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Research Article

Female top performers in higher education STEM and humanities: socio-emotional perceptions and digital learning-related characteristics during COVID-19

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Abstract

In Germany, the 2020 summer semester was substantially influenced by the COVID-19 pandemic. In an empirical study, we focus on female top performing students in STEM and the humanities. Of particular interest was whether the measures associated with the pandemic constitute a risk-factor for a re-traditionalization of gender roles. Before lectures or courses began, students at a full-scale university were invited to participate in an online survey. We investigated four research questions: 1) Are women underrepresented in our sample among the top performers in STEM and the humanities? Are there gender differences among top performers with regard to (2) digital readiness, (3) socio-emotional and (4) learning related variables? The sample of the study consisted of 2,849 higher education STEM and humanities students. The study took place as an online survey. In the week before the start of the official lecture period, all students enrolled at the university were invited to take part via an e-mail correspondence from the Vice President of Education (survey access link). Participation in the survey took place via the Questback platform and was activated for 10 days. The cut-off point for the ability level was set at the 95th percentile of previous university achievements. To test Q_1, we performed a hierarchical loglinear analysis with posthoc Chi^2 tests. In research questions Q_2 - Q_4 two-way ANOVAs were used to test the effects of gender and subject. Results indicate equal shares of female and male students among the top performers, with women overrepresented in the humanities and men overrepresented in STEM relative to their proportion of the student population. The analysis of socio-emotional and learning-related factors showed risk factors for high performing female students such as lower self-efficacy, but no major emotional vulnerability. Overall, the data suggest that at the beginning of the COVID-19 pandemic, female top performers had still been able to compensate for the risk factors.

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Introduction

Research indicates that top talents and performers contribute disproportionately to cultural (Ericsson, Hoffmann, Kozbelt, & Williams, 2018), social (Rindermann, Sailer, & Thompson, 2009) and economic progress in their societies (Hunter, Schmidt, & Judiesch, 1990; O'Boyle, & Aguinis, 2012; Pfeiffer, Foley-Nicpon, & Shaunessy-Dedrick, 2018; Rindermann, 2018). This appreciation is reflected in the global trend to identify and promote talent (Dai, & Kuo, 2017; Shavinina, 2009; Subotnik, Olszewski-Kubilius, & Worrell, 2019).

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With an increasing regard for the highly able, competition for talent and top performers has increased in all levels of society (Joyce & Slocum, 2012; Rindermann, 2018). This was verbally condensed in the expression "War for Talent," coined by Steven Hankin of McKinsey & Company (Michaels, Handfield-Jones, & Axelrod, 2001).

Universities are now also taking part in this competition and attracting talent and top performers with a wide range of offers such as scholarships (e.g., FAU, 2020a), mentoring (e.g., Cidlinska, 2019; FAU, 2020b; González, 2001), and advanced placement programs (e.g., Hargrove, Godin, & Dodd, 2008; Warne, 2017).

In the competition for talents and top formers, there are two observations that certainly require another, more nuanced glance. First, the competition for talent is not equally as intense across all fields. One field that has received notable attention is STEM (Science, Technology, Engineering, and Mathematics) (Braun, March, Mertens, & Nisser, 2020; Johnson, Peters-Burton, & Moore, 2016). Another observation is that many groups, especially minorities, are underrepresented in two ways. First, they are less frequently recognized as talented in formal identifications, and second, they are underrepresented among the top performers (Card & Giuliano, 2016; Crawford, Snyder, & Adelson, 2019; Wai & Lakin, 2020).

Women comprise a talent group that is underrepresented in the upper performance segments. They are identified as talents less frequently than men (Petersen, 2013), and are underrepresented in many fields at top performance levels (Ceci, & Williams, 2007; Meyer, Cimpian, & Leslie, 2015; Upson, & Friedman, 2012), including STEM (Lincoln, Pincus, Koster, & Leboy, 2012; Stoeger et al. 2016). The "eminence gender gap" (Eagly & Miller, 2016) is additionally reinforced in STEM by a robustly proven Matilda Effect, i.e. equal performances of women are recognized less than performances of men such as in the allocation of scientific prizes (Lincoln et al. 2016).

