et stereotypt bilde av naturvitenskapen kan skape nye steoreotypier av hva det vil si å være jenter og gutter. Vi argumenterer at man ved å forholde seg til to kategorier utelukkende basert på kjønn når verdier og preferanser for yrkesvalg skal beskrives, går glipp av verdifulle nyanser som vi mener er avgjørende for at ulike jenter og gutter skal kunne tilføre et større mangfold til disse fagfeltene.

Gender patterns in gender equal societies

According to the Gender Gap Report published by the World Economic Forum (WEF), Norway is the second most gender equal society in the world, behind only Iceland (Hausmann, Tyson and Zahidi 2010). The index described in the report is based on an analysis of females' ability to participate in the economy, access to education, and political participation as well as their health conditions. In spite of females' equal access to education and the labor market, Norway has one of the most gender segregated workforces in the OECD (EU 2009). This situation is particularly prevalent within science, technology, engineering and mathematics (STEM) related occupations, which are largely male dominated. While one could previously observe that differences in educational choices within the STEM subjects corresponded with differences in girls' and boys' performance in these subjects, this is no longer the case.

The last Trends in International Mathematics and Science Study (TIMSS) report showed a substantial decline in gender differences in performance in science subjects (Onstad and Grønmo 2009). Further, according to the OECD's Programme for International Student Assessment (PISA) there are only minor differences in girls' and boys' performances in science subjects (Kjærnsli and Roe 2010). When it comes to interest in science subjects the differences are, however, major. A number of studies confirm that girls and boys tend to choose very different science subjects when given a choice (Schreiner 2006), and a number of explanations have been advanced to explain this pattern (see for example Sjøberg and Imsen 1988).

Girls and boys make different choices from high school to university level. Although more than 60 % of university students in Norway are young women, females remain a minority in physics, mathematics, computer science, technology and engineering (Ministry of Research and Higher Education in Norway 2010). The same pattern can be found in other western countries such as the UK (Phipps 2008) and USA (AAUW 2010).

As a result of the choices made at secondary/tertiary educational level, the gender patterns in the labor force remains segregated. By 2004 women accounted for 44.5 % of workers in all occupations in the UK, but represented only 4.7 % of engineering professionals and 0.8 % in the skilled construction and building trades (UK Resource Centre for Women in SET 2007). Female natural scientists and engineers at the universities and university colleges in the EU member states constitute roughly 20 % of the total employees (EU 2009).

Much research has been conducted to understand the phenomenon of girls in so-called gender equal societies making traditional choices of subjects and careers (see e.g. Bøe, Henriksen, Lyons and Schreiner 2011). The choices have often been explained by differences in interests which arise due to nature or nurture or both. The recommendations to policymakers are hence often based on an implicit understanding that girls and boys make different choices because they are different, with respect to interests, attitudes and values. Interventions to reduce the gender gap have therefore often tried to accommodate these differences by suggesting means for adjusting science subjects to suit girls' interests, and recruit role models who break with the notion of masculine scientists.

According to a strategy adopted by the Ministry of Education and Research in 2006, Norway faces a situation in which the needs of society and industry for competence in mathematics and some fields of science and technology are not being met (2006). It has proven particularly difficult to recruit girls to subjects and disciplines within mathematics, physics, information technology and engineering. This situation has lead to an increase in the funding of projects aiming to explore the reasons for the gender gap in science and to suggest ways of overcoming the gender gap. The predominant research project in Norway is the project designated "Lily".

Lily: a Norwegian research project

Project Lily (Norwegian: Vilje-con-valg) aims to develop new knowledge and theoretical perspectives, and to stimulate informed discussions, on how to recruit and retain more young people in STEM careers. The project was initiated by the Norwegian Centre for Science Education and the Department of Physics, University of Oslo, in 2008. Lily focuses on students in Norwegian universities, colleges and upper secondary schools. The overall aim of Lily is to contribute to improving recruitment, retention and gender equity patterns in STEM educations and careers. Lily is related to, and has served as a pilot to, the IRIS project (Interests & Recruitment In Science), which is an international research project focusing on factors influencing recruitment, retention and gender equity in science, technology and mathematics higher education (http://iris.fp-7.org/about-iris/).

Lily included almost the entire Norwegian cohort of first year students. More than 5,000 students from STEM disciplines and approximately 2500 from non-STEM studies responded to the pen-and-paper questionnaires in the fall of 2008. This corresponds to approximately 70 % of the target population (Schreiner, Henriksen, Sjaastad, Jensen and Løken 2010). Based on their responses, recommendations have been made to policymakers as to what initiatives are needed in order to encourage young people and girls in particular, to choose STEM related careers.

Lily has contributed robustly to our knowledge about student choice in STEM subjects. The project has, in contrast to several other gender initiatives over the last decade, based their recommendations on solid scientific analysis of data documenting students' choices. The project has in an impressive way managed to make the results from the study available far beyond academic circles. In that way Lily has contributed to create a broad, open and constructive public debate about recruitment to STEM subjects. By looking at Lily from a perspective derived from feminist critics of science, this article represents an attempt to contribute to this debate by pointing to some of the implicit gendered assumptions that can be found within projects focusing on gender issues in STEM subjects, and what consequences these assumptions might have.

