Exploration of Girls' Role Models: Are there Female STEM Role Models in Sight?

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Abstract: This study explores the presence and impact of female role models in Science, Engineering, Technology and Mathematics (STEM) education due to the underrepresentation of girls in STEM fields. The objective is to assess girls' role models, particularly the role they play in their interest and in a career choice in STEM. A survey was distributed through an online panel and 546 valid answers from girls aged 14-20 in Germany were received. The analysis links to social cognitive theory and revealed that immediate family members (50,1%), musicians, actors and artists (12,4%), and media influencers (9,6%) were the top role model categories. Male role models dominated in teachers, entrepreneurs, and friends, while female role models were prominent in the family category. Female scientists and entrepreneurs who could serve as STEM role models, were found to be underrepresented. The study also showed that girls with STEM occupational role models in their immediate surroundings were more likely to have an interest in STEM subjects.

Keywords: Women in STEM, Role Model, Career Choice, Inspiration

1. Introduction

People working in Science, Engineering, Technology and Mathematics (STEM) are regarded as sources of innovation, competitiveness, productivity, and economic growth in their countries (Grigg et al., 2018) and it is vital to foster STEM-related occupations in the labor market (Jiang et al., 2023). Yet, the female STEM workforce is severely underrepresented, and girls and women are less likely to choose a STEM career path (Verdugo-Castro et al. 2022). Researchers have noted that upon entry to primary school, girls exhibit similar mathematical abilities to their male peers. However, girls' attraction towards mathematics and the sciences tends to diminish as they progress through the education system (Happe et al., 2021; Cheng et al., 2017). Female students tend to pursue advanced coursework in mathematics and science less frequently than their male peers in secondary school. This trend ultimately leads to a dearth of women in certain STEM fields, particularly in the hard sciences disciplines such as engineering and computer science (Hess et al., 2023; Beede et al., 2011).

The study of Aronson et al. (2001) indicated that student`s stereotypes can be reduced through attitude adjustment intervention in the context of African American students. González-Pérez et al. (2020) show that females with STEM careers who speak in school as part of a role model intervention have a favorable and substantial effect on math enjoyment, math significance, math expectations of success, and girls' STEM ambitions, but a negative effect on gender stereotypes e.g. that "girls have lower interest in computer science and engineering" than boys (Master et al., 2021, p. 1). Role models are persons who the girls want to imitate as "standard of excellence" (Lewis and Robinson , 2003, p. 14).

This study is driven by the pressing need to investigate the drivers of interest in STEM careers, particularly in girls' careers. The aim of the study is to explore girls' role models and more particular, to assess the role of STEM occupational role models.

2. Literature Review

The under-representation of girls in STEM fields has received considerable research attention and still continues among European countries (BMBF 2020). Also in the USA, parents, teachers, and peers convey views and attitudes about STEM, impacting girls' perspectives (Eccles, 2015; Raabe, 2009). In Finland, girls are discouraged from pursuing STEM areas during childhood and teenage years owing to gender stereotypes, parental expectations, peer pressures, and a perceived mismatch with their personal aspirations (Kaleva et al., 2019). Parents', instructors', and classmates' views, behaviors, perceptions, and attitudes toward STEM can be conveyed, either implicitly or overtly, impacting girls' attitudes toward STEM in the USA (Eccles, 2015; Raabe, 2009) and in Germany (Steffen et al., 2023). Eccles (2015) concludes that exploring gender disparities in parental attitudes and actions is particularly enlightening in uncovering the development of gender bias within STEM careers, even when girls and boys perform equally well in math and science during their school years. A recent investigation from China also highlights the influential role of role models in enhancing students' academic

performance by fostering higher aspirations (Golan and You, 2021). A role model is defined in this article as "a person considered as a standard of excellence to be imitated" as proposed by Lewis and Robinson (2003, p. 14).

