

WHY DO DUTCH GIRLS DO NOT CHOOSE FOR SCIENCE AND ENGINEERING? A FOCUS ON GENDER STEREOTYPES AND A LACK OF FEMALE ROLE MODELS

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ABSTRACT

In The Netherlands, much stronger implicit and explicit gender stereotypes of science and engineering professions prevail than in other countries. Compared to 66 investigated nations, The Netherlands scores highest on gender-stereotypical images of science and engineering and lowest on influx of female students in STEM bachelors. To increase the number of students opting for science and engineering studies, many actions have been taken, one of which is the option to choose a Research and Design track at specific secondary schools (the O&O track at the Technasium schools). Although such efforts have resulted in a higher percentage of girls choosing a STEM-oriented track in secondary school, still only 27% of the girls that start a BA university program enrolls in a STEM-study. Possible reasons for this may relate to the implicit and explicit gender-stereotypical attitudes that prevail in The Netherlands and to a lack of female STEM role models. In this paper, we present the results of a qualitative interview study with pupils and teachers from Research and Design tracks at different secondary schools in The Netherlands. Results show that even in the Research and Design tracks at secondary school, pupils and teachers seem to be unaware of the importance of explicating the low influx of female STEM students and its relation to implicit gender stereotypical images and a lack of female role models. As a consequence, very few female STEM role models are provided to pupils and little conscious effort is put into countering potential gender stereotypes and stimulating girls to choose for science and engineering.

1 INTRODUCTION

1.1 Underrepresentation of women in STEM

In The Netherlands, the representation of women in science and engineering professions is low and much lower than in many other countries. International research has shown that an important reason for women's underrepresentation may be that, although we seem to have a gender-balanced culture, much stronger implicit and explicit gender stereotypical images of science and engineering professions prevail in The Netherlands than in other countries. Compared to 66 investigated nations (e.g., USA, Canada, Russia, Egypt, Australia, and Iran), The Netherlands scored highest on male gender-stereotypical perceptions of science and engineering and this correlated with the lowest influx of female students in STEM (Science, Technology, Engineering and Mathematics) bachelors [1]. According to the authors of that study, this may result in a loop effect: the high domain-specific sex segregation in The Netherlands, whereby male beta-scientists and engineers outnumber female beta-scientists and engineers nearly four to one in both educational and employment enrolment, results in a lack of positive female role models for girls, which in turn may reinforce gender-stereotypical images.

To remedy this situation, the past decade there has been intense policy action in The Netherlands to stimulate the choice of STEM subjects by secondary-school students. These efforts were partly successful. In the academic year 2018/2019, among the girls who were doing the highest level of secondary education (university preparatory education, VWO) 59% chose for an exam program that consisted of STEM subjects [2]. These girls form the prospective candidates for higher STEM education. Therefore, we would expect the increase in the popularity of the natural science & technology subject clusters at secondary school level to be reflected in the statistics of higher STEM-education. Although the percentages are growing (in 2019, 27% of all the girls who started a university program chose a beta-science or technology study path [2]), the number of girls opting for an advanced STEM higher education program is still much lower than we would expect based on the number of girls choosing a secondary school STEM program. It should also be noted that there are large differences in female enrolment between university programs. For example, of the students that started a BA program in 2018/2019 in computer science or mechanical engineering only around 13% was female, while these percentages were much higher for biomedical sciences (70%) or architecture (46%) [3].

1.2 The importance of female role models

Several international studies have shown that, in general, girls seem to lose their interest in STEM around the age of 15, but that an important way to bolster their STEM interest is to provide them with interesting and inspiring female role models (women working in STEM fields, women in STEM institutions, film or TV characters). For example, on average, across 12 European countries including The Netherlands,

41% of girls with female role models reported an interest in STEM study paths, compared to 26% of girls without female role models [4].

