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Girls in Science and Technology: the development of a discourse

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ABSTRACT   *This article discusses the contribution of educational research to the emergence of a discourse on 'the problem of girls in science and technology' in the Netherlands. Research has not only produced findings and recommendations, but also conceptualisations of the problem. We argue that it has gradually become self-evident to think of the attitudes, achievement and choices of girls pertaining to science and technology as* the *problem of gender inequality in education. The results of many studies focusing on connections between teacher behaviour, the subject matter and school characteristics on the one hand and attitudes, achievement and choices of girls on the other, appear to be disappointing. We suggest that both the questions that were asked and the way they were investigated are responsible for the disappointing results. We propose that research on gender and education should not be limited to the investigation of statistical correlations between school characteristics and student outcomes, but should also study the mechanisms and processes that mediate between these factors. Insights from women's studies on the social construction of gender and on the development of gendered identities could be useful in addressing this issue.*

Introduction

During the past 15 years in educational policy and research increasing attention has been paid to 'the problem of girls, science and technology'. Research in this field has provided insights into factors that determine girls' participation and achievements in education in this field and has suggested strategies to make science and technology curricula and courses more accessible and attractive for girls. Besides 'findings' and 'recommendations', however, this research has also produced results at another level: the level of conceptualisations: a discourse on girls, science and technology has developed in which girls, rather than science and technology, are often defined as the problem.

We use the word 'discourse' to emphasise the idea that concepts, theories, research questions and methods, in short, ways of thinking about a subject, are social constructions. Research does not just reflect reality but is a product of social processes, of traditions, of power relationships and of struggle. This position is inspired by the

post-modern emphasis on the importance of language in how people think and understand the world. Being aware of the fact that the social is constructed and discursive, many feminist and post-modernist researchers concentrate on deconstructing discourses. This approach has evoked criticism: post-modernists have been accused of political disengagement and even moral cowardice, because of their scepticism towards the possibility of 'emancipation, democracy, liberation' etc. in or through education (see the discussion between Giroux, 1988; McLaren, 1988; Ellsworth, 1989; Lather, 1991).

This article is an attempt to deconstruct the discourse on girls, science and technology that has been produced in the Dutch research in this field. To us, 'deconstruction' does not mean a lack of involvement. On the contrary, we think that reflecting on the way policy-makers, teachers and researchers (including ourselves) talk about girls and their 'problems' with mathematics, physics, information technology etc., can lead to a better understanding of these 'problems', and of the (lack of) effectiveness of strategies that try to address them. We will show that the 'problem of girls' approach, although often taken for granted, is not self-evident, but rather the outcome of a process in which the issue of gender, science and technology is defined.

Changing Conceptualisations in the Research on Gender and Education

In the Netherlands research on gender and education started at the end of the 1970s. The first studies were announced in a policy document in which a number of policy objectives pertaining to gender equality were formulated (Ministry of Education and Science, 1979). One of the objectives emphasised the fact that girls were lagging behind in education, another one was more critical, containing a plea for 'reappraisal of the feminine'. Thus, the objectives represented 'the feminine' both as a set of values that should be incorporated in education, and as a problem, a cause of inequality (see also Arends & Volman, 1992).

The research on gender and education in the Netherlands mainly consists of research commissioned by the Government and, therefore, these policy objectives have been decisive in determining the questions that could be asked. From the start, research on gender and education has been an area of competing definitions and debate, which is partly due to the ambiguity of the policy objectives. Little interest was shown, however, in gender questions in academic educational research, and in women's studies, which were developing at the same time, there was not a great deal of interest in educational questions (Ten Dam & Volman, 1991).

In the first literature studies, which were published in the early 1980s, researchers tried to analyse the role of education in the reproduction of gender inequality—a very broad question (Jaarsma, 1979; Veeken *et al.*, 1982; Dekkers & Smeets, 1982; Jungbluth, 1982). They were reluctant to define the issue as a problem of girls and they protested against the lack of interest the Government showed, despite the policy objectives, in 'the incorporation of feminine values' and in the role of education itself in the reproduction of gender inequality. As to the last issue, a plea was made for research aimed at revealing socialising mechanisms in schools. Policy-makers partly adopted this analysis; in the third policy document (Ministry of Education and Science, 1985) such topics as educational organisation, teaching methods and teacher expectations were discussed, and measures to change these were suggested. The operationalisation of the objective of 'reappraisal of the feminine', however, proved much more difficult, both in research and in policy.

