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RESEARCH ARTICLE

Do Students Still Hold Stereotypical Views of STEM Careers? Comparison of Turkish and Australian Student Responses to a STEM Stereotypes Questionnaire

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Abstract

Stereotypical views of STEM careers are major barriers to students choosing to engage with STEM subjects and careers, particularly for students who identify as female. Stereotypes include trait-based beliefs (e.g. people in STEM careers are geniuses, technology-obsessed), gender-based beliefs (e.g. males are more successful in STEM careers), and socio-economic status (SES)–based beliefs (e.g. upper-middle-class, well-educated families are better positioned to enter STEM careers). However, little is known about the differences between stereotypes in each STEM domain and the cultural factors that influence STEM stereotypes. This study describes students' perceptions of careers within each individual STEM domain in terms of perceptions of traits, gender, and SES, and compares perceptions between students in Türkiye and Australia, two countries with significantly different distributions of genders within STEM professions. There was no significant difference between Australian and Turkish students regarding their beliefs about necessary traits for STEM careers. However, Australian students were more likely to believe that STEM careers were more accessible to higher SES families than Turkish students. Comparison of gendered views of STEM careers revealed biases about the suitability of these careers for males rather than females held by all Australian students, particularly males, and by Turkish males only.

Keywords STEM stereotypes · Traits · Gender · SES · Cross-national

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Introduction

Two challenges currently exist related to STEM fields. One is lower interest in STEM careers over non-STEM careers worldwide (CHE, 2023; NCSES 2023; Nguyen & Riegle-Crumb, 2021). The second is the underrepresentation of certain groups, such as females and individuals with low socio-economic status (SES) in specific STEM fields, such as engineering and physics (CHE, 2023; EL-Deghaidy et al., 2025; Ketenci et al., 2020; NCSES, 2023; Pagkratidou et al., 2025; van den Hurk et al., 2019; WISE, 2018). Studies indicated that stereotypes about STEM fields are one of the chief factors influencing students' STEM interest and the underrepresentation of female and minority groups in STEM fields (Eddy & Brownell, 2016; Leslie et al., 2015; Master & Meltzoff, 2020; Meyer et al., 2015; Piatek-Jimenez et al., 2018; Storage et al., 2016; Van der Vleuten et al., 2018). Stereotypes are 'beliefs or associations that link whole groups of people with certain traits or characteristics' (Kassin et al., 2017, p. 158).

Stereotypes influence individuals' career interests (Archer et al., 2013, 2014; Charles & Bradley, 2009; Cundiff et al., 2013; Dunlap & Barth, 2023; Luo et al., 2021; Makarova et al., 2019; Master & Meltzoff, 2020; Napp & Breda, 2022), disciplinary identity (Cundiff et al., 2013; Dunlap & Barth, 2019; Smith et al., 2015; Starr & Leaper, 2024; Starr & Simpkins, 2021; Steinke, 2017), self-competence (Ertl et al., 2017; Garriott et al., 2017; Luo et al., 2021), sense of belonging (Cheryan et al., 2009; Master, 2021; Master & Meltzoff, 2020; Stout et al., 2013), hiring decisions (Corbett & Hill, 2015; Reuben et al., 2014), and teacher expectations (Auwarter & Aruguete, 2008; Gentrup et al., 2024; Glock & Kleen, 2020) in STEM-related fields which might lead to the underrepresentation of certain groups such as females in STEM (Thébaud & Charles, 2018).

Studies also have indicated that stereotype threat, happening when individuals have anxiety that they will confirm a negative stereotype about a group to which they belong (Corbett & Hill, 2015, p. 3), results in gender- and SES-related differences in academic outcomes (e.g.Croizet & Claire, 1998; Spencer & Castano, 2007) and STEM participation (Dost, 2024; Marchand & Taasoobshirazi, 2013; Meador, 2018). Thus, examining students' STEM stereotypes is crucial to promoting their STEM career interests and diversity in STEM fields.

This study fills several gaps in the current literature. First, the current literature on STEM stereotypes is mainly related to gender- or trait-related stereotypes, and SES-related stereotypes are rarely investigated. Second, studies have generally only addressed one aspect of stereotypes within the same study (e.g. McNeill & Wei, 2025), whereas investigating different dimensions, such as trait, gender, and SES-related stereotypes, and the interaction between these dimensions in the same study is rarely observed. Third, STEM stereotypes have been generally considered in a unified way by combining fields such as science and mathematics, while previous research and current STEM profession statistics indicate that the underrepresentation of females is not consistent across STEM fields (CHE, 2023; Cheryan et al., 2017; WISE, 2023). Based on social role theory, different representation rates might lead to different group stereotype patterns. The

theory suggests that the stereotypes mainly form through observing participation by social categories such as sex, age, and race. The observation can be direct via personal experiences or indirect via social communication and cultural representations (Eagly & Koenig, 2021; Eagly & Wood, 2012; Eagly et al., 2020). For instance, gender stereotypes arise when individuals observe male and female behaviours and conclude that the sexes have different or similar traits required for particular social roles in the society to which they belong (Eagly & Wood, 2012). According to Eagly and Koenig (2021), there is a vicious cycle between stereotypes and social roles. Once the stereotype is created as a result of historical and cultural norms, it prevents category members from moving into new roles with different requirements, as the stereotype describes them as suited for their current roles but not for the new ones, maintaining gender segregation. The observation of category representation in certain fields, such as engineering and computer science, might reinforce gender stereotypes. Consistent with this theory, it was observed that students demonstrated different stereotypes across different STEM fields (Fralick et al., 2009; Leslie et al., 2015; Makarova et al., 2019; Master & Meltzoff, 2020). A recent study investigating stereotypes for STEM fields indicated that the development of stereotypes is not the same across four STEM fields (Tang et al., 2024). All these results and theoretical assumptions suggest that inspecting students' stereotypical beliefs about each STEM field separately is necessary. It should be noted that examining students' stereotypes for four STEM fields individually does not conflict with the integrative STEM education approach (Kelley & Knowles, 2016). On the contrary, it provides nuanced prescriptions about stereotypes for each component of integrative STEM, which enables stakeholders to design an inclusive integrative STEM education for all students.

Finally, there have been a limited number of studies investigating cross-cultural differences in STEM stereotypes (e.g.Moè et al., 2021; Musso et al., 2022; Napp & Breda, 2022). The studies indicated that culture plays a significant role in stereotype content. For instance, Cuddy et al. (2015) found that male stereotypes were more consistent with cultural norms of societies than female stereotypes. Additionally, there are significant differences in the underrepresentation of females in STEM fields among different cultures (McNeill & Wei, 2025). Thus, the present study also aimed to investigate what stereotype types are moderated by cultural differences by examining students' perceptions about individual STEM fields regarding gendered-, trait-, and SES-based dimensions in two countries with different cultural (individualistic vs collectivist) and economic backgrounds (Australia: a developed, high-income economy where individualism is highly valued versus Türkiye: a developing upper-middle-income economy where the culture tends to be more collectivist in nature).

This study addressed the following research questions:

RQ1. Do students hold differing stereotypical views of careers in science, technology, engineering, or mathematics?
RQ2. Are there differences between Turkish and Australian students' stereotypes in each scale (trait-based, gender-based, and SES) across STEM domains?

RQ3. Are there differences in stereotypical views of STEM careers between males and females, and are these different for Turkish and Australian students?
RQ4. Do students hold implicit gender stereotypes about careers in each STEM domain, and are these implicit stereotypes the same for males and females, and for Turkish and Australian students?

STEM Stereotypes

STEM stereotypes are stereotypes of individuals about STEM fields. The present study examined middle school students' STEM stereotypes in three dimensions: trait-based, gender, and SES stereotypes.

Trait-Based Stereotypes

People in STEM fields are stereotyped as geniuses, eccentric, obsessed with technology, thinking objectively, rational, non-emotional, and socially awkward (Archer et al., 2010, 2013; Barbercheck, 2001; Cheryan et al., 2009; Garriott et al., 2017; Masnick et al., 2010; Starr, 2021; Starr & Leaper, 2019).

Trait-based stereotypes affect individuals' identity (Archer et al., 2010; Starr, 2018; Starr & Leaper, 2024), self-efficacy (Garriott et al., 2017; Luo et al., 2021; Starr & Leaper, 2019), interest (Garriott et al., 2017), value beliefs (Starr, 2021; Starr & Leaper, 2019), outcome expectations (Luo et al., 2021), and career interests (Archer et al., 2013; Cheryan et al., 2013; Luo et al., 2021) in STEM fields.

