Empowering women in STEM: A scoping review of interventions with role models

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Abstract

Exposing women and girls to female role models is considered essential to break down gender-stereotypical beliefs on STEM interest and engagement. However, evidence remains controversial regarding the efficacy of these interventions. Here, we provide a scoping review of fifty-seven empirical studies that considers information about: (1) research type, (2) target, (3) type of intervention, (4) role models' characteristics, (5) variables of interest and (6) effects of the study. Our findings show that research is considerably heterogeneous in terms of role models, interventions, variables of interest and effects. Role models are frequently female STEM professionals or a mixed-gender group of STEM workers. Interventions mainly consist of asking participants to read a brief article about the role model and the effect of being exposed to a role model is mostly tested on participants' characteristics, e.g. attitudes toward STEM and performance. This heterogeneity comes at a price, i.e. it is difficult to understand the effectiveness of role models' exposure. Future research should focus on whether and how the heterogeneous characteristics of role models influence the efficacy of these interventions.

I. Introduction

In 2019, 9.9 million American workers were employed in Science, Technology, Engineering and Mathematics (STEM), accounting for 6% of the total U.S. workforce. This sector is constantly expanding and jobs are expected to grow by 8% between 2019 and 2029 (U.S. Bureau of Labor Statistics, 2021). However, STEM education is attracting mostly men, with women largely still underrepresented (Alam and Sanchez Tapia, 2020).

Among the most important factors for the existence and persistence of this gender gap, there is people's endorsement of gender stereotypes associating the STEM domain with men (Nosek et al., 2002). As claimed by Eagly and Wood (2012), the underrepresentation of women in STEM-related jobs determines people's gendered attribution of characteristics and roles. Once internalised, this

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attribution favours the endorsement of gender stereotypes, for instance, the fact that STEM would be a masculine sector and men would possess higher abilities in math-related tasks (Papastergiou, 2008; Plante et al., 2009).

As highlighted in a report drawn up by UNESCO (2017), female participation in STEM can be influenced by many factors and one in particular – the exposure to role models – seems to be especially effective in reducing gender inequality. This consists of providing girls and women with female positive examples, usually successfully employed in STEM sectors.

The exposure to female STEM professionals would be beneficial in two ways. On the one hand, these exemplars would expand women's horizons by showing pathways never previously perceived as being viable (Morgenroth et al., 2015). On the other hand, they would challenge the stereotypical association of men with STEM (Dasgupta and Greenwald, 2001).

Indeed, given that gender stereotypes reflect the unequal representation of women in STEM professions (Eagly and Steffen, 1984), seeing female STEM workers would counteract entrenched stereotypes. For instance, Miller et al. (2015) showed that in countries where female participation in tertiary education in science was higher, there were weakest implicit and explicit gender-science stereotypes.

However, the efficacy of these interventions is still controversial. Only a few studies provided a comprehensive overview of studies on the effect of role models on female engagement in STEM (Olsson and Martiny, 2018; Prieto-Rodriguez et al., 2020). To fill this gap, our review followed a systematic methodology to summarise studies measuring the effect of role models addressing women in STEM fields.

II. Background

Several studies have tried to identify the root-causes of the STEM gender gap, with explanations ranging from individual characteristics to environmental aspects. Some of these focused on the pervasive presence of gender-science stereotypes, i.e. the belief that women and men would differ in their mathematical and scientific abilities, with men traditionally considered outperforming women in STEM (Nosek et al., 2002). Research on gender-science stereotypes suggested that these influence females' performance in scientific tasks, self-concept and attitudes toward math (Cvencek et al., 2015; Nosek et al., 2002; Nosek and Smyth, 2011). Evidence indicates that they can also affect choices and behaviour, e.g. career aspirations (Schuster and Martiny, 2017; Steffens et al., 2010).

According to the 'social role theory' (Eagly and Wood, 2012), these stereotypical beliefs would derive from the perception of women and men in different social roles and occupations. In the context of STEM, observing men more frequently as STEM professionals would induce to infer a sector-gender association, which in turn would influence women's experience in this sector. Therefore, observing female STEM professionals could break this association. A popular way to do this is to expose young women to positive exemplars, usually referred to as 'role models'.