Our analysis of Lily is based on the main report from the project published in the Norwegian publication, Kimen (Schreiner et al. 2010). The report is written to inform stakeholders about the main findings and recommendations from Lily. In our analysis we focus on what perspectives of gender and science/science education are reflected in the assumptions and recommendations from Lily. Lily does not position itself within a certain feminist or gendered position. Feminist theory is thereby used in this analysis to uncover gendered assumptions implicit in the research project. We argue that all initiatives that address gender inequity in science education reflect an implicit understanding of how the pupils' gender impacts on how they *learn and engage in science education*. By using feminist critique of science to show different perspectives of how gender can be seen to impact on scientific inquiry, we try to make the implicit gendered assumptions within project Lily explicit. We argue that this is helpful in order to get a clearer understanding of what assumptions and recommendations contemporary initiatives aiming at gender equity actually reflect, and thereby also get a clearer picture of what types of actions they may lead to.

The category gender refers to both men and women. We here use the term gender to represent biological sex and/or social sex, but still embrace different conceptualizations of the term gender, following the ongoing discussions among feminist scholars. For a long time, and still, gender has been used in order to distinguish the sociocultural construction of the roles assigned to men and women, from female and male sexes as biologically

determined. This distinction between sex and gender was introduced by the feminist anthropologist Gayle Rubin in mid 1970s (Rubin 1975). The last twenty years, "gender" has become a more complex category as a consequence of feminist theorizing and critique of the sex/gender dichotomy. Currently, in science education literature, it seems that the term gender may often be used as a euphemism in the English language as a replacement for the word sex, in order to avoid sexual connotations. The distinction between the use of the word gender and sex is, as emphasized above, not unproblematic and is still widely discussed by feminists. But even if one accepts that an ability to engage in science and become a scientist is not determined by sex, sex can still be an influencing factor affecting females' participation and performance in science. This is because we live in a gendered society where sex is a main organizing principle and hence a major determining factor of how males and females are raised.

Positioning ourselves within this field

Both authors of this paper have been working with gender issues in science education for years. Astrid Sinnes' work has centred on using feminist critiques of science to analyse science initiatives mainly in Africa. Marianne Løken, as part of the research group working with project Lily, has contributed a chapter to the report from Lily. Although her project is different from Lily both methodologically and theoretically, she has profound knowledge about project Lily. Her contribution to the report is from her own PhD project connected to Lily. In her PhD project she goes deeper into the stories of girls choosing to study science in order to explore what influenced them to choose to study a STEM subject and how gender is represented, experienced and materialized in the narratives (http://www.naturfagsenteret.no/c1515605/prosjekt/vis.html?tid=1519446).

Three approaches to gender equity in science education

Our argument starts from the assumption that all initiatives that address gender inequity in science education reflect a certain understanding of how the pupils' sex/gender impacts on how they *learn and engage in science education*. Initiatives may for instance assume that girls and boys have exactly the same abilities to succeed on equal terms in science subjects, and that gender inequities in these subjects are caused by discriminating attitudes towards one of the two sexes. Other initiatives might assume that girls and boys are different, for instance when it comes to interests, abilities and values, and that these differences need to be addressed and catered for in order to reduce the gender differences in science education. Initiatives may also operate within a different understanding about the impact of gender on *scientific inquiry* in general. While some initiatives might argue that more women are needed in science and technology simply because more labor is needed, others might build on the assumption that females will bring something different into scientific inquiry, something genuinely feminine that will change priorities and practices within science.

Although all initiatives reflect certain understandings of how girls and boys, men and women may differ and how these differences might impact on how they engage in science and science education, these understandings are seldom formulated explicitly by gender initiatives. By not being explicit, and perhaps not even conscious about what understanding the initiative is actually promoting, initiative recommendations might become inconsistent in terms of their suggestions as to what needs to be done to secure gender equity.

Feminist critique of science offers several perspectives on how gender might be seen to have an impact on scientific inquiry. However few have attempted to apply feminist theories and critiques of science to analyze and plan gender and science education initiatives. The first author of this article, Astrid Sinnes (2006), made use of feminist theory to develop an analytical framework specifically designed to analyse gender perspectives implicit in education reform programmes in science education. In this framework she showed three alternative approaches that initiatives might choose to secure increased gender equity in science education; a *gender neutral,* a *female friendly* and a *gender sensitive approach.* These concepts are widely used within literature on gender issues in science education. Often, however, they are used variably and without consistent meaning. Hence this framework represents only *one* understanding of how gender can be seen to impact on science and science education. Constructing a framework based on other, non Anglo-American, theories and perspectives would likely look different.

We will now analyze what we consider to be some underlying assumptions within a *gender neutral, female friendly* and *gender sensitive* science education. We will thereby take a closer look at project Lily to see which of these perspectives is most prevalent within this contemporary research project.

Gender neutral science education: girls and boys are equal in their engagement in science education

The first perspective we will discuss is that there is no difference in how males and females engage in science education. These perspectives include the understanding of male and female as, in principle, equal in their approach to science. Positions focusing on the similarities between males' and females' approaches to scientific inquiry (here labeled *equality feminism*) have in feminist literature been referred to as "feminist empiricism" (Harding 1986), "liberal feminist critique" (Keller 1987) and "first wave feminism" (Barton 1998). Common to these perspectives is an understanding that females in principle will produce exactly the same scientific knowledge as males provided that sufficient rigueur is undertaken in scientific inquiry. Equality feminists recognize that females have been kept away from science because of political and social forces external to science (Howes 2002).

