

Chapter 13

Troubling Norms and Values in Science Teaching Through Students' Subject Positions Using Feminist Figurations

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13.1 Background

Several researchers argue that the norms and values of science teaching in school are based on its culture and traditions, affecting students' interest in the subject and their view of nature, society and people (Brickhouse 2001; Östman 1995, 1998; Roberts 1998). Within feminist research, many have long since pointed out science as an exclusionary culture with androcentric features (Fox Keller 1977; Haraway 1988; Harding 1986). They argue that it is a relic since the late 1600s when modern science emerged and women were excluded. Accordingly, Cartesian rationalism was adopted, and its dualistic tradition of thought divides life into, among others, male/female, culture-nature and mind-body. These dualisms have survived to this day in science class, textbooks and tests (see Ah-King 2013; Berge and Widding 2006; Ståhl and Hussenius 2016; von Wright 1999). In school science practice, they appear in the form of an objective, logical and rational appearance, for example, the science language in textbooks (Halliday and Martin 1993), and in the way students are expected to think, speak and act (Alsop 2011; Arvola Orlander and Wickman 2011; Ståhl and Hussenius 2016). Hence, it is not surprising that students often perceive this practice as very special and strange, as free of values and subjective judgments and, at worst, as something that does not concern them (Lemke 1990; Östman 1995; Sjøberg and Schreiner 2010). This belief may be enhanced when the myth of the solitary male genius such as Einstein is reproduced along with its stereotypical contrast, often incompetent, or women made invisible. Ultimately, it creates the image of science as being difficult and inaccessible, only provided for an elite (Lemke 1990, 2011).

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Nancy Brickhouse argues that, if we are to create a scientific education with which students can identify, we need knowledge that is based on "... how students engage in science and how this is related to who they are and who they want to be" (Brickhouse 2001, p. 286). From a broader perspective, this means saying yes to an embodied science (Arvola Orlander and Wickman 2011; Brickhouse 2001; Haraway 1991), in which the whole individual contributes to creating science, unlike a science that separates the mind and body. She argues, supported by Etienne Wenger (1998) theories of learning, that we ought to find out what students are involved in and interest them instead of doing the other way around as many previous projects have tried to do, in various ways that attempt to attract students to science. This should be done in relation to what the students identify with and want to identify with because "Learning is not merely a matter of acquiring knowledge, it is a matter of deciding what kind of person you are and want to be ... " (Brickhouse 2001, p. 286). The current study is part of a thesis in which this perspective is partly the focus. In a previous study (Ståhl and Hussenius 2016), the norms and values in the Swedish national examinations in chemistry for the period of 2009–2012 were examined from a feminist and critical didactic perspective. The results show that the Cartesian and androcentric features in science as Evelyn Fox Keller (1977), Sandra Harding (1986) and Donna Haraway (1988) revealed very long ago also appear in the Swedish national tests in chemistry.

13.2 Aim and Research Questions

In the present study, the aim is to problematise the androcentric and Cartesian characteristics of the Swedish national tests in chemistry in relation to how students relate to these norms and values. The aim is also to show a possible alternative chemistry teaching with the help of feminist figuration theory (Braidotti 2002, 2011; Haraway 1991, 1997). Teaching encompasses everything that students encounter in the chemistry classroom and thereby also the national tests.

A total of 188 written student responses from the 2009 Swedish national tests in chemistry were investigated to obtain views on how students relate to the norms and values in the chemistry test. The first part was designed to examine the positions that students take in their reply in relation to issues used in the test item and to science, technology, nature, society and people. The second part interpreted the students' positions in terms of feminist figurations. Feminist figurations should be seen as alternative interpretations of students' attitudes/criticism to the actual discourse in the test and as a positive vision and alternative to this discourse. The critical side of the figurations consists of what students express in their texts, which opposes the prevailing discourse of the tests in terms of both textual content and linguistic expressions. At the same time, this critical side is seen as positive visions for an alternative to the hegemonic and androcentric chemistry that the tests mediate. From these positive visions, I have aimed to sketch a possible chemistry teaching

based on critical didactic and feminist perspectives. In relation to these aims, the following questions have been formulated:

- How do the student texts relate to the prevailing discourse in the test, that is, to science, technology, nature, society and people?
- What subject positions appear in the texts based on the answers originated from the above question?
- What possible figurations emerge based on the different positions formulated?
- How can a sketch of science teaching be formulated, based on the visions of the feminist figurations?

13.3 Theoretical Background

The theoretical framework for this study aims to understand and gain perspective on the androcentric norms and values in the Swedish national tests in chemistry that are mediated to students. The framework consists of a critical didactic perspective/curriculum studies (Englund 1997; Klafki 1997; Roberts and Östman 1998) and a feminist perspective on the culture, teaching and learning of the natural sciences (Brickhouse 2001; Haraway 1988, 1991; Harding 1986; Miller 2006). With this framework, the assumption is made that there are norms and values in all teaching, the so-called offer of meaning (Englund 1997) or companion meanings (Roberts and Östman 1998), and they can be androcentric. These norms and values, mediated in teaching, are developed based on the interpretations of curriculum and syllabus, subject traditions and teachers' own aims and objectives in order to form good teaching. Accordingly, they somewhat reveal which scientific traditions, view of knowledge, nature, society and people underlie the design of the national tests. The assumption includes viewing these norms and values as affecting students' interest in a subject as well as their view on nature, society and people (Englund 1997; Miller 2006; Östman 1995).

13.4 Interpretive Framework

In this study, Judith Butler's performativity theory (2007, 2011) is used to understand how the test calls on students to embrace a "scientific position". In Butler's theory, the focus is on the creation of a subject position in terms of gender. In this study, the perspective is broader and more general and also applies to other subject positions that students express. A materialistic vision is assumed thereby that the whole context is materialised before the students, including the students themselves who have their own agency (Barad 2007; Haraway 1991, 1997). The students' text is viewed as embodied, meaning that the actors/subjects have thought and acted through their bodies, with all their physical abilities (Braidotti 2002; Brickhouse

2001; Haraway 1991). Butler argues that gender is performative, and gender identity is created through repeated acts. When repeated enough times, these acts solidify and become fixed in a special form. A norm for a particular identity is created, for example, how one should look and dress and what characteristics one possesses, properties which become biologically essential (Butler 2007, 2011). This study assumes that the test and any previous teaching of chemistry have “called on” (Butler 2011, p. 81–82) students to adopt a scientific identity that tells them how to behave as scientists, speak and think and, among other things, how to relate to nature, society and people. These discourse borders can be seen not only as obstacles to students but also as a means to producing the right products from a teacher’s perspective, in this case, to produce future scientists (Foucault 2008).

I am also inspired by Dorte Marie Søndergaard’s (1996) description of the gendered body as a gender-marked body that, in different contexts and discourses, is attributed to different associations. Possible associations that students in this study may form are that chemistry/science is difficult, inaccessible and elitist and that scientific work only takes place in the brain (Lemke 1990). It may also produce associations that scientists are not women since, in the 2009 test, they appear to be clumsy, irrational and emotional in both words and images and in contrast to the merited image of how scientists should act (Ståhl and Hussenius 2016). The androcentric associations may have also been strengthened by the use of the oil and mining industry and its products in the majority of the test items, since these occupations traditionally have a male gender structure.

13.4.1 *Feminist Figurations*

The concept of feminist figurations is described by Nina Lykke (2009 p. 49) as a vision of a different and positive way of looking at the subject that breaks with the androcentric hegemonies by which society is characterised, in which the norm is a man, and where male and female subjects are often regarded as their opposites: good versus less good. Science practices can be seen as androcentric hegemonies (see Haraway 1988; Harding 1986; Hasse 2002), which the previous study (Ståhl and Hussenius 2016) of the Swedish national test in chemistry (2009–2012) has also proven to be. Above all, it is about the remaining positivist view of science as objective, rational and logical, which in the inception of modern science in the 1600s was attributed to male characteristics contrary to women’s and nature’s emotional and irrational behaviour.

