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The role of teachers in combating stereotype threat.

A systematic review.

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Abstract

While there is a significant number of scientific papers addressing stereotype threat among various groups and under various circumstances, the focus on reducing stereotype threat has only arisen recently.

Most of the strategies introduced ask for a change in the student affected by stereotype threat. Less is known about how teachers in secondary education can help reduce stereotype threat among their students, specifically their female students. The aim of this thesis is to investigate strategies that teachers can adopt to achieve a reduction of stereotype threat for female students in secondary education.

I conducted a systematic literature review and deeply analyzed ten papers. The results show that interventions can be classified into those targeted at (1) students, at (2) teachers, and at (3) instruction. Research also indicates that, although the effectiveness of interventions might be varying regarding different categories, interventions lead to long-lasting results.

To my Papa, in loving memory.

Introduction and Theoretical Framework

Stereotype Threat

In 1995, Steele and Aronson introduced the concept of Stereotype Threat (ST), which describes the situation in which a member of a stereotyped group fears to conform to a negative stereotype of their social group, leading to pressure that might affect their self-concept and consecutively, their behavior and their performance. Steele and Aronson's research was the first to show that ST among Black students impaired their test performance.

Since then, research has demonstrated that ST affects multiple stereotyped groups, as also, for example, women (Spencer et al., 1999) or students from a lower social economic background (Croizet & Claire, 1998). ST is, furthermore, present in various domains of life as, for example, it affects work climate (Casad & Bryant, 2016), health (Aronson et al., 2013), test performance (Lewis & Sekaquaptewa, 2016), motivation (Fogliati & Bussey, 2013; Thoman et al., 2013), and self-confidence (Muzatti & Agnoli, 2007). ST in the school setting has also been subject of many studies, adding insights to Steele and Aronson's observations. It was shown that female students experiencing ST showed to downrate the competence of their teacher (Adams et al., 2006) or had less motivation for the STEM field per se (Smith et al., 2015).

From the examples shown, it becomes apparent that ST can affect multiple stereotyped groups in various aspects of life, which also includes students. Hermann and Vollmeyer (2022) state that research in gender-related stereotype threat was first focused on adult women. Interest concerning primary and secondary school students only followed later. Research in this field is closely tied to the concepts of STEM - Science, Technology, Engineering, and Mathematics (Cadaret et al., 2017; Gentile et al., 2018; Shapiro et al., 2012), where test performance in

mathematics has been prominently researched. The influence of stereotype threat on the mathematics performance of women has been well-demonstrated in several meta-analyses (Doyle & Voyer, 2016; Nguyen & Ryan, 2008; Picho et al., 2013). This leads me to conclude that awareness of gender-related ST has been established in the scientific community. Knowledge about an issue, however, does not necessarily lead to change, which is why this thesis aims at presenting various strategies to diminish ST for female students in secondary education.

Spencer et al. (2016) distinguish between three ways in which ST can be diminished: (1) “reconstrual interventions” (p. 427) that aim at reducing the perceived ST by the person affected, (2) “coping interventions” (p. 428) that acknowledge the persistence of ST and therefore use strategies such as self-affirmation, mindfulness training, or educating those affected by ST and (3) “creating identity-safe environments” (p. 428). The literature assumes that there are several additional ways in which an environment of reduced ST can be created. While the installation of role models, as for example presenting on females in the science field, has been presented as beneficial (Bagès & Martinot, 2011; Bagès et al., 2016; Betz & Sekaquaptewa, 2012), so have social psychological interventions. Examples listed were the reappraisal or use of the growth mindset model (Spitzer & Aronson, 2015) and the fostering of a sense of belonging in a group (Martiny & Fröhlich, 2019). Spencer et al. (2016) propose that educators play a significant role in establishing a safe environment for students. This thesis aims at presenting research on the teacher’s role in creating a safe environment in order to reduce ST.

The role of the teacher regarding ST in the classroom

While the effects of the perceptions of individuals have been studied intensively, little is known about the role that teachers take in diminishing ST. As highlighted by Dai et al. (2021), teachers holding beliefs about stereotypes negatively impact their students. Female students

being taught by teachers holding stereotypes about girls not performing as well as boys in mathematics confirmed this stereotype. Moreover, these beliefs held by the teacher negatively impacted the female students far beyond their school career, which shows the importance of reducing gender-related ST for those affected.

Gajda et al. (2022) argue that teachers are often not aware of their own impact and might even reinforce gender stereotypes without explicitly intending to, which could lead to gender polarization.¹ Generally, they found, teachers are cognizant of gender stereotypes but not about ST per se. Consequently, this could result in a decreased level of achievement as well as ambition among female students. Furthermore, stereotyped behavior among male students might also be reinforced, which could lead to the establishment of a vicious cycle that once again might prove disadvantageous for females in the classroom. Gajda et al. (2022), therefore, point out that teachers must help alleviate ST and subsequently “showing [*sic*] students the strength and benefits of equality” (p. 20).

Nouwen and Clycq (2019) examined the effect of the teacher-student relationship on ST among secondary students from ethnic minority backgrounds in Flanders. They based their study on the ideas of Klem and Connell (2004) that were able to show that within the environment of the school, the relationship a student has with their teacher can predict the student’s commitment and achievement. Nouwen and Clycq (2019) found that a good teacher-student relationship might have beneficial effects for minority students affected by ST, as the relationship prevented students from “the occurrence of psychological disengagement, discounting of negative feedback and disidentification from education” (p. 1573). They could also show that perceived hostility from the teacher would result in an effect pointing in the opposite direction.

¹ Bem (1993) defines gender polarization as the description of gender as dichotomous. Behavior that deviates from what is considered female or male is perceived as problematic by society.

