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# The Role of Gender and Culture in Vocational Orientation in Science

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**Abstract:** Females and people belonging to ethnic minorities tend to be underrepresented in science occupations. The goal of this paper was to investigate the needs of students of different gender and ethnicity in terms of vocational orientation in order to tailor future interventions to their needs. This paper finds that students of different gender and cultural background differ in their preferences in terms of vocational orientation in science. Two studies were conducted: (1) secondary school students (N = 450) were asked about their current activities and needs in terms of vocational orientation; (2) university students' (N = 342) retrospective views on their vocational orientation were investigated. Among the secondary school students (1), we found no significant differences in science aspirations, when differentiating between students' culture and their gender. However, females with migration background tended to wish for information from different sources than other students (contacts with university, teacher feedback, i.e., more formal/professional sources). Male participants without migration background tended to rely more strongly on informal sources such as online video platforms. This study (2) confirmed the finding that more professional feedback would be beneficial. These findings suggest that vocational orientation in science should be more specific to the target group in order to reach those who are currently underrepresented in science.

**Keywords:** science career; culture; gender; science aspirations; vocational orientation

## 1. Introduction

Women are still underrepresented in natural science [1,2] and similar findings have been reported on for some minorities [1]. Although choosing a career path is perceived as the action of an individual, career choices are heavily influenced by the social context: some social groups tend more strongly than others to think of science as being “not for me”. This is especially true for female and working-class students [3,4]. This can be interpreted as the result of social inequalities that shape self-perceptions and choices. However, how might this be changed?

The present research addresses this issue from the perspective of vocational orientation. The aim is to determine in what ways vocational orientation measures could be designed to appeal to groups that are currently underrepresented in science. The research is part of the project “Diversity Sensitive Support: vocational orientation in STEM for female adolescents with a migration background in cooperation with parents (DiSenSu)” which is conducted in Germany. In Germany, every teacher is required to integrate career orientation into their teaching [5]. Vocational orientation thus takes place mainly at school but the teachers are supported by other professionals (e.g., from the job center or/and from companies, universities, etc.). In the DiSenSu project, we want to reach secondary school students who are at an age at which career orientation is important. In particular, we focus on female students with a migration background. We proceed in two phases. In the first phase, we investigate

the needs of young people in their vocational orientation in science. The theoretical insights from the first phase pave the way for intervention. This is carried out in the second phase. Here, we design and implement a measure for vocational orientation in science with which we want to reach young women with a migration background. In this paper, we report on the results from the first phase of the project. A broad overview of the project can be found in [6].

We conducted two studies. In study 1, we investigated the vocational orientation of secondary school students regarding science using a paper-based questionnaire. We asked them about their science aspirations, their need for information about science-related jobs, the sources they use, and those through which they would like to receive more information about careers in science. In all analyses, we considered the possible effects of gender and migration background. In study 2, we were interested in university students' retrospective evaluation of their vocational orientation. This was conducted with university students enrolled in science and non-science subjects using an online questionnaire. These students had already made an important decision for or against studying science. Taking the two studies together, we try to draw a picture of students' perceived needs in terms of vocational orientation in science. By considering both the perspectives of secondary school and university students, we seek to inform the choice of target group specific interventions.

## 2. Theoretical Framework

### 2.1. *The Impact of Gender, Race, and Class on Career Choices*

Gender, class, and race influence individual career development. These variables were chosen because research had shown their particularly important impact on science career aspirations (see below). They are sociological background variables that act upon aspirations, expectations, and many other aspects that fall traditionally into the domain of psychological research. Theoretical models in vocational orientation or career development are therefore situated in between psychology and sociology (for an overview see [7]). Some of these models stress the psychological and therefore individual aspects of career development. This applies for example to the widely used RIASEC model developed by Holland (e.g., [8]). It explains vocational behavior through the matching between personality traits and the occupations' characteristics. Since it is designed for counseling practice, it focuses on individual variables and not on the social context. However, it can also be used to analyze differences between social groups and therefore serve as a tool for sociological investigations.

Eccles' value-oriented model (for science see [9]) shifts the attention to the values that are relevant in the career decision-making process, i.e., interest values (e.g., enjoyment and interest), attainment values (e.g., belief in success), utility values (e.g., financial security and prestige), and the perceived cost associated with a career. Social cognitive career theory [10] extends Bandura's social cognitive theory (e.g., [11]) on the field of career development and takes personal traits as well as external, social variables into account. The intertwinement of "external", sociological, with "internal", psychological variables can be conceptualized in terms of Bourdieu's notions of habitus and capital [12]. This theory has proven to be a powerful framework for explaining career aspirations and decision making [13,14]. Since the present research focuses on the influences of gender and cultural background on students' vocational orientation, we adopt this theoretical lens and assume that individual career decisions are inseparably intertwined with social class, gender, and race [15,16].