The critique of science pursued by equality feminists was developed mainly as a critique of unfair employment practices within sciences without accusing scientific knowledge of being inherently masculine (Harding 1986). The basic assumption within this critique is that men and women are equal and should therefore have equal opportunities in the research society. This would benefit women as they would have their opportunities and equity rights extended. It would also benefit the society in general as there would be more women contributing to the development of scientific knowledge. The ability to create valid scientific knowledge is, according to adherents to this position, not determined by gender or sex but by one's scientific training. Women and men are thus equally capable of contributing to scientific development. If any sexual bias can be detected in science, this is, according to the feminist empiricist, a consequence of insufficient rigor in the scientific methods employed, and not because the scientists are males (Harding 1992). Scientific knowledge is not regarded as discriminating against females since any competent observer in scientifically controlled observations will understand phenomena in precisely the same way as another. Scientific methods are supposed to be powerful enough to eliminate any social biases that might find their way into scientific hypothesis because of the social identity of the scientist. (Harding 1992). Some people adhering to this type of feminism would acknowledge the impact of the researcher's gender on the research priorities, while the actual science inquiry would not be affected by the gender of the researcher.

Although equality feminism is said to have been the dominating feminist philosophy of science in the 1960s and 1970s (Barton 1998), several people who engage in questions of females and science today, still adhere to this understanding of the role of females in science. Elaine Howes (2002) asserts that most initiatives currently addressing gender issues in science education operate under the premises of equality feminism. Such initiatives would seek to recruit more females to science without challenging possible masculinities implicit in scientific knowledge.

So what are the possible implications of this position for a science education designed to increase gender equity? The key to improving female participation in science for initiatives grounded in equality feminism would, according to Sinnes (2006), be to address and change the political, educational and social factors that keep females away from science.

Initiatives that build on the assumption that females and males are equal in their approach to science, and that inequality in science and science education is caused by political, educational and social factors external to science, would be expected to focus on removing these external obstacles. In a gender and science reform program operating under the premises of equality feminism, a central goal would therefore be to give girls and boys exactly the same opportunities and challenges. It would be important to avoid discrimination caused by placing girls and boys in traditional gendered roles. Girls and boys should be encouraged to develop similarly without emphasizing their sex.

In order to avoid discriminatory practices of males and females, society should, particularly in traditional and patriarchal societies, be sensitized to understand the equal ability of males and females to become scientists and engage in science. This could be done through campaigns where female role models who had succeeded on equal terms as men in scientific positions are used to visualize the equal ability of females to pursue scientific careers. Policies should be implemented that would make it impossible to discriminate against girls' opportunities for schooling.

A gender reform program in science education operating under the premises of equality feminism would be expected to focus on removing all gender biases and practices discriminating against females. In this regard, it would be important to develop gender neutral education material. This could be done either by removing all references to sex, referring equally to the two sexes, or challenging traditional gender roles in texts and illustrations. It would also be important to avoid pictures that, for example, portray males in active and females in passive positions. Curricula and teaching materials should accommodate the pupils' experiences and interests equally without emphasizing one sex over the other. Great care, however, should be taken in curriculum and teaching material development not to convey stereotyped images of males and females.

In a science education inspired by equality feminism, science teachers should play an active role in the avoidance of treating males and females differently. Teachers should give equal attention to boys and girls in class. They should also not say anything that could be understood as discriminatory to girls and boys, in the sense of giving the impression that males and females are different in their engagement in science and science education. Ideally, there should be an equal number of male and female science teachers to underline the point that males and females are equally capable of pursuing a career in science education.

Science curricula and examinations should be developed to be gender neutral and equally relevant to boys and girls. Science education operating under the premises of equality feminism would tend to be a science education that could be described as "gender neutral science education". The characteristics suggested by Sinnes (2006) of a gender neutral science education are outlined in Table 1.

Table 1 Suggested implications of equality feminism, difference feminism and postmodern feminism on science education

	Curriculum	Educational material	Teacher development
Equality feminism ↓ Gender neutral science education	Curriculum should be gender-neutral and hence be equally relevant to both boys and girls	Develop gender-neutral education materials either through Equal number of the words "he" and "she", and equal number of illustrations showing males and females, or Remove all references to sex, or Portray males and females in untraditional gender roles	Teachers should be sensitised not to discriminate against girls Teachers should give equal attention to girls and boys in class Teachers must avoid saying anything that could be understood as discriminatory to girls Preferably there should be an equal number of female and male science teachers Teachers must make sure that girls are given equal responsibilities in the lab
Difference feminism ↓ Female friendly science education	Curriculum should be developed to accommodate girls Build on research regarding how girls learn in science education Be responsive to feminist critique of science and incorporate the contributions of women and other oppressed groups	Teaching materials should be female-friendly Build on girls' special interests and experiences Incorporate scientific knowledge developed by females and oppressed Show examples of how scientific knowledge is biased by its developers Be political in terms of visualising the oppression of females and non western people	Teachers should be responsive to girls' special interests, and sensitized on how girls learn Teach in small groups Develop a non-competitive environment in science class Focus on health/body and personal development whenever possible Link science education to girls' out of school experiences Link science education to societal/environmental issues Visualise the masculine bias in scientific knowledge and priorities Visualise the special contributions of females to science Pay extra attention to females in class Separate into girls/boys groups Separate schools for girls/boys