In the second half of the 1980s it became clear that gender differences in educational careers were not only a problem in terms of justice or equal opportunities, but were also

an economic problem. In the Netherlands comparatively few women have a paid job (41% in 1988—in Europe only Ireland and Spain have a lower percentage of women in paid employment—see Brouns & Schokker, 1990) and when in the 1980s a shortage of technically trained personnel became evident, women were 'discovered' as a reserve of 'talent'. Equal opportunities policy focused more and more on stimulating women to participate in the labour market.

This shift also influenced the way the problem of 'girls and education' was constructed in educational research on gender inequality. In the course of the 1980s the focus in educational research changed from the broad question, 'what role does education play in the reproduction of gender inequality?' to the much narrower question, 'why don't girls choose courses that offer them more opportunities on the labour-market?' (Volman *et al.*, 1993). This determined the issues that were considered to be worth researching.

Results of Research on Gender, Science and Technology

The definition of the problem of gender inequality in education emphasising opportunities in the labour market meant that research on girls and science and technology could flourish. These are the subjects and courses of studies that are supposed to provide girls with a favourable position in the labour market. However, not every question could be posed in research.

Firstly, the Government was mainly interested in a certain kind of research question: 'why do so few girls choose mathematics, physics etc. in general secondary education and technical courses in vocational education?' Only in 1993 was a common curriculum introduced in lower secondary education in the Netherlands. Prior to 1993 there were two parallel systems of vocational education and general secondary education. Within general education mathematics and science could be dropped after 1 or 2 years; in lower vocational education a choice between technical, administrative or domestic courses had to be made at the start. This situation in the educational system partly explains the focus of research on 'choices'. Secondly, the institute that allocates research funds for the Ministry of Education and Science supports a view on educational research that favours quantitative research methods and looks at qualitative methods of data gathering and data analyzing rather suspiciously. This meant that not only the research questions on gender and science and technology were restricted but also the methods used to investigate these.

However, the criticism made in the early studies of the exclusive focus on girls as a problem, and the plea for attention to be paid to socialising mechanisms in schools, had not been forgotten. As a result, there is tension in many studies on girls and mathematics and science between the definition of girls as the problem on the one hand and the notion that there are factors in education that should be challenged on the other. Most research questions combine the 'school' side and the 'girl' side of the problem. We will now briefly discuss a number of Dutch studies on girls in science and technology. First we focus on research on mathematics and physics. These studies deal with the role of the teacher, the subject matter and teaching methods, and with the relationship between certain school characteristics and characteristics of students' careers. Then we will look at the research on technology courses.

The Teacher

One of the first studies in this field looked at the relationship between students' choices of mathematics and science in general secondary education and the *gender* of the teacher (Van der Werf *et al.*, 1984). It was found that girls who are taught by women do not choose these subjects more often than those taught by men. However, the *problem awareness* of the teacher did appear to be related to girls' choices of mathematics and science.

A second study looked at *teacher behaviour* and its effects on achievements in, choices of and attitudes towards mathematics in secondary education (Kuyper & Meulenbeld, 1989; Kuyper & Otten, 1989). Behaviour was assessed by observations in the classroom and interviews with teachers. The kind of behaviour that was studied involved categories like: 'giving turns', 'giving positive feedback', 'making a disciplinary remark'. Consistent differences between girls and boys were found on achievement, choices and attitudes, but these gender differences did not seem to be related with teacher behaviour.

Subject Matter

Since the beginning of the 1980s feminist teaching methodologists have pointed out the role of the subject matter in reinforcing masculine images of mathematics and science. Several early studies looked at the occurrence of women and girls in teaching materials and at gender stereotypes, both in text and in the illustrations in school books (e.g. Mottier, 1988). Another line of approach was based on the idea that examples and contexts chosen in textbooks usually do not fit in with girls' interests. Teaching materials were developed that paid more attention to issues in everyday life, particularly the activities and experiences of girls (De Leeuw, 1987).