Evidence regarding the intertwinement of science aspirations and preferences with sociological variables comes from a large body of research investigating the role of socioeconomic status, ethnicity, and gender in science-related career decisions. It is well documented that students with a strong socioeconomic background are much more likely to choose science subjects in school [1,17,18]. Further, gender differences have been shown. In many countries, males are more likely to choose science subjects than females [2,18,19]. This leads to an underrepresentation of women in many science fields [2,20]. Further, gender differences exist regarding the type of science occupation students aspire to. Female students tend to see themselves in the medical field, while male students aspire more

strongly to careers in engineering. This is reflected in enrolment rates at university: health- and biology-related subjects tend to be dominated by women, while physics and engineering-related subjects are dominated by men [21]. Further, some ethnic minorities are clearly underrepresented in science occupations, although there are some exceptions [1,22,23].

These differences in the individuals' choices are reflected in a set of psychological variables. In Western countries, females tend to have lower science self-concepts than males, i.e., lower confidence in their abilities in science (e.g., [24]). Further, gender roles and stereotypes influence career development, an influence transmitted through the older generation [25,26]. For instance, some jobs are perceived by students as being gendered and females tend to prefer occupations in which women dominate the field, while males tend to prefer domains that are dominated by men (e.g., [7]). Science aspirations are gendered, classed, and racialized, in favor of white middle-class males [16,27–29]. Since this observation is based on studies from the U.K. and the U.S., this means that boys and young men who belong to the dominant ethnic group ('Whites') and who are situated in the middle or the upper end of the social hierarchy develop science aspirations more easily than females, people of color, and people belonging to the working class. Here, the intersection of race, class, and gender becomes clear. Science fields tend to be not only gendered in favor of males, but also associated with white middle-class students. Young women with a migration background could, therefore, be facing a twofold disadvantage in Germany, being both female and belonging to an ethnic minority. However, it can be assumed that liking *doing* science, which belongs to the psychological dispositions, is more equally distributed among students, while a deeper identification with science is much more difficult for female, working-class, and some minority students. Archer and colleagues [3] had called this the *doing/being divide* ('doing' science vs. 'being' a scientist).

## 2.2. Sources of Information in Vocational Orientation in Science

Given this evidence for the considerable impact of social positions on career choices in science, we need to reflect on how these social inequalities could be reduced. The question is, how could we reach groups of students for whom it is not as easy to identify with science as for white middle-class males? Analyzing and possibly changing vocational orientation measures could be one way to address groups that are currently underrepresented in science. In the following, three domains will be discussed: vocational orientation activities inside school, outside school, and online.

A school is an important place where vocational orientation takes place. In their literature review, Reinhold, Holzberger, and Seidel [30] present evidence that, in general, schools have positive effects on vocational orientation in science. Practical work experiences that are embedded in the school curriculum, as well as a well-developed network of contacts between teachers and companies, seem to contribute to good vocational orientation in science [31]. However, science career education in school through teachers seems to have deficits, either discouraging students from a specialization in science, or lacking a clear structure, or being absent altogether [30].

Robertson [31] evaluated the influence of several activities outside the school on the choice of choosing science at university. Work experiences seemed to be very influential for some students in their choice for a career in science [31]. Further, contacts with universities seemed to have an important impact. This includes the attendance of open days as well as more individual contacts with career advisors at university. However, it is important to notice here that the participants in Robertson's study were university students. Different outcomes regarding the importance of career orientation could be expected in groups that do not go to university. It is interesting, though, that activities at university seem to have a larger impact on female students than on males. Science fairs and professional career advisors were less influential, compared to work experiences and the orientation at university. Robertson also looked at influences in the social domain, i.e., family members employed in science and friends. Here, the family members seemed to have a larger influence than friends. More precisely, young women tend to consider their mothers as more important in their vocational orientation, while young men tend to rely on their fathers [32].