In the research literature, a variety of causes have been suggested for the underrepresentation of women in the upper performance segment in STEM. While for a long time into the last century, biological and nativist explanations played a strong role (e.g., Beckwith, 1983; Benbow & Stanley, 1980), they can be considered obsolete today. Moreover, the counter position that gender differences are solely attributable to "outright discrimination" of women is hardly advocated anymore. Instead, "the accumulation of smaller experiences that determine whether a female student identifies with and persists in a scientific field" is considered more important (Grunspan et al. 2016, p. 2). What causes these different experiences and how they translate into the underrepresentation of women is still the subject of intensive research.

On the level of society, gender differences can be understood as cultural and psychological consequences of living in a WEIRD (Western, Educated, Industrial, Rich, and Democratic) and androcentric world (Yalcinkaya & Adams, 2020). Traditional patriarchal practices continue to dominate women's experiences (Anderson, 2015). These are passed on, for example, through socialization experiences (Crowley, Callanan, Tenenbaum, & Allen, 2001; Robinson-Cimpian, Lubienski, Ganley, & Copur-Gencturk, 2014). These include exposure to role models (Herrmann et al. 2016; Luong, Knobloch-Westerwick, & Niewiesk, 2020) and gender stereotypes (Bian, Leslie, & Cimpian, 2017; Storage, Horne, Cimpian & Leslie 2016). Their acquisition is ultimately reflected in a social identity in STEM, according to which women are less talented than men. Mechanisms such as stereotype threat mean that women have great difficulty in discarding this social identity (Murphy, Steele & Gross, 2007; Steele, 2013; Wu, Park, & Dasgupta, 2020). Moreover, it is repeatedly reinforced by many every day and academic experiences of women in STEM (Makarova, Aeschlimann, & Herzog, 2019; Stadler, Duit, & Benke, 2000). Such pro-male biases (Grunspan et al. 2016) include that professors and lecturers are more likely to react to emails from males seeking council (Milkman, Akinola, & Chugh, 2015), and are more likely to call on males in class (Eddy, Brownell, & Wenderoth, 2014). Faculty members from research-intensive universities rated the application materials of male students as more competent and offered them more mentoring (Moss-Racusin et al. 2012). As a result, it can be assumed that a large number of reasons and lived experiences add up to cumulative disadvantages (DiPrete, & Eirich, 2006) for women, which ultimately leads to their underrepresentation in STEM (Feldon, Maher, Roksa, & Peugh, 2016). It is interesting to note that it is by no means sufficient to close the gender gap at any given point in time. The experience gained in the next phase will indeed contain cumulative disadvantages for women, so that the clock will again be set back. For example, for men and women that had achieved identical prerequisites at the end of secondary schooling with regard to both subject studied and grades, substantial gender gaps continued to emerge (Delaney & Devereux, 2019).

COVID-19 as a Critical Life Event that can Lead to Re-Traditionalization in STEM

It is well documented that critical life events can play a major role in the development of excellence (Ericsson et al. 2018; John, Gropper, & Thiel, 2019; Lott, Gardner, & Powers, 2009). In contrast to everyday life experiences such as daily hassles and uplifts, wins and losses, critical life events are extraordinary experiences that lead to major adjustments and that are accompanied by extreme emotions, in particular (Berntsen, Rubin, & Siegler, 2011; Hentschel, Eid, & Kutscher, 2017). They can cause non-linear developments and especially, abandonment (Simonton, 2018, 2019). Without a doubt, the COVID-19 pandemic is a critical life event for many that was likely accompanied by extreme emotions. Holman et al. (2020) describe it as a "mental health crisis of unprecedented scope and scale" (p. 1), which can lead to serious mental and emotional impairments and health problems (Holmes et al. 2020; Vindegaard, & Benros, 2020). Measures that governments around the world have had to take to contain the pandemic may even have exacerbated mental health problems. They included travel restrictions, curfews, and the closing of educational institutions (Bozkurt et al. 2020; Cheng, Barceló, Hartnett, Kubinec, & Messerschmidt, 2020). Indeed, by the 20th of March, the Federal State of Bavaria in Germany- where our research takes place - announced far-reaching measures to curb the COVID-19 pandemic. Bavarian universities completely switched to online courses; the students stayed at home.