Nouwen and Clycq's (2019) study is supported by Zheng (2022) who focused on the teacher-student relationship or teachers' interactional behavior, which can be described as sometimes verbal and sometimes non-verbal based on "mutual respect, trust, warmth, and little conflict" (Zheng, 2022, p.2) with the effect that students will feel safe, valued, connected to, and supported by their teacher, which ultimately will lead to higher behavioral, affective and also cognitive outcomes on the part of the students. Zheng (2022) argues that teachers aiming for a positive teacher-student relationship are also interested in the well-being of their students.

In line with what has just been discussed, Ober et al. (2021) propose that teacher support has a positive effect on students' attitudes toward mathematics and subsequently on their achievement. Hereby, they draw upon the ideas by Klem and Connell (2004) that argue that teacher support needs to find the right balance between student autonomy and considering each student's individual needs. In their study, Ober et al. (2021) found that students of minority backgrounds or double-jeopardy students might not experience an as strong effect of teacher support as students from majority backgrounds.

A further point that has been prominently researched is teacher expectation. Research goes back to Rosenthal and Jacobsen (1968) that were able to find a positive effect of teacher expectations on student achievement. Since then research has focused on how teacher expectation relate to self-fulfilling prophecies. Although Jussim et al. (1996) argued that this perspective might be too oversimplified, the interest in these studies is still stable (Shevchuk & Glock, 2022; Timmermans & Rubie-Davies, 2022). Shevchuk and Glock (2022) state that at this point the impact of the relationship between stereotypes and teacher expectation cannot be definitely explained. While literature suggests a generally more positive trend for female students, students of ethnic minority backgrounds might be affected in a more negative way,

although results also seem to differ for this student group. Timmermans et al. (2018) argue that individual teachers' expectations might differ. The meta-analysis by de Boer et al. (2018) demonstrates that a change in teacher expectation seems hard to reach, although its benefit for students is undebatable. However, in this respect, one must consider the limited amount of studies addressing the issue.

As there is a relationship between ST and student outcome, and therefore, subsequently also student achievement, I argue, in line with the work of Dai et al. (2021), that teachers can affect a student's experience of ST. Studies discussing how biased teacher judgment will negatively affect student performance have been of great interest in literature (Holder & Kessels, 2017; Jussim & Harber, 2005; McKown & Weinstein, 2008). In my argumentation of why the role of teachers should be considered when discussing ways to diminish ST for female students in secondary education, I want to quote Créton et al. (1993, p.2) "[...] it is easier to change one person instead of twenty-five."

This Study

Liu et al.'s (2021) meta-analysis indicates that research on how to alleviate ST is extensive. However, only a few studies concerned with gender actually focus on the role of secondary school teachers. Through the help of a systematic review of current literature, this thesis aims at identifying what interventions concerning teachers could be realized to diminish ST for female students in secondary education.

Method

Pati and Lorusso (2018) defined a systematic review as "a systematic way of collecting, critically evaluating, integrating, and presenting findings from across multiple research studies on a research question or topic of interest" (p.15). They specifically mention that systematicness

derives from the methodology used that focuses on quality-related issues such as “bias, replicability, credibility” (p.15). Compared to other more traditional forms of reviews, systematic reviews offer a broader and more comprehensive view of a topic.

Selection criteria

For this review, I focus on studies that included female students in secondary education. It is assumed that students in secondary education are between 10 and 19 years old. This assumption is based on the fact that in some countries like Austria and Germany, students start secondary school at the age of ten (Huebler, 2012) and these students should not be excluded from this review. There will be no restrictions on the ethnicity of the participants or the country in which the studies were conducted as this review aims at documenting existing literature.

Furthermore, each study must be concerned with the teacher dimension that is expected to affect the reduction of ST. The timeframe applied is not restrictive to allow a broader picture of the field. Moreover, it must be noted that only articles written in English were included in this thesis.

A general comment needs to be made about the nature of the papers in this review. In order to provide a concise picture of the field, there were no restrictions imposed concerning the type of scientific writing. Consequently, this means that contrary to common practice, neither systematic reviews nor meta-analyses were excluded, as research questions underlying these papers were of interest for this review too.

For the literature search, the following search string terms were defined.

Table 1.

Search String.

Categories have been added using ‘AND’

Stereotype threat	"stereotype threat*" OR "stereotype*"
Female students	"gender" OR girl* OR female* OR woman OR women
Teacher dimension	"teacher* effect*" OR "teacher* role" OR "teacher* behavior*" OR "teacher* perspective*" OR "teacher* interpersonal behavior*" OR "teacher* student* relation*" OR "teacher* mindset*" OR "teacher* practice*"
Age group	"secondary classroom*" OR "secondary education" OR "secondary class*" OR "secondary school*" OR "high school*" OR "secondary school teacher*" OR "secondary teacher*"
Outcome	"student* outcome*" OR "student* grade*" OR "student* well being" OR "student* achieve*" OR "student* success*" OR evaluation OR achieve* OR success*

Literature was collected between April and Mai 2023. ERIC, PSYCHINFO, SCOPUS, and WEB OF SCIENCE were used to search for articles. Dissertations and unpublished work were excluded from the process of article collection.