Table 1 continued

	Curriculum	Educational material	Teacher development
Post modern feminism ↓ Gender - sensitive science education	Curriculum should be developed to accommodate a broad variety of interests Curriculum should visualise the social, political and psychological dimensions of science Curriculum should incorporate other knowledge systems	Teaching materials should be gender sensitive Teaching material should reflect differences in interest in science Teaching materials should visualise the relations between science and society and how social and political factors impact science Teaching materials should include science developed by minorities and other cultures and visualise the differences between different types of scientific inquiry	Teachers should be responsive to the different perspectives of all pupils irrespectively of their sex Teachers should build on pupils' experiences irrespectively of their sex/apply constructivist teaching methods Teachers should visualise that scientific knowledge is constructed by human beings and hence influenced by its creators Teachers should acknowledge that all pupils are different and that great differences in interests exist also within groups of pupils of the same sex Teachers should introduce questions of sex, race and class when it is relevant Teachers should not divide pupils into groups based on sex, but rather on interests

Female friendly science education: girls and boys are different in their engagement in science education

The next alternative we will discuss is that there is a difference between girls and boys in terms of how they engage in science education. Either because of biological differences or since society is not gender neutral, girls and boys have developed differently, developed different interests and attitudes and these differences will impact on how they engage in science and science education. This position is here labeled *difference feminism*. Difference feminists claim that either by nature and/or through nurture, women have developed what society refers to as "feminine" or "female" characteristics and particular skills women are seen to possess should be recognized and acknowledged for their own value (Nash 2000). They see the notion of "equality" as problematic because it is seen to reproduce a male norm. Difference feminists have criticized feminists claiming that males and females are equal in their approach to science, for producing a "patriarchal masquerade of neutrality" (Franklin 2000, p. 434) and for valuing characteristics associated with masculinity which are considered higher than feminine or female characteristics (Tong 2000). Difference feminists argue that scientific knowledge, its processes and priorities are influenced by the identity of the researcher and that whether the researcher is male or female is of seminal importance. They claim that science has been developed historically without the contribution of women and people from non-western cultures. This has made scientific knowledge and knowledge production "masculine", "western" and hence unwelcoming and discriminating towards women (Harding 1998). Since science has been developed mainly by western males, it lacks certain "feminine" attributes that would widen and improve the practices and effects of science, particularly its social impact. The assumption is made that scientific inquiry is still very influenced by the positivist tradition of the seventeenth century. Difference feminists claim that even though the scientific ideology, its values, goals and assumptions, has expanded after the seventeenth century, the assumptions of the essential nature of science; that scientific facts are grounded in sound scientific theory largely free of personal, social and cultural values, has persisted (Keller 1985).

Some feminist voices emphasizing the differences between males and females have claimed that the qualities of females are better than those of males. Carol Gilligan (1982) described women's moral reasoning to be dominated by an "ethic of care" as compared to men's "ethic of rights". While some feminist critics of science, like Sandra Harding (1993), have argued that females, due to their underprivileged position in many societies, are capable of undertaking more objective observations of the world, others like Vandana Shiva (2001) claim that a feminine science would be more socially responsible and more capable of advancing a more democratic and environmentally responsible science.

Sue Rosser claims that females apply different research methods in their approach to science and would therefore advance a more socially responsible science (1990). Using examples from research carried out from a number of female scientists, she has created a set of descriptions she believes characterizes women's ways of engaging in science. The perspectives she is a proponent for have gained substantial critique from other feminist critics of science.

While several feminist critics have identified masculine biases in scientific inquiry, some have also proposed alternatives to a male oriented science. Ruth Bleier (1986) has summarized some characteristics of what she calls a feminist science:

> Feminist science, being a better science, recognizes the true complexity of nature and of each individual human nature. It constantly resists efforts to reduce explanations of

> complex phenomena to single causes and to strip human behaviours and characteristics of the social and political contexts within and from which they developed. (p. 16)

Through her "standpoint methodology" Harding has developed a way for the researcher to become conscious of her/his own role as a researcher. She argues that if science is ever to increase its level of objectivity, scientists must recognize and acknowledge the social forces that shape their beliefs (Harding 1991). The standpoint methodology starts out by including and reflecting on the situatedness of the researcher in order to make visible the genderedness of the knowledge (Harding 1993). This, according to Harding, is called "strong objectivity".

Harding (1992) argues that the standpoint of the researcher will always impact upon knowledge production. Initiatives aiming at increasing female participation in science hence need to be based on the assumption that female scientists would contribute to science in different and better ways than male scientists, and challenge the androcentricm inherent in science.

Although the understandings of what causes these gender differences in males' and females' approach to science varies a great deal between difference feminists, they all tend to put an emphasis on the importance of acknowledging and valuing differences between males and females.

In a science education reform program operating under the premises that males and females are different, and that females might even be able to contribute in a special way to science, it would be important to encourage and acknowledge the differences between the sexes. Within such initiatives girls should be encouraged to value, appreciate and develop their own experiences and interests as females. Teachers operating within this position should therefore pay extra attention to and be aware of research documenting differences in girls' and boys' approaches to science education and their interest in it. In a "difference feminist" science classroom the teacher would be expected to pay extra attention to females and make sure that their special gendered interests and needs are followed up. Organizing strategies such as groups divided by sex, single sex schools, etc., could be applied according to research on girls' interests and particular ways of learning.

In a science classroom based on the assumption that males and females have a different approach to science, it would also be important to show examples of how scientific knowledge is influenced by its developers. Such a science education would hence be expected to incorporate scientific knowledge developed by women. Science education operating under an understanding of males and females as different would therefore be political in the sense that it would focus on visualizing how the oppression of, and discrimination against, women has hampered their opportunities to contribute to the development of scientific knowledge. We would label a science education that acknowledges the differences between males and females and is designed mainly in order to accommodate females, a "female friendly science education". The characteristics suggested of such an education are also presented in Table 1.