Of considerable note was a warning from Jutta Allmendinger, the President of the Berlin Social Science Center. Based on surveys and as a consequence of the corona pandemic, she feared a "horrifying re-traditionalization" of women (Allmendinger, 2020a). In a television interview, she quantified the impact of the re-traditionalization with regard to progress in female empowerment in concrete terms: "I don't believe that this can be caught up on so easily and that we will lose at least three decades as a result" (Allmendinger, 2020b). Presumably, the backdrop of this assessment was that women were again being forced into the traditional role of the woman tied to the house. Such a regression into traditional role patterns could also have an impact on the study of STEM and humanities subjects. Traditionally, females prefer the humanities, while males prefer STEM (Trusz, 2020).

The Current Research

During the lockdown caused by the COVID-19 pandemic, and just before the beginning of the 2020 summer semester, we conducted a study with students enrolled at a German university. It was the time when stress, anxiety, and depression were said to be at their highest (Zhou, MacGeorge, & Myrick, 2020). For comparison purposes, we decided to examine STEM as a typical male-dominated field, and Humanities as a typical female-dominated field with regard to the number of students. In our research, we investigated four research questions.

Q_1: The research literature has repeatedly found that women are underrepresented among the top performers. However, the university where the research was conducted is taking a variety of measures to achieve gender equity. The first question therefore, focused on whether women are underrepresented in our sample among the top performers in STEM and the humanities.

Q_2: The second research question focused on possible gender differences among top performers with regard to digital readiness. Digital readiness is a complex construct that includes many facets (Kim, Hong, & Song, 2019). While the focus is often only on the person – acquisition or presence of digital skills, attitudes, motivations, and confidence about using digital technology for academic activities – we would like to broaden the term *digital readiness*. From an action perspective, we are interested in whether the participants in our study were able to carry out digital learning successfully. This also includes an examination of infrastructure. From previous studies, we know that high performing women in STEM have excellent equipment and learning resources (Ziegler, Debatin, & Stoeger, 2019). In this respect, we would not expect to find differences between female and male top performers in STEM and the humanities. This assumption takes into account the fact that our study was conducted during the lockdown. The female participants were also able to draw on aspects of digital readiness that they had previously cultivated during their studies.

Q_3: The third research question focused on possible gender differences among top performers with regard to socio-emotional variables. The literature is not yet clear whether gender differences actually exist (Rokach, 2018). Nor is the hypothesis of a re-traditionalization helpful to formulate a specific outlook. However, the case is different for emotions. In our own studies, we found that gifted females have a higher emotional intelligence than gifted males (Alabbasi, Alaa, & Ziegler, 2020). However, a re-traditionalization would suggest that women in the stressful situation of the pandemic would show more emotions that are consistent with the gender stereotype. For women, these are attributes such as gentleness, empathy, sensitivity, expressiveness, greater anxiety, and worry. For men, these are attributes such as assertiveness, independence, courage, and emotional stability (e.g., Brody & Hall, 2010; Hofstede, 2001; Wood & Eagly, 2002). However, precision is key to a more thorough understanding: it is by no means the case that gender stereotypes regarding emotions are actually true. Recent studies show clear discrepancies between stereotype and reality (e.g. Gong, Wong, & Wang, 2018). When we speak of re-traditionalization, we do not mean a relapse into historical patterns of emotion. These are also not known. Rather, we mean a tendency toward alignment with the gender stereotype.

Q_4: Of particular interest was the question whether the generally stressful situation of the COVID-19 pandemic also affects learning-related variables. Alignment with the stereotype of STEM as a male domain would mean that top-performing women should exhibit less functional learning behavior overall.

We investigated four research questions: 1) Are women underrepresented in our sample among the top performers in STEM and the humanities? Are there gender differences among top performers with regard to (2) digital readiness, (3) socio-emotional and (4) learning related variables?

Method

Research Model

The study reports on the first of three measurements within a longitudinal study of the 2020 summer semester. It took place as an online survey to which all students at a full university were invited. Participation in the study was voluntary and compliance with data protection was supervised by the university´s data protection officer.

Participants

Altogether, the sample of the study consisted of 2,849 students that had indicated *female* or *male* as their gender (7 students selected 'diverse') and of which the average grade of the past study achievements was present. The missing values for the average grades were largely due to the fact that grades were not yet available for first-year students and students changing subjects. Of the final sample, 1,618 were either members of the Faculty of Science or the Faculty of Engineering, hereafter referred to as STEM students. Among them were 701 female, M_{age} = 22.52, SD = 3.19, and 917 male, M_{age} = 22.96, SD = 3.26. The humanities faculty had a total of 1,231 students in our sample: 962 were female, M_{age} = 23.93, SD = 5.87, and 269 were male, M_{age} = 24.95, SD = 6.93. Please note that the participants had been randomly assigned to three groups, each of which was presented with a further block of questionnaire scales. Thus, the analyses were based on the subsamples that had answered the respective questionnaire scales.