One of the basic assumptions concerning the subject matter was that girls would benefit from a more contextual approach in mathematics and science. In 1985 a reform in mathematics education was introduced in the Netherlands, primarily aimed at enhancing the link between secondary and higher education. Part of the experiment was the introduction of a contextual programme for mathematics: it was evaluated in the years following (Van der Werf, 1989). In the experimental schools two kinds of mathematics were offered, both optional. Mathematics A, the contextual programme, was primarily aimed at students who would continue their education in social or economic sciences, whereas mathematics B prepared students for technology or science courses. It was found that in schools that had introduced the new programme both girls and boys chose mathematics as an examination subject more often. The increase was slightly higher for boys. However, girls chose mathematics A far more often than B, whereas boys more often chose mathematics B or even both mathematics A and B. Gender differences in achievement did not diminish, and attitudes of students did not become more positive. Soon after the introduction of mathematics A and B it was decided that mathematics B was required for admission to technology and science courses in higher education. So the introduction of the new 'girl-friendly' programme excluded girls even more from technical courses than the old one had done. However, mathematics A and B have now been introduced in all secondary schools. What is striking in this evaluation research project is that no analysis or explanation was given of which elements in the programme actually were supposedly favourable for girls.

Another study, on physics education, is more explicit about what the researchers consider to be 'good physics education for both girls and boys', i.e. education that

discusses usefulness and applications of physics or education that creates possibilities for co-operation (Jörg *et al.*, 1990). The experience and appraisal of secondary school students of physics books differing on a number of criteria were studied. The researchers did not look, however, at connections between the teaching materials used and choices and achievements. They did find connections, for both girls and boys, between the perceived relevance of physics, feeling competent, final marks and choosing physics. What is important is that the researchers found that gender differences in interest and achievements in physics increase during secondary education.

School Characteristics

An increasingly influential kind of educational research in the Netherlands is connected with the 'effective schools' movement. The main question of this research is: 'which school characteristics are related to more successful educational careers and to less successful?' (Reynolds & Cuttance, 1992; Scheerens, 1992). This approach has also been applied to the question of gender differences in educational careers. Researchers have been especially interested in the so-called beta-effectiveness of schools.

In the first study, beta-effectiveness was defined as the extent to which girls choose science and mathematics (Dekkers, 1985). The only hypothesis about factors related to effectiveness for girls that could be confirmed, pertained to the extent of systematic and active career counselling in the school. In addition, some general school characteristics were found: diversity of opinions and tolerance among teachers, constructive discipline, a positive image of the efforts of students etc. Participation of schools in equal opportunities projects did not appear to be related to effectiveness for girls.

In a second study a broader definition of beta-effectiveness was used, namely a combination of choices for and achievements in mathematics and science (Kristensen & Jenneskens, 1991). It was found that measures taken specifically to enhance girls' participation and achievements in these subjects were not related to beta-effectiveness for girls. Only a school climate with both achievements and the personal development of pupils as objectives was found to be favourable for the achievements and choices of girls.

A third study defined school effectiveness as the 'extent of suitability of the subject specializations of students on the labour-market' (Bosker, 1990). A quite sophisticated instrument was developed to evaluate this suitability. However, again problem awareness of teachers, an equal opportunities policy and other measures aimed at gender equality in the school, like extra career counselling for girls, appeared not to make any difference.

Technical Courses

In the Netherlands much more research has been done on gender and mathematics and science than on gender and technology in education. One reason may be that the problem of personnel was not as serious in those sectors requiring lower technical training. As to higher technical education, the reasoning might have been that the problem of subject choice in secondary education had to be tackled first in order to create a potential group of students for higher technical education.

The research that has been done on technical education is often linked to reform programmes in education and is usually more qualitative than the research on science and mathematics. Most studies were small-scale, aimed at formulating recommendations for making technology education more accessible for girls and women. The main question is: what are the obstacles encountered by girls and women in these courses?