Gender sensitive science education: the differences in science engagement among pupils of the same sex are as important as the differences between the two sexes

The third alternative Sinnes (2006) describes is inspired by ideas expressed by postmodern feminists. Feminist thinkers informed by postmodernism have challenged the belief that women are united by biological sex and have asserted that the "category of women" is neither natural, nor essential, but socially constructed (McPherson 2000).

Difference feminists have been criticized by postmodern feminists for treating all women alike. They argue that by treating women as one single group, all the voices that exist among different women will not be heard. Women are, according to postmodern feminist thinkers, not one identical group. They do not have one identical story to tell. Within the group of women there are huge differences. According to postmodern theories the standpoint of the researcher as a subject and all other subjects differ from each other. The knowledge that can be achieved about the world is therefore of an individual character and contains no universal truths (Rustad 1996).

An influential contributor to feminist critique of science within a postmodern position is the North-American biologist and historian of science, Donna Haraway. She argues against the view that there are some positions that are more epistemologically privileged than others (2003). Haraway's alternative to Harding's "standpoint methodology" is the theory of "situated knowledge". According to this theory all knowledge is situated and no position is more privileged than another when it comes to viewing the world. Haraway argues that nobody, no matter if they are being oppressed or are oppressors, can see the world more clearly than another can. We can only see the world from our personal perspective, and hence all knowledge is situated. Haraway argues that although not all stories about the world are equally valuable, several stories are better than one (1989).

Because women are not epistemologically privileged compared to men, the reason for recruiting more girls to science would not, according to Haraway, be that they would produce better knowledge than men would. The reason for more women to be involved in science would be that many stories would not be heard if women did not have the possibility of telling their scientific story. Gaining access to the world, the natural as well as the social world, is about "the power to see" (Haraway 1991, p. 188). By excluding women from science the power to see would be in the hands of men. This power to see should not be reserved for men.

Science education reform programs inspired by postmodern feminist ideas would be expected to challenge the idea that female and male pupils are united by biological sex. Science education initiatives acknowledging the differences between all individuals would be expected to encourage all pupils, regardless of their sex, to value their own experiences and interests and make them relevant to the learning of science. Gender reform programs, operating under a postmodern feminist understanding, would be expected to enforce an increased awareness of marginalized groups, irrespective of their sex. In the same light, it should not be taken for granted that pupils have the same preferences and needs just because they have the same sex. Single sex school settings would therefore probably not be adapted in schools inspired by postmodern feminism.

Science education reform programs operating under this understanding of gender and science might explore differences in interest found among pupils of the same sex and develop teaching materials to accommodate this broad variety of interests. A teacher operating in a postmodern feminist classroom would be expected to be cautious about the varieties in interests and abilities that exist among pupils in the classroom without separating them into categories based on their sex. Since we live in a society where gender is often used as a structural factor, care should, however, be made not to overlook gender as a significant issue shaping young people's identity.

A science curriculum based on this understanding would be expected to put much emphasis on visualizing the social, political, cultural and psychological dimensions of science. Science should not be presented as a fixed body of knowledge, but as knowledge that is continuously developed, challenged and changed. Teachers should visualize how all scientific knowledge is constructed and contextualized and how researchers are all

influenced by the time in which they live. Pupils and the rest of the public society should be informed about the social, political and gendered assumptions that underpin knowledge production and how social context shapes all knowledge. Pupils should further be encouraged to look for hidden assumptions in scientific knowledge and make them explicit. Pupils in a science classroom inspired by post modern theories should also be encouraged to be explicit about what assumptions they make when making their own statements. Science reform programs based on an understanding that all knowledge is contextualised should be committed to helping pupils see various approaches and solutions to the same problem, also within science.

Sinnes (2006) labels a science education that is designed to accommodate diversity, various interests and abilities, without assuming that such varieties are a result of having different sex, a "gender sensitive" science education. The suggested characteristics of a gender sensitive science education are outlined in Table 1.

In Table 1 we present some suggested implications for science education from the perspectives of the three understandings described above. The implications of the different positions for the teaching of the nature of science are written in italics in this table (Sinnes 2006).

Perspectives of gender within Lily

Being one of Norway's key contemporary research projects aiming to produce informed advice towards an increased recruitment to STEM subjects, it is interesting to see what perspectives of gender and science can be found in project Lily. In our analysis we have chosen to focus on three gender based assumptions that we identified in the major report on Lily (Schreiner et al. 2010): (1) That males and females have different values, (2) that females seek to reinforce their feminine identity through their educational choices; and (3) that feminine role models are important in order to recruit more females to STEM subjects. We do, however, acknowledge that the assumptions that we have detected are marked by our background and knowledge and that people analyzing the report from a different position might have found other perspectives in the report. We will now turn to discuss the main gendered assumptions we detected in the Lily report.

1. Males and females have different values

One of the gendered assumptions we see in the report from project Lily is that females are more ethically oriented than males and hence will pursue a more sustainable science and technology approach. Whether females have other uniquely feminine based qualities and how these qualities will influence their engagement in STEM is, as the previous review shows, a central question particularly within difference feminist critique of science. Lily's focus on the differences between males' and females' values has commonalities with those perspectives found within *difference feminism.*

According to the findings from Lily, girls have a tendency to value idealism, meaning and the 'social' more than boys and hence want to use their competencies to contribute to society:

> In spite of the gender differences being small when it comes to expectations for a future job, we have observed a tendency for girls to value idealism, meaning and the social higher while the boys values more to build and repair, develop technology and use tools (Schreiner et al. 2010, p. 96, our translation).