Role models are defined as people who show others: (1) how to perform a skill and achieve a goal – behaviour; (2) that a goal is attainable – representation of the possible; (3) that a goal is desirable – inspiration (Morgenroth et al., 2015). Different initiatives have been undertaken to favour female empowerment in STEM via role models, although with mixed effects. Some studies have found a positive effect, others a negative one and some no effect at all. Furthermore, the effectiveness of role models also varies depending on both the context in which the exposure is tested and the characteristics of role models.

When assigned to a female experimenter, presented as highly competent in math, female undergraduates performed better in a math test compared to those assigned to a female experimenter described as not competent (Marx and Roman, 2002). After a one-hour visit of a female scientist, female high-school students showed weaker stereotypical beliefs on gender and STEM and were more likely to apply and be admitted to a selective science major in college (Breda et al., 2020). Cheryan et al. (2011) engaged female undergraduates in interacting with senior students majoring in computer science, who shared information on their major and personal life. They manipulated role models' perception as 'nerds' through hobbies and clothes. Students who interacted with a woman embodying computer science stereotypes were less interested in majoring in computer science and, moreover, showed a weaker sense of belongingness to the field, compared to those who interacted with a 'neutral' woman. Surprisingly, interacting with a 'neutral' man was more effective in increasing students' interest than interacting with a stereotypical woman.

Given this heterogeneity in findings and types of interventions, the current debate on the efficacy of role models on the STEM gender gap would benefit from an exhaustive summary of studies on the theme. However, few reviews exist that unfortunately do not fulfil this purpose.

Lenton et al. (2009) conducted a meta-analysis of interventions aimed at reducing automatic gender stereotypes, including – but not limited to – the exposure to female role models. Similarly, Lawner et al. (2019) conducted a meta-analysis on the effect of in-group role models on performance and interest in STEM of students belonging to an under-represented social group. However, they included only studies on which they could measure the effect size of the interventions on interest and performance in STEM and targeted at all students belonging to a social group underrepresented in STEM. This implies that only two variables were actually investigated and the population also included minority groups other than women.

Olsson and Martiny (2018) published an overview of research-based interventions, in which girls and women observed and interacted with counter-stereotypical role models. Unfortunately, as acknowledged by the authors themselves, this review lacked a systematic approach. Finally, Prieto-Rodriguez et al. (2020) presented a systematic review of studies on STEM interventions targeted at girls. However, their review included also interventions not involving role models and was restricted to studies on female students in secondary school.

To fill this gap, our review summarises studies measuring the effect of role models addressing women in STEM areas. In particular, we extracted information about (1) research type, (2) target, (3) type of intervention, (4) role models' characteristics, (5) variables of interest and (6) effects of the study.

III. Methods

We followed the guidelines of the JBI Manual for Evidence Synthesis (Peters et al., 2020). We, first, developed an a priori research protocol, by defining research questions, inclusion and exclusion criteria, search strategy and data sources. From March to April 2021, we selected the studies using four online databases (i.e. PsycInfo, Web of Science, Proquest and Scopus) and citation searching.

Starting from the search strategy in Lawner et al. (2019), we established the combination of search terms by including also a string on gender. We also tested whether the search strategy would have benefited from the inclusion of other relevant terms referring to exposure, stereotypes and influence. Since these additional strings drastically reduced the number of sources and excluded relevant studies from the review, we set the final combination to include three strings: role models, gender and STEM (see Table A1 in the Supplementary Material).

We merged results from the first screening into all four databases and removed any duplicates. Title, abstract and full-text screening were conducted by two authors of this paper independently and based on the criteria established a priori in the research protocol, reported in Table 1. Any disagreement was resolved upon consensus.