STEM stereotypes can be transmitted by role models. Television and film, for example, frequently portray scientists and engineers in stereotypical ways (for example, CBS's television show The Big Bang Theory). Evidence from the USA shows that exposure to these stereotypes is particularly harmful for women (Cheryan et al., 2011). In particular, the findings of Cheryan et al. (2011) showed that women's interest in computer science suffered both an immediate and long-lasting setback when they were exposed to a stereotypical role model e.g., portrayed as a nerd character. When women interacted with the stereotypical role model in computer science, their sense of belonging in the field diminished, mediating differences in interest at both times. A more typical and also familiar person who acts as a role model is thus believed to increase girl`s interest in STEM. Positively perceived STEM role models might subsequently get girls more motivated to become interested in computer science, just like their male classmates. In this process, role models are important for student`s inspiration. Golan and You (2021) found in a field experiment in China that role models can impact student`s school performance by increasing ambitions. The occupation type of parents influences student's STEM long-term outcomes in early adulthood, including STEM degree completion and STEM employment. Therefore, parental growth mindset, along with any role modelling effect transmitted through their work, appears to have an independent influence on student outcomes (Cheng et al., 2017). Furthermore, the analysis of Drury et al. (2011) suggests that increasing women's perceived likeness to role models is important for both recruiting and keeping women in STEM disciplines. Both studies have been conducted in the USA. The discussion above with examples from Western countries and China shows that the girls' underrepresentation in STEM fields and STEM stereotypes are transmitted in many different countries.

Currently, more males work in STEM jobs than females. Due to the underrepresentation of females in STEM jobs, girls are less likely to report a female occupational role model in their immediate surroundings of family and friends. Thus, the following hypothesis is formulated:

> **Hypothesis 1:** *Girls are more likely to report male STEM-related occupational role models (e.g. father, uncle, male friend) than female STEM-related occupational role models (e.g. mother, aunt, other relative, female friend).*

Role models are very important in demonstrating desirable capabilities (Lewis and Robinson, 2003). A family member or friend with a STEM related occupation is perceived to increase interest in STEM because these role models demonstrate desired skills. This relationship links to social cognitive theory. Social cognitive theory indicates that role models may increase students' self-efficacy through perceived competence, perceived likeness and perceived attainability of the role model (Gladstone and Cimpian, 2021). To test whether STEM occupational role models are related to girl`s STEM interest, the following hypothesis is formulated:

> **Hypothesis 2:** *Girls who have a STEM related occupational role model in their lives (e.g., STEM occupation of mother, father, aunt, uncle, friend etc.) are more likely to have an interest in STEM than girls who do not have a STEM related occupational role model in their lives.*

The study objective is to assess girls' role models, particularly the role they play in their interest and in a career choice in STEM, using a quantitative survey.

3. Methodology

A quantitative survey was distributed in a youth panel by a reputable market research company in Germany. The survey asked closed questions about general interest in STEM subjects, it investigated life values, the girl`s subject preferences, perceptions about STEM jobs and whether or not the girls have people in their immediate surroundings (like family and friends) who work in STEM and could potentially act as role models. The quantitative analysis was done using SPSS. Descriptive statistics and chi-square tests were used to assess independence between variables.

Additionally, the survey contained open questions about the girl`s role models. Girls reported who their role model is and how they first heard of this role model. The overall sample size of the survey was 777 girls who were between 15-20 years. All participants were officially registered at the market research panel so that no ethical concerns about surveying minors occurred. They were randomly selected by the panel provider and invited to participate via email. 546 provided a valid comment about their role models. A common procedure in the analysis of qualitative studies is to code the data, construct typologies and to analyze the content in a more detailed analysis (Taylor et al. 2016, p. 161). Accordingly, the open answers were coded into role model

categories one after the other in an iterative process of several loops until no more new categories emerged. All role models which were unknown to the authors, were looked up in a search engine. After reading up on the person, the role model was placed into the appropriate category for further analysis.

Table 1 describes the sample in more detail. The age distribution is mixed with more girls who have progressed further in their grade level. The sample contains some students aged 16 or below, but most girls are above 16.