Trait-based stereotypes generally resonate with gender and SES stereotypes, as certain groups, such as females, are stereotyped as lacking those traits. Archer et al. (2013) argue that associating science with cleverness, which is also linked with males and persons with higher SES, may prevent females and persons with low SES from developing a science identity and career interest in science as the stereotypical beliefs attributed to them lead them to believe that they lack that trait.

Gender Stereotypes

Gender stereotypes are generalised beliefs about the traits that males and females are likely to have (Kessels, 2005). They can be descriptive, what men and women are, and prescriptive, what men and women should be, according to societal norms. Descriptive gender stereotypes define agency properties as being associated with males and communality properties as being associated with females. Agency-based characteristics include being competent, ambitious, task-focused, assertive, dominant, forceful, independent, self-reliant, decisive, rational, analytical, logical, and objective. In contrast, communality-related characteristics include being kind, caring, considerate, warm, friendly, collaborative, obedient, respectful, self-effacing, and emotionally sensitive. Prescriptive stereotypes share the content of descriptive stereotypes and set gender norms, defining what characteristics and behaviours are appropriate and inappropriate for men and women (Heilman, 2012).

Gender stereotypes documented in STEM fields are consistent with those listed above. STEM fields are generally considered masculine fields (Cheryan et al., 2009; Master, 2021; Smeding, 2012) in which agency traits are required for success. For instance, males are frequently stereotyped as more competent than females in STEM (Cundiff et al., 2013; Ertl et al., 2017; Leslie et al., 2015; Master, 2021).

Studies have indicated that the endorsement of gender stereotypes differed for males and females (Dunlap & Barth, 2019; Furnham et al., 2006; McGuire et al., 2020; Moè et al., 2021; Musso et al., 2022). For instance, Musso et al. (2022) and Moè et al. (2021) observed that male STEM students demonstrated male-favouring stereotypes more than female STEM students.

SES Stereotypes

Research has also indicated stereotypes about individuals with different socio-economic statuses (Croizet et al., 2001). Individuals with low SES are stereotyped as being less competent, intelligent, responsible, motivated, and hardworking than those with high SES (Archer et al., 2010, 2013; Cozzarelli et al., 2001; Croizet et al., 2001; Durante & Fiske, 2017; Gorski, 2012; Lindqvist et al., 2017; Régner et al., 2002; Spencer & Castano, 2007). In a cross-cultural study, Durante and Fiske (2017) found that individuals with high SES are stereotyped as more competent but colder than those with low SES, and these stereotypes get more pronounced in more economically unequal societies.

Expectation states theory claims that the group with dominant status is more likely to adopt stereotypical beliefs, in this case that people with high SES are more likely to have STEM careers than people with subordinate status (Ridgeway, 2001). Similarly, Duru-Bellat and Tenret (2012) argued that people with higher status because of gender, income, and social class generally endorse meritocratic beliefs more. In addition, teachers' SES stereotypes may shape their expectations of students with low SES (Gentrup et al., 2024; Glock & Kleen, 2020). For example, Gentrup et al. (2024) observed that teachers had lower expectations for students with low SES than those with higher SES in German language and mathematics.

Cultural Differences in Stereotypes

Stereotypes vary across countries due to cultural norms (Napp, 2023). Research highlights notable cross-cultural differences, especially in gender stereotypes, which tend to be stronger in more industrialised nations (Breda et al., 2020; Costa Jr et al., 2001; Cuddy et al., 2010; Napp, 2023; Napp & Breda, 2022). For example, Breda et al. (2020) found that the belief that males excel in mathematics is more prevalent in developed countries. Similarly, Napp and Breda (2022) observed that stereotypes about girls lacking talent and boys being inherently brilliant are more common in these nations.

Cultural values—individualism versus collectivism—also influence stereotypes (Cuddy et al., 2015). Collectivist cultures emphasise group norms and communal goals, while individualist cultures prioritise autonomy and personal goals (Triandis,

2001). Türkiye is generally categorised as having a collectivist culture, whereas Australia is a country with an individualist culture (Hofstede, 1984, 2024).

Meritocracy is another factor linked to cultural differences in stereotypes. In meritocratic societies, higher status is seen as earned through talent and effort, reinforcing social inequalities (Duru-Bellat & Tenret, 2012; McCoy & Major, 2007). Individualist and economically developed countries tend to hold stronger meritocratic beliefs (Duru-Bellat & Tenret, 2012; Heuer et al., 2020; Kunovich & Slomczynski, 2007).

These cultural and ideological differences are reflected in STEM participation. Australia, the 12th largest economy with high average household incomes (Australian Government, 2022), has a STEM workforce that is only 15% female (Department of Industry Science & Resources, 2023). Although 39% of STEM enrolments in 2022 were female, only 19% completed engineering and 21% IT degrees. Additionally, female students showed lower self-efficacy in science and mathematics than males but higher in technology (Kennedy et al., 2020), and females were consistently less positive than males about STEM careers (McLure et al., 2021). Only 37.5% of students taking higher mathematics in Year 12 were female (AMSI, 2024).

In contrast, Türkiye, the 18th largest economy and classified as developing (OECD, 2023), had 34% female STEM graduates in 2014 (Ciftci et al., 2020). Female students constitute 36% of the students in physics departments, 31% of students in engineering and technology departments, 61% of students in natural science departments (excluding physics), 65% in health departments, and 51% in mathematics departments (CHE, 2023). Studies show Turkish girls often report greater interest and confidence in science and mathematics than boys, who favour engineering and technology (Kaya, 2024), and that self-efficacy, rather than gender or SES, influences Turkish students' interest in STEM careers (Küçükaydın & Ulum, 2025).

Research on Middle School Students' STEM Stereotypes

Middle school is a pivotal time when stereotypes formed in earlier years become more entrenched, often negatively affecting girls and minority groups (e.g.Miller et al., 2018; Muzzatti & Agnoli, 2007). Studies have explored stereotypes in mathematics (Casad et al., 2017; Gutierrez-Aguilar & Tejeda, 2024; Huguet & Régner, 2009; Luo & Chen, 2024; Muzzatti & Agnoli, 2007; Riggs & Gonzalez, 2024; Smeding et al., 2013), science (Fralick et al., 2009; Liu et al., 2024; Miller et al., 2018; Steinke et al., 2007), technology/computer science (Opps & Yadav, 2022; Pantic et al., 2018; Schorr, 2019; Tellhed et al., 2023; Yücel & Rızvanoğlu, 2019), and engineering (Ergün & Balçin, 2019; Fralick et al., 2009). However, engineering stereotypes are less studied, and few studies address SES stereotypes. Only one study examined gender stereotypes across all four STEM fields (Tang et al., 2024).

Middle school students frequently hold gendered STEM stereotypes, with males perceived as more capable across disciplines. In mathematics, this belief is widespread and consistent across cultures, particularly among boys (Gutierrez-Aguilar & Tejeda, 2024; Luo & Chen, 2024; Muzzatti & Agnoli, 2007), and even students who initially favoured their own gender often shift towards male superiority by

middle school (Huguet & Régner, 2009). These stereotypes negatively affect girls' performance and self-concept, while boys' performance is unaffected or enhanced (Casad et al., 2017; Gutierrez-Aguilar & Tejeda, 2024; Luo & Chen, 2024; Smeding et al., 2013). Similar male-dominant views are found in science, often shaped by media (Steinke et al., 2007), with girls increasingly adopting views of science as male by middle school (Liu et al., 2024). Although depictions of male scientists have declined over time, children—especially older ones—still predominantly draw male figures (Miller et al., 2018). In technology, stereotypes portraying males as more competent reduce girls' interest, particularly when reinforced by portrayals of computer scientists as nerdy, male, and socially isolated (Opps & Yadav, 2022; Pantic et al., 2018; Tellhed et al., 2023; Yücel & Rızvanoğlu, 2019). Engineering stereotypes follow the same pattern, with students typically viewing engineers as male and solitary workers (Ergün & Balçin, 2019; Fralick et al., 2009).

Methods

Participants

This study was carried out with students in two public middle schools (grade 6–8: ages 12–15) in Türkiye (180 students who identified as females and 148 who identified as males) and with students from three independent schools (grades 8 and 9: ages 13–15) in Australia (144 students who identified as female and 136 who identified as male). Five students in the Australian sample chose not to identify as either male or female, and although their views are important, due to the small number of students within this group, they were removed from the dataset. In the Turkish data, 21 students did not respond to more than 50% of items within one or more scales. These students' data were removed leaving a total of 307 responses (141 males, 166 females). The Turkish students all lived in a large metropolitan area in Türkiye, while the Australian students were from a regional city and a remote town. Turkish students' parents, on average, had completed high school, while the Australian students' parents had completed tertiary study. Participants were selected using a convenience sampling method and informed consent was obtained from the schools, parents, and students. Participation was voluntary, anonymous, and only limited demographic information (gender, grade level, parental education level) was gathered.