A third domain in which vocational orientation takes place might be gaining importance. It is the field of online videos and fictional characters in movies and series. In vocational orientation, some professional institutions make use of social media. However, this seems to be the case only rarely [33]. In contrast, there is an abundance of non-institutional science channels on YouTube. Science channels have gained rapidly in popularity in recent years. The influence of these YouTubers on young peoples' career development seems not to have been sufficiently understood. The YouTubers who appear in these videos could be an important source for the identification processes of young people. Similarly, popular series such as "The Big Bang Theory" in which scientists and their talking about science play an important role could be sources of career orientation. The impact of TV characters on adolescents' views on careers has been shown [32,34]. This is especially true for young people with a low socioeconomic status who tend to identify with the characters' professional roles more strongly than students with a higher socioeconomic status. Further, the use of YouTube is gendered [35]. An analysis of fictional literature with engineer characters concluded that the presented stories and characters are unlikely to appeal to young people in general and women in particular [36]. However, the authors argue that different stories could have a strong potential in young peoples' identification processes.

### 3. Research Questions

Females and some ethnic minorities are underrepresented in science. We do have some knowledge about which measures have an impact on vocational orientation in science. However, we do not know which measures appeal specifically to those groups that are currently underrepresented in science. In the present investigation, we therefore aimed at characterizing the vocational orientation behavior and the needs and wishes of students of different gender and cultural backgrounds in Germany.

We looked at this from two perspectives: (1) we investigated the situation of secondary school students who have not yet enrolled in a study program or chosen a job; (2) we were interested in the retrospective views of university students on what had helped them in their vocational orientation when they were in school. We differentiated between students with and without a migration background. Further differentiation between different types of migration backgrounds would be desirable for future research in order to understand the situation of students, accounting for their particular cultural background. Further, the students' socioeconomic background was not considered because access to these sensitive data is very restricted in Germany. The focus in the present study is, therefore, on the impact of students' gender and migration background.

The following research questions guided our research:

- (Q1) Secondary school students. How do male and female secondary school students with and without a migration background differ in their vocational orientation regarding science?
- (Q1a) Do they differ in science aspirations?
  - (Q1b) Do they differ in their need for more information on jobs in science?
  - (Q1c) What sources of information do they use in their vocational orientation regarding science?
  - (Q1d) What sources of information would they like to use more in their vocational orientation regarding science?

Regarding Q1a, we expected gender and migration background not to have a significant effect on science aspirations. DeWitt and colleagues [37] showed that only having an Asian background has a significant positive effect on science aspirations; other ethnicities did not differ significantly. Based on these findings, we expected that migration background would not have a significant effect on science aspirations in our German sample because, in Germany, the proportion of Asian students is much lower than in the U.K. Regarding Q1b, there was no literature available that reported on the impact of gender and ethnicity on 'the need for information' about jobs in science. Here, this study remains exploratory in nature. The goal is to determine whether some students have a greater need for vocational orientation than others. Further (Q1c), we assumed that students would use the same

sources in science orientation that they use for vocational orientation in general. Here, it had been found that internet searches, TV, and radio programs are most popular among German students (these are vocational orientation activities that students in Germany usually do at home in their leisure time), followed by discussion with career advisors, work experiences, and activities for vocational orientation at university (these activities are often organized by the schools in Germany). The latter had been used by a small number of students only [38]. Further, we expected online video platforms such as YouTube to play an important role in vocational orientation in science [32] as well as fictional series and movies with characters who are scientists. Regarding the sources the students would like to use more (Q1d), we assumed that some students would like to make more use of online video platforms and fictional movies and series about scientists because professional vocational orientation is often still based on rather traditional approaches [33] and high-quality material in the form of online videos is scarce although these formats appeal to a lot of young people [32,34]. In particular, we supposed that male students would wish for more orientation via online videos, series, and movies [35].

(Q2) University students. How do university students of natural science and other subjects differ in their vocational orientation?

(Q2a) Do the students differ in their reasons for studying their subject?

(Q2b) What sources of information did they use in their vocational orientation?

(Q2c) What sources of information would they have liked to use more in their vocational orientation?

Concerning university students' reasons for choosing science or non-science subjects (Q2a), we assumed that no significant differences exist. We supposed that financial security and prestige would be of minor importance [39]. Regarding the sources used in vocational orientation (Q2b), we assumed that we would find two differences. First, we assumed that online video platforms and fictional movies would be slightly less important in this group. For this, we see two reasons. First, these students' vocational orientation took place some years ago and these media have gained in importance in recent years. Second, middle-class students who are less influenced by movies and social media in their vocational orientation will probably be overrepresented in this group. In addition, we supposed that activities at university were important to these students [31]. We also expected the vocational orientation of science and non-science students to be similar. Concerning the sources the different groups of students would like to use more (Q2c), we could not formulate explicit hypotheses because research in this field is lacking.