Research resulted in teaching materials and manuals for administrators, teachers and counsellors.

The emphasis of research varies with the level of education concerned. In the lower levels of education, research has focused on recruitment of students, counselling, subject matter and teaching methods (Laeven, 1984; Gunnink & Dekkers, 1987). At the middle level, the emphasis was first on the attitudes of teachers and fellow students and on the experiences of girls themselves (Udo, 1985, 1987; Alting, 1987). Gender reform programmes were later implemented and evaluated. The special position of girls is a recurrent theme, often discussed in connection with the dilemma that on the one hand special attention and counselling for girls is desirable, while on the other this reinforces their special position.

Research in higher education focuses on recruitment of girls and their special position. The first study in this area asked why so few girls go to technical universities (Van Vonderen & Raaff, 1981). More recently possibilities for enhancing the intake of girls in higher technical education have been investigated again (Rinck *et al.*, 1987; Dekkers, 1990). In addition to the special position, research identifies the educational climate and the attitude of women towards technology as reasons for drop-out and deferral in higher technical education (Marinussen *et al.*, 1987; Brouwer *et al.*, 1990). Women appear to find the exclusive focus on technology too restricted (Everts & Van Oost, 1985). It is striking that there has hardly been any research on the achievements of girls in technology courses.

Research on technology education resulted in many insights into barriers for girls in these courses. However, they did not result in 'evidence' of connections between school factors, choices, attitudes and achievements. Moreover, although theories on socialisation were often used as a framework, research results were not related to the theory. As a result the insights of these studies are not often quoted in mainstream educational research.

Conceptualisations

To summarise, the results of the research on mathematics and science were quite disappointing: having a female mathematics teacher does not seem to make a difference to the educational choices of girls. Teaching behaviour that was related to the achievement, choices and attitudes of girls towards mathematics could not be identified. A mathematics curriculum that paid attention to daily life and that was assumed to be 'favourable for girls' did stimulate girls to choose mathematics, but this was not the mathematics curriculum that was soon to be required for science and technology courses. In the research on school effectiveness only some very general school characteristics were found to be related to the percentage of girls choosing science and mathematics. The research does not help us very much in understanding why girls do not choose science and mathematics as much as boys.

The research on girls in technology courses resulted in many insights into exclusion mechanisms, assumptions about girls and dilemmas encountered by them in technical education. Moreover a lot of ideas about how to improve these courses were developed. However, although these were welcomed in educational practice, they were not really taken seriously in educational research, because no hypotheses were tested on the effects on the participation, achievements and attitudes of girls towards these courses.

Besides 'findings' and 'recommendations', both research on science and mathematics and on technology also produced results at the level of conceptualisations. We have

already mentioned that it gradually became self-evident to think of girls and science or girls and technology as *the* problem of gender and education: it is their attitudes, achievements, choices and more recently their learning styles that are 'different'. During the second half of the 1980s, early feminist questions like, 'why is so much importance attached to mathematics, science and technology and so little to languages, home economics etc?' disappeared. More recent questions arising from feminist research about the gender bias of mathematics, science and technology (e.g. Keller, 1985; Harding, 1986) are not being posed in educational research.

The disappointing results of research on science and mathematics even underscore the definition of girls as a problem; the findings could easily provoke the conclusion that education does not really make a difference, and that it is girls themselves and their families that should change. Meanwhile, policy measures have also been reinforcing this image. A lot of money was put into an information campaign encouraging girls (and their parents) to choose science and mathematics, while funding for reform programmes in education was stopped. The role of education in the reproduction of gender inequality is now mentioned in policy documents in the context of the argument that education often is not compatible with girls' learning styles. No conclusive research has been done on this issue in the Netherlands, however.