Instrument

A STEM stereotypes questionnaire was designed based on prior studies of STEM stereotypes (e.g.Archer et al., 2013; Barbercheck, 2001; Hughes et al., 2013; Starr, 2018) to separately measure students' perceptions of careers in science, technology, engineering, and mathematics. It was validated using exploratory and confirmatory factor analyses and was found to have good fit indices for each sub-scale (TLI > 0.90) for data obtained from both Turkish and Australian students (Yerdelen-Damar et al.,

Table 1 STEM stereotypes questionnaire examples of scales and items for the science domain

Scale	No of items	Example
Trait-based	4	People who work in science-related fields are usually geniuses
Female-oriented	3	A person working in science-related fields is more likely to be a female
Male-oriented	3	A person working in science-related fields is more likely to be a male
SES	6	People whose families have middle- or high-incomes are more likely to prefer science-related jobs

2025). In addition, composite reliability for each scale was greater than 0.60 for all scales and greater than 0.70 for most scales, exceeding the minimum requirements for exploratory research (Hair et al., 2022). The full questionnaire can be accessed from Yerdelen-Damar et al. (2025). The STEM stereotypes questionnaire was administered online and in paper-based form to students. Examples of scales and items of this instrument are found in Table 1. The STEM stereotypes questionnaire measures students' perceptions of STEM careers, subjects, and projects in terms of trait-based characteristics, suitability for females, suitability for males, and likelihood of people with higher SES backgrounds participating on a four-point Likert scale (strongly disagree, disagree, agree, strongly agree) (Table 1). Each domain has identical items replacing 'science' with mathematics, technology, or engineering. A four-point scale was chosen to force a choice from students rather than allowing for a neutral option, which can sometimes become a default position. Importantly, students are asked to respond separately to each item for science, technology, engineering, and mathematics careers. In the case of the Turkish data, in cases where missing responses to less than 50% of items within a scale were found, the average response value for that scale was substituted. The STEM stereotypes questionnaire had a robust scale structure measured by exploratory and confirmatory factor analysis. In each domain, the percentage of variance explained was between 54.45% and 67.73% for the Australian data and between 60.30% and 69.20% for the Turkish data. Both a female-oriented scale and a male-oriented scale were included because of strong negative reactions from students when asked to respond to explicit statements probing gendered stereotypes such as 'Science careers are more appropriate for males than females'. This reaction is consistent with the findings of McGuire et al. (2020), that the majority of adolescents endorse statements such as 'both boys and girls should be good at STEM'. This raised the concern that students' beliefs in what *should* be the case—no gender differences in ability—may mask underlying implicit gender stereotypes, which may not be revealed using explicit statements about gendered stereotypes. In order to reveal any implicit gender stereotypes, we therefore chose to modify the gender stereotypes scale, which compared genders to create two scales: a female-oriented and a male-oriented scale. This allowed us to compare students' responses to the female-oriented and male-oriented scales to determine whether students hold implicit gendered stereotypes (Yerdelen-Damar et al., 2025). A student who believes that there are no gender differences in ability or accessibility to STEM careers would be expected to disagree with the statements on both scales. However, while students may defend the equality of ability

for all genders in STEM, differences in how strongly they agree or disagree with the female-oriented and male-oriented items reveal whether a student implicitly believes that STEM careers are inherently more suited to males rather than females or vice versa (e.g. by responding with 'disagree' to a female-oriented item and 'strongly disagree' to the corresponding male-oriented item).

Analysis

Before carrying out comparisons by gender and country, the skewness and kurtosis of the data were checked for all variables. All absolute skewness values were less than 3 and all absolute kurtosis values were less than 10, indicating that the data met multivariate normal distribution conditions required for t-test comparisons (Stevens, 2009). Following skewness and kurtosis checks for normal distribution of the data in each scale of each domain, means and standard deviations were calculated for each scale for both Australian and Turkish data.

In order to address RQ1, descriptive statistics (mean and standard deviation) were obtained for Turkish and Australian data in each domain (science, technology, engineering, and mathematics), and paired sample *t*-test comparisons were then carried out between student responses for the same scale within domains. For example, students' responses to the trait-based scale in the engineering and science domains were compared for both Turkish and Australian students.

To address RQ2, independent *t*-test comparisons were made between Turkish and Australian student responses to each scale within each domain. Levene's tests for equal variance between the two groups were carried out, and where these were found not to be equal, Welch's *t*-test values were used (Reed & Stark, 2004).

To address RQ3, gendered differences in perceptions of each scale within each STEM domain, differences between males' and females' perceptions were measured using independent *t*-test comparisons for both Turkish and Australian data. Levene's test for equality of variance was used to compare male and female results and where they were found to be unequal, Welch's *t*-test values were used.

To address RQ4, uncovering any implicit gender stereotypes, paired sample *t*-test comparisons were also made between each student's responses to the male-oriented and female-oriented scales for each STEM domain for both Turkish and Australian data. Comparison of each student's response to corresponding items within the male and female orientation-towards-careers scales allows for exposure of any implicit gender stereotypes that students hold, which may be hidden in questionnaires that directly compare gender-based beliefs about ability or suitability of careers. If, for instance, students hold implicit beliefs that careers are more appropriate for males than females, one would expect significant differences in the choices that a student makes for female-oriented gender scale items and male-oriented gender scale items.

Further to this analysis, each student's response to the female-oriented scale was subtracted from their response to the male-oriented scale to compare implicit gender stereotypes in perception of the suitability of careers within each domain for males versus females using independent *t*-tests. Mean differences were calculated for male and female Turkish and Australian students. Comparison of these differences was

Table 2 Descriptive statistics for each dimension

Scales	Mean (standard deviation)							
	TR S	AU S	TR T	AU T	TR E	AU E	TR M	AU M
Trait-based	2.67 (.56)	2.66 (.45)	2.82 (.64)	2.91 (.61)	2.73 (.67)	2.69 (.52)	2.73 (.61)	2.71 (.52)
Female-oriented	1.87 (.76)	2.15 (.50)	1.91 (.80)	2.29 (.58)	1.91 (.81)	2.33 (.64)	1.99 (.81)	2.32 (.61)
Male-oriented	2.00 (.82)	2.47 (.61)	2.19 (.96)	2.58 (.62)	2.23 (.94)	2.59 (.67)	2.10 (.87)	2.50 (.64)
SES	2.23 (.70)	2.66 (.48)	2.27 (.77)	2.67 (.55)	2.28 (.80)	2.68 (.54)	2.19 (.75)	2.68 (.49)

AU, Australian data; *TR*, Turkish data; *S*, science; *T*, technology; *E*, engineering *M*, mathematics

also made by country using independent *t*-tests. Finally, implicit gender stereotypes were compared between male and female students by country using independent *t*-test comparisons. Significant differences between values can sometimes be observed between values that are quite small (Sullivan & Feinn, 2021). In order to test the practical importance of the results, Cohen's effect sizes and 95% confidence intervals were also calculated where comparisons were made between countries and genders. A small effect size corresponds to a value of $d < 0.2$, a medium effect size $d \cong 0.8$, and a large effect size $d > 0.8$ (Cohen, 1988).

Results

RQ1. Do Students Hold Differing Stereotypical Views of Careers in Science, Technology, Engineering, or Mathematics?

Descriptive statistics (mean and standard deviation) for each scale within each domain are presented in Table 2.

Australian students held the most trait-based stereotypes about technology careers, followed by mathematics careers, then engineering, and the least trait-based stereotypes about science careers (Table 3). Paired sample *t*-tests between Australian students' trait-based beliefs in separate domains (i.e. S. T. E. and M.) (Table 3) revealed that students had significantly more stereotypical views of technology than science, engineering, and mathematics (i.e. they were more likely to think that you needed to be a genius or obsessed with technology and facts than for these other domains). This may not be surprising as the obsession with technology was one of the items on this scale, and students could assume that this is a prerequisite for engaging with a career in technology. Australian students also held significantly more stereotypical views of mathematics careers than science careers.