## 4. Methods

### 4.1. Study 1: Secondary School Students

#### 4.1.1. Sample

In the first study, we wanted to gain insights into the current activities and needs of secondary school students regarding their vocational orientation. It was conducted with 450 secondary school students from 19 classes in 8 German secondary schools. A total of 206 (45.8%) students were female, 243 (54.0%) were male and 1 student did not respond to this question. The students were aged 13–19 ( $M = 15.3$ ) and enrolled in grades 8–11. With this range, we intended to reach students who are in the decision-making process regarding their vocational choices because some students leave school after the completion of grades 9 or 10, while some students in grammar school continue after 12 or 13 years. We included students from all secondary schools except for special needs and vocational schools. Of the students, 223 (49.6%) had a migration background, with a Turkish background being most frequent (56 students, 12.4%), while 8 students (1.8%) did not answer this question. The female participants with a migration background, who were of special interest in this study, made up 20.9% of the sample (94 students). A total of 97.3% of the participants were aged 14–17, which we had defined

as the age group we were interested in because we assumed that these students were at the stage of considering their careers. Only three students were 13, six students were 18, and three students were 19. See Table 1 for further information on the sample.

**Table 1.** Study 1: Composition of the sample of secondary school students.

Age	Total Number of Students (% of the Total Sample)	Female (% of the Age Group)	with Migration Background (% of the Age Group)
13	3 (< 0.01%)	1 (33.0%)	3 (100.0%)
14	85 (18.9%)	40 (47.1%)	39 (45.9%)
15	200 (44.4%)	96 (48.0%)	94 (47.0%)
16	107 (23.8%)	44 (41.1%)	56 (51.4%)
17	46 (10.2%)	19 (41.3%)	27 (58.7%)
18	6 (0.01%)	3 (50.0%)	2 (33.0%)
19	3 (< 0.01%)	3 (100.0%)	2 (33.0%)
value is missing	–	1 (< 0.01%)	8 (< 0.01%)
total	450 (100%)	206 (45.7%)	223 (49.6%)

#### 4.1.2. Instrument

A paper-based questionnaire was employed. A pre-test was conducted focusing on the language in the items because an important number of students have difficulties in reading comprehension. Based on the experiences of this pre-test, some sentences were re-structured or abbreviated in order to make them more comprehensible. With the final instrument, we measured the students' science aspirations and their need for information on jobs in science with four-point Likert scales. For science aspirations, we translated the scale that had been used in the ASPIRES project [37]. Two researchers translated the items independently, then checked for differences and developed a common translation. This was discussed in the research group consisting of the two researchers, a science teacher, and an experienced researcher in science education. The need for information scale was based on items that had previously been used in the German literature (items 1 and 4 [38]; items 2 and 3 [40]), which were only slightly modified to fit the context of vocational orientation in science. These items were checked in the research team as well.

The second part of the questionnaire consisted of a list of sources that the students (a) had used and (b) would like to use more in their vocational orientation concerning careers in science, such as career advisors, their teachers, or open days at university. These were binary variables (used/not used, would like/would not like to use more). The list of sources was adapted from German literature [38]. We used this list but updated it slightly because the article had been published in 2005 and we assumed that the use of media in vocational orientation had changed since. We differentiated between male and female family members as sources in vocational orientation and added one further section on informal sources, i.e., online video platforms such as YouTube, movies, and series. For measuring the students' migration background, we employed the official definition of the German 2013 census [41]. We included an explanation of the criteria for having a migration background in the instrument. This was included as a data protection measure. We did not want the students to reveal sensitive details about their families' migration history. Therefore, we asked the students to judge on their own whether they have a migration background according to the given criteria.

#### 4.1.3. Analysis

Since the scales had been either translated or slightly modified, we first analyzed their reliability calculating Cronbach's  $\alpha$  and assessed model fit in confirmatory factor analyses. Following this, we conducted two-way ANOVAs to check for differences in the students' science aspirations and their need for information, regarding gender and migration background. In the last step, we analyzed the impact of gender and migration background on the sources the students would like to use more in

their vocational orientation. This was carried out with logistic regression because the variables were binary. In the case of missing data, we used pairwise deletion. All analyses were carried out using R [42], in particular the packages car [43], lavaan [44], psych [45], and stats [46].

#### 4.2. Study 2: University Students

##### 4.2.1. Sample

In the second study, we were interested in university students' *retrospective views* on their vocational orientation—what had helped them and what they would have wished for. We collected data from 342 university students from four German universities. Slightly more than half of all students (199, 58.2%) were enrolled in at least one science subject. A total of 294 (86.0%) participants were female and 48 (14.0%) male. On average, the students were 23 years old, with an age range from 18 to 53 years. The students were enrolled in bachelor's degree courses in their respective fields. In this sample, only 56 students (16.4%) had a migration background.