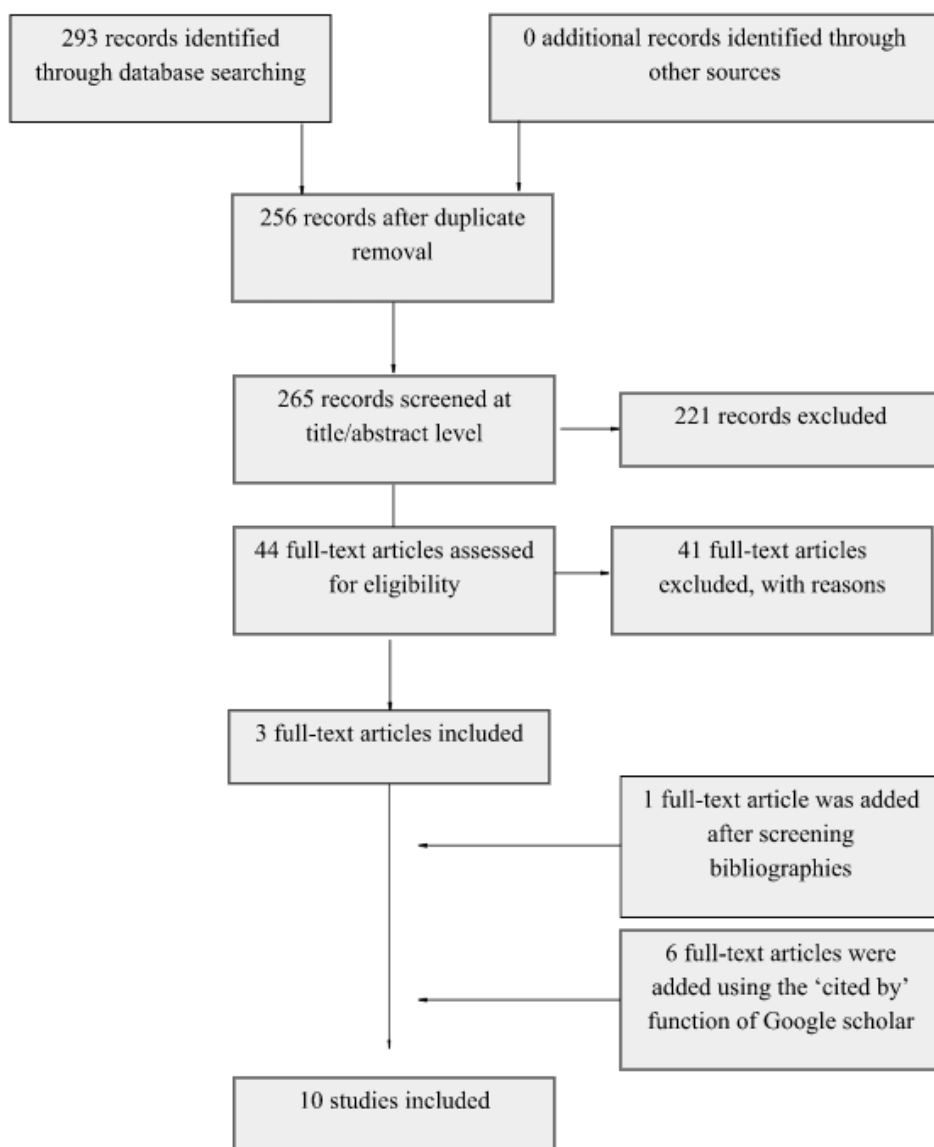
Selection and exclusion procedure

CADIMA (Kohl et al., 2018) was used to collect articles and identify duplicates that were removed before screening. The traditional selection procedure for systematic literature reviews was followed, first screening title and abstract (Metzendorf et al., 2019). Articles that did not focus on female students in secondary education were excluded. So were those that did not include the teachers' sphere (n=144).

After the screening of the title and abstract, the full texts were screened (Metzendorf et al., 2019). The long text screening resulted in the exclusion of 141 papers, which led to a final number of three papers. Then, bibliographies of the remaining papers were screened for potential relevant articles (n=1). Moreover, further papers were identified by using the ‘cited by’ function in Google Scholar (n=4) and by screening the bibliographies of the articles returned (n=2).

Figure 1.

Flowchart of article search



Each observational study selected for the review was assessed in regard to its quality according to the *STROBE assessment tool* (Vandenbroucke et al., 2007). For the literature reviews included in the final selection, a combination of the *PRISMA 2020 Checklist* (Page et al., 2021) and the *JBI assessment tool* was used (McArthur et al., 2020), while the *PRISMA 2020 Checklist* was used for the meta-analysis by Liu et al. (2021).

Quality Assessment

Using the *STROBE assessment tool* (Vandenbroucke et al., 2007) on the qualitative studies in this review, a general fitting level of quality could be traced with all studies (Dalal et al., 2021; Good et al., 2003; Lokhande & Müller, 2019; Seo & Lee, 2021).

Most of the descriptors could be verified for Dalal et al.'s (2021) study. However, hypotheses were mentioned by the authors. Furthermore, variables were not clearly defined and the process of coding was not explained. More concise information on participants, such as the number of participants at each stage, as well as a flow diagram, were not included. Key results of the studies were mentioned although more information would have been beneficial. The same applies to the interpretation of results. Information on funding was omitted.

Concerning Good et al.'s (2003) study, the descriptors of the categories title and abstract, introduction, and methods could be verified with the exception that it was not explained how the issue of missing data was approached. Regarding the results, information on participants was limited with respect to participation numbers at each stage and excluded regarding non-participation. Furthermore, a flow diagram was not included in this section. For the discussion, all descriptors could be verified. Information on funding was again lacking.

Lokhande and Müller (2019) did not provide their readers with information on addressing the issue of missing data. Additionally, also here no flow diagram was used to indicate

participation, although the numbers of non-participation as well as participation at each step in the intervention were mentioned in the text. Apart from that all descriptors could be verified, with the exception of information on funding.