Similarly, Turkish students held the most trait-based stereotypical views of technology, followed by mathematics and engineering, and the least about

Table 3 Paired sample *t*-test comparisons between students' perceptions of STEM domains

Scale	Domains compared	Difference between domains	
		Australian students	Turkish students
Trait-based	Engineering-science	0.03	0.06*
	Mathematics-science	0.05*	0.06*
	Technology-science	0.25***	0.15***
	Mathematics-engineering	0.02	0.00
	Technology-engineering	0.22***	0.09**
	Technology-mathematics	0.20***	0.09**
Female-oriented	Engineering-science	0.18***	0.04
	Mathematics-science	0.17***	0.12***
	Technology-science	0.14***	0.04
	Mathematics-engineering	0.03	0.08*
	Technology-engineering	0.04	0.00
	Technology-mathematics	0.03	−0.08*
Male-oriented	Engineering-science	0.12***	0.23***
	Mathematics-science	0.03	0.10**
	Technology-science	0.11***	0.19***
	Mathematics-engineering	−0.09***	−0.13***
	Technology-engineering	−0.01	−0.04
	Technology-mathematics	0.08***	0.09**
SES	Engineering-science	0.02	0.05
	Mathematics-science	0.02	−0.04
	Technology-science	0.01	0.04
	Mathematics-engineering	0.00	−0.09*
	Technology-engineering	−0.01	−0.01
	Technology-mathematics	−0.01	0.08*

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

science. Once again, this may be accentuated by the item which states that people who are engaged with technology careers are technology-obsessed.

Paired sample *t*-tests comparing perceptions of the female orientation of careers in different domains showed that Australian students thought that science careers were less female-oriented than mathematics, technology, or engineering careers. No significant differences were noted between perceptions of technology, engineering, and mathematics careers as female-oriented. On the other hand, Turkish students saw mathematics careers as more female-oriented than science, technology, or engineering careers.

Paired sample *t*-tests comparing perceptions in the male orientation of careers in different domains showed that Australian students thought that engineering and technology careers were more male-oriented than science and mathematics careers. Similar perceptions were found for Turkish students.

Table 4 Independent *t*-test comparisons of scales by country

Domain	Scale	Difference between Australian and Turkish student perceptions	Cohen's effect size (*d*)	95% confidence intervals (difference)
Science	Trait	−0.01	−0.01	−0.08 to 0.09
	Female orientation	0.28***	0.40	0.16–0.37
	Male orientation	0.47***	0.64	0.35–0.59
	SES	0.43***	0.72	0.33–0.53
Technology	Trait	−0.09	−0.12	−0.08 to 0.09
	Female orientation	0.38***	0.53	0.19–0.43
	Male orientation	0.39***	0.46	0.26–0.52
	SES	0.40***	0.59	0.36–0.56
Engineering	Trait	−0.04	−0.06	−0.03 to 0.15
	Female orientation	0.42***	0.54	0.25–0.49
	Male orientation	0.36***	0.43	0.24–0.51
	SES	0.40***	0.59	0.30–0.51
Mathematics	Trait	−0.02	−0.01	−0.06 to 0.13
	Female orientation	0.33***	0.43	0.28–0.53
	Male orientation	0.40***	0.51	0.23–0.50
	SES	0.49***	0.71	0.30–0.53

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

There were no significant differences between Australian students' perceptions of the need for a high SES for success between any of the domains. Australian students generally held high levels of stereotypical views about the likelihood of doing STEM careers being greater if you come from a highly educated and/or well-off family. Turkish students, however, thought that students with higher SES were more likely to have careers in technology and engineering than in mathematics.

Differences between domains in implicit gender biases between STEM domains are presented in RQ4.

RQ2. Are There Differences Between Turkish and Australian Students' Stereotypes in Each Scale (Trait-Based, Gender-Based, and SES) Across STEM Domains?

Descriptive data in Table 2 and independent *t*-tests comparing Turkish and Australian responses (Table 4) indicate that, on average, students from both Australia and Türkiye agreed with the trait-based propositions that careers in STEM require high intelligence, lack of emotion when making judgements, and an obsession with technology (mean > 2.5). This result implies that trait-based beliefs are still a major barrier to STEM participation for many students in both Türkiye and Australia, and that these stereotypes may not be influenced by culture.

Australian students, on average, thought that careers in each STEM domain, except for science, were more male-oriented (Table 2: mean > 2.5), while Turkish

students were more likely to disagree (Table 2: mean < 2.5) that STEM careers were more male-oriented. Independent *t*-test comparisons between countries showed that Australian students were significantly more likely to believe that STEM careers were more male-oriented than Turkish students (Table 4).

Both Australian and Turkish students, on average, disagreed that STEM careers are female-oriented (Table 2: mean < 2.5). However, Australian students were significantly less negative about the female orientation of STEM careers in each domain than Turkish students (Table 4). This might suggest that Australian students have higher expectations than Turkish students about participation in STEM careers for both males and females. Possible reasons for these differences become more evident when these results are separated out by gender (see results for RQ3 and RQ4).

Australian students, on average, believed that engaging with STEM careers was more likely if you come from a high SES background (Table 2: mean > 2.5), while Turkish students, on average, were more likely to disagree with this proposition (Table 2: mean < 2.5). These differences in perceptions were significant between countries with a moderate effect size (Table 4).

RQ3. Are There Differences in Stereotypical Views of STEM Careers Between Males and Females and Are These Different for Turkish and Australian Students?

Responses to the STEM stereotypes questionnaire were separated by gender. Comparison of male and female perceptions of STEM stereotype scales was made using independent *t*-test comparisons for both Turkish and Australian data (Table 5). While there was no significant difference in Australian male and female perceptions of the female orientation of STEM careers, Australian males were significantly more positive about careers in science and technology being male-oriented than were Australian female students. Australian males were also more likely to believe that trait-based stereotypes such as genius, obsession with technology, and unemotional stance were necessary in engineering careers than female Australian students. Additionally, Australian males were also significantly more likely to think that careers in technology and engineering were more appropriate for people with high SES than their female counterparts.

There were no significant differences between Turkish male and female perceptions of the trait-based beliefs and female orientation towards careers. However, in each STEM domain, Turkish male students were significantly more positive about careers being male-oriented than Turkish females. The difference between perceptions about the male orientation of careers for Turkish males and females is much larger than for Australian males and females, partly due to female Turkish students much more strongly disagreeing that STEM careers are male-oriented than the female Australian students (Table 5).

Turkish and Australian male students were also more likely to believe in the importance of coming from high SES backgrounds for success in STEM careers compared to their female counterparts (Table 5). This suggests that both Turkish and Australian females are more likely to believe that social mobility is possible than their male counterparts.

Table 5 Independent *t*-test comparisons of Australian male's ($n=136$) and female's ($n=144$) scores and Turkish male's ($n=141$) and female's ($n=166$) scores

	Females		Males		Male-female		Cohen's effect size (*d*)		95% confidence interval (difference)	
	Australian M (SD)	Turkish M (SD)	Australian M (SD)	Turkish M (SD)	Australian	Turkish	AU data	TR data	Australian data	Turkish data
Science										
Trait beliefs	2.63 (.42)	2.65 (.53)	2.69 (.48)	2.67 (.58)	0.06	0.02	0.14	0.03	−0.04 to 0.17	−0.11 to 0.14
Female orientation	2.19 (.46)	1.94 (.76)	2.12 (.54)	1.83 (.78)	−0.07	−0.09	−0.14	−0.14	−0.19 to 0.05	−0.28 to 0.06
Male orientation	2.39 (.57)	1.85 (.70)	2.56 (.63)	2.18 (.90)	0.17*	0.33***	0.29	0.41	0.03–0.31	0.14–0.51
SES	2.62 (.45)	2.11 (.65)	2.71 (.51)	2.39 (.72)	0.09	0.28***	0.20	0.40	−0.02 to 0.21	0.12–0.43
Mathematics										
Trait beliefs	2.69 (.46)	2.73 (.56)	2.73 (.57)	2.71 (.67)	0.04	−0.02	0.08	−0.03	−0.08 to 0.16	−0.15 to 0.12
Female orientation	2.34 (.58)	2.04 (.79)	2.29 (.65)	1.96 (.83)	−0.05	−0.08	−0.09	−0.10	−0.20 to 0.09	−0.27 to 0.10
Male orientation	2.45 (.59)	1.98 (.76)	2.55 (.69)	2.26 (.95)	0.10	0.28**	0.15	0.33	−0.05 to 0.25	0.09–0.47
SES	2.63 (.44)	2.07 (.72)	2.73 (.53)	2.39 (.77)	0.10	0.32***	0.20	0.42	−0.02 to 0.21	0.15–0.48
Technology										
Trait beliefs	2.89 (.60)	2.81 (.61)	2.94 (.63)	2.85 (.70)	0.05	0.04	0.08	0.05	−0.10 to 0.19	−0.11 to0.18
Female orientation	2.29 (.54)	1.96 (.80)	2.29 (.54)	1.86 (.81)	0.00	−0.10	0.01	−0.11	−0.14 to 0.15	−0.27 to0.09
Male orientation	2.51 (.63)	2.03 (.83)	2.66 (.61)	2.43 (1.06)	0.15*	0.40***	0.25	0.43	0.01–0.30	0.19–0.61
SES	2.55 (.52)	2.16 (.74)	2.79 (.56)	2.41 (.78)	0.24***	0.25**	0.45	0.33	0.11–0.37	0.08–0.42
Engineering										
Trait beliefs	2.61 (.48)	2.75 (.64)	2.79 (.54)	2.71 (.69)	0.18**	−0.04	0.35	−0.06	0.06–0.30	−0.19 to 0.11
Female orientation	2.34 (.59)	1.96 (.83)	2.33 (.70)	1.91 (.82)	−0.01	−0.05	−0.01	−0.06	−0.16 to 0.15	−0.23 to 0.14
Male orientation	2.54 (.66)	2.04 (.85)	2.64 (.68)	2.47 (.99)	0.10	0.43***	0.15	0.47	−0.06 to 0.26	0.23–0.64
SES	2.62 (.53)	2.11 (.75)	2.75 (.55)	2.48 (.80)	0.13*	0.37***	0.25	0.48	0.00–0.26	0.19–0.54