##### 4.2.2. Instrument

Since the students were asked about their retrospective view, we needed to apply a different instrument than in the study with secondary school students. The study was conducted using an online survey. We measured the university students' reasons for choosing their science or non-science subjects on four-point Likert scales. For this part of the questionnaire, we adopted existing scales [47,48] and added some items to form more coherent subscales. In total, we had five subject-specific subscales that were grounded in Eccles' model of values [9]: inclination (interest value), belief in success (attainment value), financial security, prestige, and the importance for society (utility values). We added another section for subject-unspecific reasons. The students also had the chance to name other reasons if they wished to.

In the second part of the questionnaire, we asked the students about the sources they had used in their vocational orientation. Here, we used the same instrument we had employed in study 1. We asked the university students to tick the sources they had used in their vocational orientation and those they would have liked to use more. For measuring the students' migration background, we used the same definition of migration background as in study 1.

##### 4.2.3. Analysis

We analyzed the scales' reliabilities and factor structures. This was performed using Cronbach's  $\alpha$  and confirmatory factor analyses. In our further investigations, we did not differentiate between students with and without a migration background. The reason for this was the small number of university students with a migration background in our sample. Further, the large majority in our sample was female. We, therefore, concentrated on the impact of the chosen course (science vs. non-science) on the variables we were interested in. We compared the science and non-science students' reasons for their course choices in t tests regarding the five subscales separately. Then, we focused on the students' use of sources in vocational orientation. For this, we looked at descriptive statistics and analyzed differences in the students' choices using  $\chi^2$  tests because the variables were binary. There was no data missing since the online survey could only be completed when values for all items were selected. The analyses were carried out using R [42], in particular the packages car [43], gmodels [49], lavaan [44], psych [45], and stats [46].

## 5. Results

### 5.1. Study I: Secondary School Students

In the first step, we analyzed the reliability of the translated science aspirations scale and the need for information scale that we had adapted to the context of science. Both showed quite high

reliabilities, with values of Cronbach's  $\alpha$  of 0.87 for the science aspirations scale and 0.74 for the need for information scale. These can be qualified as good reliabilities because (i) both are high, especially when considering that the scales are rather short with four and five items, keeping in mind that a small number of items generally leads to lower values of Cronbach's  $\alpha$  [50]. (ii) The values are below 0.90 (values above 0.90 can point to redundancies [50], which is not the case in this study). (iii) The reliability of the scales did not improve if any of the items were dropped in the analysis.

The next step was to assess the model fit in confirmatory factor analysis. There is an ongoing discussion about cutoff criteria and the use of "golden rules" regarding model fit indices. The influential study by [51] on fit indices has been interpreted by many authors as providing such rules. Following this rationale, a good model fit would be given if CFI and TLI > 0.95, SRMR < 0.08, RMSEA < 0.06, and the  $\chi^2$  test is non-significant. However, the authors do not present them as fixed values [51], so there have been misunderstandings and simplifications in the reception of these values [52]. For example, the  $\chi^2$  test is sensitive to large sample sizes. This leads to significant test results even when minor misfits occur. A rejection of such a model would constitute a type 1 error, i.e., the false rejection of an acceptable model [52]. The sample size in the present study is relatively large compared to the small number of items. For this reason, we did not consider the  $\chi^2$  test in our evaluation of the model to avoid type 1 errors. We used maximum likelihood estimation and fixed the variance of the latent variables to 1. This was carried out to estimate all factor loadings and error terms.

The measurement model for science aspirations ( $df = 2$ ) converged after 16 iterations. It showed an acceptable model fit with very good values for SRMR (0.029) and CFI (0.964) but high RMSEA (0.193; 90%  $CI_{RMSEA}$  0.140, 0.251) and low TLI (0.892) values. The model for need for information ( $df = 5$ ) converged after 13 iterations. All indicators suggested a poor model fit (CFI = 0.685; TLI = 0.371; RMSEA = 0.314; 90%  $CI_{RMSEA}$  0.279, 0.350; SRMR = 0.138).