The abstract by Seo and Lee (2021) provided only little information about their study. Furthermore, hypotheses were not included in the introduction. However, information on the method used was concise and complete according to the descriptors of the STROBE assessment scale. Concerning the result section, information on participants was limited as non-participation and a flow diagram were not added. Information on participants' characteristics as well as missing data was also not offered in the descriptive data section of the paper. The main results would have needed more clarification compared to other papers assessed here. The discussion section offered comprehensible elaboration and information on funding was included at the end of the paper.

For Liu et al.'s (2021) meta-analysis *PRISMA 2020* was used, as it can also help indicate the level of quality of a meta-analysis (Page et al., 2021). Liu et al.'s (2021) meta-analysis appears to be of high quality when considering the items listed in *PRISMA 2020*. In the introduction, both the rationale and the objective were clearly outlined. The method section provided a concise picture of the approach, detailing information on the search strategy, data collection, and risk of bias assessment. Concerning the study selection process the authors did not visualize this in the form of a flow chart. The characteristics of each study were presented as a table, documenting the type of intervention, the strategy used, the type of ST, the immediacy of the effect, the setting as well as the effect size. The discussion section presented what *PRISMA 2020* specified. Information on the registration of the meta-analysis was not found, however, the authors suggested that future research into the field of ST should be registered. Furthermore, no

information on funding or “competing interests of review authors” (Page et al., 2021, p. 2) was included in the paper.

For the remaining articles presented below a synthesis of *PRISMA 2020* and the *JBI assessment tool for text and opinion* (McArthur et al., 2020) was used. This decision was made as the papers could not be grouped under a specific type of paper.

Godsil et al. (2016) indicated that their paper was a report. Sources in the text were clearly identified and a list of references was added at the end. The sources used could, furthermore, be classified as of quality. The paper also presented the interest of the relevant population in the center of the article. The authors did not provide the reader with information on the analytical process of information presentation. A mismatch between various literature sources was not discussed.

For the Kuchynka et al. (2022) paper only a small amount of descriptors from *PRISMA 2020* could be verified, as the authors did not provide the reader with any information on methodology, while also no descriptor in the results section could be ticked. However, the authors indicated a clear rationale for their paper, although no objectives were listed. Furthermore, as the main aim of the paper was to present “implications of the results for practice, policy and future research” as indicated by *PRISMA 2020* (p. 2), this descriptor could be verified. Sources were added throughout the paper as well as at the end, clearly indicating who the authors based their opinion on. The sources could also be identified as having a “standing in the field of expertise” (McArthur et al., 2020, p.2) among the other descriptors that could be verified.

Most of the descriptors of McArthur et al.’s (2020) list could be verified for the chapter by Rydell and Boucher (2017). However, it remains debatable how specific the analytical process could be outlined. Furthermore, any mismatch between different sources was not thoroughly

discussed by the authors. Additionally, information on methodology was completely lacking from the paper, which can also be said for the results section.

Schmader and Hall (2014) indicated that their paper was a literature review. Their introduction did not provide the reader with a clear statement of the rationale for the paper nor did they add objectives. Information on the methodology was omitted, as was information found in the results section. The discussion provided some thoughts on limitations and clearly outlined the implications for school officials and teachers alike. At the end of the paper information on conflicting interests and funding was included. Two of the statements listed in the JBI assessment tool could not be completely clarified. It remains unclear whether the focus of the paper actually lies on the relevant population and in how far the analytical process could be outlined.

For Singletary et al.'s (2009) paper a majority of descriptors from *PRISMA 2020* could not be verified, as no information was provided about the methodology and results. No objectives of the paper were listed, and the rationale was not outlined in detail. For the discussion section, however, all descriptors could be verified. Information on funding was provided, although no mention of conflicting interests was added. As for the *JBI assessment tool*, the paper lacked information on the analytical process and on incongruences.

Analytical procedure

As soon as a final list of included literature was established, intervention types from the articles were clustered. From the cluster, three themes emerged: (1) strategies targeted at students, (2) strategies targeted at instruction, and (3) interventions on the teachers. These themes were taken from and adapted based on the meta-analysis by Liu et al. (2021) and deduced from

the clustered results. For all categories, subcategories will be presented in the review. It will be organized according to those established themes.

For (1) strategies targeted at students, I shall adhere to the meta-analysis by Liu et al. (2021), who propose a taxonomy for interventions against ST that serves as a necessary backbone to this part of the systematic review. Liu et al. (2021) suggest a categorization of ST interventions into (A) primary-appraisal based ST interventions with a subcategorization of (1) belief-based, (2) identity-based interventions, and (B) secondary-appraisal-based ST interventions with the subcategory (3) resilience-based interventions.

Results

The articles returned from the literature search can be either categorized as literature overviews in the sense that they offer a synthesis of different strategies (n=6) to diminish ST or as qualitative studies (n=4). All the papers presented hereinafter portray the alleviation of ST in secondary education, while three studies included students as participants, only one study's population consisted of teachers. Three of the studies presented were conducted in the US, while only one study was conducted in Europe. None of the papers returned presented the situation in other parts of the world.

The publication date of the papers presented in this review span from 2003 (Good et al., 2003) to 2021 (Dalal et al., 2021; Liu et al., 2021; Seo & Lee, 2021), while 80% of the studies were published from 2014 onward, and half of these since 2020.

Table 2.

Overview of all included studies.