Table 1: *Inclusion and exclusion criteria*

	Inclusion criteria	Exclusion criteria
Participants	All age groups and gender/sex	
Concept	Exposure to typical and/or atypical role models in the STEM context (atypical= female in STEM, male in non-STEM; typical=female in non-STEM, male in STEM); Role models should be unknown	Role models known before the intervention, e.g. teachers, professors, family members; Mentors
Context	Addressing gender stereotypes on STEM	Not addressing stereotypes or non-STEM context
Type of studies	All (include also grey literature)	Published in languages other than English

We established non-restrictive inclusion criteria, especially on the outcome of interest and type of intervention to explore the literature widely. However, two characteristics were particularly relevant, i.e. unfamiliar or unacquainted role models and interventions addressing the underrepresentation of women in STEM. This review aims to inform future interventions targeting this issue via exposure to role models. This required gaining information on interventions that could potentially be replicated elsewhere and with various samples. While parents, peers and teachers can serve as role models, they cannot be part of short-term, replicable, exogenous interventions. This led us to exclude research that examined the effect of these types of role models.

The data extraction from all included sources focused on six information: i.e. research type, target, type of intervention, role models' characteristics, variables of interest and effects of the study. For each factor, we extracted information from each study and compared them to find similarities and differences. Based on this comparison, we then grouped those who had similar characteristics together. The results section reports these categorisations for each factor.

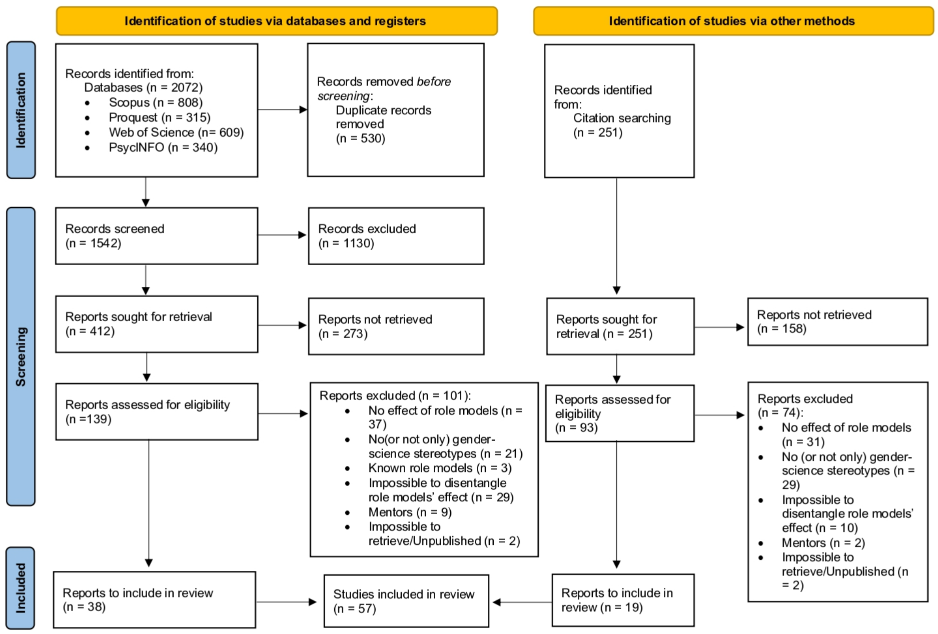
IV. Results

The database search returned 2,072 references, of which 530 were removed before screening because duplicated. We then screened the titles of 1542 studies and the abstract of 412 studies after the title's screening. 139 studies eventually resulted eligible from the abstract screening while 38 of these passed the full-text screening and were finally included in the review. The screening of the included studies' references identified 251 potentially relevant studies. Of these, 19 were eligible and were included in the review, for a total of 57 articles, published between 1981 and April 2021.

i. Research type

Regarding the research type, most studies adopted a quantitative approach (86%), mainly experimental, whereas the remaining studies adopted either a qualitative (5%) or a mixed (9%) approach.

Figure 1: *PRISMA 2020 flow diagram*



ii. Target

Regarding the study target, the sample mostly consisted of students of various ages. Half of the studies targeted students aged 19 or below, while the other half were addressed to undergraduate and graduate students. Only in six studies, was the sample taken online from Amazon Turk and so varied in age, from 18 to 60 years old. Regarding nationality, 81% of studies were conducted on individuals from the United States, 7% from France and 4% from Canada, with small samples from other countries. 47% of studies targeted only females, while 53% both males and females.

iii. Role models' characteristics

Role models were usually STEM professionals, either from the academic sector or the private sector. In some cases, they were peers at an advanced stage of their studies. For instance, for undergraduate students, the role model could be a senior student in college (Howard, 2015) or one attending an upper-division major (Nickerson et al., 2017). For students in high school or below, role models were college students (Breda et al., 2020; Evans et al., 1995; Merritt et al., 2021).