We analyzed the items' content and reflected on what could have caused the misfit. We identified possible errors in the first item of the need for information scale. (i) Difficulties in reading comprehension could have occurred due to two nested subordinate clauses. (ii) It comprises two statements instead of a single one, possibly causing ambiguity. We, therefore, ran another factor analysis without item 1. This analysis ( $df = 2$ ) converged after 14 iterations and showed very good model fit (CFI = 0.993; TLI = 0.978; RMSEA = 0.052; 90%  $CI_{RMSEA}$  0.000, 0.121; SRMR = 0.020). The items all showed significant positive factor loadings (Table 2). We decided to work with the reduced need for information scale and recalculated Cronbach's  $\alpha$ , which decreased to 0.69. Considering that only four items remained in the scale, this was acceptable.

**Table 2.** Study 1: Results of the CFAs regarding the two measurement models for science aspirations and the need for information. \*\*\* =  $p < 0.001$ .

Latent Variable	Indicator	b	SE	z	$\beta$	sig
science aspirations	sa1	0.744	0.041	17.976	0.762	***
	sa2	0.761	0.041	18.758	0.786	***
	sa3	0.784	0.037	21.305	0.858	***
	sa4	0.770	0.041	18.856	0.789	***
need for information	ni2	0.376	0.053	7.097	0.370	***
	ni3	0.629	0.049	12.724	0.648	***
	ni4	0.805	0.049	16.365	0.855	***
	ni5	0.576	0.052	11.173	0.567	***

We wanted to determine whether gender and migration background have an impact on secondary school students' science aspirations. Further, we were interested in the interaction between the two variables. We, therefore, conducted two-way ANOVAs, differentiating between cultural background and gender. Levene's test was not significant—neither for gender ( $p = 0.74$ ), nor for migration background ( $p = 0.44$ ), nor for the interaction of the two variables ( $p = 0.77$ ). Thus, we conducted the



ANOVA, which revealed no significant main effects—neither for gender  $F(1428) = 0.010$ ,  $p = 0.919$ , nor for cultural background  $F(1428) = 0.146$ ,  $p = 0.703$ , nor for the interaction of the two variables  $F(1428) = 0.986$ ,  $p = 0.321$ . This indicates that science aspirations do not differ significantly between male and female students with and without a migration background.

In a second ANOVA, we analyzed the differences in the culture and gender groups regarding their need for information about jobs in science. As in the first analysis, Levene's test was not significant—neither for gender ( $p = 0.33$ ), nor for cultural background ( $p = 0.44$ ), nor for the interaction of the variables ( $p = 0.68$ ). The ANOVA could thus be conducted. It revealed no significant differences regarding gender  $F(1423) = 1.565$ ,  $p = 0.212$ , cultural background  $F(1423) = 0.004$ ,  $p = 0.950$  or the interaction of the variables  $F(1423) = 0.317$ ,  $p = 0.574$ . The need for information on science jobs seemed to be comparable between the groups we focused on. It seems like students have the same need for information on careers in science, regardless of their gender and migration background.

Further, in our analysis, we wanted to determine whether the students had used a comparable number of sources in their vocational orientation regarding science jobs. Here, too, we differentiated between male and female students with and without a migration background. Levene's test was not significant—neither for gender ( $p = 0.36$ ), nor for migration background ( $p = 0.27$ ), nor for the interaction effect ( $p = 0.48$ ). The ANOVA revealed no significant main effects of gender  $F(1438) = 2.033$ ,  $p = 0.155$  and cultural background  $F(1438) = 0.403$ ,  $p = 0.526$  but a significant interaction effect  $F(1438) = 5.870$ ,  $p = 0.016$ . In the German subgroup, the females ( $M = 4.73$ ) had made use of more sources than the male participants ( $M = 3.61$ ), while among the students with a migration background, the males ( $M = 4.13$ ) had used more sources than the female participants ( $M = 3.84$ ).

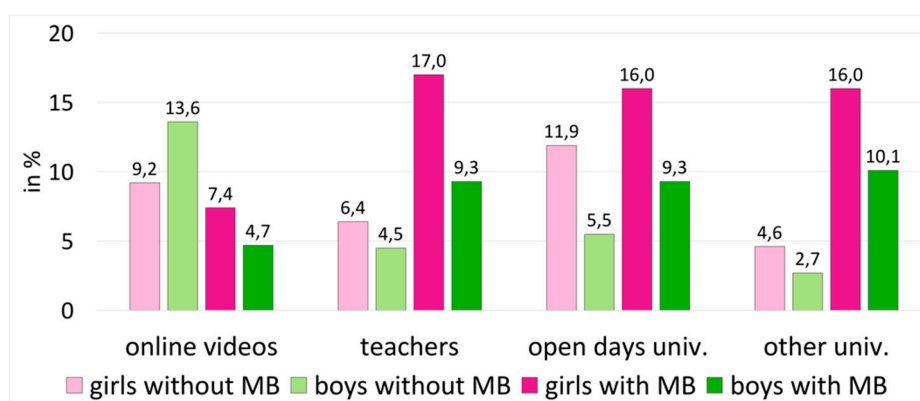
Regarding the number of sources the students would like to use more, we conducted the same type of analysis. Levene's test was not significant for gender ( $p = 0.21$ ), migration background ( $p = 0.16$ ) and the interaction variable ( $p = 0.16$ ). The ANOVA revealed no significant effects of gender  $F(1438) = 2.116$ ,  $p = 0.147$ , cultural background  $F(1438) = 2.538$ ,  $p = 0.112$  and the interaction of the variables  $F(1438) = 0.660$ ,  $p = 0.417$ .