Data Collection Tools

The participants were asked about socio-demographic variables such as their gender, study semester, and faculty enrollment.

Academic Achievement Level

Academic achievement level was assessed by the current average grade. In accordance with student assessment studies (TIMSS, PISA and PIRLS), the 95th percentile was used as cut-off point for ability level.

Digital Readiness

We measured four aspects as indicators for student digital readiness: students' equipment, earlier experiences, digital learning resources, and self-reported skills for digital learning in terms of digital tool application and information sharing behavior.

First, students were asked to provide more information on the availability of digital equipment (desktop-PC, notebook, tablet-PC, mobile phone, wearables, scanner, printer, internet availability, and the possibility to study at a quiet workplace without disruption). For each device, students indicated their use on 4-point Likert scales ranging from "no access at all" to "almost daily use." Furthermore, their experiences with nine different e-learning tools employed for learning at the university (downloadable lecture notes/literature, lecture recordings, live streams of lectures, digital media in courses, online learning modules, online communication and collaboration, other online-supported learning opportunities, e-tests, online self-tests, etc.) were assessed using questions with a yes/no answer format (see Froebus & Bender, 2019).

Digital learning resources were assessed with a shortened version of the Questionnaire of Educational and Learning Capital (QELC; Vladut, Liu, Leana-Tascilar, Vialle, & Ziegler, 2013), which was adapted to the field of digital learning. While the original questionnaire contained 50 items, the short version contained 20 items. Systematic research had shown that even shortened and domain-specific scales have good reliability (Reutlinger, Pfeiffer, Stoeger, Vialle, & Ziegler, 2020; Ziegler et al. 2019). A sample item from the original QELC cultural educational resources reads, "In my social environment, learning is considered to be very important." The reformulated item read, "In my social environment, digital learning is considered to be very important." Cronbach's α = .91.

Digital skills were measured with eight items of two subscales from the Digital Readiness for Academic Engagement questionnaire (DRAE; Hong & Kim, 2018). The items focused on the application of digital tools (sample item: "I can use software or apps on a computer or mobile device") as well as on information-sharing behavior (sample item: "I can interact with fellow students using real-time communication media, e.g. video conferencing tools or messenger services"). Both scales turned out to be internally consistent (digital tool application with 4 items: Cronbach's α = .77, e. g. "I can manage software or apps from a computer or mobile devices;" information sharing behavior with 4 items: Cronbach's α = .85, e. g. "I can interact with classmates using real-time communication tools, for example, video conferencing tools or messengers.").

Socio-Emotional Variables

To assess students' socio-emotional perceptions at the beginning of the digital term, two standardized instruments based on a 6-point Likert scale (ranging from "not true at all" to "absolutely true") were applied. First, stress-related emotions were measured with a short German version of the PSQ – Perceived Stress Questionnaire (PSQ-20; Fliege et al. 2001, 2005). In particular, we assessed students' worries (e.g., "I fear I may not manage to attain my goals."), tension (e.g., "I feel tense"), joy (e.g., "I feel I am doing things I really like"), and overload (e.g., "I have too many things to do") – each with five items (Cronbach's α = .82 - .89). Second, emotional loneliness was assessed with a scale based on six items (e.g., "I miss the pleasure of the company of others" Cronbach's α = .68) and social loneliness with five items (e.g., "There are many people I can trust completely" (to be recoded), Cronbach's α = .88) by Gierveld and van Tilburg (2006).

Learning-related Scales

The Online Self-regulated Learning Questionnaire (OSLQ, Barnard et al. 2009) measures self-regulation in the online learning environment as active and volitional behavior in order to learn successfully. We administered five subscales (environment structuring, Cronbach's α = .73; goal setting, Cronbach's α = .71; time management, Cronbach's α = .67; help seeking, Cronbach's α = .65; self-evaluation, Cronbach's α = .61) each consisting of four items based on 6-point Likert scales (ranging from "not true at all" to "absolutely true").