Participants were exposed either only to women (49%) or both women and men. Only in one study (Pietri et al., 2021a), the role model was a man. There was heterogeneity also in terms of the number of models presented. In 46% of studies, participants were exposed only to one role model, whereas in the other cases, they were exposed to more than one.

iv. Interventions

It was rare to find two or more studies investigating the effects of the same intervention, although they did share certain commonalities. We classified them based on three characteristics, i.e. the type of activity proposed, the location in which the intervention took place and its duration. Table 2 shows the number of studies for each category. We identified nine types of interventions, based on the type of activity required to participants and how and to what extent they were exposed to role models.

Table 2: *Interventions' characteristics*

Intervention	Number of studies
Type	
Reading biographies, essays, or articles	24 (42%)
Watching a video	15 (26%)
Listening to and interacting with keynote speakers	12 (21%)
Attending a workshop	6 (9%)
Visit job site guided by the worker	2 (4%)
Seeing and listening to the experimenter	2 (4%)
Playing a game with a virtual mentor	1 (2%)
Seeing the image of a character in the exercise sheet	1 (2%)
Location	
School	25 (44%)
Laboratory	20 (35%)
Online	6 (11%)
Conference/workshop	5 (9%)
Summer camp	1 (2%)
Duration	
Less than 1 hour	12 (21%)
1 to 3 hours	26 (46%)
1 to 2 days	8 (14%)
1 month or less	3 (5%)
1-6 months 5 (9%)	
More than 6 months	3 (5%)

In most studies, participants did not meet the role models in person and could, thus, not interact with them. In these cases, they were either asked to read something about the role model, e.g. an interview (Betz and Sekaquaptewa, 2012) or a biography (Hoffman and Kurtz-Costes, 2019), or to watch a video. In these last cases, the content of the video greatly varied: it could be an interview (Pietri et al., 2021b) a lesson on STEM contents (Good et al., 2010), a movie with a female leading character (Ziegler and Stoeger, 2008), footage of women and men interacting (e.g. Van Loo and Rydell, 2014) or a commercial (e.g. Lamers and Mason, 2018).

In other cases, participants met the role models and could, thus, interact with them, e.g. when role models were invited to talk in class, during a workshop (O'Brien et al., 2017) or in a guided visit to the role model's job site (e.g. Bamberger, 2014).

Finally, two interventions stood out, as they were applied only in one study. These are: Morin-Messabel et al. (2017), who exposed participants only to images of the role models, printed on the top of the task sheet; Cherchiglia (2019) who proposed a virtual agent as a role model who then accompanied students while playing an online STEM game.

These interventions usually took place either in participants' schools or in a laboratory and they were very brief. Only in a few cases, they lasted more than a couple of hours. For instance, talks with speakers usually lasted from one to three hours but could be repeated for a month or so, whereas workshops and conferences could last one or two days.

v. Variables

The factors on which the role models' effect was tested (here, called 'variable of interest') showed the greatest variation among studies. We identified five macro groups, of which three related to the target, one to role models and the last one to the intervention. For the macro groups on the target, the first includes all factors measuring participants' characteristics, i.e. opinions, feelings, attitudes and behaviour. We decided to exclude any attitude or behaviour referring to plans for the future or stereotypes from this macro class, which were grouped respectively, in the second and third macro classes. This distinction was informed by the 'expectancy-value theory' (Eccles, 1987), according to which, stereotypes indirectly affect career and educational-related choices by shaping certain individual characteristics, e.g. self-efficacy beliefs, interests, expectancies of success and subjective values. Therefore, the first three macro groups distinguish the three components of this mediation model, whereas the last groups opinions and attitudes toward the intervention itself. Table 3 shows for each macro group the number of studies in which there was at least one specific measure.