*$p<0.05$, **$p<0.01$, ***$p<0.001$

RQ4. Do Students Hold İmplicit Gender Stereotypes About Careers in Each STEM Domain, and Are These İmplicit Stereotypes the Same for Males and Females, and for Turkish and Australian Students?

Mean differences between each student's views of male orientation of STEM careers versus female orientation are presented in Table 6. These revealed that Australian students believe that STEM careers in each domain (science, mathematics, technology, and engineering) are more male-oriented than female-oriented, that is, they tended to agree with statements such as 'a person working in a science-related field is more likely to be male' while agreeing less strongly or disagreeing with a statement such as 'a person working in a science-related field is more likely to be female'. Likewise, Turkish students thought that careers in all four domains were more male-oriented than female-oriented.

When comparing Australian students' implicit gender stereotypes in different STEM domains, students had significantly larger differences between perceptions of male orientation versus female orientation in science compared to mathematics, in engineering compared to mathematics, and in technology compared to mathematics careers.

On the other hand, the Turkish students had much larger differences in perceptions of the male orientation versus female orientation of engineering and technology careers than they did for careers in mathematics and science. That is, they were less likely to hold implicit male-oriented gender biases about careers in mathematics and science than about careers in technology and engineering.

The only significant difference between national perceptions of the differences between male orientation and female orientation of careers in STEM domains was in the domain of science, where Australian students were significantly more likely to consider science careers more male-oriented than female-oriented compared to Turkish students.

However, the picture changes considerably when implicit gender stereotypes are separated by gender. Comparison of gendered differences between responses to items related to male orientation versus female orientation (as represented by the difference between a student's response to these two scales—implicit gender stereotypes) is displayed in Table 7. The mean difference in implicit gender stereotypes regarding male orientation of careers revealed that both Turkish and Australian girls hold less gendered views of careers than boys.

Australian boys have a significantly greater belief that careers in science, mathematics, and technology are more male-oriented than girls. However, the difference between the views of Australian boys and girls about engineering careers in terms of them being more male-oriented than female-oriented is not significantly different since both genders, on average, perceive engineering to be male-oriented (see Table 5: mean > 2.5).

The female Turkish students, on the other hand, had quite similar perceptions of male and female orientation of careers in STEM (differences close to zero, Table 7), and in the cases of science and mathematics, the average Turkish female student thought that careers in these areas were slightly more female-oriented than male-oriented.

Table 6 Difference between male-oriented and female-oriented scale responses. Paired samples *t*-tests comparing implicit gender stereotypes in STEM careers for Australian and Turkish students, and independent *t*-tests between Australian and Turkish students

Comparison of male-oriented versus female-oriented scales	Mean difference (SD)		Australia-Türkiye (standard error)	Cohen's effect size (*d*)		95% confidence interval of the difference	
	Australian data	Turkish data		Australian data	Turkish data	Australian data	Turkish data
Science	0.32*** (.65)	0.12* (.67)	0.20***(.05)	0.50	0.17	0.25–0.40	0.04–0.19
Mathematics	0.18*** (.54)	0.11* (.71)	0.08 (.05)	0.34	0.15	0.12–0.25	0.03–0.19
Technology	0.30*** (.61)	0.29*** (.85)	0.00 (.06)	0.49	0.35	0.22–0.37	0.20–0.39
Engineering	0.25*** (.70)	0.30*** (.87)	0.04 (.07)	0.40	0.35	0.17–0.34	0.20–0.40

*$p<0.05$, **$p<0.01$, ***$p<0.001$

Table 7 T-test comparisons of implicit gender stereotypes about STEM careers by gender

	Mean difference Females (SD)		Mean difference Males (SD)		*t*-test (males vs females)		Cohen's effect size (*d*)		95% confidence interval (difference)	
	Australian data	Turkish data	Australian data	Turkish data	Australian data	Turkish data	Australian data	Turkish data	Australian data	Turkish data
Science	0.20 (.57)	−0.08 (.51)	0.45 (.70)	0.35 (.76)	3.18**	5.81***	0.38	0.69	0.09–0.39	0.29–0.58
Mathematics	0.11 (.53)	−0.06 (.53)	0.26 (.54)	0.30 (.84)	2.48*	4.45***	0.29	0.53	0.03–0.28	0.20–0.52
Technology	0.23 (.54)	0.07 (.61)	0.37 (.66)	0.56 (1.01)	2.03*	5.04***	0.25	0.60	0.00–0.29	0.30–0.68
Engineering	0.20 (.59)	0.08 (.67)	0.31 (.81)	0.56 (.99)	1.24	4.86***	0.15	0.57	−0.06 to 0.28	0.29–0.68

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

However, male Turkish students had significantly higher levels of difference between their views of careers as male-oriented compared to female-oriented. That is, they were significantly more likely to think that careers in all four domains were more appropriate for males than for females than were their female classmates.

In summary, these findings reveal a complex picture of the stereotypical views held by Australian and Turkish students. While there are some common threads across countries, such as the strongly held beliefs in trait-based characteristics of those who participate in careers in all STEM fields, the more strongly held views by males than females that STEM careers are more male-oriented than female-oriented, and male perceptions that higher SES is required for success in at least some STEM careers, there are also significant differences in stereotypical beliefs, both between genders and between Türkiye and Australia. In the following discussion, we propose some possible reasons for these differences.

Discussion

Both in-country comparisons of data and between-country comparisons revealed some interesting differences in perceptions, both of stereotypical views of the separate STEM domains and of trait-based, gender-based, and SES-related stereotypes.

Differences Between Stereotypical Views of Science, Technology, Engineering, and Mathematics

Previous studies have indicated that stereotypical views are not identical across STEM domains (Fralick et al., 2009; Leslie et al., 2015; Makarova et al., 2019; Master & Meltzoff, 2020). The results of this study confirmed that there are significant differences between student perceptions of each STEM domain. Of the stereotypes examined, the strongest stereotypes that both Australian and Turkish students hold are trait-based stereotypes. Students mostly agreed or strongly agreed with the stereotypes that people in all STEM fields are brilliant, nerdy, logical decision-makers and exclude emotions from their decision making (c.f., Archer et al., 2010, 2013; Starr & Simpkins, 2021). It seems that the representations that students are encountering of people involved in all STEM careers continue to reinforce these stereotypes. This is particularly evident for both Turkish and Australian students for careers in technology. Considering the frequent representation of computer programmers and IT specialists in popular national and international television and other media as awkward nerds who do not relate to people well, this is not surprising. Turkish and Australian students' perceptions are similar to those found in a study by Opps and Yadav (2022) that showed that female middle school students are more likely to draw computer scientists as male and both male and female students have similar, strong trait-based views of computer scientists. The fact that Australian students held significantly more stereotypical views of mathematics careers than science careers is consistent with the low and decreasing uptake of advanced, calculus-based, and intermediate mathematics at senior high school level in Australia, which

represented only 9.2% and 17.6% of the student cohort respectively in 2020 (AMSI, 2024).