Author	Year	Country	Sample	Method
Dalal et al.	2021	US	7 teachers	Qualitative data analysis

Godsil et al.	2016	Not specified	N/A	Report
Good et al.	2003	US	138 grade 7 students	Intervention study
Kuchynka et al.	2022	Not specified	N/A	Review
Liu et al.	2021	N/A	142 articles 181 intervention studies	Meta-analysis
Lokhande & Müller	2019	Germany	Wave 1: 820 Wave 1&2: 668 students in integrated secondary school	Experimental study
Rydell & Boucher	2017	Not specified	N/A)	Literature review
Schmader & Hall	2014	Not specified	N/A	Literature review
Seo & Lee	2021	US	65 grade 9 students	Intervention study
Singletary et al.	2009	Not specified	N/A	Literature overview

Strategies targeted at students

As outlined before, Liu et al. (2021) introduced two categories, (A) primary-appraisal based ST interventions with a subcategorization of (1) belief-based, (2) identity-based interventions, and (B) secondary-appraisal-based ST interventions with the subcategory (3) resilience-based interventions. They found that (A) primary-appraisal based ST interventions had a bigger effect size than (B) secondary-appraisal based ST interventions, although a diminishing effect on ST could be traced for all categories. Within both categories we find strategies targeted at students. Those strategies have been discussed in eight sources returned from the literature search: Good et al., 2003; Kuchynka et al., 2022; Liu et al., 2021; Lokhande & Müller, 2019; Rydell & Boucher, 2017; Schmader & Hall, 2014; Seo & Lee, 2021; Singletary et al., 2009.

It can be inferred from Liu et al.'s (2021) meta-analysis that while some strategies can only be realized by those affected, hereby referring to (2) identity-based interventions, teachers

can integrate some of the proposed strategies into their teaching. Strategies can be incorporated into lessons targeting (1) belief-based and (3) resilience-based interventions. As the main focus of this review lies on teachers, this section will focus on the two latter mentioned. Furthermore, only strategies presented in the meta-analysis that proved effective and can be realized by teachers will be reported.

In the category of (1) belief-based interventions, it is suggested that teachers focus on making group characteristics explicit that are shared by those affected and those not affected by ST, so in order to “blurr[...] the group boundaries” (Liu et al., 2021, p. 923). Schmader and Hall (2014) propose a mentoring program for those affected by ST. They argue that those affected are prone to feeling excluded and, thus mentoring programs aimed at communicating acceptance might be especially effective. A mentoring program would in this respect allow students to feel included and thus part of their peer group.

Furthermore, the integration of material in lessons that allow students to realize that an ST situation may have been overcome by other people affected by ST has proven to be as beneficial, as has the integration of “in-group role models” (Liu et al., 2021, p.923). Singletary et al. (2009) go as far as to propose that ST can be alleviated already if those administering the test come from the stigmatized group and thus argue for the diversification of the teaching and administrative staff.

Singletary et al. (2009), furthermore, argue that educators should ensure that students are aware that bad performance is not due to them belonging to a certain stereotyped group, but rather that bad performance stems from bad preparation. This argument can also be connected to the growth mindset theory which will be discussed in detail later.

Above all, Kuchynka et al. (2022) state the importance of educating students on the topics of gender discrimination, the historically derived uneven distribution of power, and the effect thereof. Educating students should, as they argue, be linked to teaching about racism and its consequences. They stress the importance of establishing a zero-tolerance policy towards sexism as well as racism to establish a sense of rightness of behavior already with young children in order to allow for all students to feel welcome and acknowledged. If interventions like these are set as early as primary school, they expect students to develop a mindset shaped by egalitarianism and inclusiveness.

Furthermore, they propose to replace traditionally male-attributed artifacts in the STEM classroom with more neutral ones. The aim here is to allow every student to feel welcome and valued. Additionally, Kuchynka et al. (2022) advise diversifying the STEM classroom by including research by female scientists and scientists of minority backgrounds.

(3) Resilience-based interventions that can be realized by teachers aim at “improving confidence” (Liu et al., 2021, p. 923) by providing positive feedback to the students that heighten their motivation and confidence. Moreover, introducing students to learning techniques and reinforcing that hard work can help anyone achieve mastery has also proven to be quite beneficial in diminishing ST. The latter-mentioned strategy has become known as Growth Mindset Theory, which can be described as someone’s view that intelligence is malleable and can grow due to exposure and hard work.

Good et al. (2003) hypothesized that students affected by ST learning about the growth mindset theory would outperform those adhering to a fixed mindset. In an intervention study, they tested whether Texan students in seventh grade, which is assumed to be extraordinarily challenging for students as it is seen as a transition year, would perform better given one of four

conditions. All 138 students participated in a mentoring program. In the incremental condition, participants learned about the growth mindset theory. Students in the attribution condition were told that many students are prone to struggling in transition years. The third condition combined the first and second, while students in the control condition learned about the effects of drug abuse. The students were mentored by college students and received information on their assigned topic in analog and digital ways. After the intervention, students took a math achievement test. Results showed that with the exception of the control condition, the gender gap in Maths had closed, while females in the incremental condition reached remarkably higher scores than in the attribution or combined condition. Good et al.'s (2003) results were adopted by Schmader and Hall (2014) and Rydell and Boucher (2017). Both papers suggest a growth mindset intervention to ease ST.

Regarding the growth mindset theory, Kuchynka et al. (2022) further propose that educators should teach about neuroplasticity. They argue that adopting a growth mindset will additionally lead to enhanced motivation and higher achievement. Furthermore, they argue that it is vital for teachers to adopt a growth mindset view as there is a correlation. This is further discussed by Seo and Lee (2021).

Seo and Lee (2021) tested whether there was an effect on ST if teachers held a fixed mindset. Their study included approximately 6040 ninth graders from 65 public schools in the US who were randomly assigned to two intervention conditions. Results indicate that if students perceive their teacher as having a fixed mindset, those students are more prone to experiencing ST. Additionally, a relationship between a fixed teacher mindset and math anxiety could be found. Ultimately, math anxiety negatively impacts mathematic achievement. Seo and Lee (2021) therefore, conclude that “it is essential to identify various teacher attitudes, behaviors, and

practices that are linked to students' perceptions of fixed mindset climate" (p. 1419).