Table 3: *Variables of interest*

Variable of interest	Number of studies
Target's characteristics	49 (86%)
Target's future	17 (30%)
Stereotypes	26 (46%)
Role models	20 (35%)
Intervention	5 (9%)

Target's characteristics was the most frequent variable of interest (86%). This group collects a long and heterogeneous list of factors, most of which were tested only in one study, with a few exceptions. Within this macro group, attitudes towards STEM and performance were the most frequently tested characteristics, respectively in 56% and 33% of studies. Here, for attitudes toward STEM, we adopted the definition proposed by Mao et al. (2021), which considered this as a multi-constructs concept, including interest, self-efficacy – beliefs in our own abilities to succeed and be competent in science – and societal relevance – usefulness. Performance was either tested after the intervention (e.g. Van Loo and Rydell, 2014) or assessed using administrative data on academic performance, e.g. final GPA in college (e.g. Van Camp et al., 2019). Other characteristics were: sense of belonging (14%), identification with science (11%), self-assessed performance (5%) and self-esteem (5%). The complete list of variables is reported in the Supplementary Material (see Table F1).

Variables related to the *target's future* were tested in 30% of studies. This macrogroup includes academic (12%) and career intentions (9%), interest in (12%) and attitudes toward a STEM career (4%) and knowledge of STEM careers (2%). Unlike other studies, Breda et al. (2020) were able to obtain information on both major choice intentions and the concrete choice of higher education curricula. Using administrative data, they tested the role models' effect on the probability of being observed in a science-related track one year after the intervention.

Following the target's characteristics, *stereotypes* is the second most frequent variable of interest. We found, again, remarkable heterogeneity in how stereotypes were measured and tested. Most studies of this group tested gender stereotypes' endorsement, however, these varied in the content of the stereotype.

While most studies measured gender stereotypes on STEM abilities (12%), a minority tested gender stereotypes on other factors, e.g. perception of math and hard science as masculine fields (Plant et al., 2009), importance to understand physical science (Buck et al., 2002) and suitability for ICT (Lamers and Mason, 2018). Other stereotypes – not directly related to gender differences, but indirectly associated with the STEM gender gap – consisted of viewing STEM either as a non-communal field (Clark et al., 2016; Lawner, 2014) or a 'nerd' field (Baylor et al., 2006). Furthermore, some studies measured other factors related to stereotypes, i.e. the awareness of the existence of a gender bias (Pietri et al., 2021a, 2018), the perceived representativeness of women and men in STEM fields (e.g. Ramsey et al., 2013) and attitudes toward women in science (e.g. Bailer, 1998). In two studies on elementary-school children (Bailer, 1998; Buck et al., 2002), participants were asked to depict what they thought a scientist looked like, either verbally or by drawing,. These images were then coded based on a set of common characteristics, among which gender. Finally, four studies tested stereotype threat, i.e. 'a concern that one might inadvertently confirm an unwanted belief about one's group' (Inzlicht and Schmader, 2011).

Role models-related factors were measured in 35% of studies. About half of these asked participants if the role model possessed certain characteristics, whereas the other half assessed how the role model related to the participant. Among the investigated role models' characteristics were competence, generic likeability, communality and success. As regards how the role model related to the participant, studies were mainly interested in whether participants could identify with their role models or felt that they were similar and relatable to them. In a minority of cases, studies assessed participants' feelings for the role models, e.g. whether they admired them (Rule et al., 2019), found them inspirational or, conversely, intimidating (Marx and Ko, 2012). Few other studies asked participants their opinions on the contents delivered by the role model, e.g. things they learned about scientists (Van Raden, 2011), whether the role models said interesting things or things that facilitated learning about science (Cherchiglia, 2019). Finally, in a few cases, studies were interested in how participants interacted with their role models, e.g. whether they felt a sense of friendship and were interested in interacting with their role models Pietri et al. (2021b).

While all these factors concerned the role models that participants were exposed to during the intervention, in Ramsey et al. (2013) participants were asked whether they had supportive peer role models in STEM. A full list of the factors included in this macro group is reported in the Supplementary Material (see Table F1).