Most students perceived that STEM careers, particularly in technology, engineering, and mathematics, required genius and other personality traits often associated with 'male characteristics'. This coincides with other studies of stereotypes held by middle school students in the areas of technology (Opps & Yadav, 2022), engineering (Ergün & Balçin, 2019), mathematics (Casad et al., 2017; Luo et al., 2021; Riggs & Gonzalez, 2024), and science (Fralick et al., 2009; Liu et al., 2024). The intersection between trait-based beliefs about these careers and students' descriptive and proscriptive gender-based beliefs (Heilman, 2012), namely that maleness is associated with agency while femaleness is associated with communality and that females 'ought' to be less decisive and more socially aware than males, compounds female students' beliefs that these careers are not for them (c.f., Starr & Leaper, 2024). This can also act in reverse. For instance, male Australian students held stronger trait-based stereotypes about engineering, traditionally a male domain, than female students, which may be the result of an intersection between descriptive male stereotypes, such as ambition, assertiveness, and rationality, and a belief that they should display those characteristics and their belief that these characteristics are required for jobs in this field. Although both Australian and Turkish students held trait-based stereotypical views of those who work in science, these were less strong than for the other STEM fields and may be related to the greater number of female role models available in this field.

Surprisingly, Australian students thought that engineering, technology, and mathematics careers were more female-oriented careers than a science career, considering that females are a distinct minority in each of these fields in the Australian context (AMSI, 2024; Department of Industry Science & Resources, 2023). It should be noted, however, that students tended to disagree with statements that careers in any of the STEM domains were more appropriate for females. On the other hand, Australian students thought that technology and engineering were more male-oriented careers than science and mathematics careers, which appears to be more consistent with the actual percentages of females employed in each of these areas in Australia. While only 19% of engineering graduates and 21% of computer science graduates in Australia are female, 67% of life scientists were female in 2023 (Department of Industry Science & Resources, 2023). Hence, Australian students have the opportunity to see far more female scientists than they do female engineers or computer programmers.

Interestingly, Turkish students saw mathematics-based careers as more female-oriented than technology, engineering, or science fields. The relatively high percentage of females studying mathematics at Turkish universities (51%) compared to engineering and technology (31%) (CHE, 2023) is consistent with this finding. Once again, it should be noted that Turkish students, on average, also disagreed with statements that suggested that each of the STEM domains was a likely career for females. Turkish students thought that engineering, technology, and mathematics were all more likely careers for males than science, and that technology was a more likely career for males than mathematics. This is consistent with the much higher proportion of male enrolments in engineering and technology degrees at the

university level in Türkiye and the greater proportion of males engaging with these careers (CHE, 2023). Hence, both Turkish and Australian students have many more opportunities to meet male engineers and computer programmers than female ones.

Finally, there was no significant difference in the ways that Australian students perceived the importance of SES in pursuing careers in any of the STEM domains. On the other hand, Turkish students perceived that coming from a family with a higher SES was an advantage in pursuing careers in technology and engineering compared to mathematics. This may well be due to lower ownership of and familiarity with technology in low SES families in Türkiye. The Australian students who took part in this study all attended fee-paying schools and were thus more likely to come from middle- to higher-income families with good access to technology.

Differences in Turkish and Australian Students' Views of STEM Careers

There were some notable similarities and differences between Turkish and Australian students' stereotypical views of each of the STEM domains, which suggest stereotypical beliefs might have the nature of being both culture-bound and culture-independent. For instance, there were no significant differences between Turkish and Australian students' views of traits required for engagement with each of the STEM domains. This suggests that beliefs that people who engage in STEM careers are geniuses, eccentric, obsessed with technology, think objectively, rational, non-emotional, and socially awkward, found in prior research (Archer et al., 2010, 2013; Barbercheck, 2001; Cheryan et al., 2009; Garriott et al., 2017; Masnick et al., 2010; Starr, 2021; Starr & Leaper, 2019) may be quite consistent across cultures.

However, differences between Australian and Turkish perceptions of female orientation, male orientation, and the benefits of coming from a higher SES background were significant. In each of these scales within each domain, Australian students were more likely to agree with the propositions that suggested that careers were appropriate for males and people from higher SES backgrounds than Turkish students. However, as discussed above, both Turkish and Australian students tended to disagree that careers in these fields were more suited for females; Australian students just tended to disagree less strongly. On the other hand, Australian students were more likely to agree with statements that suggested that careers in technology, engineering, and mathematics were more appropriate for males while disagreeing that science was more appropriate for males. Notably, engineering is a predominantly male career in the Australian context (Department of Industry Science & Resources, 2023), which may influence males in thinking that these male-dominated careers require, what they perceive to be, 'male characteristics'. Turkish students, on the other hand, were more likely to disagree with these statements in all STEM domains. It appears from this data that Australian students, on the whole, held more stereotypical views of technology, engineering, and mathematics careers as male-oriented than Turkish students. This finding is consistent with other findings such as the large study by Breda et al. (2020) that indicated that stereotypes that males are better at mathematics are stronger in more developed countries, like Australia, and less prominent in developing countries, like Türkiye. Likewise, the findings of

Napp and Breda (2022) indicate that the belief that girls are less talented generally than boys is more prevalent among 15-year-olds in developed countries compared to developing countries. Further, the study of word embeddings across nations by Napp (2023) showed that more economically developed, individualistic nations, such as Australia, had more stereotypical representations of males and females in writings, particularly in mathematics and science, than less economically developed, collectivist nations, such as Türkiye. This is surprising considering the focus on gender equality in most economically developed nations. Napp (2023) and Napp and Breda (2022) suggest that in these countries, while efforts to reduce gendered differentiation favouring males in the public and legal space have been effective, a discourse around gender of 'equal but different' (Napp, 2023, p.7) has replaced prior norms in order to sustain social identities. This may be compounded by the individualistic nature of societies, like Australia, where self-expression and self-realisation are given great importance. This gives space to express identity in terms of essentialist norms (Napp & Breda, 2022), for instance, that females are more socially sensitive, flexible, and caring than males—a perception that does not fit the trait-based stereotypes of many STEM careers.

Costa et al. (2001) suggest that attribution theory may explain the differences between individualistic and collectivist cultures. In a wealthy, individualistic culture, like Australia, financial security may give greater freedom for females to choose not to engage with subjects such as mathematics and sciences and to engage more with personal interests in subjects such as the arts. They then attribute their choices not to engage with STEM topics to gender attributes rather than gender roles, hence perpetuating and even strengthening gender stereotypes. On the other hand, in a collectivistic culture, such as Türkiye, choices of careers may be seen as the result of sex role norms and social requirements rather than individual choice, so they are less constrained by essentialist gender stereotypes. The gendered nature of students' stereotypical views is further elaborated in the following section.

Significant differences with moderately large effect sizes were seen between Australian and Turkish students' perceptions of the effects of SES on STEM participation. In each domain, Australian students had much stronger beliefs that coming from a family with higher income and education was necessary in order to participate in STEM careers than their Turkish counterparts. In fact, Turkish students were more likely to disagree with statements such as 'People whose families have middle- or high-incomes are more likely to prefer science-related jobs'. It should be noted that the students in the Australian sample were all attending fee-paying schools and hence were more likely to come from middle- or high-income families, whereas the Turkish participants were all from government schools and so may have come from diverse economic backgrounds. Additionally, Australian students in this sample had parents with higher educational qualifications than the Turkish students.

It is interesting that despite having lower SES than the Australian students, Turkish students had more confidence that SES was not a factor in determining access to STEM careers while the Australian students saw SES as a determining factor. Expectation states theory may be useful in explaining this difference (Ridgeway, 2001). The Australian students represent a group who have dominant status within Australian society and hence are more likely to see success in high-status careers,

such as STEM careers, as a result of being hardworking, intelligent, highly motivated, and responsible—all characteristics which they attribute to individuals who have high SES compared to individuals with lower SES (Croizet et al., 2001). In addition, an individualistic culture, like the one in Australia, tends to believe in a meritocracy, where hard work and ability are rewarded by increased status and hence high SES is deserved and social inequities are explicable as being the result of less effort (Duru-Bellat & Tenret, 2012). On the other hand, a collectivist culture, like the one in Türkiye, has less belief that social status is based on merit, but rather on other factors such as belonging to a ruling class or powerful political group which results in reducing the belief in a meritocracy and hence that SES is an important factor influencing success in high-status careers such as those in STEM (Duru-Bellat & Tenret, 2012; Heuer et al., 2020; Kunovich & Slomczynski, 2007). This raises the question as to whether students from more economically underdeveloped countries may suppress their SES concerns. There are at present no other cross-country comparisons of SES stereotypes.

Cross-national Male Versus Female Views of STEM Domains and Scales

This study fills the gap in the STEM stereotypes literature which mostly depends on male-favouring items rather than female-favouring items. That is, several studies have used explicit items that assume a male superiority stereotype (e.g.Ertl et al., 2017; Starr & Leaper, 2024; Stout et al., 2013; Tomasetto et al., 2015). Male superiority stereotypes may not be strong across all STEM domains anymore (c.f., McGuire et al., 2020). For example, in Türkiye, there is no big gender gap in interest in science careers except for physics (male) and biology (female) (Ciftci et al., 2020). As seen earlier, Turkish students tended to disagree with both male and female superiority statements.