Self-efficacy was measured with the short scale for measuring general self-efficacy beliefs by Beierlein, Kemper, Kovaleva, & Rammstedt (2013). On a 6-point Likert scale with five items, it measures the assessment of one's own competencies to plan and execute actions in order to achieve desired goals. Cronbach's α = .85. A sample item reads, "I can master most problems well by myself."

Data Analysis

In accordance with student assessment studies (TIMSS, PISA and PIRLS), the cut-off point for the ability level was set at the 95th percentile. However, different samples or subsamples were used to test the individual hypotheses. Since the students were only working on one of three sets of measurement instruments, limiting the analyses to our total sample of students with academic performance in the 95th percentile across both STEM and humanities would have led to an insignificantly low statistical power of analyses. Therefore, we were flexible in our identification of the high ability group, and selected the students according to the analyses performed. To test Q_1, the 95th percentile was applied to faculty achievement, and did not take gender into account. We performed a hierarchical loglinear analysis with posthoc Chi^2 tests. In research questions Q_2 - Q_4, two independent variables were analyzed. Two-way ANOVAs were used to test the effects of gender and subject. Regarding gender, only male and female students were included, as the number of students who identified as gender diverse was too small for further analysis. Subject referred to either STEM or the humanities.

Procedure

In the week before the start of the official lecture period, all students enrolled at the university were invited to take part in a survey on the general conditions of digital teaching via an e-mail correspondence from the Vice President of Education (survey access link). Participation in the survey took place via the Questback platform and was activated for 10 days. To reduce questionnaire length, a simple form of a multi-matrix design was implemented in the study (cf. Smits & Vorst, 2007). In a first step, all students gave personal details and answered questions about their previous academic achievements and digital literacy. In a second step, they were randomly assigned to three groups, each of which was presented with a further block of scales.

Results

By way of this empirical study, we pursued four research questions. Q_1 asked how women are represented among the top performers in STEM and humanities. Table 1 shows the frequencies and percentages of male and female students in STEM and the humanities, broken down by ability level. A hierarchical loglinear analysis with backward elimination was performed. The 3-way-interaction of gender, subject, and ability level was significant ($Chi^2(1)=2.96$, $p = 0.05$, one-tailed). Post-hoc Fisher's exact tests show that women tend to be underrepresented, i.e. marginally significantly, in STEM ($p < .10$, one-tailed) and men significantly in Humanities ($p < 0.05$).

Table 1.

Frequencies and Percentages of Male and Female Students in the STEM and Humanities Broken down by Ability Level

Gender	Subject	High Ability	Average Ability	Total
Female	STEM	31 (4.1 %)	725 (85.9 %)	765 (100 %)
	Humanities	47 (4.6 %)	965 (95.4 %)	1012 (100 %)
	Total	78 (4.4 %)	1690 (95.5 %)	1768 (100 %)
Male	STEM	57 (5.9 %)	905 (94.1 %)	962 (100 %)
	Humanities	5 (1.8 %)	277 (98.2 %)	282 (100 %)
	Total	62 (5.0 %)	11.82 (95.0 %)	1244 (100 %)

Digital Readiness

Digital readiness (Q_2) was analyzed in four steps. In the first, we tested whether top performing female and male STEM and humanities students had equal access to digital equipment (desktop PC, notebook, tablet PC, mobile phone, wearables, scanner, printer, internet availability, and the possibility to study at a quiet workplace without disruption). Separate 2 x 2 ANOVA were performed, but no significant main effects or interaction effects were observed (all $p > 0.05$, two-tailed).

Second, we examined student experiences with nine different e-learning tools employed for learning at the university (downloadable lecture notes/literature, lecture recordings, live streams of lectures, digital media in courses, online learning modules, online communication and collaboration, other online-supported learning opportunities, e-tests, online self-tests) (see Froebus & Bender, 2019). To this end, hierarchical loglinear analyses with backward elimination were performed. None of the 3-way- interactions proved to be significant (all $p > 0.05$, two-tailed). Furthermore, Chi² tests showed no differences between genders and between subjects (all $p > 0.05$, two-tailed).