Finally, the last macro group includes a few studies where participants' opinions concerned the *intervention* itself. This was frequently asked in open-ended questions, individual interviews or focus groups. Researchers were usually interested in generic feedback on the intervention, e.g. whether participants enjoyed it and if there was something they would have changed. Only in a few cases, they were interested in more specific information, instrumental to check participants' effective exposure to the intervention.

vi. Effects

The heterogeneity of populations, interventions, methods and variables of interest did not allow us to calculate an average effect and so perform a meta-analysis of the effects of these interventions. Nevertheless, we created a structured synthesis classifying findings by their aim. When similar, aims were grouped together and we reported whether the effect (or association) was either positive, negative, null or mixed. Note that, grouping aims was not always possible as many were specific and tested only in one study (see Table 4). We identified two types of aim, i.e. those referring to the intervention and those to role models.

Although some studies also included male participants, here we focused entirely on the effect on girls. Note that we refer to studies' results using the term 'effect' as most of them were tested using an experimental approach. For the sake of simplicity, we did not always specify whether in some cases, using the term 'association' would be more appropriate.

Table 4: *Effects*

Aim and type of effect	Number of studies
Intervention	
STEM role model's presence (presence wrt absence/no STEM model)	37 (65%)
Positive	19
Mixed	15
Absent	2
Negative	1
Reflection on role model (reflection wrt no reflection)	3 (5%)
Positive	3
Seeing the role model (seeing wrt hearing/reading)	2 (4%)
Positive	2
Feedback from role model (positive wrt negative)	1 (2%)
Positive	1
Information on role model (job and private life wrt job only)	1 (2%)
Positive	1
Information on gender bias in STEM (information wrt no information)	1 (2%)
Mixed	1
Role model	
Role model's gender (female wrt male)	18 (32%)
Positive	11
Absent	6
Mixed	1
Role model stereotypicality (high wrt low/neutral)	7 (12%)
Positive	2
Negative	3
Mixed	2
Role model's competence (high wrt low)	5 (9%)
Positive	4
Mixed	1
Similarity to role model (similar wrt non-similar)	2 (4%)
Mixed	1
Absent	1
Role model's success (hardworking wrt gifted)	2 (4%)
Positive	2

Most studies (65%) tested the effect of being exposed to a role model compared to not being exposed to a role model or, rather, being exposed to a non-STEM role model. Half of these studies found a positive effect, with in 41% of cases the effect varied depending on the variable of interest. Only in two cases, the study reported a null effect, while in one case, the effect was negative.

Besides this main line of research, a few studies tested how the characteristics of the intervention influenced the results, i.e. reflecting on the role model after the intervention, seeing the role model rather than only hearing or reading about them, receiving positive rather than negative feedback by their role models, being provided information also on their private life and, finally, receiving information about gender bias in STEM. These strategies were more effective than the standard implementation, with only one exception. Being explicitly informed about gender bias in STEM before the exposure to role models increased women's identification with female role models but did not help them identify with a male scientist even when he was relatable (Pietri et al., 2018).

Some studies were also interested in how the characteristics of the presented role models influenced and mediated the intervention effect. We identified five characteristics tested in these studies, which are linked to the variables of interest we presented in the previous section. The most frequently tested characteristic was the role model's gender (32%). In 60% of these studies, participants benefited from a female role model more than from a male role model, while in the remaining there was any difference between being exposed to a female rather than a male role model.

In seven studies, role models varied in the level of stereo-typicality (high compared to low or neutral) endorsed. Stereo-typicality here refers to the endorsement of behaviour and attitudes typically associated with females, e.g. clothing, hobbies and preferences (Cheryan et al., 2011; Howard, 2015) or communal behaviours (Lawner, 2014). Results were quite heterogeneous. For instance, Howard (2015) found that women's interest in physics increased after exposure to a feminine female role model such that they had equivalent interest compared to men. On the contrary, Betz and Sekaquaptewa (2012) found that, compared to neutral models, feminine role models made middle-school girls feel less capable and interested in math.

Other role model characteristics were the level of competence, similarity to the participant and reason for success, i.e. being hardworking compared to gifted. In most studies, competent role models had a more positive influence on female participants than low competent ones, e.g. by increasing their performance (Marx and Roman, 2002) and self-efficacy (Thiem, 2016). For the similarity to the role model, the hypothesis that more similarity would increase role models' efficacy did not achieve consensual results in two studies (Marx and Ko, 2012; Merritt et al., 2021). Finally, when presented with a hardworking role model, girls performed as well as boys on a math test, whereas the opposite occurred when exposed to either a gifted role model or a control condition (Bagès et al., 2016).