Although a review of the literature shows that there is a range of factors that may contribute to women's STEM choices (psychological, sociological, and educational factors), awareness and conscious countering of cultural stereotypical images is an often overlooked factor. Providing female role models and specifically stimulating girls to take up beta-technical topics may contribute to a more positive identification of girls with the STEM field [5]. Seeing a female exemplar who embodies traits compatible with how girls see themselves may engender the sense of belonging that girls need to become interested in STEM [6].

1.3 Research and Design Education

To increase the number of students opting for science and engineering studies, one action that has been taken is the option to choose a new Research and Design track at specific secondary schools. Usually, research and design projects are embedded in traditional science subjects as short-term projects. In 2004 a new initiative was launched to include a special O&O course (Dutch abbreviation for 'Onderzoeken en Ontwerpen', which means Research and Design). This track consists of research and design projects and is taught 4–6 hours a week to all grades in secondary education at so-called Technasium schools. O&O includes different fields of STEM (such as industrial engineering, ecology, etc.) and also includes non-STEM topics, it is entirely project-based and student-centered, and focuses on authentic research and design tasks, which are negotiated by real local companies and carried out in groups of students [7].

The main goals of the Technasium schools are (1) to prepare pupils for study paths and work in the beta-technical domain and (2) to stimulate pupils to develop themselves into competent designers and researchers. All pupils at the Technasium schools follow the track during their first three years of secondary school. After their third year, they can choose to continue the track until their final exams or to drop the course. Recent research showed that, in general, pupils in the O&O track reported more positive attitudes towards doing research and design activities than regular pupils. In addition, the same study showed that girls in regular schools reported significantly lower levels of perceived self-efficacy for research and design activities than boys did, but that girls who followed the O&O track reported similar levels of perceived self-efficacy as their male classmates [7]. Thus far, we do not know whether girls' increased enjoyment and perception of self-efficacy also leads to a greater intention to opt for a STEM bachelor at university level. The same study showed slightly higher future aspirations among boys and girls in the O&O track for design-related studies, but not for beta science studies and many of these girls seem to prefer to study medicine or architecture, rather than engineering, math or computer science.

One important aspect that has not been studied within the O&O schools is whether the assignments and projects specifically focus on countering cultural gender-stereotypes and providing positive female role models. Many schools seem

to think that aspirations to choose for a STEM study path will grow naturally, if pupils gain more experience and confidence in doing research and design activities. A review of the literature, however, shows that this is not necessarily the case, especially when cultural bias is strong [5]. Therefore, in the present qualitative pilot study we explored to what extent conscious effort is taken to discuss the role of women in STEM fields, whether girls receive enough female role models in the O&O track and are stimulated to choose specific beta-technical assignments, and whether the O&O teachers are aware of their role in stimulating girls in such domains. The results of this interview study may provide additional input to the discussion about the need for creating more awareness on gender-biases in STEM education.

2 METHODOLOGY

2.1 Participants

Focus group interviews were conducted with small groups of third-grade pupils (14-15 years of age) and their O&O teachers at five different Technasium schools in different parts of The Netherlands. A total of 26 pupils (16 boys and 10 girls) and 17 teachers (10 male and 7 female teachers) were interviewed by means of a structured interview format. Pupils and teachers were asked by their schools to volunteer in the interviews. In order to get a broad perspective, both male and female pupils and teachers were asked to participate. A procedure for active consent that complies with the ethical standards of the university was used. This means that teachers, parents and pupils were informed about the nature of the interviews and that they provided signed consent to participate. Teachers and pupils were interviewed anonymously; names and other personal information was not reported in the written summaries of the interviews. During their third grade, pupils need to choose whether they want to continue the O&O track and what type of exam program (STEM or non-STEM) they want to choose. Ten pupils were already sure to continue the O&O track, four were sure they would not, and twelve were not sure yet. The O&O track encompasses both STEM and non-STEM subjects and is taught by teachers from different disciplines. In our sample, nine teachers were STEM teachers (e.g., physics, biology) and eight teachers were non-STEM teachers (e.g., art, physical education, history). None of the teachers had completed a Master degree at university level, but they did complete their domain-specific Bachelor, regular teacher-trainer programs, and a special short course for O&O teaching (not a full O&O teacher-trainer program at university level).