If Butler’s performativity theory and Søndergaard’s association theory help to understand how the subject positions are created, Rosi Braidotti’s (2011) and Haraway’s (1991) theories of feminist figurations (Lykke 2009, p. 48) reveal that the nomadic subjects and the cyborg are the basis for these study’s views on the subject and also the analytical tool of students’ subject positions. The term “subject” refers to mind, body and emotions, everything that makes individuals human. In Braidotti (2002, 2011) and Haraway’s (1991) interpretation, the subject is creative. It has its

own agency, can offer resistance and can change its situation while drawing inspiration from its past experiences. From this perspective, the subject always has the option to choose which position to take. According to Haraway (1991), humans are all cyborgs, hybrids of machine and organism. The cyborg is a biocultural process in constant change with its fluid boundaries that, among other things, is challenging the Cartesian dichotomies of nature and culture, body and mind. Haraway (1991) argues that, with the help of the cyborg theory, many of the dualisms that arose during the Age of Enlightenment can be fought. In Haraway's cyborg manifesto (1991), the human body is united with its gender and can be understood "... as well as discourse, as the result of human and non-human actors' interaction and trickster ... dimensions that cannot be separated" (Lykke 2009, p. 98, translated by the author from Swedish). A trickster is an intrinsic agent, present in all matter, and can be interpreted as an expression of a behaviour counter to a prevailing discourse or against what is considered right and proper. In other words, the cyborg figuration can help determine whether and how students in their answers are challenging the scientific dichotomies and how they relate to the human dependency on science and technology.

Haraway's cyborg and Braidotti's nomadic figuration also entail that the subject is entirely bodily present and acting with its own agency, contrary to the Cartesian thought where only the mind is present and active. Hence, the subject in Braidotti's and Haraway's theoretical framework may offer resistance and change its situation. The figuration concept proposes that students can deal with the conditions and terms that apply to the here and now as well as write answers to test items in chemistry. It also signifies a movement towards something else, "... this nomadic style is an integral component of the concept of 'becoming' ..." (Braidotti 2002, p. 8). According to Braidotti (2002) and Haraway (1991), it can be regarded as a force that is driven forward in the form of other possible alternatives, for example, to think, act and offer resistance as well as provide constant feedback to what is currently happening. Like Braidotti, I compare this concept to embodiment "... to think through the body, not in a flight away from it. This in turn implies confronting boundaries and limitations" (Braidotti 2002, p. 5).

The figurations presented in the second phase of this work, which are alternative interpretations of students' subject positions, should be regarded as fictional and potential but not as being fixed and finished.

13.4.2 Apparatus of Bodily Productions

Inspired by Haraway and the "apparatus of bodily production" (Haraway 1991), I want to emulate the test at an apparatus, which emerges from the interweaving of various "material-discursive" (Alaimo and Hekman 2008) practices and in the meeting with the students, which give rise to different positions. Thus, the meeting between the students and the test is akin to what the Science and Technology Studies (STS) and what Bruno Latour (1999), Karin Knorr Cetina (1999) and Andrew

Pickering (1995) describe as an interaction, a mangling. In their case, it is between “apparatus” (the researcher’s object of study/tool) and the researcher.

Both the apparatus and humans have agency as well as hold an uncontrollable trickster (Haraway 1991). The subject positions should thus be seen as discursively constructed and “mangled” by the joint interaction between the apparatus (the test) and students and both their inherent and uncontrollable tricksters. The mangling can be described by Butler’s performativity theory (2007, 2011) that the test calls on students to take a scientific position, for example, be objective, logical and rational, that students react to this and that they act unconsciously through their tricksters (Haraway 1991). The trickster in the test may be such that the test designers are not aware of it, unlike the conscious motives behind the test items. Previous research (Ståhl and Husenius 2016) has noted this issue, the so-called offers of meaning (Englund 1997), norms and values found in the tests, in the form of, for example, gender bias. The student trickster can be students’ unconscious reaction to androcentric and anthropocentric features in the test or other excluding traits. Together, this mangling between the test and the students produces different positions.

13.5 Method

This study examines a specific discourse, the 2009 national tests in chemistry and related student responses, with its particular norms and values to which students should relate. How students relate to this practice is first examined using a discourse analysis to determine the possible positions within which students position themselves. Subsequently, the subject positions have been interpreted on the basis of Haraway’s (1991) and Braidotti’s (2011) feminist figurations.

The discourse analysis is inspired by James Paul Gee’s model of discursive building blocks (Gee 2014). This includes viewing the students’ verbal statements as seven actions that together build something. In this case, I study how students build subject positions in relation to the scientific position that the test is mediating. These consist of the following building blocks in the analysis requested in the students’ texts:

1. What is highlighted in students’ texts (e.g. science and technology achievements or its negative sides)?
2. What connections to other topics are made in relation to the subject matter of the test (e.g. hygiene, cooking, medicine, nature, which the test does not include)?
3. What is valued explicitly or implicitly in the texts (technology, nature, human behaviour, people’s bodies, other people, the world, things)?
4. To what extent and in what ways are values and reinforcing expressions used, that is, how high is the evaluative text volume in the texts (Ståhl and Folkeryd 2016)?
5. What language system is used (e.g. everyday language or scientific language)?

6. How is the relation to the reader presented in the students' texts, (are personal pronouns or passive form used)?
7. Which subject positions are projected on the basis of the answers that have emerged to the above questions? Do students stick to the stipulated discourse or do they choose to deviate from it? If the latter occurs, which subject positions do they assume?

The subject positions must be seen in relation to the scientific position that the chemistry test mediates its views on science, nature, society and people (see Ståhl and Husseinius 2016).

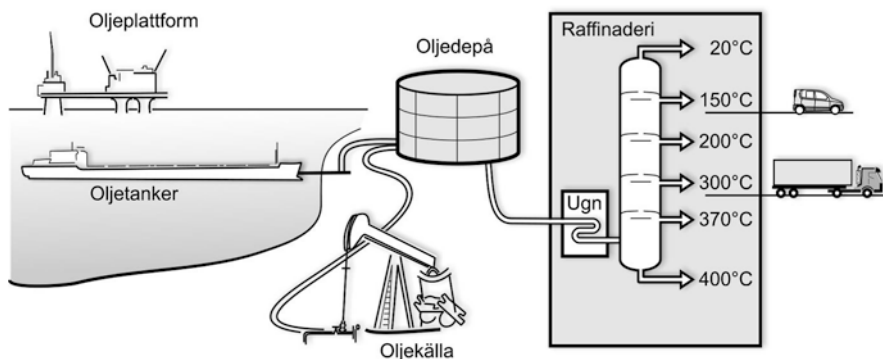
In a previous study (Ståhl and Folkeryd 2016), the analytical tool appraisal was used to study the positive and negative evaluative expression in students' texts in relation to the topics about which students have chosen to write. Together, these linguistic expressions constitute the text prosody, here called *the evaluative text volume*. Prosody refers to the rhythm, dynamics and stress in a text and can therefore reveal the writer's commitment and interests (Folkeryd 2006). The analysis was meant to assess the degree of evaluative text volume in student texts. In the current study, these results are used to categorise the subject positions that students present. The focus is to what extent and in what ways values are projected in the texts and thus the degree of evaluative text volume the texts convey. This means that the fourth building block can be answered by the results of this previous study (Ståhl and Folkeryd 2016).