Although it is stated in the report that the gender differences are small when it comes to expectations for a future job, the tendency of girls to value idealism and meaning is given a central place in the report thus claiming that girls are more idealistically oriented than boys:

> Girls are more idealistically oriented than boys. They want to contribute to something that is important for society, help other people, work with animals or contribute to find solutions to environmental problems (Schreiner et al. 2010, p. 100, our translation).

In the report the authors present as their underlying assumption (in Norwegian labeled; *tese*) that more females involved in the development of science and technology would lead to more sustainable solutions. It is also claimed that more men within the health sector could lead to more technological solutions and a better offer:

> Scientific and technological development represents important driving forces in the development of society. When women's qualities only to a limited extent are represented in this, democracy is challenged and it might give an unbalance in values that drives the development. Our theses is that more females involved in the development of science and technology would lead to more sustainable solutions (Similarly more men within the health sector could lead to more technological solutions and better offers) (Schreiner et al. 2010, p. 100, our translation).

A distinction is made in the Lily report between males and females when people's values and interests are described. Although it is stated that the differences detected between males and females are not always major, the categories are still used throughout the report. The report does not question the image of males and females it conveys according to a broader discussion of how gendered identities are developed within a modern society. Postmodern feminist critique of science has offered a massive critique of the notion of women as a group being more socially responsible and ethical in their considerations than males. It is claimed that the ability of women to see from a more ethical standpoint than men is an illusion (Haraway 1991). Haraway has also argued that a perspective of females as ethically united by their sex is deterministic and overlooks the diversity among women and men (Haraway 1991). Nancy Brickhouse et al. (2000) among others has showed the diversity present among girls' interests, values and aspirations when it comes to science education.

The assumption that women are more idealistically oriented than males is identified in the report from Lily to be used as an argument for recruiting more females into science and technology:

> Exactly because women and men in general express different interests, values and ideals the gendered segregation of the labour force in general, and within the science and technology specifically, is problematic (Schreiner et al. 2010, p. 100, our translation).

The difference feminist perspective is followed up in the recommendations/initiatives in the Lily report. Because females are more idealistic, stakeholders aiming for higher entries of females into the STEM disciplines are recommended to make the social dimensions of science and technology more explicit:

> Recruitment initiatives must show there is room for self development, idealism and meaning in STEM disciplines. There are indications that the zeitgeist has changed

> from an ideal of "working creatively" with film or design, towards "saving the world" through renewable energy or work for social justice and development. The close association between STEM subjects and challenges within health and environment may not be apparent to all young people. Pointing out how STEM professionals contribute in medical diagnostics and treatment, climate research, renewable energy development, providing clean water and cheap energy in third-world countries etc., may be effective in STEM recruitment – particularly for girls (Schreiner et al. 2010, p. 13).

In spite of the assumption that more females will lead to a more sustainable and socially responsible science and technology, the Lily report, in contrast to feminist critics of science, does not raise any profound critique against the current male dominance in knowledge and practices within STEM subjects and disciplines beyond claiming that the image change in STEM disciplines must be "honest" and reflect a "true picture" of reality within these fields (Schreiner et al. 2010, pp. 98–99). Margaret Eisenhardt and Elizabeth Finkel (2001) noted that science education that does not question the nature of science itself are unlikely to attract more women and minorities to science. While Harding argues "What is progressive about mounting heroic campaigns to "add women and gender" to the social structure and subject matters of the sciences without questioning the legitimacy of science's social hierarchy and politically agendas more generally?" (1992, p. 59), Lily recommends to show the social dimensions of STEM. Perhaps it makes sense for initiative research projects developed to increase recruitment into STEM not to raise critique against practices within STEM. It could, however, be seen as an inherent contradiction in the project. On the one hand it is claimed that women are more ethical and would contribute to a more socially responsible STEM practice. On the other hand visualizing the socially responsibility within (the currently male dominated) STEM practices is recommended as an action to recruit more females to STEM subjects. By not raising any profound critique of the masculine and un-social practices within STEM disciplines, but instead recommend changing the image of STEM, we would argue that the chances are that the gender gap problem will remain unsolved.

2. Females wish to reinforce their feminine identity through their choice of career

Another gendered assumption that we see present in the Lily report, is the claim that females wish to reinforce their feminine identity through their choice of career. When it comes to the descriptions of what constitutes female identity and how identity might influence students' choice, the report separates between male and female identity. According to the findings from Lily, girls want to develop their female identity through their educational choice and they have a clear understanding of what their female identity comprises; an identity different from that of a man:

> A girl does not want to dress up in men's clothes and she does not want to carry a man's identity. She has no plans of "choosing untraditional", like some campaigns have encouraged her to do, and she does not consider to "show that she can" enter the man's arena (Schreiner et al. 2010 p. 97, our translation).

According to the Lily report females consciously choose "traditional" occupations that reinforce their feminine identity. Choosing untraditional occupations in order to prove that females are capable of accomplishing the same as males is considered old fashion. Girls, according to Lily, no longer have to choose 'untraditional' to show their abilities since girls are now self confident and secure about what they are capable of doing. Besides being more concerned about idealistic values than males, girls also want to "appear as women":

> Some decades ago girls who chose such (STEM- our comment) subjects might have had a motive of contributing to increased gender equality. They wanted to show that girls "can" –just as well as men. Today's girls know they can. But many do not want. On the contrary they want to choose something that suits them. In addition to the fact that girls more than boys are concerned about for instance idealistic values we know that girls also want to appear as women. Some girls do not want to enter a scientific education on men's premises (Schreiner et al. 2010, p. 97, our translation).