Table 1: Sample description

Sample description	Characteristic	No.	%	Total N
School Class / Grade	7 or below	2	0,3%	**757**
	8	28	3,7%	
	9	59	7,8%	
	10	99	13,1%	
	11	141	18,6%	
	12	227	30,0%	
	13	201	26,6%	
Age	16 or younger	178	23,4%	**762**
	17	114	15,0%	
	18	223	29,3%	
	19	111	14,6%	
	20 or older	136	17,8%	
desired school-leaving qualification	Secondary school leaving certificate	71	9,3%	**760**
	University entrance qualification	58	7,6%	
	A-levels / High school diploma	631	83%	

The high number of students who desire A-Levels as school-leaving qualification probably stems from the fact that many of the students in the sample are 18, 19 or 20 years old. These students have already passed 10th grade and have already received their secondary school leaving certificate and are aiming to receive a higher qualification. The number is thus not unusually high when surveying older students.

4. Analysis of Role Models

4.1 Analysis of Girls' Role Models Based on the Open Question

When asking girls openly who their role model is, 136 noted that they have no role model. 15 girls noted that they themselves are their role models and these were excluded because this is impossible by definition. The 410 mentioned role models were categorized inductively into 8 different categories. The three largest categories of role models include immediate 'family members and friends' 48,5%, 'musician, actors and artists' with 12,0 % and `people and shows in the media (including influencers) with 9,6% of all entries.

Table 2: Role model categories

	Role model category	Role model category description	No. female	No. male	No. thing /neutral/ numerous	Total No (%)
1	Media / Influencer	This category includes media e.g., TV shows, influencers, internet stars and models.	14 (36,8%)	12 (31,6%)	12 (31,6%)	**38** (9,6%)
2	Teachers	This category includes schoolteachers.	4 (13,3%)	7 (23,3%)	19 (63,3%)	**30** (7,6%)
3	Science (*)	This category includes scientists.	6 (28,6%)	12 (57,1%) *	3 (14,3%)	**21** (5,3%)
4	Entrepreneurs and successful people (*)	This category includes entrepreneurs, companies, and successful people (e.g., in positions high up the firm hierarchy) and people who are perceived as happy with their live.	3 (12,0%)	9 (36,0%) *	13 (52 %)	**25** (6,3%)
5	Musicians, actors, artists (*)	This category includes musicians, actors and film characters, writers, book authors and artists.	26 (53,1%) *	19 (38,8%)	4 (8,2%)	**49** (12,4%)
6	Family and Friends	This category includes family members, friends, acquaintances, and sports team members.	75 (37,9%)	53 (26,8%)	70 (35,3%)	**198** (50,1%)

7	Occupational groups	This category includes occupational groups e.g., medical doctors, politicians, and athletes.	6 (30,0%)	6 (30,0%)	8 (40,0%)	**20** (5,1%)
8	Other	This category includes a variety of role models e.g., religious role models and those which don`t belong to any other category.	5 (35,7,0%)	2 (14,3%)	7 (50,0%)	**14** (3,5%)
	Total (percentage)		**139 (35,2%)**	**120 (30,4%)**	**136 (34,4%)**	**395 (100%)**

'* A Chi-Square test revealed significant difference in the distribution between male and female numbers at p< .05 for the categories 'science', 'entrepreneurs and successful people' and 'musicians, actors and artists'.

Table 2 shows all extracted role model categories and the category descriptions. Students named more female (35,2%) than male (30,4%) role models overall. The role model categories are explained in more detail in the following paragraphs.

4.1.1 Media Influencers

28 different media and media influencers were mentioned in this category. Examples are Pamela Reif (N=3), social media general (N=3), influencers in general (N=2), Daniel Jung (N=2), Ramona (N=2) and many individuals who were only mentioned once. The Chi-Square tests did not reveal statistically significant differences between the number of reported males, females and things (e.g. like a reported series).

4.1.2 Teachers

This category comprises of teachers as role models. All reported role models either included particular teachers e.g. 'my chemistry teacher' or teachers in general like 'my teachers´. The German language allows for a differentiation of the gender (e.g. Lehrerin (female) vs. Lehrer (male)), so that it was possible to note the genders as well. If 'teachers' in general were reported, a neutral gender was counted. Overall, more male than female teachers were reported to be role models but the Chi-Square test was not significant at p<0.05.