V. Discussion and conclusion

Exposure to (counterstereotypical) role models is a widely diffused strategy to enhance women's empowerment in the STEM sector, with initiatives ranging from online-based resources (e.g. 'San Diego STEM Role Model Initiative', 'Techbridge Girls',) to school projects. Furthermore, producers of toys, books or movies are trying to balance the representation of male and female characters, especially in STEM (e.g. Ignotofsky, 2016).

In this context, there is a need for academic research to inform these initiatives, assess the efficacy of various options and provide guidelines for their design and implementation. By applying a systematic approach to studies' selection, we tried to summarise research on the effect of role models, by focusing on research type, targeted population, type of role models, type of interventions, variables of interest and effects. Our findings showed significant heterogeneity in all these factors, with the only exception of research type and target population.

Interventions with role models were mainly targeted at students in high school or attending the first years of university. The youngest students exposed to role models were children aged 9 years old, with no studies involving pre-schoolers. Role models were frequently professionals working in the STEM sector and took part either alone or with other role models in the intervention. In the first case, role models were always females, while in the second case they were mixed in gender. These interventions greatly varied in the type of exposure, the most frequent being asking participants to read something about the role model. However, other interventions allowed participants to interact with their role model, for instance, because these were invited to talk in the class. The effect of these interventions was tested on many factors, mostly related to targets' characteristics such as attitudes toward STEM and performance. Half of the studies were also interested in measuring the effect on stereotypes and some tested the effect on factors related to participants' future and their perceptions of the role models.

Finally, most studies aimed to simply test the difference between being exposed to role models compared to either not being exposed or being exposed to non-STEM role models. In some cases, studies also tested how different characteristics of both the intervention and role models affected the efficacy of the exposure. Results suggest that, depending on the study and the type of intervention, researchers had low or high control over the characteristics of the chosen role models. This is pivotal as previous research found that role models' characteristics play a role in determining their influence. As stated in the 'motivational role model theory' (Morgenroth et al., 2015), to be effective, role models should be perceived as being (1) similar, (2) desirable and (3) their achievements as attainable. This is why in some – still few – studies participants were asked whether they identified with or felt similar to their role models, whether they found them interesting or inspirational, and if they perceived the role model's success as attainable. However, in the two studies included in this review, which explicitly tested the difference between feeling similar to and not feeling similar to the role model, the results were discordant. Merritt et al. (2021) did not find any difference between girls asked to give feedback on their favourite role model and those who gave feedback on a randomly chosen role model. Marx and Ko (2012) on the other hand, found that participants' performance improved the closer the perceived similarity to the role model was; however, this similarity was irrelevant whenever the role model was highly competent. These results deviate from what has been usually found on ingroup role models (Asgari et al., 2012).

Research also varied in terms of types of interventions, including the type of action required by participants (i.e. reading, listening, seeing), the possibility to interact with the role model, the exposure's duration and participants' involvement in the activities. Given that role models is such if they inspire someone, anyone can potentially serve as a role model for someone else, even unwittingly. This is why the interventions ranged from a stylised graphic of a character on the exercise's sheet to female scientists talking about careers in science in a workshop. While we could consider heterogeneity and diversity as beneficial, even necessary here, it is likely that the effectiveness of these different types of interventions is not the same. The few studies included in the review testing the difference between seeing rather than reading about or hearing the role models, suggested a difference in the effectiveness of these interventions. Pietri et al. (2021b) found that students who watched a video interview with a female computer scientist showed a higher interest in computer science and perceived the scientist as warmer and more competent compared to those who only read the interview transcript. Baylor et al. (2006) compared a situation in which participants could see role models from the engineering sector with one in which they could only hear their voices. Results showed that in the former case, participants were significantly more likely to consider engineering as useful and reported higher self-efficacy, interest in engineering-related fields and STEM engagement.