We looked at descriptive statistics to determine which types of sources had been used by the students in vocational orientation in science. The most popular options were series and movies (52.9%), and online video platforms (50.4%). Since we wanted to determine whether different subgroups use different types of vocational orientation, we also analyzed differences in these preferences. For this, we used logistic regressions with the respective source as the outcome variable and migration background and gender as the explanatory variables. The results can be found in Table 3. For females, the odds of using online platforms were lower than for males but the odds were higher for discussing science occupations with female family members and attending a fair. Among students with a migration background, the odds of talking to a male family member were lower.

We also analyzed which types of sources the students would like to use more. The most popular choices were work placements (13.6%), fairs (11.6%), fictional series and movies (10.7%), brochures, open days at university, and company tours (all 10.2%). As in the previous analysis, we used logistic regressions in order to investigate the effects of gender and migration background on the sources the students would like to use more (Table 3). For females, the odds of wishing for more open days were higher. For students with migration background, the odds were higher for wishing for more discussions with teachers and more visits at university. The odds were lower for online videos. Looking at descriptive statistics (Figure 1), it becomes clear that it is the female participants with a migration background in particular who would wish for more contacts with the university. Further, they form the group of students who wish most strongly for more guidance and counseling through their teachers. In contrast, the male participants without migration background wished most for more online videos in vocational orientation, while more conventional options were not as popular. What becomes clear as well is the fact that more females than males tend to be interested in open days at university.

**Table 3.** Study 1: The effects of gender and migration background on the sources that secondary school students wish to use more in their vocational orientation, computed in logistic regressions. fem = female, mig = with migration background, \* =  $p < 0.05$ , \*\* =  $p < 0.01$ , and \*\*\* =  $p < 0.001$ .

		Sources the Students have Used					$p$	Sources the Students Would Like to Use More					$p$
		$b$	$SE$	$e^b$	$CI_{lower}$	$CI_{upper}$		$b$	$SE$	$e^b$	$CI_{lower}$	$CI_{upper}$	
online video platforms	fem	−0.70	0.19	0.50	0.34	0.73	< 0.001 ***	−0.11	0.34	0.89	0.45	1.76	0.752
	mig	0.23	0.19	1.25	0.86	1.83	0.245	−0.74	0.36	0.47	0.23	0.94	0.038 *
teachers	fem	0.09	0.23	1.09	0.70	1.70	0.701	0.59	0.34	1.81	0.93	3.56	0.081
	mig	0.01	0.23	1.01	0.65	1.57	0.970	0.96	0.36	2.61	1.31	5.49	0.008 **
male family member	fem	0.24	0.21	1.27	0.85	1.92	0.244	0.08	0.62	1.08	0.31	3.68	0.896
	mig	−0.52	0.21	0.59	0.39	0.89	0.012 *	1.52	0.79	4.59	1.16	30.40	0.053
female family member	fem	0.57	0.21	1.77	1.17	2.67	0.007 **	−0.74	0.60	0.48	0.13	1.46	0.220
	mig	−0.16	0.21	0.85	0.57	1.29	0.454	0.54	0.56	1.71	0.58	5.66	0.344
fair	fem	0.56	0.22	1.75	1.14	2.71	0.011 *	0.59	0.30	1.80	1.00	3.29	0.053
	mig	−0.30	0.22	0.74	0.48	1.15	0.181	−0.02	0.30	0.98	0.54	1.77	0.946
open day university	fem	−0.10	0.27	0.90	0.53	1.52	0.702	0.71	0.32	2.04	2.09	3.88	0.027 *
	mig	0.21	0.26	1.24	0.74	2.08	0.422	0.43	0.32	1.54	0.83	2.91	0.177
other activity university	fem	0.06	0.36	1.06	0.52	2.14	0.872	0.53	0.36	1.70	0.85	3.46	0.137
	mig	0.11	0.36	1.12	0.55	2.28	0.754	1.38	0.42	3.97	1.84	9.56	< 0.001 ***



**Figure 1.** Sources the secondary school students would have liked to use more in terms of their vocational orientation for science (mean values). Only sources with significant effects of gender or cultural background.