4.1.3 Science

The most often reported scientist who serves as a role model was Albert Einstein (N=7) which represents 33,3% of answers in this category and besides the parents (mother or father) the most often individual stated overall. Marie Curie (N=4), Stephen Hawkings (N=3), Jane Godall (N= 2) and Marc Robert Lehmann (N=2) were mentioned by name as well. Some gender-neutral role models like "scientists" were also mentioned. Of all 408 role models that were mentioned in the whole data set, only 6 role models were female scientists (1,5%). Overall, the category `Science` only represents 1,5% of all reported role models. A chi-square test reveals that the actual number of reported scientists is higher for males (N=12) than for females (N=6), (χ^2 = ,048).

4.1.4 Entrepreneurs and Successful People

This category includes entrepreneurs or successful people of general public interest who were explicitly mentioned (e.g., Elon Musk (N=5), Michele Obama (N=1)). It furthermore includes reported role models of people that are successful or happy ('people who are happy`, 'people who live their dream` or have a high position in a firm (e.g., 'my boss`, 'my supervisor'). There are no statistically significant differences between female and male role models in this group. In total, 6,1% of role models fall into this category. For 'Entrepreneurs and successful people" also more males were mentioned (N=9) than females (N=3), (χ^2 = ,028) but the category size is too small for valid results.

4.1.5 Musicians, Actors, Artists

12,4% of role models fall into this category. Included in this category are musician, actors, film characters, writers and artists. Examples include Shirin Davin (3), Emma Watson (3) or BTS (3) which is a Koreen boy band. A chi-square test reveals that the number of female role models (N=26) is higher than males (N=19), (χ^2 = ,045).

4.1.6 Family and Friends

Family and friends represent almost half of all reported role models (48,5%), whereas 169 of the 198 reported role models are family members e.g., mother, father, aunt, uncle, sister, brother etc. and the rest are acquaintances (e.g., school friend or a member of the same sport team). Overall, more female role models

(N=75) than male role models (N=53) were reported in this category. If more than one role model e.g. both parents were mentioned, the `numerous ´category (N=70) was chosen. The gender difference (chi-square) test between reported male and female role model was not significant at p<0.05.

4.1.7 Occupational Groups

With 20 reported role models (4,9%) overall, this is the smallest role model category. Medical doctors for humans or for animals were mentioned most often (N=4), followed by different individuals like 'Rosa Parks', politicians or athletes were all mentioned only once. The Chi-Square test did not reveal gender differences.

4.1.8 Other

The `Other` category is also a relatively small category with 3,5% of all reported role models. It includes all reported role models, which do not fit into any of the other categories. The reported role models include e.g., 'my religion`, `Jesus Christ', `every person` or 'a lot of people'.

To conclude, the chi-square tests revealed significant difference in the distribution between male and female role models at p < .05 for the categories 'Science', 'Entrepreneurs and successful people' and 'musicians, actors and artists' category. The gender distribution of the reported role models was as follows: female (35,2%), male (30,4%), several people e.g. medical staff or teachers, and 34,4% reported items or aspects without a gender (e.g. her religion). Male role models dominate in the following categories: 'teachers' and 'entrepreneurs', whereas female role models dominate in the category family and friends. The gender difference is not statistically significant at p < .05. Family (particularly the parents) and friends dominated as single responses.

Female scientists were clearly underrepresented in the answers with 1,5% of all role models mentioned. Whereas girls mentioned Elon Musk, Albert Einstein, or Stephen Hawkings, only very few female role models were mentioned overall. Among the few STEM-related role models were only Jane Goodall and Marie Curie who were both mentioned once and twice, respectively. In addition, there were a few comments on the girls' female teachers. The males which were mentioned most often besides family and friends were Albert Einstein (6 times) and Elon Musk (5 times). The females which had the highest frequency overall were Marie Curie (3 times), actresses Zendaya (3 times) and Emma Watson (3 times).

In addition to asking girls about role models, the survey also assessed whether the girls have STEM-related occupational role models (STEM ORM) in their immediate surroundings. The analysis of these answers is shown in the next section.

4.2 STEM Occupational Role Model in the Girl`s Immediate Surroundings

Girls were asked whether they know someone who works in the STEM field, i.e., math, computer science, natural sciences or technology (e.g. software developer, biologist, engineer, etc.) in a multiple response set. Overall, in the sample of 777 girls, 472 (65,8%) reported to have a STEM ORM, whereas 244 (34,1%) do not have a STEM ORM.