Interestingly, Seo and Lee (2021) did not find an as strong association between ST and math anxiety among White females, compared to Latinx and Black females, although past studies produced more distinct associations.

Another strategic approach in the (3) resilience-based interventions category relies on self-affirmation theory. In a replication study, Lokhande and Müller (2019) tested an intervention study that had been conducted in the US (Cohen et al., 2006) among German students in eleven integrated secondary schools in the city of Berlin. They hypothesized that females and students of Turkish and Arab backgrounds prone to experiencing ST receiving a self-affirmation intervention would receive higher scores in a mathematics test than females in the control condition. Furthermore, they expected an enduring effect of the intervention. Students were given a cognitive test before being randomly assigned to either the intervention or the control condition. This was followed by a standardized mathematics test and a questionnaire. A week later students received their assessment on an individual basis including recommendations on how to improve. For the self-affirmed students, researchers expected that "affirmative recursive cycles" (Lokhande & Muller, 2019, p. 64) would start allowing the students to improve even further. It remains unclear how the experiment continued from this point onwards.

Results indicated that female students in the intervention condition outperformed their peers in the control condition, however, the hypothesis that the effect of the intervention would be long-lasting for females could not be verified, although, it was found to be true for students of Turkish and Arab background. In their conclusion, Lokhande and Müller (2019) argue that teacher training should incorporate instruction on self-affirmation and reflection on the role and social position of the teacher. Offering an intervention to enhance self-affirmation allowing

students to reflect on their own values is also proposed by Schmader and Hall (2014) and might lead to better coping mechanisms, as they argue.

To sum up, Liu et al. (2021) state that educators should actively use strategies to help diminish ST, especially as it has been proven that interventions have long-lasting effects. When designing interventions, attention should be paid to effect sizes, and the timing of when interventions should be performed needs to be considered. If interventions are conducted shortly before an assessment, and thus the focus is directed at the affected group, the effects might not be as beneficial. Furthermore, recruitment material for students could be diversified to “blur group boundaries, promote social belonging, and provide in-group role models” (p. 941).

One additional remark connected to this section is made by Singletary et al. (2009) and Godsil et al. (2016) although it is rather directed at those creating standardized testing than at teachers. They argue that a reframing of the test by using different language could furthermore alleviate ST.

Strategies targeted at instruction

A further category of strategies that aims at diminishing ST is targeted at instruction. Naturally, all students will be affected by changed instruction, however, the primary focus of these strategies does not exclusively lie on those affected by ST. Four papers point the way in this respect: Dalal et al. (2021), Godsil et al. (2016), Kuchynka et al. (2022), and Rydell and Boucher (2017).

In their literature review that discusses gender roles, implicit bias, and ST among females and its consequences, Godsil et al. (2016) suggested various ways to decrease ST for female students, after elaborating on ST among females in various aspects of life. Besides discussing the role parents play and suggesting reframing test situations, as has been mentioned earlier, they

propose adapting instruction to alleviate ST. Firstly, they present collaborative learning as a way to enhance peer interaction. They argue that if female students collaborate on mathematical tasks, interest might increase which could consecutively lead to higher maths achievement. This is also mentioned in Dalal et al.'s (2021) study. In their qualitative data analysis study, Dalal et al. (2021) interviewed teachers as part of an intervention targeted at instructors of engineering programs in high schools. Teachers stated that collaborative work would have students learn about the importance of working together and leaving one's comfort zone. It was further mentioned that those skills could benefit students in their later work life. Rydell and Boucher (2017) argue that collaboration on tasks could also lead to a deeper understanding of the subject matter, and thus consecutively lead to better results.

This aspect is also discussed in Kuchynka et al.'s (2022) review. They suggest fostering "intergroup cooperation and collaboration" (p. 269) as an integral part of the STEM classroom. When assigning collaborative work, they state that it is vital to establish that students do not work along traditional gender roles, according to which male students would engage in leadership tasks, while female students would support their male colleagues. Ultimately, collaboration helps students to develop a "common identity" (p. 270) as "STEM students" (p. 270) when working on a task together, and might lead to forming meaningful relationships across gender lines, which can be seen as beneficial for all students. Rydell and Boucher (2017) state that collaboration across gender lines could also change the students' perspective of stereotypes in the STEM field.

Furthermore, Kuchynka et al. (2022) advocate for a "relational classroom" (p. 267) that allows for meaningful relationships not only between peers but also between students and teachers. They argue that STEM classrooms are heavily focused on knowledge building, while

also positive relationship building should be focused on. Instruction and curricula need to be altered to achieve this goal. A change of perspective and a reflection thereof, rules for discussions, and a change of the seating plan were mentioned in this respect.

When asked about how to address ST, the teachers in Dalal et al.'s (2021) study mentioned that a change in environment might be a prerequisite for decreasing ST ultimately. In this regard, team-building activities such as ice breakers to help female students feel more included were mentioned as ways to create a “friendly, competitive, positive student centered atmosphere” (Dalal et al., 2021, Addressing negative stereotypes section). Further measures to be taken included activities such as

engaging students in role-play activities, inviting students to become peer tutors to build their confidence, providing role-models and vicarious experiences, arranging buddy programs to invite other students to experience the engineering classroom and the curriculum, and initiating after school robotics programs. (Dalal et al., 2021, Addressing negative stereotypes section.)

A further strategy is proposed both by Godsil et al. (2016) and Rydell and Boucher (2017). Both argue that a change from frontal instruction towards applied learning, meaning teaching subject matter through tasks that have relevance to the students' lives can help decrease ST. Godsil et al. (2016) highlight that females traditionally are more drawn to professions that aim at reaching “communal goals” (p. 61). Therefore, STEM professions need to be presented in a light that will allow young females to re-evaluate their beliefs. They propose visiting museums that showcase technology's positive impact on society, inviting female researchers for workshops or talks, and teaching students in an applied and active way.