The claim is made in the report that that a minority of girls still exists who wants to "stand out" by choosing untraditional occupations. It is therefore argued that employers must make sure to also cater for these very few girls who break the general rule:

> There are still some girls who want to stand out just by making untypical educational choices. For education institutions and employers the question will then be whether they can offer a good alternative to a majority of girls, preferably without altering the ideals of the (very few) girls who want to make atypical choices (Schreiner et al. 2010, p. 97, our translation).

According to the report from Lily, females are more idealistic than males and want to "appear as women" and dress like women. The term "female identity" is used without a critical discussion of the different facets of such an identity or of contemporary factors influencing the development of feminine identities.

Postmodern feminist thinkers have argued against the fixing of gendered identities because they claim that females –or males do not wish to be bound to one specific identity regardless of which identity this might be (Zalewski 2000). Defining what constitutes a feminine or masculine identity is according to postmodern thinkers an act of power. Creating such meta-theories is by several postmodern thinkers considered to be survivors of ideas from the enlightenment project to gain precise knowledge, predictions and control. Instead postmodern thinkers are interested in understanding the actions, process and effectivity in individuals' efforts to create their own identity (Zalewski 2000).

In its recommendations to stakeholders, Lily again recommends that the image of STEM be changed in order to show how it is compatible with a female identity.

> We recommend countering the assumption that STEM studies are particularly suited to only a small number of particularly dedicated and gifted individuals. In order to recruit girls to male dominated educations and careers, girls must see that a STEM career is compatible with a feminine identity. Recruitment initiatives should show that STEM disciplines have room for persons with a range of different values, aims and experiences (Schreiner et al. 2010, p. 15, our translation).

In its recommendations as to how STEM might be changed in order to be more compatible with "a female identity" emphasis is placed more on changing the image of STEM to match females' interests and values than on changing the actual masculine practices within STEM fields.

We would question whether the feminine identity according to Lily, that females want to reinforce through their occupational choice, is an identity created by the girls themselves or whether it is actually more an *idea* about a feminine identity that has been created by an increasingly gender segregated society. If the latter should be the case, the result of the recommendations from Lily would be to adjust the image of science to a stereotyped image of femininity created by society and not to include young people's individual and diverse identity projects into the STEM disciplines. In order to make STEM disciplines more

attractive to a diversity of identities, we would, in line with post modern feminist thinkers, argue that it will not be sufficient to change STEMs image. We agree with Lily's request for honesty when presenting the social dimensions of STEM fields. We do, however, adhere to the feminist critique claiming that this would require profound changes in STEM practices by critiquing and challenging the power structures that shape the disciplines and in that way open for multiple identities to be developed within the STEM disciplines.

3. Feminine role models are important to recruit more females to STEM

Project Lily emphasizes the importance of "significant others" like parents and teachers in student educational choices. Presenting role models and examples of successful former students in university and college information material is also recommended. It is argued that mentors and role models should be carefully detected and trained in order to become positive ambassadors and generate interest in STEM subjects. According to Lily it is important to select ambassadors that are "typical, up to date and feminine, who enjoy themselves and fit in instead of selecting role models who "work on men's premises":

> To make more girls choose male dominated subjects, one must show that the subjects are suitable for girls. Instead of showing girls within science and technology who work on the boys premises, one must show typical, up to date, feminine girls- who enjoy themselves and fit in (Schreiner et al. 2010, p. 98, our translation).

We would argue that choosing role models with certain characteristics that girls are expected to identify with could challenge Lily's stated aim of changing the image of science to become more diverse. It builds upon an underlying assumption of females to identify, not only first and foremost with other females, but also with a certain *type* of female. We would argue that Lily's choice of role-models also have certain difference feminist characteristics: One should portray and select feminine role-models with different characteristics than males and not girls who, according to an equality feminist perspective, would live up to a male norm. Although Lily recommends detecting female role-models and hence could be associated with difference feminism, we believe that difference feminists would recommend a different type of female role-model than those recommended by Lily. If a project, like Lily, builds on the assumption that females are more ethical and idealistic than males, we would expect a recommendation from the project to be to detect role-models who represented this difference rather than role-models that "fit in" to the current (masculine) practice of STEM fields. Initiatives building on difference feminist ideas would be expected to find role-models who have used her feminine values to challenge the masculinity of science. Although Lily reflects certain difference feminist assumptions, the project has not positioned itself within a difference feminist perspective. The recommendations are therefore more on the level of changing the image of STEM fields than actually critiquing the masculine practices within STEM fields and change STEM accordingly.

Gendered education in a gendered world? Exploring the gender gap in science education

Analyzing the assumptions and recommendations from Lily according to a framework derived from feminist critique of science raises some questions about the description and creation of female and male identities and the image of STEM fields. We will now turn to discuss some of these issues.

Challenging or creating stereotypes?

The results and recommendations from Lily contribute to and correspond with dominating discourses or the "meta-narrative" told about females in STEM subjects after much research on gender issues in science education. The meta-narrative tells us that: females are more collaborative than males, less competitive (Chetcuti 2009), more interested in biology related topics than technology (Schreiner 2006), they are more concerned about context (Stadler, Duit and Benke 2000) and wish to know why things happen in science rather than what happened (Osborne and Collins 2001), have a more theoretical approach to science (Staberg 1994), are more people oriented (Miller, Slavinski-Blessing and Schwartz 2006) and think it is important to have a job where they can help others (Holter, Svare and Egeland 2009), have lower self-efficacy and self-concept in science (Kjærnsli, Lie, Olsen and Roe 2007), with fewer relevant science experiences from their early childhood (Sjøberg 2000) and that females are more willing to use their science competencies to work towards a better world (see for example Schreiner et al. 2010).