2.2 Interviews and procedure

The present study was part of a larger study that also included interviews among pupils and teachers on higher-order thinking in O&O projects. In this paper, we only present our results on female role modeling. The types of questions in our interview format were of course slightly different for pupils and teachers, but were set up to be

able to compare the results among both groups. Each interview took about 50-60 minutes to complete and was held in a separate room in the school building during or just after regular school hours. For privacy reasons, interviews were not audio-recorded, but participants' answers were written down by the interviewers on a pre-structured form.

The interview format offered closed-end answers and opportunities for open-ended reflection and explanation of given answers. The questions focused on (1) attitude aspects (perceived importance of more women in STEM, perceived usefulness of female role models, and perceived importance of girls or female teachers to be role models or to raise awareness) and (2) on the extent to which respondents experienced deliberate focus on gender bias and female role models in O&O assignments (specific attention for women in O&O education, efforts to raise awareness for gender stereotypes in STEM fields, the occurrence of female role models or employees in the O&O assignments, the use of female exemplars through other educational materials or websites, the presence of female O&O teachers, and the occurrence of direct stimulation for girls to choose beta-technical assignments).

3 RESULTS

3.1 Pupils

Table 1 provides an overview of the closed-end answers of pupils and teachers. All pupils reported that they think it is important to have more women in STEM fields. Some pupils provided explanations that relate to the personal development of girls, such as: "Girls can be good in STEM as well", "Girls should at least try it", "It is basically men's work, but women could do it as well", or "Girls should feel that this is a possibility for them too". In addition, some societal reasons were raised, such as "Mixed groups generate better ideas" or "Women's thinking is different than men's, so this could lead to better solutions". At all schools, pupils commented that they thought that there were not enough girls in the O&O track (at one school there were 4 girls on 40 boys) and some pupils thought that girls might be reluctant to choose O&O because they might not have enough girlfriends in those classes.

None of the pupils could report specific attention for women in STEM during the O&O classes or assignments. In general, pupils observed that there were mainly male employees or clients responsible for the authentic assignments from companies.¹ Seven students reported some female company role models, but they commented that they were not necessarily related to STEM topics. Pupils predominantly reported that they doubt whether female role models would be useful in O&O assignments. Six students from the same school reported that they do think it would be useful, but other pupils commented that they think it would not

¹ This observation is in line with a quick scan that we performed on a random selection of 28 assignments from the complete database of O&O assignments (all theme groups) of the Technasium schools. Of these assignments, only one specifically mentioned a female client.

necessarily raise their interest for STEM. Half of the pupils reported having female O&O teachers, but many of those teachers were non-STEM teachers. Ten pupils (both girls and boys) reported that it was important to have girls as role models, but they commented that this was especially important for publicity at open days of the school to attract more girls to the O&O track. Sixteen pupils indicated that they never really thought about that.

None of the pupils reported that their teachers deliberately stimulated girls to take up beta-technical assignments. In addition, they did not report specific appreciation by their teachers for choosing beta-technical assignments. Some pupils commented that it was not specifically stimulated or appreciated, because they were free to choose the topics they like and that teachers' appreciation mainly concerned the way they carried out their assignments irrespective of the topic. At one school, pupils commented that the question was irrelevant for them, because they did not choose beta-technical topics anyway.