Table 2 shows mean values and standard deviations for digital learning resources and digital skills. Separate 2 x 2 ANOVA were performed. Subject was irrelevant for these variables (digital learning resources, $F_{(1, 53)} = 0.00$, $p > .10$, $\eta^2 = .00$; digital tool application, $F_{(1, 80)} = 1.67$, $p > .10$, $\eta^2 = .02$; information sharing behavior, $F_{(1, 80)} = 3.27$, $p < .10$, $\eta^2 = .04$). Overall, the conditions here are good, but not perfect. With regard to gender, however, there was a significant difference in regard to digital tool application ($F_{(1, 80)} = 6.92$, $p < .01$, $\eta^2 = .08$) and a marginally significant difference in regard to digital learning resources ($F_{(1, 53)} = 2.36$, $p < .10$, $\eta^2 = .04$). Female top performing students had fewer digital tool application skills and fewer digital learning resources than male top performing students. There was no significant difference between male and female top performing students in their information sharing behavior ($F_{(1, 80)} = 1.75$, $p > .10$, $\eta^2 = .02$). The interactions between subject and gender did not reach statistical significance (digital learning resources, $F_{(1, 53)} = 0.29$, $p > .10$, $\eta^2 = .01$; digital tool application, $F_{(1, 80)} = 0.01$, $p > .10$, $\eta^2 = .00$; information sharing behavior, ($F_{(1, 80)} = 3.43$, $p < .10$, $\eta^2 = .04$).

Table 2.

Digital Learning Resources and Digital Skills (Mean Values and Standard Deviations) Broken Down by Gender and Subject

	Female		Male	
	STEM	**Humanities**	**STEM**	**Humanities**
Digital Learning Resources	3.72 (.067)	3.83 (0.62)	4.13 (0.87)	4.03 (0.71)
Digital Skills				
Digital tool application	4.72 (1.05)	4.41 (0.86)	5.41 (0.69)	5.06 (0.69)
Information sharing behavior	5,31 (0.78)	5.23 (1.00)	5.41 (0.98)	4.46 (1.07)

Table 3 shows the mean values and standard deviations of the socio-emotional variables (Q_3). No significant differences were found for subject (loneliness social, $F_{(1, 62)} = 2.93$, $p < .10$, $\eta^2 = .05$; emotional loneliness, $F_{(1, 62)} = 0.12$, $p > .10$, $\eta^2 = .01$; worry, $F_{(1, 63)} = 0.73$, $p > .10$, $\eta^2 = .01$; joy, $F_{(1, 63)} = 0.18$, $p > .10$, $\eta^2 = .00$; tension, $F_{(1, 63)} = 0.09$, $p > .10$, $\eta^2 = .00$; overload, $F_{(1, 63)} = 0.01$, $p > .10$, $\eta^2 = .00$). Similarly, no differences between the genders were found (social loneliness, $F_{(1, 62)} = 0.096$, $p > .10$, $\eta^2 = .00$; emotional loneliness, $F_{(1, 62)} = 0.87$, $p > .10$, $\eta^2 = .01$; worry, $F_{(1, 63)} = 0.13$, $p > .10$, $\eta^2 = .00$; joy, $F_{(1, 63)} = 0.05$, $p > .10$, $\eta^2 = .00$; tension, $F_{(1, 63)} = 0.50$, $p > .10$, $\eta^2 = .01$; overload, $F_{(1, 63)} = 0.78$, $p > .10$, $\eta^2 = .01$) and neither were significant interactions of gender and subject (social loneliness, $F_{(1, 62)} = 1.25$, $p > .10$, η^2

= .02; emotional loneliness, $F_{(1, 62)}$= 0.93, p >.10, η^2 = .02; worry, $F_{(1, 63)}$= 0.01, p > .10, η^2 = .00); joy, $F_{(1, 63)}$= 0.98, p > .10, η^2 = .01; tension, $F_{(1, 63)}$= 0.00, p > .10, η^2 = .00; overload, $F_{(1, 63)}$= 0.03, p > .10, η^2 = .00).

Table 3.

Socio-emotional Variables (Mean Values and Standard Deviations) Broken Down by Gender and Subject

	Female		Male	
	STEM	**Humanities**	**STEM**	**Humanities**
Loneliness				
Social	2.98 (1.11)	2.29 (0.91)	2.63 (0.98)	2.48 (0.97)
Emotional	3.28 (0.78)	3.17 (0.84)	3.29 (0.66)	3.12 (0.76)
Emotions				
Worry	2.95 (1.00)	3.18 (1.33)	2.81 (1.22)	3.10 (1.12)
Tension	3.08 (1.08)	2.99 (1.17)	2.87 (1.03)	2.80 (1.24)
Joy	3.90 (0.65)	4.01 (0.75)	3.86 (0.99)	4.14 (0.70)
Overload	2.97 (0.97)	2.94 (1.19)	2.67 (1.11)	2.74 (1.09)