13.6 Empirics

The empirics in this study include the 2009 Swedish national tests in chemistry for 15-year-olds, the assessment guidelines and 186 student responses from one of the test items in the chemistry test. Each year, schools randomly collect a number of student responses. In 2009, a total of 200 responses were gathered out of approximately 33,000 possible responses, from students born on certain dates of the year. Each year a total of 100,000 students take the national test in chemistry, physics and biology. Therefore, one-third of the students take the chemistry test. The Swedish National Agency decides which schools should take which test. This means that students do not know in advance which of the three tests they will have to complete.

Of the 200 collected student responses, 186 have been used to answer this survey. The student responses excluded lacked answers to this study's specific item alternatively applied to summary to adequately be analysed. The test item (Fig. 13.1) from which the students' responses are derived is an open task: there is not only one right answer but many, and students are able to express themselves relatively freely. The item, as shown below, relates to the social, ecological and economic issues based on the Education for Sustainable Development (Government Official Reports: SOU 2004, p. 103). The aim of the item from the Swedish National Agency for Education according to the guidelines is to test students' ability to provide examples of industrial applications in chemistry and give examples of how the oil refining industry

Products derived from crude oil have the last 100 years changed the way we live. Crude oil is a mixture of different hydrocarbons. By refining, cracking and other processes crude oil converts into various products.



Petrol and diesel are examples of products made of crude oil.

- Give another example of a product made from crude oil that has affected how we perceive the world around us.
- Explain how the discovery of refining crude oil has had an impact on how we live and how we perceive the world around us.
- What made us start refining crude oil?
- Choose another discovery in chemistry. Describe how this discovery has changed humans' ways of thinking and doing things.

Fig. 13.1 Test item from the 2009 assessment (Skolverket 2014) (Courtesy of the Swedish National Agency for Education)

and other selectable discoveries in chemistry have affected people's lives, perceptions of the world and way of thinking. It consists of four sub-items (a–d) of which the first three concerns (a–c) oil refining, whereas the last item (d) provides an opportunity for students to choose a discovery in chemistry to discuss.

Given that students often make no distinction between the first three sub-items dealing with oil refining but write about them all in the same context, I have chosen to deal with these as one item. In the future, the sub-items in those cases where they are mentioned will be specified as (a, b, c) and (d).

13.7 Results and Descriptions of the Derived Subject Positions

Based on the chemistry position that the test enhances, students are advised to adopt a specific scientific perspective from which to reason and view the world. This includes using only the rational, logical and objective intellect and is thus distinct from the emotional, irrational and subjective expression that the body produces. It also involves viewing the world and nature from an anthropocentric Western standpoint (Ståhl and Hussenius 2016).

The results of the completed discourse analysis contain three main categories based on students' outspoken or non-declared relation to science and technology. In their texts, some students take a (1) *scientific positive position*, an intermediate category where students can be said to stand on their own two feet, a (2) *scientific positive and critical position* and a third variant in which students remain quite a distance from science and technical inventions and a (3) *scientific critical position*. Group 2 means that the students, on the one hand, affirm the scientific achievements. On the other hand, the students criticise them. Based on this overall positioning, several subgroups have emerged. Below is a description of each of the overall discourses and their subgroups.

1. Description of the scientific positive position (71 texts)

Common feature of the scientific positive position texts is that they provide a thoroughly positive overview of the scientifically and technically produced society. This is accomplished although to varying extents. The majority of the texts have a low evaluative text volume. These texts often only implicitly express a positive and personal hold position, although this is possible and permissible on the basis of how the item is formulated. However, a small group of texts is exactly the opposite. These texts have a high or very high evaluative text volume and express many explicit and positive values about discoveries/inventions in science and technology. Criticism towards crude oil, its products or how it is used does not appear in any of the texts. Thus, environmental issues are not part of the students' reviews, and nature is missing. People are rarely mentioned or appear only very peripherally. One could state that the texts are "tinglified" and that the real agent (the human) is hidden. This is a known feature of scientific texts. However, in such a context, this is accomplished by using the passive tense and by turning verbs into nouns (Halliday and Martin 1993). In students' texts humans are omitted, and these grammatical traits are very rarely employed.

All students whose texts concern the scientific positive position have answered the first part of the item (a, b, c), the one about how the oil refining has influenced society. They all responded by enumerating what "we" have received in terms of an increased standard of living and principally in the form of time gains thanks to oil refining. The question of how "we perceive the world around us" is either not answered or answered by stating that the world is perceived as being smaller because travel time has been reduced. Most texts belonging to the positive position may be described as stationary. The texts indicate that students feel satisfied with society regarding their standard of living and they rely on technical and scientific solutions if problems arise.

Given the significant discrepancy in the evaluative text volume among students' texts, which in turn brings other differences, there are two subgroups of this position: (1a) *the reserved positive position* and (1b) *the enthusiastic position*. Below are examples of texts and descriptions of these two positions.

(1a) The reserved positive position

Example 1

(a, b, c) Plastic. We drive car powered by gasoline and call with plastic cell phones.

(d) The discovery that atoms can be split has changed many people's thinking. Einstein's theories have also changed many people's thoughts. The development as a result of the things above is the reason that we nowadays have nuclear power plants and that we can extract an incredible amount of energy.

Example 2

(a, b, c) Ethanol is another product made from crude oil, which has affected what fuel we use for cars and other motorised vehicles. Refining has influenced us because we have gasoline and diesel which means that our motorised vehicles can be driven. We wanted to explore what we could produce from crude oil.

(d) A different chemical discovery is glycol which we use in the cooler in cars and other motor vehicles to prevent the water from freezing.

The two texts above show a very low evaluative text volume. When evaluations appear, they are usually implicit. A positive attitude is, in other words, not explicitly expressed. For instance, comments on how nuclear plants can extract an incredible amount of energy that we can operate motorised vehicles using petrol and diesel and that glycol prevents water from freezing have been considered as implicitly positive evaluations. The above and all other texts within the group comply with a kind of template, that is, to an enunciation and statement of what we can do, thanks to things such as crude oil. In isolated cases, explanations are also provided as to why this is good. For example, Example 2 expresses that both gasoline and diesel are good for driving the vehicle and glycol is good because otherwise the water in a car's radiator would freeze.

(1b) The enthusiastic position

Example 3

(a, b, c) Diesel and kerosene. With the help of crude oil, one can do a lot of things. One can make engines work, heat houses, lubricate and make clothes. All large engines are run by some kind of petroleum products. And without machines today, we would hardly be able to survive. But we can also make polyester fabric which is made of oil. Sometimes, we even burn oil to heat houses. When trying to invent an engine, one needed something to make it work. So, it was probably somebody who understood that crude oil is easily ignited and used as an ignition gas in the engine. We also used petroleum products in paraffin lamps, but they have been replaced with oil.

(d) To create and use electricity. Electricity is the most widely used on earth. Without electricity, we would die. We use electricity to do almost everything. Heat, light, cars, tools. Electricity is generated by turbines that lead to a reactor that creates electricity. Electricity is produced by air, water, fire and nuclear power.

Example 4

(a, b, c) Asphalt from crude oil has made a big difference for humans. We would not be able to drive as easy and quickly if we did not have asphalt roads. If we had not been able to refine crude oil, we could not produce different kinds of oils, petrol or

diesel. Then, we might not have been able to drive or fly anywhere. We humans were a little more settled in our own countries then. For example, it would not be possible to travel abroad for 1 week only. We began refining crude oil because we knew one could extract a variety of things from it. We also understood that the lightest hydrocarbons would evaporate first when heated, so refining crude oil was a good option.