Table 1. Overview of pupils' and teachers' answers to the interview questions

	Pupils		Teachers		
	Yes	No	Yes	No	To a certain extent
Perceived importance of women choosing STEM studies and professions	26	0	8	6	3
Specific attention for women in O&O education	0	26	8	7	3
Raising awareness for gender stereotypes in STEM	-	-	2	13	2
Occasional female role models in O&O assignments	7	19	0	17	
Female examples through other educational material or websites	-	-	0	17	
Perceived usefulness of female role models in O&O assignments	6	20	12	3	2

Female O&O teachers (STEM and non-STEM)	13	13	12	5	
Perceived importance of girls or female teachers as role models or to raise awareness	10	16	13	2	2
Direct stimulation of girls to select STEM topics/assignments	0	26	2	15	
Perceived appreciation for girls' STEM choices	0	26	-	-	

3.2 Teachers

As shown in Table 1, less than half of the teachers reported that they think it is important that more women choose a STEM study path or career. Teachers in favor of this explained that this was important for girls' personal development, with similar reasons as the pupils had provided, such as "Women are equally good at STEM as men are", "Girls should keep an open mind", or "Girls should not feel reluctant to pursue a STEM career". In addition, they provided societal reasons, such as "Women bring in qualities to the STEM field that could improve things" or "There should be an even distribution of women and men in STEM, but this should also be the case in other domains, such as nursing". Teachers who did not think it was important to have more girls in STEM fields commented that prospective students can choose whatever they want, that they did not see it as their role as teachers to stimulate a certain direction, and that the O&O track encompasses all sorts of disciplines and is predominantly focused on doing research and design, irrespective of the domain.

Whereas pupils did not experience specific attention for women in STEM during the O&O classes or assignments, eight teachers did report that this was sometimes the case, but mainly when it popped up in class. Teachers were asked whether they thought they had a role in raising awareness for this issue, but only two teachers answered affirmatively. Reasons mentioned for not raising awareness were "I never really thought about that", "Pupils know this themselves, so I would only be reinforcing stereotypes", or "We think it is more important to raise awareness for the benefits of O&O in general". None of the teachers was able to specify how they deliberately created more awareness for women in STEM fields. In addition, none of the teachers could mention a specific female role model in the O&O assignments and none of the teachers ever used additional educational materials, such as specific websites targeted at women in STEM fields. The majority (12 teachers) did, however, think it would be useful if more female role models would be provided in O&O assignments. And they also (13 teachers) thought that a female STEM teacher could be a role model. Several teachers did mention, however, that they were reluctant to stipulate the issue too much, because they

thought they would be paying too much attention to stereotypes and they thought pupils would find this “irritating”.

Only two teachers reported that they deliberately stimulated girls to select beta-technical O&O topics, but as mentioned above, they did not specify how they did that. Reasons not to stimulate girls specifically were again that teachers did not want to highlight a stereotype, that they thought that they should not treat boys and girls differently, and that they wanted to comply with girls’ own interests, rather than stirring them towards certain topics.

As a last open question, teachers were asked whether they saw room for improvement, for example by altering the O&O assignments to include more female role models or to look for technical companies with a better gender balance. Some teachers responded that they never really thought about that. Some teachers mentioned that it could be possible with large technical companies that are open to the issue, while others responded that they thought it would be difficult, because they experienced difficulties finding companies with authentic assignments that they could use anyway.

4 CONCLUSION

The results of the present qualitative pilot study show that even in specific Research and Design tracks at secondary school, pupils and teachers seem to be unaware of the importance of explicating the low influx of female STEM students in The Netherlands and its relation to implicit gender stereotypical images and a lack of female role models in STEM fields. Although all pupils and half of the teachers thought it is important to have more women in STEM fields, it seems as if both groups do not see a role for themselves in this and that they think that boys and girls should feel free to choose the topics or study paths that interest them the most. Although this is of course a valuable opinion, at the same time it indicates that respondents seem to underestimate the power of implicit cultural gender biases and the positive potential of female role models to counter those biases. Several teachers specifically indicated that they did not think it would be wise to counter gender stereotypes and stimulate girls to choose for science and engineering, because they thought that this would emphasize gender stereotypes. The results have implications for the Dutch O&O tracks and for engineering education in general. Apart from making pupils more aware of their competencies in research and design, schools should also focus on implicit personal and societal attitudes towards women in STEM and on the benefits of positive female role models that may enhance girls’ identification with STEM studies and professions.

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