Table 4 summarizes the mean values and standard deviations for the learning-related variables (Q_4). There were no significant differences between the subjects (self-efficacy, $F_{(1, 44)}$= 0.78, p > .10, η^2 = .02; environmental structuring, $F_{(1, 44)}$= 0.12, p > .10, η^2 = .00; goal setting, $F_{(1, 44)}$= 3.04, p > .10, η^2 = .07; time management, $F_{(1, 44)}$= 0.21, p > .10, η^2 = .01; help seeking, $F_{(1, 44)}$= 0.95, p > .10, η^2 = .02) with the exception of self-evaluations, which were more frequently practiced by STEM students ($F_{(1, 44)}$= 6.62, p < .05, η^2 = .14). Regarding gender, two highly interesting gender differences were found for self-efficacy, which was lower among women ($F_{(1, 44)}$= 5.38, p < .05, η^2 = .11), and help-seeking, which was more frequently practiced by female students ($F_{(1, 44)}$= 8.90, p < .01, η^2 = .17). Self-evaluations were marginally significantly more frequently practiced by female students ($F_{(1, 44)}$= 3.79, p < .10, η^2 = .08). No gender differences were found for the other learning-related variables (environmental structuring, $F_{(1, 44)}$= 0.04, p > .10, η^2 = .00; goal setting, $F_{(1, 44)}$= 2.21, p > .10, η^2 = .05; time management, $F_{(1, 44)}$= 2.43, p > .10, η^2 = .05). All interactions were not significant (self-efficacy, $F_{(1, 44)}$= 0.28, p > .10, η^2 = .01; environmental structuring, $F_{(1, 44)}$= 0.00, p > .10, η^2 = .00; goal setting, $F_{(1, 44)}$= 0.87, p > .10, η^2 = .02; time management, $F_{(1, 44)}$= 0.32, p > .10, η^2 = .01; help seeking, $F_{(1, 44)}$= 0.07, p > .10, η^2 = .01; self-evaluation, $F_{(1, 44)}$= 0.19, p > .10, η^2 = .01).

Table 4.

Learning Related Measures (Mean Values and Standard Deviations) Broken Down by Gender and Subject

	Female		Male	
	STEM	**Humanities**	**STEM**	**Humanities**
Self-efficacy	4.55 (0.58)	4.63 (0.48)	4.95 (0.92)	5.27 (0.68)
Self-regulated Learning				
Environmental structuring	4.70 (0.58)	4.59 (0.89)	4.64 (1.00)	4.55 (1.08)
Goal setting	4.42 (0.65)	4.17 (0.93)	4.25 (1.06)	3.44 (1.09)
Time management	4.30 (0.72)	4.33 (0.73)	4.02 (0.96)	3.73 (1.30)
Help seeking	4.61 (0.87)	4.38 (0.89)	3.73 (1.14)	3.33 (1.11)
Self-evaluation	4.20 (0.65)	3.56 (0.82)	3.75 (1.13)	2.85 (1.07)

Discussion and Implications

As it stands, there are no available studies addressing the effects of COVID-19 on high ability university students. In particular, research of a gendered perspective is essentially nonexistent in the field.

According to Allmendinger (2020a, 2020b), there is a risk that the measures associated with the social reactions, such as curfew, homework, and digital teaching could lead to a re-traditionalization of gender roles. Such a development would be more than a drastic social step backward, it would certainly destroy accomplishments in terms of gender equality. Re-traditionalization would also have substantial negative effects in terms of lessening the cultural, social, and economic contributions of high-performing women, for example.

When considering student academic achievement, we focused on the top 5% of students in the upper performance segment. Interestingly, we found that women are underrepresented relative to men at the highest performance level in STEM, but overrepresented in the Humanities. The situation in STEM resembles the familiar picture of the gender eminence gap with the well-documented under-representation of women in the top segment of achievement (Ceci, & Williams, 2007; Lincoln, Pincus, Koster, & Leboy, 2012; Meyer, Cimpian, & Leslie, 2015; Stoeger et al. 2016; Upson, & Friedman, 2012). In contrast, the situation in the Humanities is similar to the equally well documented gender achievement gap (Voyer & Voyer, 2014; Workman & Heyder, 2020), that nonetheless, refers to average achievement. In fact, on average, women now perform better than men in most subjects. With regard to the university where our study took place, we concluded that in relative terms, the measures to promote women in STEM are not yet adequately effective for the promotion of female top performers, specifically. In the humanities, *peer* equality for female students has been established, but is still missing from the upper echelons of academia, e.g. regarding the number of professors employed.