(d) Nitroglycerine. If explosives had never been discovered, tunnels and foundations would have to be excavated by hand. It has been important to be able to build better roads and enable people to build their houses where they want. Being able to blast rocks has resulted in more opportunities to do things. For instance, make caves and such.

Unlike the *reserved positive* texts, the *enthusiastic positive* texts make explicitly positive evaluations towards science and technology. These are emphasised through discussing our high standard of living and set against its opposite, a life without oil and technological achievements, a life in the Middle Ages using horse and carriages or the end of civilisation. Example 3 provides a good example of this: ... *without machines today, we would hardly be able to survive*, or ... *without electricity, we would die*. The discovery of oil and other technical scientific solutions are, in these texts, considered vital. With the help of these contrasts and the accentuated positive attitude, the lack of criticism becomes even clearer, and natural science is shown to be infallible. The texts show a strong faith in science and technology's ability to solve all the problems that society is facing. Despite this, problems are rarely presented in the texts. They only appear in situations concerning our bodies.

Example 5

(d) How to purify water. If we had not discovered this, we would not be able to drink water or be so healthy today.

Example 6

(d) All medicine currently used is obtained chemically. Without these drugs there had been many deaths today. Many mentally ill individuals would never be able to recover.

That water can be dirty and make humans become sick is formulated in the texts as obvious problems from which science can save us. Our bodies are vulnerable, but not science. These examples are, from the scientific positive position, among the few texts that mention people and the human body. Four other texts implicitly mention the human body, but in more rational terms, as in the example below.

Example 7

(d) Radiation. Radiology and diagnostics improved, and they started to think about internal injuries.

Among the enthusiastic positive texts, all students answered item d; this is only found in one-third of the reserved positive texts. The majority of the enthusiastic positive texts mention inventions/discoveries that are characterised as an important part of our daily lives and are close to the human body. They are also characterised by the choice of topics to discuss that do not conform to the test choice topics. They

include medical discoveries, hygiene products, packaging and storage innovations, polyester fabric, photography and light bulbs. Of these, six have chosen to talk about elements associated with the needs of the human body in the form of soap, shampoo, food, medicine and clean water. Regarding the reserved positive texts, the one-third that has answered item d has focused on petroleum products or car and oil products. Alternatively, they have chosen something that was already included in the test (metals and dynamite) or inventions in the energy sector, nuclear power plants and electricity. These students can be said to follow the tests' chosen path of subject matter, whereas the respondents of the enthusiastic positive texts have taken a different path based on everyday life.

2. Description of the positive scientific and critical position (89 texts)

In the positive scientific and critical position, the students are expressing positive values of our high standard of living that we enjoy thanks to oil refining and other chemical discoveries. At the same time, they are not satisfied with the status quo. Unlike the positions taken by the tests and the scientific positive position that both regard discoveries and inventions from a positive perspective, the positive scientific and critical position also considers the downside.

All texts in the scientific positive and critical position hence express positive evaluations about scientific and technological discoveries/inventions as well as criticism of the same. The criticism is directed both against the oil industry's impact on the environment and against its links to armed conflicts involving the atomic bomb and people's amoral behaviour in terms of issues such as environmental awareness, consumption and abuse. Since the texts sometimes treat one or more of these critical inputs, the overall position is divided into the following subgroups: (2a) *the scientific positive and environmentally critical*, (2b) *the scientific positive and environmental and ethical and/or moral critical* and (2c) *the scientific positive and morally critical*. Below is a description of each perspective. The middle position is also divided into ethical and moral criticism, (2b.1) and (2b.2).

(2a) The scientific positive and environmentally critical position

Example 8

(a, b, c) Asphalt is used on roads for cars, bicycles, buses, etc. We walk or drive on it every day. It was positive to start refining crude oil from an energy perspective, but it's not so good for the environment. We use oil of some type every day, such as fuel and asphalt, but the environment is damaged by it. Fish die, animals get sick and plants die, but they have a little hope. Since it takes millions of years to produce new crude oil, it will one day run out.

The writer believes that it was beneficial from an energy perspective to refine oil but not for the environment. The criticism is of human's use of oil and its impact on the environment. Nature is tangible and concrete. Animals and plants are referred to and described according to their fragility; they can get sick and die as a result of our daily use of oil products. However, the student does not moralise about human behaviour. The problem will be solved when the oil runs out.

(2.b.1) The scientific positive and environmental and ethical critical position

Example 9

(a, b, c) It's mainly gasoline and diesel fuel that have affected us both positively and negatively. Gasoline enables us to drive. We can visit places faster. If oil had not been produced, it would take me 3 hours a day to get to school; now it takes 25 minutes. But oil has also affected us negatively; only to produce oil is hazardous to the environment and all ecosystems and recycling. Not only nature has been adversely affected, but also oil also creates wars around the world, such as in Iraq and Saudi Arabia where lots of people have died because of it.

In this text, oil's impact on the environment is criticised by how it leads to armed conflict, but humans are free of guilt. It is oil's fault that the environment has suffered and that many people have died. It can be seen as a tinglification that the blame is transferred to non-humans. This can be compared to how written natural science language objectifies and hides the "real" agent through using the passive tense. By using the word "people", a certain distance to those who die is also described. The writer himself/herself is, however, clear about describing the positive time gains obtained through the use of oil products. Even nature is described concretely by speaking of ecosystems and natural cycles, and the term "nature" is used in contrast to the "environment". This view of nature inclines to biocentrism. Thus, it involves seeing nature's well-being based on nature's own sake and not anthropocentrically. In this text, countries considered to be outside of "our world" to which the test item is referring are highlighted. A major topic of conversation in student texts, which is also visible in the above text, is weapon production in the form of inventions such as the atomic bomb, nitroglycerine and residual products from nuclear power plants, which have created an unstable world where many people have been killed. When students in test item d may choose which discovery/invention to discuss, many write about weapon production, as the following text shows.

Example 10

(d) I think nuclear weapons (atomic bombs) have changed the way we think the most. It was quite an unnecessary discovery used for nothing but evil. Therefore, a lot of people have died in wars and so on, thanks to atomic bombs. And it has not been used for something good, and it will certainly never be. It has made us humans more aggressive and callous, I think. Not that war is ever good, but it was better in the past when one fought with horses and swords instead of guns, aircraft and bombs.

The above text shows that the writer has her/his own agency who, in contrast to the national test, is not hiding the ethical and emotional dilemmas that the use of oil and other natural science discoveries/inventions brings with it. In the above text, it is mainly nuclear weapons that are condemned. The evaluations are clearly emotional, as opposed to the objective and rational language mediated by the chemistry position in the test. The text has a high evaluative text volume, and the student can thus be considered to have a high commitment to what she/he writes about. Additionally, by choosing to mention nuclear weapons, the student expands the discussion beyond the topics that the chemistry test has chosen to present, which

focus on the mining and oil industry (Ståhl and Hussenius 2016). In the above text, the student sheds light on an invention that has negative overtones. The test does not highlight the fact that there are negative aspects of discoveries and inventions in chemistry.

(2.b.2) The scientific positive and environmentally and morally critical position

In many texts human behaviour is singled out explicitly and turned into a moral issue. More than half of the students have focused on negative human behaviour in relation to environmental problems, armed conflicts, drugs, alcohol and body ideals. One could state that it is partly akin to the traditional deadly sins in the form of human foolishness, stupidity, greed, laziness, selfishness and pride. Some students provide ideas about how moral issues should be resisted. They believe that people do not understand that the earth will perish if oil is not renewed and/or replaced by fossil-free fuels. The message from many students is to cycle more and travel less by car. Sometimes, the criticism is only directed towards others. However, sometimes the students involve themselves in the criticism; in other words they express a ... *we have* ... instead of ... *people need*. The following text is an example of such a moral theme.