However, the picture changes when comparing male and female students' perceptions of each scale within each STEM domain. Firstly, the stereotypical traits thought to be held by STEM practitioners of genius, technologically obsessed, and lack of emotion are more frequently attributed to males who are believed to display agency-based characteristics thought to favour STEM careers rather than to females who are believed to display communality-related characteristics thought to be incompatible with STEM careers (Heilman, 2012). Both male and female Turkish and Australian students had similar views of the traits required for STEM careers and, on the whole, agreed that people in these professions were indeed geniuses, 'nerdy', and unswayed by emotions.

While there were no gender differences in perceptions of STEM careers as female-oriented for either Turkish or Australian students, Australian male students were significantly more convinced than females that science and technology careers favoured males. On the other hand, Turkish males had a significantly stronger belief than Turkish females that all STEM careers favoured males. This finding is consistent with studies in other countries, which showed that males hold significantly higher STEM gender stereotypes than females (Dunlap & Barth, 2019; Furnham et al., 2006; McGuire et al., 2020; Moè et al., 2021; Musso et al., 2022) and that

male stereotypes are more consistent with cultural norms of a society than female stereotypes (Cuddy et al., 2015).

Additionally, Australian males held much stronger male-oriented stereotypes about each of the STEM career areas than Turkish males. Likewise, Australian females held stronger male-oriented stereotypes about STEM careers than Turkish females. This can be partly explained by social role theory and the differences in representation of genders within each country. Turkish female participation in fields such as mathematics and science, particularly at the university level, is high, and even in engineering and technology fields is higher than that of female participation at Australian universities. As Eagly and Koenig (2021) have pointed out, the greater participation rate of males compared to females in various STEM fields reinforces acceptable gender roles within society and hence gender stereotypes. This feedback loop is difficult to break. However, it is noteworthy that Türkiye has been successful in changing gender participation rates, and this may be influencing students' views of gender stereotypes.

An additional explanation for the difference between Australian and Turkish males' beliefs about male orientation of STEM careers may be found when considering the differences between Australian and Turkish societies and their beliefs in meritocracy. As discussed earlier, an individualistic society like Australia has greater confidence that social standing is based on merit than is found in collectivist cultures like Türkiye. Since males continue to dominate Australian society, particularly in STEM fields, as those with dominant status, Australian males will tend to believe that this status is earned through the merit of particular characteristics which they attribute to maleness. On the other hand, Turkish males, while dominating Turkish society, are less likely to attribute this to individual effort, rather to social and group norms (Duru-Bellat & Tenret, 2012) and hence will not hold male-oriented stereotypes as strongly as Australian males.

By providing students with two scales, a male superiority scale and a female superiority scale, implicit gender stereotypes that may not otherwise be revealed can be exposed. By finding the difference in each student's responses to the male and female superiority scales, a clearer picture arises of the degree to which students think differently about the possibility of males and females engaging in STEM careers. Although Australian female students generally held a more male-oriented view of STEM careers, their belief in male superiority in these careers was significantly less for science, technology, and mathematics careers than their male classmates. The only domain in which they held similar views to the males about male superiority was in engineering. This is not surprising considering the low level of female representation (19%) (Department of Industry Science & Resources, 2023) within engineering-focused careers in Australia (Department of Industry Science & Resources, 2023). However, careers in mathematics and technology are also predominantly male, so it is surprising that Australian girls are less likely to view these careers as male-oriented than the males in their classes. Nevertheless, Australian girls did, on average, believe that careers in all STEM domains are more male-oriented than female-oriented (Table 7: mean differences > 0). A study that investigated Australian students' feelings of self-efficacy in STEM subjects showed that Australian girls have lower self-efficacy in science and mathematics than boys, which may

contribute to views that these domains are more male-oriented than female-oriented, but surprisingly, girls had higher feelings of self-efficacy in technology (Kennedy et al., 2020). These effects may be compounded by the negative attitudes that girls have towards STEM subjects in general in Australia, compared to boys (McLure et al., 2022a, 2022b).

For the Australian female students, the beliefs they hold regarding traits necessary for success in STEM careers intersect with beliefs about gender. For instance, if it is believed that you need to be a genius, goal-oriented, and ambitious to study engineering and that females are less likely than males to have these characteristics, females will be more reluctant to engage with engineering careers and see those careers as male-oriented, as they do not see themselves as having the necessary traits for success in this career. However, the opposite appears to be the case for both Turkish and Australian male students. In this case, the trait-based stereotypes that they hold confirm their beliefs that STEM careers are male-oriented, since they see these traits as essential characteristics of males. To students, these beliefs appear to be confirmed by participation rates for males and females within their respective countries.

While Australian female students appeared to hold implicit gender stereotypes about the superiority of males in all STEM careers, Turkish female students were less convinced of the superiority of males in STEM careers. Although they were slightly more convinced of the suitability of engineering and technology careers for males, they tended to believe that mathematics and science careers were, in fact, more suitable for females than males (Table 7). This is consistent with the relatively high enrolment of female students in mathematics and science programs at Turkish universities (CHE, 2023) and confirms the important influence on under-represented groups of seeing representations of female participation within a society (c.f., Miller et al., 2018). This is also consistent with Kaya's (2024) study, which showed that Turkish girls in middle school have higher self-efficacy in mathematics and science than Turkish boys. This appears to translate into higher percentages of females studying mathematics and sciences at Turkish universities than in Australian universities (Australian Government, 2021; CHE, 2023). It appears, however, that despite the greater representation of females in these domains, Turkish boys still held strong beliefs about male superiority in each of the STEM domains. While this is understandable in terms of the higher male enrolment in engineering and technology degrees in Turkish universities and hence the significantly greater representation of males within these fields (CHE, 2023), as well as higher feelings of self-efficacy of male Turkish students in these fields during middle school (Kaya, 2024), Turkish male beliefs in the male orientation of careers in science and mathematics are less explicable simply based on self-efficacy and representation data.

Finally, in terms of gendered views of the importance of SES to STEM careers, Australian males were more convinced of the importance of SES than females in the fields of engineering and technology, while Turkish males were significantly more convinced than females about the importance of SES in all STEM domains. Once again, this may be explained by expectation states theory, which describes the way in which dominant groups tend to explain their dominance. These results suggest that male superiority and SES stereotypes are connected for male students in

both countries. Gentrup et al. (2024) note that, while characteristics such as gender, ethnicity, and SES are individually related to power distribution within society, the effects that they have may also be interdependent with each other. Further research is required to elucidate these findings.

Implications

This study provides several implications for probing and challenging middle school students' STEM stereotypes that influence their interest in STEM fields and careers (Dou et al., 2020). The study indicated that students in both Australia and Türkiye held gender- and SES-based stereotypes and strong trait-based stereotypes across STEM fields. Thus, more work is required in both Australia and Türkiye in giving opportunities for students to see or meet STEM professionals from diverse gender and SES backgrounds and hear their stories, particularly stories that could overcome the strongly held stereotypes that people who go into STEM careers have to be geniuses, have no other outside interests, or are technology-obsessed or must come from wealthy, well-educated families. Employing growth mindset strategies, attributing success in STEM fields to effort and hard work rather than inherent talent, in schools, teachers can help students overcome genius stereotypes (Kuchynka et al., 2022; Master & Meltzoff, 2020). The results of this study revealed that trait-based stereotypes are country-independent, which might suggest that the representations of STEM professionals in the global media, curricular materials, and textbooks can be primarily responsible for developing trait-based stereotypes. The continued prevalence of depictions of males as typical STEM professionals and of stereotypical representations of people who work in STEM, particularly in technology-related fields, needs to be challenged. Policymakers should establish formal guidelines for curriculum developers, textbook writers, and media producers who create programs primarily targeting middle school students to ensure that stereotypical narratives and depictions are avoided.