The percentage of male and female students that are also top performers as indicated in our study reflects performance rates captured before the onset of the COVID-19 pandemic. In contrast, the other variables reported refer to the moment at the beginning of the COVID-19 pandemic, when the psychological stress was presumably highest (Zhou, MacGeorge, & Myrick, 2020). The students' answers are more or less strongly influenced by previous experiences before the COVID-19 pandemic.

Some of the measures in our study are best regarded as potential risk factors for a re-traditionalization but are less suited to unequivocally indicate a re-traditionalization at the beginning of the COVID-19 pandemic. In particular, the top female students had fewer skills in digital tool application, and fewer digital learning resources. In fact, these findings do not quite fit the picture that high performing women, especially in STEM, are usually strong learners (Ziegler et al. 2019). Nevertheless, we assume that both access to digital equipment and experience with e-learning tools have hardly changed compared to the pre-COVID-19 era. Though they do not indicate a re-traditionalization, it cannot be ruled out that this is a seedbed for subsequent re-traditionalization. There are, however, aspects of this study's data that indicate resilience in top-performing women.

It would be consistent with traditional role stereotyping that women are more emotional, more dependent on others, less self-regulated, more assiduous in fulfilling their commitments, and less self-confident (Gottzén, Mellström, Shefer, 2020; Skelton, Francis, & Smulyan, 2006). We did not find such a simplified categorization in this study. Contrary to the stereotype of the emotionally vulnerable female, no evidence was found that top-performing female students were more emotionally shaken by the COVID-19 pandemic than male students. Though they do not report more worry, more tension or more overload, they indicate a lower self-efficacy. However, two additional aspects must be considered. First, the effect sizes are not high and thus, a pronounced problem of female students cannot be assumed here. Second, female students also seem to have certain compensatory strategies. They practice help-seeking significantly more often, which reduces their potential risk factors like having lower digital learning skills. Their tendency toward stronger self-evaluation also indicates a greater alertness to react to undesirable developments. However, we cannot investigate the latter claims any further because in doing so, we will have reached the limitations of our study and the data presented therein. Overall, it is not explicitly clear whether re-traditionalization would have occurred at the beginning of the COVID-19 pandemic.

Recommendations

Modern knowledge societies benefit from talent for cultural, social, and economic progress. It is critical, therefore, that society identify and promote all talents according to ability. This has not been done effectively with female talents, in particular. Our study shows that society has not yet achieved gender equity, and identifies a real need for intervention addressing the eminence gender gap, especially in STEM. However, this requires a better understanding of the conditions under which people develop their talents. To that end, our study indicates that the COVID-19 pandemic could potentially become a risk factor for top-performing women.

For Further Study

Our study referred to the time at the beginning of the COVID-19 pandemic. The cross-sectional study should be supplemented by a longitudinal study. It should go beyond the description of risk factors for talent development and address causal mechanisms and contextual factors.

For Applicants

Universities strive to enable their students, and especially their top-performers, to optimally develop their skills. Our study shows that female top-performers could potentially represent a vulnerable group. At the same time, however, our research also shows that they are actively seeking support, especially during the COVID-19 pandemic. Universities should give female top-performers the opportunity to articulate their learning needs and then provide them with appropriate support. Mentoring programs might present one possibility for support.

Limitations of Study

Finally, we would like to identify four limitations of our study. First, our work was descriptive in nature so that no causal statements could be made. Correlations between indicators that could have provided information about a re-traditionalization in high-performing female students were not analyzed in this study. This is due to two further limitations: a convenient sample cannot claim to be representative; and the sample test power for the significance tests was too small for more complex statistical analyses. By definition, top performers are rare. Prospectively large samples are needed to investigate relationships – so large in fact, that a university of almost 40,000 students (as captured in this study) could not assuage that precondition. Nevertheless, our study provides interesting findings. Since this is a report of the first measurement point of a longitudinal study, we hope that further measurement points will provide additional information, at least on the individual aspects of our research.

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