Example 11

(a, b, c) Other products produced from refining oil are different varieties of oils and asphalt. When we discovered that we could extract fuel for cars and other vehicles by refining crude oil, we could produce fast vehicles and travel faster, enjoy more comfortable lifestyles and contaminate the soil and drain its resources. We perceive our world as a never-ending resource that gives us everything we want so that we can live as comfortably as possible.

(d) People have discovered various medications through different chemical laboratories. These medicines and vaccines have made fatal diseases almost harmless and raised the average life expectancy in many countries.

This text has a strong focus on human greed and selfishness. We pollute and give ourselves the right to do what we want with the earth's resources for our own convenience. The oil and its products are not valued. However, human's positive side is highlighted when they have succeeded in producing medications that can cure deadly diseases and improve the average life expectancy in many countries. Nature is not spoken of directly, but in terms of the earth's resources. This signals a greater distance from nature than in the two previous texts.

(2c) The scientific positive and morally critical position

The concrete and tangible body is included in the arguments of one-third of the students' texts in the scientific positive and morally critical position. It comes in the form of criticism of people's consumption of fuel, that is, people are lazy and will become obese with such a behaviour. It is also shown in students' answers to sub-item d where discoveries and inventions that concern the body, such as medicines, hygiene products, contraceptive pills, radiology, anatomy, drugs, alcohol, carbohydrates, fats and proteins, are discussed. Below is such an example.

Example 12

(a, b, c) One example is plastic that we use in everything from clothing to furniture. To refine oil means that one can separate the various hydrocarbons from each other. Various hydrocarbons burn at different rates, and that means they are useful in different situations. The discovery of refining has enabled us to use oil for a tremendous breadth of things such as gasoline, cosmetics and paints. This affects our way of living in all areas where we use products derived from refined oil.

(d) One discovery is that polyunsaturated fats are healthier than single saturated fat (which scientists currently claim). This is one of several things that have made people in today's society more aware of how their body is affected by the food they eat and more able to make wise decisions. Now that obesity, cardiovascular diseases and unhealthy people are more common than ever, there is a hysteria about lowering cholesterol, losing weight and feeling great. Most food products in shops today include a list indicating how much sugar, proteins, fats, etc. it contains. Under fat, it states which are saturated and unsaturated, sometimes even including polyunsaturated fat. The knowledge that this discovery has given us means that we can change our habits; all we need is to look at the packages first.

In the second part of this text, the body is very real, and lots of "moralising is served". People are not able to make wise decisions, even though the information is right in front of them. This in turn leads to hysteria about cholesterol levels, losing weight and feeling great. The writer talks about people in terms of being hysterical, but she/he uses the pronoun "we" when it comes to making wise decisions. There is seemingly a distance between the writer and the first group, those who misbehave, but a rapprochement with the group taking wise decisions. She/he speaks from a top-down perspective. The student seems to have a split view on science. On one hand, the writer believes that knowledge of, for instance, polyunsaturated fat is important and positive. On the other hand, one cannot trust scientists. They can change their opinions and perhaps even be wrong.

The students, like the above writer, who write about people's negative behaviour, whether it involves unhealthy eating, not exercising or abusing alcohol and drugs, devote only a few words and values to the first three questions, that is, to oil refining. The focus is instead on sub-item d in which the evaluative text volume is high and which the above text expresses.

Summary of the Scientific Positive and Critical Position

A large majority of the texts in this scientific positive and critical position, in addition to the oil theme, concern student's everyday life in the form of a close human body perspective. In these texts, students move between different positions, from the extremes to discussing "for and against". In addition to the close physical issues such as food chemistry content, medicines, drugs and hygiene products, the students talk about the light bulb (to see well), batteries for mobile phones (to have social contact), fire (to cook and warm themselves) and armed conflicts (which lead to death and misery), which are made possible by chemistry inventions through atomic bombs, nitroglycerine and waste from nuclear power. Only seven texts deal with topics that belong to basic chemistry (or physics) which the test has discussed, for

example, the structure of atoms, the periodic system, biogas and nuclear power. From a wider perspective, it may be interpreted as students move towards an embodied (Brickhouse 2001) scientific position that does not differentiate mind from the body either from an ethical/moral or emotional perspective. Nonetheless, the majority still maintain quite a strong anthropocentric attitude towards nature. The dichotomy between nature and culture persists in most of these student texts, whereas the one between the body and mind has been torn down, by many students.

3. Description of the scientific critical position (26 texts)

The critical position consists of texts that are entirely critical of scientific discoveries and inventions alternative to human behaviour. This position addresses the same subject areas as the scientific positive and critical position described above. Oil, according to students, tends only to contribute to the environment and humanity by resulting in harm and danger. Half of the students blame this situation on humanity, on our behaviour. We are greedy, selfish and lazy, and we want to live as comfortable as possible. Implicit emotions are manifested in disappointment over the human aversion to understand their own and others' welfare, including nature and animal welfare.

There are three subgroups in this position: (3a) environmental criticism without human intervention, (3b) environmental criticism on the basis of morality and/or criticism of weapon production and (3c) criticism of human morality (implicit environment critic). Below are shown examples of texts from each of these three positions.

(3a) Environmental criticism without human intervention

Texts belonging to environmental criticism without human intervention focus on the environment and nature. The texts briefly describe the consequences of what oil brings to the environment or nature. Usually, oil is blamed. Sub-item d is missing and the textual evaluative volume is low. Regarding the latter, the text below is a rare exception. Albeit short, several strong expressions (underlined> are expressed.

Example 13

(a, b, c) Plastic. Plastic is *unnatural*. It does not decompose. It *breaks down* nature.

(d) The car. *All* exhaust gases are affecting the world *negatively*.

This example is only one of its kind where some reinforcing words/gradations (text in italics) still accentuate the stated values. However, as in the other texts in this position, humans are not involved in the rendered criticism of oil. Humans are not even mentioned. Instead, oil is considered the villain. This attitude towards nature is close to biocentrism since all focus is on how nature is damaged. However, no connection is made that this would be a disadvantage for humans and no solutions pronounced to environmental problems or "hope for better times".

(3b) Environmental criticism on the basis of morality and/or criticism of weapon production

In this group, which consists of ten texts, the message is clear that humans should be blamed for the fact that earth is contaminated. It concerns human immoral behaviour, comfort, gluttony and selfishness. This can be seen in the following text.

Example 14

The discovery of refined oil has made us a little spoiled. It has led us to drive a car instead of walking, and we do not care as much about the earth becoming contaminated as long as we are comfortable.

In the example, there are no extenuating circumstances. However, some blame is put on oil, as it is spoiling us and encouraging us to drive cars and pollute the earth. Nonetheless, we do not care as long as we are comfortable.

Nine of the texts in this position have an environmentally critical focus. Although the tenth text expresses environmental criticism, most of the energy and high textual evaluated volume is placed on alcohol addictive effects in sub-item d, as shown in the following excerpt.

Example 15

(a, b, c) Refining oil has affected the way we live, because we use petrol and diesel every day. It uses a lot of energy and impacts our environment, the climate and the ozone layer. Today, our world needs the benefits of refining crude oil. I wonder how the world would have looked like if we never started doing it.