This study also found that students still had gender- and SES-related stereotypes, which is compatible with the underrepresentation of females and people with lower SES in technology and engineering fields. Studies investigating the effect of STEM outreach programs or extracurricular interventions indicated positive insights to challenge the STEM stereotypes of underrepresented groups (Kuchynka et al., 2022; Mack et al., 2024). For instance, Mack et al. (2024) suggested that having students from lower SES engage in hands-on experiences with several technologies and collaborative activities and be exposed to role models from various backgrounds can help them challenge their stereotypes about computer science. Kuchynka et al. (2022) suggested several educational recommendations to overcome STEM stereotypes based on the success of STEM outreach programs targeting underrepresented groups. These strategies can also be applied in middle school contexts and include (i) providing learning environments stressing meaningful relations across different groups based on collaboration over competition and acceptance and empathy, (ii) explicitly countering stereotypes about certain groups, (iii) building cooperation and collaboration among underrepresented and non-underrepresented groups by

ensuring the groups do not automatically adopt traditional roles, (iv) implementing growth mindset strategies enabling students to believe that intelligence evolves with effort rather than innate talent, (v) teaching the nature of STEM by r*elating it* to communal goals and values, and (vi) providing near-peer mentorship programs. In addition, designing the classroom's physical environment in a gender-neutral manner that excludes any clues suggesting masculinity and using gender-inclusive language in STEM teaching can discourage gender stereotypes (Cheryan et al., 2009; Heilman et al., 2024). The current and previous studies indicated that males demonstrate stronger STEM stereotypes than females across four STEM fields and countries. Thus, explicitly addressing male' stereotypes might contribute more to gender or group egalitarianism in STEM. The principles of the conceptual change approach used effectively to change students' misconceptions of science (Duit & Treagust, 2003) can be employed to help male students overcome their stereotypes.

Providing students with contextualised, personally relevant integrated STEM projects has been suggested as a way forward to give students more insight into the great variety of skills required for success in STEM and to build confidence in students, such as females and lower SES students, who may not have had opportunities to engage with such projects previously, which in turn promotes their interest in STEM fields. Care must be taken to ensure that the STEM projects chosen do not reinforce the stereotypes that students hold (McLure et al., 2022b). The present study's findings showed that students' stereotypes changed across countries, gender, and STEM disciplines. Thus, teachers should be aware of the changing nature of stereotypes and evaluate their students' stereotypes before designing STEM projects to provide personal and relevant STEM experiences.

Teachers and parents are other sources of students' stereotypes. Thus, they should be aware of STEM stereotypes so as not to convey them to their children or students. Teacher training or professional development programs should explicitly teach teachers about common stereotypes and teaching strategies to challenge them. Teachers or school counsellors can prepare parents' bulletins about STEM stereotypes for parents to make them aware of the effect of their (un)conscious cultural stereotypes on their children's educational paths to their future careers.

In agreement with the social role theory, the lack of representation of females and individuals from low-SES backgrounds in engineering and technology-related fields when students in K-12 meet STEM professionals means that male orientation of STEM careers and SES stereotypes is reinforced rather than being challenged. Making engineering and technology-related courses compulsory in school can increase the representation of underrepresented groups, which might restrain the vicious cycle between observation and stereotype development (Eagly & Koenig, 2021; Master et al., 2025)**.** Moreover, maintaining equal representation of teachers across different groups can be a way to challenge stereotypes about underrepresented groups (Kuchynka et al., 2022). Türkiye has more female science and math teachers than their male counterparts (CHE, 2023), which might be responsible for why Turkish female students demonstrate fewer gender stereotypes. Australian teachers of STEM are often teaching out of field and exhibit low levels of confidence in teaching these topics (e.g. 59% of female teachers and 70% of male teachers felt confident teaching technology) (Australan Government, 2024). A greater

lack of confidence of female teachers may transfer to female students in their care. Improved training of Australian STEM teachers, particularly in the field of technology and professional development programs to upskill those already in the field, may improve teacher confidence and hence student confidence.

Furthermore, it is questionable how well students understand what careers are available in STEM and what these careers entail, which predicts their career interest (Jiang et al., 2024). Only 23% of Australian secondary non-STEM teachers and 39% of STEM teachers felt able to explain different STEM careers (Australian Government, 2024). Lack of knowledge of these careers may be contributing to trait-based stereotypes that students hold. For instance, students may not realise the ways that engineers must negotiate with different groups in society and collaborate with other professions to complete projects. Thus, middle school curricula should have explicit objectives to improve students' knowledge about STEM endeavours, which require teachers to explicitly teach about the variety of careers underpinned by science, technology, engineering, and mathematical knowledge and skills. This may help under-represented students to recognise the way in which the skills and abilities that they have can be valuable within STEM careers. In addition, opportunities for students to undertake trips in the STEM professional fields may help to expand students' understanding of these careers. As the curriculum was taught by the teachers, teacher education and professional development programs should aim to train STEM teachers about STEM careers, particularly technology and engineering-related ones, which help teachers understand the diverse career opportunities within STEM, and help students gain a deeper understanding of STEM careers.

Limitations and Future Research

This study has some limitations and recommendations for future research. First, since this study used convenience samples, it was not possible to ensure that the Turkish and Australian participants represented similar socio-economic groups. A larger sample size from both countries and more representative of different socio-economic groups would allow for more generalisable results. The Australian sample was from non-government, fee-paying schools which represent a student cohort that is generally has high SES. Inclusion of students from government schools in various areas that represent a variety of SES would improve generalisability. Likewise, the Turkish sample was relatively small and from a large city, and could be expanded to include students from rural and regional areas and a variety of SES to better understand the interplay of gender, SES, and cultural context. In a prior study, it was shown that students at independent schools in Australia have significantly less positive attitudes towards STEM careers and that females in independent schools were significantly less positive about those careers than their male classmates (McLure et al., 2021). Further investigation of differences in stereotypes comparing males and females at Australian government schools would further develop these findings. Second, the current study did not investigate students' knowledge about STEM fields and careers, which might influence students' responses in the questionnaire. Future studies should also probe students' STEM career knowledge to explore

its effect on students' stereotypes. Third, we only probed student stereotypes in this study. Future studies can also apply the same questionnaire to students' parents and teachers to test whether they have similar stereotypes. Fourth, this study suggests that gender, cultural background, and variation in STEM disciplines should be considered differentiating factors when STEM stereotypes are investigated and challenged. However, the current study collected only quantitative data with a self-report questionnaire. Future research can also collect qualitative data with interviews or observations to obtain deeper insights into students' perceptions and experiences, leading them to develop different stereotypes across different STEM fields. Fifth, considering the current body of knowledge on STEM stereotypes, further research is needed to understand implicit gender stereotypes, design and evaluation of interventions targeting SES perceptions, and longitudinal studies to track changes in stereotypes. The STEM stereotype tool employed in the present study could be used to measure the effectiveness of programs that address students' trait-based stereotypes, implicit gender biases, and SES stereotypes over time. Finally, this study contributed to the literature by comparing STEM stereotypes of students from individualistic and collectivist countries, which has been rarely investigated (Cheryan et al., 2025). Future studies can replicate this work with different individualistic and collectivist cultures to examine the consistency of findings.

Conclusion

This study fills several gaps in the literature. First, the results allow for comparison between students' stereotypical views of careers in science, technology, engineering, and mathematics. Both Turkish and Australian students held more stereotypical views of the characteristics of people in technology careers than in engineering, mathematics, or science. Second, comparison of stereotypical beliefs about STEM among Turkish and Australian students showed no significant differences in students' trait-based beliefs. However, Australian students held stronger stereotypes about the need to come from a high SES background to have a career in STEM than Turkish students. Third, male Australian students held more gendered views of science and technology careers being better for males than the Australian female students, while Turkish male students had significantly stronger gendered views than Turkish females about all STEM careers. Finally, this study compares each student's response to male superiority and female superiority scales to determine whether students held implicit gender stereotypes about the gender orientation of careers in STEM. The findings showed that while Australian females still hold beliefs that careers in all STEM fields are better for males than females, Turkish females saw little difference in the suitability of careers in mathematics and science between males and females. Both Turkish and Australian males continue to hold strongly gendered views of STEM careers. Differences between Australian and Turkish students' stereotypical beliefs can be explained by cultural differences, such as individualistic versus a collectivist society.

Author Contribution All authors contributed to the study conception and design. Material preparation and data collection were performed by Felicity McLure, Sevda Yerdelen-Damar, Kübra Kaya, and Zeynep Aydin, and analyses were performed by Felicity McLure and Sevda Yerdelen-Damar. The first draft of the manuscript was written by Felicity McLure and Sevda Yerdelen-Damar, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data Availability The datasets generated during and/or analysed during the current study are not publicly available due to the fact that permission was not sought from participants to share the raw data with anyone other than the researchers on this project but may be available from the corresponding author on reasonable request.

Declarations

Ethics, Consent, and Permissions Ethics review boards at Bogazici University and Charles Darwin University (H23051) approved this study. Informed consent was obtained from all participants and their guardians to participate in this study and for the findings obtained to be published. All data are aggregated.

Conflict of Interest The authors declare no competing interests.

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