Analysing the assumptions and recommendations from Lily according to an analytical framework derived from feminist critique of science, shows that the project reflects certain difference feminist perspectives on gender. Even though the results from Lily along with the broader meta-narrative about gender issues in science is supported by much research, looking at this research from a feminist theoretical perspective shows that this research seems to be based on the same underlying assumption; males and females have a different approach to STEM subjects because of their sex. Brickhouse et al. makes this point when they discuss the well established story of gender and science: "This is the story we tend to hear about girls. Each of these claims is well known and supported by research. It is a story that was constructed by the comparison of boys and girls; studies which focused on the differences between the two groups" (Brickhouse, Lowery and Schultz 2000, p. 442).

Brickhouse acknowledges the importance of what we here describe as the meta-narrative "in terms of creating an awareness that girls generally do not fare well in science classes. Furthermore, it illustrates for us that this inequity is a social problem that can be fixed" (Brickhouse et al. 2000, p. 442). She does, however, claim that the meta-narrative has created a stereotyped picture of girls that does not help us to understand the diversity among girls and boys (Brickhouse et al. 2000). Presenting results and recommendations from a project like Lily can face a similar dilemma. On the one hand gender inequity *is* a problem within STEM subjects, and stakeholders want clear answers to how the problem can be solved. The project is also based on quantitative data that actually represents the response of the respondents. On the other hand the process of making broad generalizations based on differences due to sex stands the risk of losing important nuances that again might lead to the creation and cementing of stereotypes. Haraway (1991) has brought to the forefront the importance of listening to the many smaller stories in order to gain knowledge about the world. By going deeper into the stories of females making "untraditional" choices, Marianne Løken through her "Write about your choice" project unravels more diverse narratives about females choosing STEM careers than the one represented in the meta-narrative about females and science. These girls challenge the mainstream norms about female values and claim that they feel alienated by the descriptions given of typical girls and feminine values in the public space (Løken, Sjøberg and Schreiner 2010).

The assumptions and recommendations from projects like Lily, raise the question about whether our efforts to remove stereotypes from science, might create new stereotyped images of girls and boys, men and women.

Gendered education in a gendered world

The analysis of Lily shows that contemporary research projects do not necessarily reflect post modern ideas about gender and diversity. In a time where diversity is celebrated, sex is still used as a main sorting category to understand interests, values and choices. Several books published in the last couple of years have focused on the increased acceptance of gender segregated practices in gender equal societies. The sociologist Hanna Helseth in her book "Generation Sex" (Generasjon sex in Norwegian) (2010) shows how Norwegian youth culture is becoming increasingly sexualized and how young people are forced into defined gender roles by peers, media, and the market. Cordelia Fine in her book "Delusions of gender" describes how society and neurorsexism contributes to develop a stereotyped image of gender differences (2010). The author of the "The New Feminsm", Natasha Walter, describes how female sexuality now tends to be seen in a very narrow light and how a new interest in biological determinism runs throughout our society (2010). A recent review of how gender equality is treated in Norwegian schools is entitled "Gender equality is no longer the big issue" (Støren, Waagene, Arnesen and Hovdhaugen 2010). The title sums up the findings after asking teachers and school leaders in Norway about how gender issues are taught and discussed. The general assumption of the respondents in the report is that we already have gender equality in Norway and that this topic therefore does not require much attention in the Norwegian schools.

It is beyond the scope of this article to go deeper into an analysis of the increasing sexualisation and gender segregation in "gender equal" societies like Norway. We would however, advocate research that looks more closely at how this increased gender segregation in society influences how we look at females, their choices; and the initiatives trying to change their choices.

Increasing gender equity in STEM subjects: cosmetics or critique required?

In spite of Lily's assumption that females will contribute something different to science, no profound critique is raised against the current masculine dominance in STEM disciplines. We would argue that the recommendations made therefore, have a more cosmetic character than would result from a more thorough critique of the underlying masculinities in science. The question is whether cosmetic changes of STEM's image are sufficient to attract and keep people with diverse interests and priorities than those considered mainstream within STEM fields. We would argue that such cosmetic changes are not sufficient to achieve this aim. More fundamental changes to the practices and priorities within STEM subjects and fields are required to recruit more diverse people to these fields.

Applying feminist theories to analyze projects makes the genderedness of science education explicit. The analytical framework applied here also provides a hint as to what type of science education one could expect as a result of the different perspectives. It shows that so-called "gender equal" societies can still have gender segregated practices. This article argues that adjusting science subjects to match perceived typical girls' and

boys' interests, risks being ineffective, as it contributes to the imposition of stereotyped gender identity formation—thereby also imposing the gender differences that these adjustments were intended to overcome.

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Marianne Løken is a PhD student in science education at the Norwegian Centre for Science Education, at the University of Oslo. Her research interest is on gender issues in science education with a particular focus on narratives of females choosing a science subject where females are underrepresented. She is also involved in the national research project Lily and the collaborative international project IRIS (Interests & Recruitment in Science), both addressing the challenge that few young people choose education and career in science, technology, engineering and mathematics (STEM).