(d) Alcohol, or, in other words, ethanol, has affected humans a lot, *I think*. Many die because of alcohol. Some have tried to make moonshine (wood alcohol), but instead of becoming ethanol, it may have become methanol. Methanol is really dangerous and has resulted in people's deaths. Some have become addicted to alcohol (ethanol) and drink alcohol every day. They have since become alcoholics. Some alcoholics drink so much that they die. Many young people drink alcohol. Meanwhile, under the influence of alcohol, they are affected by it. One might do things one would never do sober. According to films and texts that we have read, *my understanding is* that people disappear a little from reality. I have never had any need for alcohol, and *I hope I never get it!*

The text begins with an environmental criticism of our use of gasoline and diesel. It is expressed with a low evaluative text volume. In the sub-item d, a black picture is painted of the harmful effects of alcohol. The text becomes much more judgmental and contains a high evaluative text volume. This part shows no strong outspoken criticism of people. Rather, the criticism lies on the alcohol itself. When values are expressed, the writer often writes herself/himself into the text: *...I think, ... my understanding is...* The solution in order not to suffer from these negative effects is to avoid entering into an alcohol addiction. The student hopes this will not happen to her/him. This is emphasised by the writer by again putting herself/himself in the text: *... hope I never get it!* Although the blame is put on the alcohol, the teaching, in the form of films and texts, receives implicit recognition as it apparently helped the writer to abstain from alcohol. This indicates a positive input, but it does not help all people to avoid alcohol.

In a third variant of text within this subgroup position, the criticism is directed against human immoral behaviour in relation to the nature/environment, human

relations and human's adverse use of weapons or, as in the text below, towards gunpowder.

Example 16

(a, b, c) They have affected us a great deal. We have become lazier and believe that the oil will never end. We drive to work. We fly to the other side of the globe with an airplane. We get fire by the light push of a button and so on. We believe that the oil will never run out, but it damages nature infinitely. The temperature rises, ice melts, lakes disappear, and more. We must act soon before something terrible happens.

(d) Gunpowder was invented by the Chinese long ago. They used it for rockets, but when West got hold of it, they used it in wars. This has now been developed a lot, which has made humans superior to other animals.

In the text, criticism regarding our laziness and ignorance is addressed to all of us, including the writer herself/himself by the use of the personal pronoun *we*, whereas the misuse of weapons and ammunition is carried out by humans. This is also consistent with the other texts expressing similar moral criticism. That is, the environmental problems are caused by us, whereas armed conflicts, gluttony and greed, among other things, are blamed on someone outside the writer by using, for example, passive tense. The text also has a more global perspective and thus goes beyond the limits of what the test item stipulates "We and our environment". This use of the "us and them perspective" on the test item is furthermore in this text vice versa. The West did wrong when they used gunpowder in war, and man's superiority to animals is not something to brag about when it is achieved by brute force. The author's view of nature can be seen to be considered biocentric. On the other hand, we must act before something bad happens, even though the "lakes and much more" have already disappeared. It can be interpreted that this is not terrible enough: the worst is when it affects us.

(3c) Criticism of human morality (implicit environment critic)

In this position, the environmental issues are implicitly expressed. The focus is instead on people's amoral behaviour and not what that conduct should produce or depend on. The following is an example of this.

Example 17

How this has affected the way we live today is pretty significant. We do not need to think so much because everything is automatic. We do not think about how much everything is destroyed, quickly and automatically. It is cheaper because no one needs to be there all the time and look at it.

As in the text above, the texts in this subposition are mostly short. Nonetheless, several students express clear values (medium evaluative text volume) about our moral compass which is out of play. The text mediates implicitly that, although our ignorance is clear, our unwillingness to see what happens that everything is destroyed and that our fully automated society and aspiration to produce goods as cheaply as possible also means that we do not have to look at it. No direct connec-

tions are made to the nature or the environment, but the text can be seen as a general reflection of society's decadence. Human's poor morality is thus clearly in focus.

Summary of the Scientific Critical Position

Generally, the texts in the critical positioning express very little hope of improvement for earth's survival or for people to change their behaviour. There seems to be no way forward. In contrast, the students show that the trickster (Haraway 1991) in nature has reacted and resisted that nature has struck back. Students have also clearly distanced themselves from human foolishness and behaviour, even though they often involve themselves in this human decadence through the use of the personal pronoun "we". There is also no trace in the texts that they rely on science and technology to solve the problems mankind has caused. Students' rejection of science and technology can be said to strike back at the positive image that the chemistry test has painted. Overall, this action can be interpreted as a feminist figuration (Braidotti 2002; Haraway 1991) that has used its agency and showed its resistance towards the science and technology community. This is manifested by the use of emotionally coloured and evaluative language and through highlighting the negative consequences. It is an emotional movement, leading away from science and the path on which the adult world has chosen to walk. Students do not show any way back and do not express any positive views on what science and technological discoveries/inventions have produced. This can be interpreted to mean that students have turned their back on science and technology forever.

13.8 Feminist Figurations and a Possible Common Educational Vision

In the present study, the aim has been to problematise the androcentric and Cartesian characteristics of the Swedish national tests in chemistry in relation to how students relate to these norms and values. The aim has also been to show a possible alternative chemistry teaching with the help of feminist figuration theory (Braidotti 2002, 2011; Haraway 1991, 1997), where other norms and values manifest than the ones that have emerged in the chemistry tests. Through the development of subject positions, student positions have been reported in relation to the norms and values that students have met in the 2009 national test. Thus, one aim of the study has been achieved, highlighting the attitudes students have towards science and technology, to their perception of nature, society and people in relation to the norms and values in the 2009 chemistry test. Subject positions have been obtained in response to the questions I have put to the material. They represent a section of students' positions in relation to the assumed perspective in the research questions. Starting from the developed subject positions, possible feminist figurations have become visible, which in turn can be interpreted as possible visions of the scientific education based on the students' developed written criticism. These figurations are reported in the following sections along with the possible educational visions.

13.8.1 Feminist Figurations Based on Students' Subject Positions

The feminist figurations are based on students' subject positions and thereby their attitude and criticism towards the actual situation, in the meeting with the chemistry discourse in the test, and what I have interpreted as positive visions of the subject positions. Thus, I understand the concept of the feminist figuration "... to be understood as a vision that the subject is about to realize, but additionally implies that a critique of the here-and-now- situation. It speaks to thought, feeling and body" (Lykke 2009, p. 220 translated by the author from Swedish). Figurations should be seen as temporary, moveable and partly fictional. They have emerged from a mangling (meeting) between, in this case, students and the test, the apparatus. The latter can be described as "... boundary-making practices that are formative of matter and meaning, productive of and part of the phenomena produced" (Barad 2007, p. 146). The boundaries of the apparatus are, in this study, the norms and values in the chemistry test (Ståhl and Hussenius 2016). Students have had to relate to these discursive boundaries, both with regard to the overall discourse in the chemistry test (2009 national test) and the discourse that applies to the current test item that students have answered.

Braidotti's nomadic subject and Haraway's cyborg can, on one hand, be understood as a new, positive way of doing gender (Lykke 2009). On the other hand, one can also see that Braidotti, with her concept of figuration, also wants to achieve something else: "I rather see them as significant sites for reconfiguring political practice and redefining political subjectivity" (Braidotti 2002, p. 3). Haraway also shifts focus away from the human subject when she states that figurations are "... material-semiotic nodes or knots in which diverse bodies and meanings coshape one another" (Haraway 1989, p. 4). Similarly, I want to see that, in the meeting between students and the chemistry test, nodes/figurations are created that, in relation to the norms and values in the test, take positions for or against science and technology. Therefore, they evaluate people's actions and nature and society, even though they describe a vision for something else. This is based on my interpretation of a possible vision of scientific education that is not based on the Cartesian tradition of thought, reflected on the national chemistry tests. Rather, it is based on students' criticism, ideas, norms and values.