Out of those girls who reported a STEM ORM, girls reported predominantly male family members and friends who work in STEM jobs, e.g., father (N=124, 26,3%), grandpa (N=33, 7,0%), other male relative (N=213, 45,13%) and a male friend (N=128, 27,1%). In contrast, fewer females were reported in all categories: mother (N=39, 8,3%), grandma (N=20, 4,2%), other female relative (N=104, 22,0%) and a female friend (N=71, 15,0%).

The distribution of STEM occupational role models by gender is summarized in Table 3.

Table 3: STEM Occupational Role Models by gender

		N	Valid %
Valid	Female STEM ORM	79	11,0
	Male STEM ORM	281	39,2
	Female and Male STEM ORM	112	15,6
	Sum of girls with a STEM ORM	472	65,9
	No relative or friend as STEM ORM	244	34,1
	Sum	716	
Missing		61	
Total		**777**	**100,0**

Approximately one third (34,1%) of girls do not have a STEM ORM. On the contrary, 65,9% of the girls have a STEM ORM. Of those who reported a STEM ORM, 16,7% of the girls have a female STEM ORM, 59,5% have a male STEM ORM and 23,7% have STEM ORM of both genders in their family or circle of friends.

A chi-square test of independence was performed to examine the relation between gender and girl's occupational role model across all categories. The relation between these variables was significant, $X2$ (3, N = 716) = 162.670, $p < .001$. There is a STEM-related difference in the distribution of role model categories. A second chi-square test of independence was performed to just compare the female (N=79) and male (N=281) STEM ORM. There is a significant relationship between gender and STEM occupational role model. Girls are more likely to report male STEM ORMs than female STEM ORMs, $X2$ (1, N = 360) = 113.344, $p < .001$.

Hypothesis 1 is thus supported. Yet, the large number of girls with both a female and a male STEM ORM suggests that the girls have a more neutral stance than these results suggest at first sight.

Table 4: Interest in STEM by STEM Occupational Role Models (STEM ORM)

	Personal interest in STEM					
	Yes		No		Total	
	N	%	N	%	N	%
Female STEM ORM	64	12,5%	15	7,4%	79	11,0%
Male STEM ORM	209	40,8%	72	35,3%	281	39,2%
Female and Male STEM ORM	94	18,4%	18	8,8%	112	15,6%
Sum STEM ORM	**367**	**71,7%**	**105**	**51,5%**	**472**	65,8%
No relative or friend as STEM ORM	145	28,3%	99	48,5%	244	34,1%
Total	**512**	**100,0%**	**204**	**100,0%**	**716**	**100,0%**

Overall, 512 (71,5%) of girls report a general interest in STEM-related topics compared to 204 (28,5%) of the girls who are not interested in STEM-related topics (see Table 4). When combining interest with occupational role models it becomes evident that of those girls who are interested in STEM subjects, 40,8 % have a male STEM ORM, 12,5% a female STEM ORM, 18,4% both female and male STEM ORMs. 28,3% have no STEM ORM role model. Of those girls with interest in STEM subjects, 28,3% have no STEM ORM. In comparison, of those girls who are not interested in STEM related subjects 48,5% do not have a STEM ORM.

The results of a chi-square test of independence show that the relation between these variables was significant. The pooled test of either having a STEM ORM or not $X2$ (1, N = 26,52), $p < .001$ was significant. The two variables interest in STEM subjects and STEM ORM are not independent from each other. Hypothesis 2 can thus be supported. 71,7% of girls who have a STEM occupational role model have an interest in STEM subjects. In contrast of those who are not interested in STEM subjects, only 51,5% have a STEM ORM.