Further research is necessary to understand whether not only role models' characteristics but also how young women are exposed to role models can influence the effectiveness of these interventions. Furthermore, apart from more traditional means of exposure, such as talks and articles, other more up-to-date and attractive strategies for young people should be investigated. It is worth mentioning here the idea of including a female virtual agent in an online game on STEM (Cherchiglia, 2019) or watching a movie with a female leading character (Ziegler and Stoeger, 2008). A study on women's representation in media content in STEM revealed that female characters account for 37% of the total (Institute, 2018). Further investigation is required to understand how this is influencing girls and whether a more equal representation of female and male characters in movies and TV shows could help to stimulate women's interest in studying STEM.

As mentioned in the introduction of this review, initiatives involving role models are usually considered instrumental in challenging the association between men and STEM (Dasgupta and Greenwald, 2001). The idea is that, since gender stereotypes derive from the underrepresentation of women in STEM professions (Eagly and Steffen, 1984), observing 'real' female STEM workers would break the association between STEM professions and men. Our review suggests that stereotypes do play a relevant role in the studies on exposure to role models – yet to a lower extent than expected. Less than half of the studies included a measure related to stereotypes with great variations from one study to another. Therefore, according to our review findings, considering a specific stereotype on gender and STEM would be misleading. We should rather refer to stereotypes on gender and STEM, as these are multiple and quite heterogeneous.

As shown in the results, the most popular gender stereotype referred to the difference in math-related abilities (Nosek et al., 2002), whereas some studies also assessed the endorsement of stereotypes on gender differences in the relevance attributed to science and its suitability for women and men. However, other stereotypes related to gender may indirectly be associated with the underrepresentation of women in STEM. Among the potential reasons for this gender gap is the traditional attribution of agentic –task-oriented – and communal – people-oriented – attributes to men and women, respectively (Sczesny et al., 2018). Besides their influence on sex roles within and outside the family, these attributes would influence also women's interest and suitability to work in STEM (Boucher et al., 2017; Diekman et al., 2017). Diekman et al. (2010) tested the hypothesis that STEM careers are perceived as less communal goals-oriented than careers in other fields and that, in turn, such perceptions would affect women's career decisions. Results confirmed this mechanism, as STEM careers were indeed perceived as incoherent with communal goals and communal-goal endorsement negatively predicted interest in STEM careers. Within this review, we found a study where, regardless of the role model's gender, participants who were asked to read about a typical day of an entry-level scientist were more likely to believe that science would allow people to achieve communal goals whenever the description included also communal tasks. This perception, in turn, mediated the effect of reading about the role model on positive feelings about a STEM career (Clark et al., 2016). Further research should shed light on whether and when exposure to role models would affect these gender stereotypes.

This review is subject to the limitations of any review of this kind, i.e. relevant sources of information may have been omitted, which is dependent on the availability of information. Furthermore, we were not able to provide a rating of the quality of evidence (Peters et al., 2020). Given this heterogeneity, we would recommend that researchers chose dependent variables fully comparable with previous research. This would help to create a systematic summary of results and provide a general picture of the effectiveness of role models' interventions for women in

STEM. This would also increase replication and findings cumulativeness. Furthermore, without this coherence, drawing any general conclusions on the beneficial or detrimental effects of role models on women in this sector is impossible.

Studies on the exposure to role models as a means to increase women's interest and representation in STEM fields are pivotal to empowering women in STEM. This review highlighted that several studies have been conducted on this theme, varying in the type of intervention tested and the characteristics of the role models presented to young women. Nevertheless, there is still scant knowledge on how the efficacy of these interventions depends on differences in the way and to whom young women are exposed. Some studies have started testing the consequences of this heterogeneity but a clear picture of the mechanisms underlying the effect of exposing women to role models is still missing.

Furthermore, the heterogeneity in the type of experimental intervention comes at a price, i.e. it is difficult to achieve a general understanding of the effectiveness of exposure to role models. Olsson and Martiny (2018) tried to circumvent this problem by assessing the efficacy of some of these interventions by targeting different age groups separately. Although a good starting point, a more systematic analysis of exposures' outcomes is required to assess the efficacy of these interventions and improve cumulativeness and replication of findings.

Our findings suggest that girls and women generally benefit from exposure to STEM role models. However, exceptions do exist, which in the worst-case scenario, could even have detrimental effects on female engagement in STEM. Further research should shed light on the causes underlying these negative and null effects.

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