13.8.2 The Critical Side of Figurations Leads to the Vision of a Different Chemistry Teaching

Using Braidotti's and Haraway's theory of figuration, each subject position, in addition to being a combined form of several students' positions regarding their relationship to science and technology, nature, society and people, is interpreted as being in possession of an alternative position, a vision of a different chemistry

teaching. This means that these students' nomadic subjects/cyborgs can be seen to have exercised their agency and taken a stand against the androcentric hegemony that the chemistry test mediates (Ståhl and Hussenius 2016). It also reflects them striving towards a new vision of chemistry teaching. Some figurations can then be viewed as striking back at the positive image of science and specifically of chemistry that the test has painted. In two of the three subject positions, in *the scientific positive and critical subject's position* and *the scientific critical position*, science adverse consequences for nature, society and humanity have been highlighted. These positions can be regarded completely conflicting with the natural sciences. On the other hand, it can be interpreted as concerning a feminist figuration that says no to the very thing that the test has mediated. Instead, it moves towards a vision, *an imagined elsewhere* (Haraway 1992, p. 295), for a change of discourse. This study takes note of the latter interpretation. Similarly, one can understand the two subpositions of *the positive science position*: the enthusiastic position and the reserved positive position. Students in these groups affirm science and technology and thus seem to lack visions about something else when they do not express any criticism. However, the texts in the enthusiastic position raise a much broader topic than the chemistry test mediates. They move between everything from outer space to everyday duties in the kitchen. This reveals, on the one hand, a feminist figuration who expresses criticism of chemistry of the test-limited choice of topics and, on the other, the vision of a broader chemistry subject that concerns young students. This involves a chemistry teaching that does not get stuck in a structurally masculine choice of topic in the form of oil and metal industry, which has been the case in all four previously studied chemistry tests (Ståhl and Hussenius 2016). Rather, it raises subject matters that are of concern and interest to all students.

In *the reserved positive position*, the students' answers are implicitly positive and characterised by short texts and a low evaluative text volume. Here, a vision is more difficult to see. However, a figuration that breathes "I'm not interested" and a desire to escape from it appears, in other words, an implicit criticism of the test and its contents. The positive vision becomes a science in which everyone gets to be heard and involved. Thus, a science education is built on many students' different visions, including that of human equality.

The science of positive and critical position aims to highlight and make natural science discoveries/inventions from many perspectives, to understand that they are part of a complex reality. Nonetheless, unlike *the positive position*, they also want to show that science and technology bring both the good and the bad, including morally indefensible actions. This is thus a feminist figuration that expresses criticism of the prevailing hegemony that mediates that chemistry is infallible. The positive vision would then be that ethical considerations must be brought to light and discussed in the chemistry classroom. This applies in relation to the problems of society and the individual, which they face/will be facing on both a small and large scale. It is about problems that need to be discussed and clarified, even when they are complex and multidisciplinary.

Science based on everyday and close human phenomena and choice of topics (chemistry in cooking, the body and cell phones, hygiene products and medications)

are also discussed in these positions. The body from a chemistry perspective is thus developed. The human side of a cyborg (Haraway 1991) also becomes evident in the students' texts, as the machines we use are from a human perspective and relation. Thus, critics are said to be directed towards the test focus on chemistry and science without human and physical involvement. That in turn would be aimed at a positive vision of a chemistry discourse interested in a close perspective and use of the physical and embodied human.

In many positions, issues of armed conflicts involving oil production, atomic bombs and nitroglycerine highlight devastating effects. The critical part of the figuration is directed towards the omission in the chemistry discourse of the negative consequences of chemistry discoveries/inventions and its lack of links to humans. It provides a positive vision of teaching from ethical and interdisciplinary perspectives, with connections to other cultures and global activities that not only affect ourselves and our world but also the whole world. This possible and positive vision also aims to achieve a cyborg perspective. We are all cyborgs, machine humans in which the human part must take ethical and moral responsibility to prevent the machine from taking over.

Environmental issues are found, in almost all positions, but discussed in different ways across the positions: anthropocentric most of the time and sometimes tinglified. That is, people should not be criticised for environmental problems but oil should. Sometimes, however, the blame is on us humans. Regardless of who receives the blame or whether the relationship to nature is anthropocentric or biocentric, the interpretation of the criticism in this figuration is directed towards the weak position of the environmental issues in the test and the absence of nature. I see a positive vision of this figuration that environmental issues should be studied from a broader perspective, a sustainable society where environmental issues are also linked to economic and social aspects, as many student texts in *the critical positions* do. That is, it is important to discuss and shed light on complex but difficult questions, such as one that many of the student texts have expressed: what happens when oil runs out, for me, for nature and for society?

The human body is central in most texts in the *scientific positive and critical* as well as *critical position*. Sometimes, this becomes pronounced by the writer when she/he does not answer the first three sub-items (a, b, c). The body takes, in other words, a lot of space, both in the literal and figurative sense, as it usually does in a 15-year-old's life. The body's prominent role in the texts speaks against the disembodied intellect that the tests appear to favour in the adoption of Cartesian dichotomies. The criticism of the figuration also focuses on the tests' absence of chemistry in relation to the body. The positive vision is then that teaching and learning should be embodied (Brickhouse 2001; Milne and Rubin 2011). The body is a prerequisite for our ability to analyse and understand (Alsop 2011). Moreover, chemistry in the body or in body-related chemistry (medicine, drugs, alcohol, hygiene products, etc.) is an everyday topic that is found in many student texts. Therefore, it should be an important focus of chemistry teaching. In other words, it involves ensuring that "Learning is not just about what the mind can do on its own; it is how the body, and

spirit interact to create a movement, the idea of embodied learning” (Milne and Rubin 2011, p. 630).

Finally, the subject positions that appear to express resentment towards natural science and technology, those that are strongly criticising or alleged and those silently protesting in the scientific critical position and the reserved positive position depict a figuration that criticises the chemistry discourse elitist attitude of exclusion. Only the “right one” may enter this epistemological community. This then leads to a positive vision of a chemistry discourse that embraces all students and their visions, not only those with obvious scientific dreams.

13.9 Some Final Thoughts

These above-described figurations speak to us, especially to those who have influence on science teaching, including national examinations, textbooks, curriculum and syllabus. If we want students to be interested in science, we must listen to them and highlight their interests and commitments that obviously exist. We need to develop a chemistry teaching that is opposed to the one built on Cartesian thought, as the one shown in the Swedish national test in chemistry. In other words, it involves a feminist teaching and learning that is “... empowering, ... close to the women’s everyday life experiences and if it builds upon the intellectual, emotional and cultural resources the participants bring to their social space” (Stromquist 1993, p. 7). This quote is from a talk that Nelly Stromquist gave at a UNESCO seminar on women’s education. However, this should apply in all teaching contexts, regardless of gender, ethnicity or class. Feminist teaching and learning are also about embodiment, unlike the science inspired by Cartesian thought that separates the mind from the body. Instead, feminist-inspired science teaching can entail “... arguing for the view from a body, always a complex, contradictory, structuring and structured body, versus the view from above, from nowhere from simplicity” (Haraway 1988, p. 589).

References

- Ah-King, M. (2013). Queering animal sexual behaviour in biology textbooks. *Confero*, 1(2), 46–89. doi:10.3384/confero.2001-4562.13v1i21d.
- Alaimo, S., & Hekman, S. (Eds.). (2008). *Material feminisms*. Bloomington/Indianapolis: Indiana University Press.
- Alsop, S. (2011). The body bites back! *Cultural Studies of Science Education*, 6, 611–623. doi:10.1007/s11422-011-9328-4.
- Arvola Orlander, A., & Wickman, P.-O. (2011). Bodily experiences in secondary school biology. *Cultural Studies of Science Education*, 6, 569–594. doi:10.1007/s11422-010-9191-4.
- Barad, K. (2007). *Meeting the universe halfway. Quantum physics and the entanglement of matter and meaning*. Durham/London: Duke University Press.