5. Discussion and Conclusion

The result of the analysis shows that many girls have role models and that girls seem to have more female role models than male role models. In the open answers, very few scientists are reported overall. Many of these are male and only 1,5% of all reported role models were female scientists. To answer the title question: There are only very few STEM-related female role models in sight. Also in the entrepreneur category, only very few female role models were identified. The role model category which girls most frequently reported are 'family and friends' with a large proportion of 48,5%. Family and friends are the most common role models for the girls. 'Musicians, actors, artists' and 'media / influencers' as categories were the second and third largest role model categories. Girls seem to spend much time with the media and heavily identify with the people and shows. This identification with e.g. an actress or social media influencer seems much stronger when looking at the number of girls who reported in the categories than with entrepreneurs and scientists. It seems as being a social media star, an actor or a musician is more appealing to girls than to become an entrepreneur or scientist. Strikingly, many girls had no role model at all, which creates an interesting future opportunity for parents and educators to exert influence on girls.

Still, due to the underrepresentation of females in STEM jobs, more males work in STEM subjects in the girls' immediate surroundings. Thus, girls report fewer female STEM occupational role models than males. It seems, as if girls lack female STEM occupations role models. This finding is even more severe when considering that almost half of the girls report family and friends as role models in the open answers. The girls have role models in their family, many of which – and particularly the females – do not serve as STEM occupational role models.

The study therefore indicates that there is still an underrepresentation of females in STEM subjects. Particularly well-known but also familiar role models are lacking. Only 6 girls named a female scientist as their role model. Overall, the scientist category (male and female) accounted for 5,5% of all reported role models only. Therefore, scientists should have greater visibility on the internet, in TV shows and in media in general so that girls' awareness of scientists as role models increases overall. Female students could acquire a genuine and gender-specific impression about their later career choices and incorporate the field of computer science more strongly if they are exposed to a variety of computer science activities at an early age, such as software development, data analysis, artificial intelligence, human-computer interaction, or cybersecurity. Exposure to various STEM fields and career options could help to decrease the girls "leaking pipeline" which typically starts at the age of 12 years (Speer 2023; Sáinz and Eccles, 2011). Yet, it needs to be addressed that boys also don`t consider IT jobs and the negative connotation with "nerds" or "geeks" as cool but males are more often represented in IT jobs in the media (Thomas and Ellen, 2006). Other research shows that the word "geek" has lost its negative stigmatism a bit and can be seen more neutral. It would be wonderful if talented and STEM-gifted kids could live without the negatively perceived stereotypes in the future (Cross, 2005).

In addition, schools should perhaps emphasize STEM role models more- no matter which gender they have- in their curriculum overall. Students should learn particularly about female scientists in school so that awareness amongst them rises. Steffen et al., (2023) found that teachers have the strongest influence to create either positive or negative incidents that affect the girls' attitude about STEM in general in their class. The personality and motivation of the teachers show more than twice as many negative incidents as a trigger category. Teachers thus serve as important role models themselves or as mediators for accelerating STEM image amongst girls. Research has indicated that teachers, acting as role models, can enhance students' academic performance by fostering their self-integrity (Aronson, Fried, & Good, 2002). However, there has also been concern about the overrepresentation of female teachers in the educational system and that boys learning styles are ignored (Tarrant et al., 2015). The research of Cushman (2008) suggests that there should be more role models in young boys' lives as well. Tarrant et al. (2015) call for an open approach in role model research and diversity, and perhaps even a gender fluid approach amongst those people who are expected to be role models.

The main limitation of the study is the sample composition. Some of the categories were very small with only a hand full of reported role models. Thus, the validity of the gender comparison tests needs to be questioned for small categories. In addition, the sample consisted of older girls who have progressed far in their school grade. Many of the girls have already lost interest in STEM occupations at the age of approximately 12 years (Sáinz and Eccles, 2011). Due to the older sample, the number of girls pursuing an A-level degree is high. Because these girls aim for a degree and are potentially interested in studying at a university, the number of girls who have an interest in STEM subjects is higher than in a younger sample. A limitation of the study is thus that younger and older girls cannot be compared. As a result, the findings cannot be generalized to the girl student population in Germany. A more representative study would be necessary to do so. Another limitation is that 15 role models had to be deleted because the girls reported themselves to be their role models. Since, a role model is someone a person imitates, it was necessary to delete these entries.

Future research could investigate younger girls' role models to see whether or not younger girls have more science-related role models. These results could be compared to boy`s role models of the same age. In addition, the role of family and friends as occupational role models should be investigated further. The strength of their influence of choosing a career in STEM could be evaluated.

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