We would like to argue that both the questions that were asked and the way they were investigated are at least partly responsible for the disappointing results. Firstly, in many of the studies discussed, psychological models were used in which choices and achievements are considered to be the result of the values students attach to subjects and courses and the chance they give themselves to succeed in these subjects (Fishbein & Ajzen, 1975; Eccles, 1987). The theory focuses on individuals. Educational factors are not basically incorporated in these models and as a result the methods used to look at what happens in the classroom were not adequate for finding gender-related mechanisms in the process of teaching. For example, in the research on teaching behaviour that we mentioned before, no attention was paid to the content of the interaction between teachers and students.

Secondly, we think the negative results of the research discussed has to do with another shift that has occurred in educational research on gender. The phenomena emphasised in the first studies on gender inequality in education were *mechanisms* or socialisation processes in schools that contribute to the reproduction of gender inequality. The more recent research on gender and mathematics, science and technology, however, does not look at mechanisms but at *factors* in schools and at the way these are related to characteristics of the educational careers of girls. When no statistically significant correlation is found, the factor is dismissed as 'irrelevant'. In this way only factors can be found on which schools differ or that result in differences between girls. Many of the mechanisms that were mentioned in the early studies, however, are processes that are supposed to take place in every school and that may be relevant in the socialisation of every girl. From the fact that no differences between schools are found in effectiveness for girls it should not be concluded that educational factors do not matter. For example, the message that studying mathematics is inappropriate for girls is probably implicitly conveyed in every school. If it is true that teaching methods in science are not compatible with girls' learning styles, it is then probably true of many, if not all schools.

It is striking that interest in this kind of process has disappeared from Dutch educational research on gender. We think it may be the absence of this interest that explains why research has not yielded insight into the way in which schools produce and reproduce gender inequality.

Future Directions

To conclude this article we will leave the path of deconstruction. What do we think should be done in future research to avoid the problems we mentioned above?

First of all, we think the problem of gender and education is broader than 'girls and science and technology'. There are also boys, teachers and parents, and there are other subjects in which gender differences are being produced. But of course the issue of gender and science and technology is both important and interesting. Our second point is that we think that the insights gained from feminist research may help in understanding the processes that mediate between the school factors (e.g. gender of the mathematics teacher, sex stereotypes in teaching materials) and the student factors (e.g. choices and achievement) at which mainstream educational research on gender and science usually looks.

Firstly, recent feminist research in women's studies considers femininity and masculinity as social and cultural categories that acquire meaning in historical processes (Scott, 1988; Nicholson, 1990). Showing that the gendered connotations of science and technology are historical products makes it easier to argue that the attitudes of girls do not reflect misunderstanding or prejudice, but social realities. It is also emphasised in feminist studies research that meanings of femininity and masculinity vary depending on time, place and context. Some researchers have shown that students are also confronted with different meanings of masculinity and femininity within education (Baker & Davies, 1989). For example, discourses in schools can emphasise simultaneously that all students are equal and convey messages about gender differences. Mathematics can be an important subject for all students yet at the same time not be suitable for girls.

Secondly, in line with this argument, the development of gendered identities can be described as the adoption of subject positions in different and often contradictory discourses (Walkerdine, 1989; Davies, 1989). Girls and boys actively make sense of these, a process in which previously acquired identities play an important role: social class, race etc. We think this idea can help to look inside the 'black box' that links school and class characteristics to achievements, choices and attitudes of girls. It can help to understand the mechanisms and processes taking place in schools and in classrooms that cause students to develop certain ideas about subjects and about themselves in relation to subjects. Relevant questions could be: Which subject positions do schools, teachers, textbooks and peers offer? How do students interpret these? And how are they related to the development of wishes and expectations pertaining to career and to the development of learning styles?

Summarising, we think we need to know more about the way meanings of gender and science and technology are produced, both historically and today, in educational practice and in educational theory. We also need to listen more to girls themselves. By starting from the assumption that girls are a problem, researchers have been led into looking at them as an object. They have concentrated on explaining the 'behaviour' of girls. We think that approaching girls as agents, who can be asked what they think and feel, makes more sense if we want to understand how they experience mathematics, science and technology, different ways of teaching these, and how and why they are compatible, or not, with being a girl. We think this can help to avoid falling into the trap of concluding that education does not really make a difference, and that it is only a misunderstanding of girls themselves that they do not like mathematics, science and technology.

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