- Berge, B.-M., & Widding, G. (2006). En granskning av hur kön framställs i ett urval av läroböcker. [An examination of how sex is produced in a section of textbooks]. Underlagsrapport till Skolverkets rapport "I enlighet med skolans värdegrund?". Umeå universitet.
- Braidotti, R. (2002). *Metamorphoses. Towards a materialist theory of becoming*. Cambridge: Polity Press.
- Braidotti, R. (2011). *Nomadic subjects. Embodiment and sexual difference in contemporary feminist theory*. New York: Columbia University Press.
- Brickhouse, N. (2001). Embodying science: A feminist perspective on learning. *Journal of Research in Science Teaching*, 38(3), 282–295. doi:10.1002/1098-2736(200103)38:3<282::AID-TEA1006>3.0.CO;2-0.
- Butler, J. (2007). *Genustrubbel: feminism och identitetens subversion* [Gender trouble: Feminism and the subversion of identity] (Suzanne Almquist, Trans.). Göteborg: Bokförlaget Daidalos AB. (Original work published 1990).
- Butler, J. (2011). *Bodies that matter. On the discourse limits of "sex"* (2nd ed.). London/New York: Routledge.
- Englund, T. (1997). Undervisning som meningserbjudanden. [Teaching as an offer of meaning]. In M. Uljens (Ed.), *Didaktik: teori, reflektion och praktik* (pp. 120–145). Lund: Studentlitteratur.
- Folkeryd, J. (2006). *Writing with an attitude. Appraisal and student texts in the school subject of Sweden*. Doctoral dissertation, Uppsala University, Department of Linguistics and Philology.
- Foucault, M. (2008). *Diskursernas kamp/Michel Foucault: texter i urval av Thomas Götselius och Ulf Olsson* [The discourse of struggle.] (Lars Bjurman and Jan Stolpe Trans.) Stockholm: Brutus Östlings Bokförlag.
- Fox Keller, E. (1977). The anomaly of woman in physics. In S. Ruddick & P. Daniels (Eds.), *Working it out* (pp. 78–91). New York: Pantheon Books.
- Gee, J. P. (2014). *An introduction to discourse analyses: Theory and method* (4th ed.). London/New York: Routledge.
- Halliday, M. A. K., & Martin, J. R. (1993). *Writing science. Literacy and discursive power*. London: Falmer Press.
- Haraway, D. (1988). Situated knowledges: The science question in feminism and the privilege of partial perspective. *Feminist Studies*, 14, 575–599.
- Haraway, D. (1989). *Primate visions. Gender, race, and nature in the world of modern science*. New York/London: Routledge.
- Haraway, D. (1991). *Simians, cyborgs and women. The reinvention of nature*. New York: Routledge.
- Haraway, D. (1992). The promises of monsters: A regenerative politics for inappropriate/d others. In L. Grossberg, C. Nelson, & P. Treichler (Eds.), *Cultural studies* (pp. 295–337). New York: Routledge.
- Haraway, D. (1997). *Modest_Witness@Second_Millennium. FemaleMan@_Meets_OncoMouse™*. New York/London: Routledge.
- Harding, S. (1986). *The science question in feminism*. Ithaca/London: Cornell University Press.
- 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. doi:10.1207/S15327884MCA0904_02.
- Klafki, W. (1997). Kritisk, konstruktiv didaktik. [Critical constructive theory]. In M. Uljens (Ed.), *Didaktik: teori, reflektion och praktik* (pp. 215–228). Lund: Studentlitteratur.
- Knorr Cetina, K. (1999). *Epistemic cultures: How the sciences make knowledge*. Cambridge, MA: Harvard University Press.
- Latour, B. (1999). *Pandora's hope. Essays on the reality of science studies*. Cambridge: Harvard University Press.
- Lemke, J. L. (1990). *Talking science: Language, learning, and values*. Norwood: Ablex, cop.
- Lemke, J. L. (2011). The secret identity of science education: Masculine and politically conservative? *Cultural Studies of Science Education*, 6(2), 287–292. doi:10.1007/s11422-011-9326-6.
- Lykke, N. (2009). *Genusforskning: En guide till feministisk teori, metodologi och skrift*. [Gender studies: A guide to feminist theory, methodology and texts]. Stockholm: Liber.

- Miller, P. (2006). Contemporary perspectives from human development: Implications for feminist scholarship. *Signs*, 31(2), 445–469. doi:10.1086/491680.
- Milne, C., & Rubin, K. (2011). Embodying emotions: Making transactions explicit in science education. *Cultural Studies of Science Education*, 6, 625–633. doi:10.1007/s11422-011-9354-2.
- Östman, L. (1995). *Socialisation och mening: NO-utbildning som politiskt och miljömoraliskt problem*. [Socialization and meaning. Science education as a political and environmental-ethical problem]. Doctoral dissertation, Uppsala University: Department of education.
- Östman, L. (1998). How companion meanings are expressed by science education discourse. In D. Roberts & L. Östman (Eds.), *Problems of meaning in science curriculum* (pp. 54–70). New York: Teachers College Press.
- Pickering, A. (1995). *The mangle of practice: Time, agency, and science*. Chicago: University of Chicago Press.
- Roberts, D. (1998). Analyzing school science courses: The concept of companion meaning. In D. Roberts & L. Östman (Eds.), *Problems of meaning in science curriculum* (pp. 5–12). New York: Teachers College Press.
- Roberts, D., & Östman, L. (Eds.). (1998). *Problems of meaning in science curriculum*. New York: Teachers College Press.
- Sjøberg, S., & Schreiner, C. (2010). *The ROSE project: An overview and key findings*. Oslo: University of Oslo.
- Skolverket. (2014, January 29). Nationellt ämnesprov i kemi våren 2009 och tillhörande bedömningsanvisningar. Umeå universitet: Institutionen för tillämpad utbildningsvetenskap. Retrieved from <http://www.edusci.umu.se/np/nap/tidigare-givna-prov-lpo94/>
- SOU. (2004:103). *Lärande för Hållbar utveckling*. [Learning for sustainable development]. Stockholm: Fritzes offentliga publikationer.
- Stromquist, N. (1993). The practical and theoretical bases for empowerment. Paper presented at the international seminar on Women's education and empowerment, UNESCO Institute for Education, Hamburg, Germany.
- Ståhl, M., & Hussenius, A. (2016). Chemistry inside an epistemological community box! – Discursive exclusions and inclusions in Swedish National tests in Chemistry. *Culture Studies of Science Education*, 1(11), 1–29. doi:10.1007/s11422-016-9730-z.
- Ståhl, M., & Folkeryd, J. (2016). Scientific norms and students' evaluative language use. In M. Ståhl, *Kemiämnets normer och värden. Diskursanalytiska studier av nationella prov i kemi och tillhörande elevtexter*. Doctoral dissertation, Uppsala University, Department of Education.
- Søndergaard, D. M. (1996). *Tegnet på kroppen. Køn: Koder og konstruktioner blandt unge voksne i akademien*. [Signs on the body. Sex: Codes and constructions among adults in academia]. København: Museum Tusulanums forlag, University of Copenhagen.
- Wenger, E. (1998). *Communities of practice*. New York: Cambridge University Press.
- von Wright, M. (1999). *Genus och text - när kan man tala om jämställdhet i fysikläromedel?* [Gender and texts – When is it possible to talk about equality in physics' textbooks?] Stockholm: Skolverket.