Creating a classroom, in which students can actively learn about and connect to the subject matter on a more personal level is also suggested by Rydell and Boucher (2017). They argue that due to the change in instruction, one can expect a higher level of engagement from all students, which could lead to a decrease in held stereotypes. They address that the link between increased engagement and decreased ST might not be acknowledged or apparent, however, they state that they expect motivated and engaged students to be less worried about stereotypes and the resulting ST.

Kuchynka et al. (2022) provide the necessary theoretical background for the assumption that active engagement in the learning process could lead to increased achievement in learning. Based on constructivist learning theory, they outline that by actively engaging students in the knowledge-gain process, the students become responsible for their own learning. Although the scientific proof for active learning is overwhelming, as they argue, they acknowledge that a shift from traditional, instruction-based teaching towards active learning can be intense on the teacher's side.

Although not directly addressing the alleviation of ST, Godsil et al. (2016) present extracurricular activities as a way of engaging female students in the STEM field. Hereby, they explicitly refer to the active nature, referring to collaboration and real-life tasks, such a project should take on. They mention “coding clubs, robotics clubs, and science-art camps” (p. 61) to help female students indulge in STEM. The same was also proposed by the teachers in Dalal et al.'s (2021) study. It was, furthermore, remarked that extracurricular activities can function as support mechanisms for female students to enter the STEM field, and thus increase the numbers of female students in STEM, which might ultimately lead to a positive re-evaluation of the field for females.

To conclude this section, there are some more strategies that have been proposed in the literature, which should now be presented. Rydell and Boucher (2017) advise having students write about how their life and STEM are connected, as this might increase their interest and also their achievement. They, furthermore, suggest testing students more often in order to alleviate ST. This could be done in the form of daily quizzes. As students revise course content on a more regular basis, the learning retention rate increases, and thus students will be better prepared for end-of-the-year exams. Referring to testing, Kuchynka et al. (2022) criticize the current practice of standardized testing and call for an adoption towards a long-term collection of data to observe growth in learning.

Intervention on Teachers

Dalal et al. (2021) criticize that teachers are hardly supported by their organizational institution or superordinate agencies to address and alleviate ST. With this in mind, the last category of this review focuses solely on the educator and the system in which they act. Two studies are, in this respect, quite influential for this review.

The first study was conducted by Dalal et al. (2021). Seven participants of a professional development program called Engineering for Us All (E4USA) that aimed at installing a new inclusive form of engineering instruction for high school students were questioned on the implementation of the program. The aim of the program was to create an engineering classroom that would allow all students to participate. Therefore, the 5-day program was designed in a way for teachers to be educated on ways to implement a more inclusive engineering classroom, participate in collegial exchange in the form of a professional community, and reflect on their own position in order to raise awareness about implicit bias and ST. Ultimately, the initiators of

the program expected that a change in the engineering high school classroom would impact students' entry into tertiary education.

Before attending the five-day training program, teachers had to read parts of Steele's (2011) *Whistling Vivaldi: How Stereotypes Affect Us and What We Can Do* in order to learn about implicit bias and ST. During the workshop, one session on participation more closely focused on the mentioned topics, among others such as growth mindset theory. At the end of the training program, a focus group discussion was held in which teachers were asked to share their opinion on Steele's (2011) book, ways to alleviate and address ST, as well as classroom experience in regard to student well-being. The data gathered was then qualitatively analyzed (Dalal et al., 2021).

The analysis conveyed that after learning about implicit bias and ST, teachers felt the obligation to address this issue. As already mentioned, beforehand, some strategies targeted at students and instruction were discussed. Furthermore, participants also realized that understanding ST and reflecting on held implicit biases was a prerequisite for alleviating ST. Participants stated that teachers would need to function as change agents and actively invite female students into the STEM field. Researchers remarked that the participants of this program might be seen as "early adopters" (Dalal et al., 2021, Discussion section) that seemed to be willing to allow for change in their instruction and classrooms, which might not be the case for other teachers.

A further intervention on teachers was presented by Schmader and Hall (2014). Their review presented information on ST and a critical analysis of educational policies and initiatives. Besides increasing the "representation of negatively stereotyped groups" (p. 32) as discussed before, they argue to implement "diversity training, designed to promote inclusive values and

reduce intergroup bias” (p. 33). Through educating teachers on diversity, they remark that ST can be alleviated in three ways. Firstly, diversity needs to be actively encouraged. Institutions engaging in those programs could, as a consequence, include diversity in their mission statement to take a stand for diversity. Secondly, diversity training might lead to a change in the norms of the organization, which would consequently lead to behavioral change. The authors argue that this change could have a diminishing effect on ST. Thirdly, training educators on diversity could ultimately affect held stereotypes. Schmader and Hall (2014) critically remark that many diversity training programs, however, are not based on theory or scientific evidence which could explain the varying outcomes of such programs. They argue that the effectiveness of those programs could increase if the programs could implement diversity as a main goal of an organization, focus and have participants reflect on implicit bias, and establish inclusiveness as “the superordinate goal” (p. 33).

While Dalal et al. (2021) primarily focus on the teacher as a change agent and realizer of changed instruction, Schmader and Hall (2014) confirm that teachers’ perspective needs to be altered in order to alleviate ST, but they also acknowledge the importance of an organization-wide adoption to sustain change towards a more inclusive environment.

What has been ingrained in both mentioned programs is the need for educators to understand ST and its impact on those affected by it. This point is also addressed by Singletary et al. (2009). They explain that there are various reasons why teachers need to be aware of ST. Firstly, teachers need to realize that ST is pervasive and can thus also affect groups that are not traditionally thought of such as white males. Adapting the perspective, thus could benefit all students. Secondly, it must be acknowledged that ST impairs performance and can affect students’ life after graduation. Due to its long-reaching effects, as the underrepresentation of

females in STEM shows, diminishing ST might have a positive impact on society. Thirdly, awareness of ST must also entail awareness of held implicit biases and stereotypes. If a teacher's behavior is thus changed, negative impacts on achievement could be lessened. One example listed by Singletary et al. (2009) is to support female students in fields they might not feel comfortable in, such as encouraging them to contribute to STEM fairs. The same point was also made by one of the teachers in Dalal et al.'s (2021) study.

Discussion

Despite the fact that Liu et al.'s (2021) meta-analysis proves that the literature on how to alleviate ST is quite extensive, as the number of papers ($n=323$) and effect sizes coded ($n=251$) show, this review could not demonstrate that the focus of interventions diminishing ST lies on those who might have the power to change environmental factors, in this respect educators. This can be assumed due to the number of papers ($n=10$) presented in this review.

Although expected otherwise, literature on interventions for teachers is quite scarce. However, the papers included in this review point in the same direction, namely, educating teachers on the matter and advocating for a change of perspective. As has been discussed in the section on growth mindset theory, interventions might be more beneficial for students if teachers back those ideas.

The articles returned through the literature search suggest that educators aiming at alleviating ST for their students can either pursue strategies targeted at students affected by ST, by increasing representation of minorities affected by ST (Liu et al., 2021; Schmader & Hall, 2014; Singletary et al., 2009) educating students on gender differences and bias (Kuchynka et al., 2022) or teaching the growth mindset theory (Good et al., 2003; Kuchynka et al., 2022; Rydell & Boucher, 2017; Schmader & Hall, 2014; Seo & Lee, 2021). Additionally, a change in the

mode of instruction in a way that allows for more student collaboration (Dalal et al., 2021; Godsil et al., 2016; Kuchynka et al., 2022; Rydell & Boucher, 2017), active and applied learning (Godsil et al., 2016; Rydell & Boucher, 2017), and re-evaluation of testing (Kuchynka et al., 2022; Rydell & Boucher, 2017) as such has proven to be beneficial to decrease ST. Interventions on teachers that would lead to a changed mindset, however, are rare (Dalal et al., 2021; Schmader & Hall, 2014)

Future Research

As Dalal et al. (2021) argue, it would be desirable to focus on teachers and their impact in alleviating ST. Firstly, students affected by ST should not be left alone in dealing with a situation that is far from being self-imposed. Furthermore, strategies proposed such as the growth mindset theory or a more active approach to instruction could benefit all students and not just those affected by ST. In this regard, it must be acknowledged that ST has a long-lasting effect that might hinder students affected (Seo and Lee, 2021). It might, ultimately, also lead to benefits for society if students are no longer hindered by ST.

Therefore, a heightened interest in how teachers can help alleviate ST would be beneficial. Programs such as the one proposed and scientifically accompanied and tested by Dalal et al. (2021) would be desirable, as these programs do not only provide data but also have an immediate impact on teachers and subsequently students.

Limitations

When critically assessing and questioning the search string, one reason that might have led to this outcome of only three papers as a result of the screening using CADIMA was identified as the inclusion of the term ‘teacher’. This could be traced back to the fact that the

articles that were found during the bibliography screening of the originally returned articles did not include the term either in their title or their abstract.

Additionally, it needs to be noted that this review could not just rely on scientific texts that are traditionally presented in systematic reviews as the scope of literature was merely too limited. The quality assessment of the sources returned from the literature search demonstrated that there was some divergence between what assessment tools propose and what the papers offered. Not including those papers though, would have lead to an ever scarcer picture.

Practical Implications

As Dalal et al. (2021) state educators are left alone in addressing issues such as ST and gender bias. Therefore, school officials, teacher training facilities, and superordinate agencies should adopt strategies to help raise awareness on the issue of ST. This could be realized in the form of pre-service teacher and teacher training that should include the topic of diversity in their curricula to increase awareness and understanding of the matter. Furthermore, specific training programs based on scientific evidence (Schmader et al., 2008) targeted at educating pre-service teachers and teachers on ST and its impact on students should form the foundation for the implementation in the classroom.

After establishing awareness on the issue of ST, interventions on teachers need to be realized. As Seo and Lee (2021), as well as, Kuchynka et al. (2022) have demonstrated adopting a growth mindset could be a beneficial change. As it was argued this also requires teachers to change their mindset if this change should be longer-lasting. Also in this respect, teacher training and education on that matter might be beneficial. In this regard, programs as the one introduced in the paper by Dalal et al. (2021) should be focused on.

Furthermore, as Dalal et al. (2021), Godsil et al. (2016), Kuchynka et al. (2022), and Rydell and Boucher (2017) proposed, a change towards a more active and collaborative approach of instruction would not only benefit those affected by ST. Therefore, training that allows teachers to change their teaching approach and support mechanisms, such as professional communities that assist teachers on their way to change their method of instruction seem to be necessary to reach a state in which ST can be alleviated. Additionally, as has been discussed, benefits could be even more extensive.

Finally, as has been demonstrated, ST can be alleviated if students feel represented by the staff at their school, as Singletary et al. (2009) propose. Therefore school administrators need to become aware of the impact a more diverse teaching and administrative staff could have and should, consequently, ensure that the staff at a school depicts the diversity of the student body. This claim, naturally, has its limitations but at some point, the vicious circle imposed by ST needs to be broken to reach a future that is more equal and just.

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