To sum up the presented findings, study 1 revealed that the secondary school students' science aspirations in this sample were comparably strong in all four gender and culture groups. The same goes for the need for information about jobs that are related to science. However, the students differ in their use of sources regarding vocational orientation in science. Females without migration background make use of a greater variety of sources than males. The inverse is true for students with a migration background. Here, the females use a smaller number of sources in their vocational orientation regarding science jobs. Further, the students of the different subgroups seem to prefer different types of sources. More male than female participants had used online videos, while more female than male participants had attended fairs and spoken to a female family member. The female participants wished for more activities at university. Further, migration background affected the preferred types of sources. Fewer students with migration background had talked to a male family member about careers in science. More students wished for more discussions with their teachers and more contacts with the university. Males without migration background seem to rely most strongly on information from YouTube channels and comparable video platforms. In contrast, the females with migration background wish for more advice from their teachers and at university.

## 5.2. Study 2: University Students

In the first step, we analyzed the measurement properties of the scales regarding the reasons for the students' course choices. We proceeded in the same way as in study 1, analyzing the reliabilities first and then conducting confirmatory factor analysis. The reliabilities of the five subscales were good, with values for Cronbach's  $\alpha$  of 0.78 for inclination, 0.70 for belief in personal success in the subject, 0.87 for financial security, 0.78 for the course's prestige, and 0.83 for its importance in society. Dropping an item did not improve the reliability in any of the scales. Since their reliabilities were at a good level, no alterations to the scales were made. The scale for subject-unspecific reasons showed an insufficient value of Cronbach's  $\alpha$  (0.63). However, this was expected due to the diversity of subject-unspecific reasons that were included and was not further investigated.

Since we were interested in the subject-specific reasons for course choices, we analyzed their factor structure in confirmatory factor analysis. We used maximum likelihood estimation and fixed the variance of the latent factors to 1. This allowed for a free estimation of all factor loadings. In addition, we assumed that all latent variables were correlated and estimated the error terms. The model with 80 degrees of freedom converged normally after 34 iterations. It showed good values for RMSEA (0.074; 90% CI<sub>RMSEA</sub> 0.063, 0.085) and SRMR (0.053) and slightly too low but still acceptable values for CFI (0.935) and TLI (0.915). The items all showed significant positive factor loadings (Table 4). Based on this analysis, we decided to use the scales in our analysis without modification.

**Table 4.** Study 2: Results of the CFA regarding the reasons for course choice subscales. \*\*\* =  $p < 0.001$ .

Latent Variable	Indicator	b	SE	z	$\beta$	sig
inclination	i1	0.576	0.033	17.676	0.857	***
	i2	0.532	0.043	12.288	0.641	***
	i3	0.462	0.029	15.739	0.783	***
belief in success	bs1	0.425	0.046	9.276	0.529	***
	bs2	0.647	0.046	14.034	0.770	***
	bs3	0.535	0.040	13.251	0.729	***
financial security	fs1	0.725	0.041	17.596	0.818	***
	fs2	0.731	0.045	16.233	0.772	***
	fs3	0.818	0.040	20.632	0.912	***
prestige	p1	0.685	0.048	14.234	0.720	***
	p2	0.738	0.049	15.053	0.752	***
	p3	0.605	0.040	15.281	0.760	***
importance for society	s1	0.759	0.052	14.611	0.726	***
	s2	0.776	0.045	17.251	0.822	***
	s3	0.818	0.046	17.838	0.843	***

We wanted to determine whether students of natural science and students enrolled in other subjects had different reasons for choosing their respective courses. This was performed using t tests. The tests indicated that the students' response patterns do not differ in quality but rather in intensity because the mean values of the students who had not chosen science were higher in all subscales. The values regarding inclination ( $p = 0.002^{**}$ ;  $M_{\text{Science}} = 10.00$ ;  $M_{\text{No Science}} = 10.56$ ), prestige ( $p = 0.007^{**}$ ;  $M_{\text{Science}} = 6.22$ ;  $M_{\text{No Science}} = 6.90$ ), and importance for society ( $p < 0.001^{***}$ ;  $M_{\text{Science}} = 7.98$ ;  $M_{\text{No Science}} = 9.33$ ) were significantly higher. Regarding the other subscales, there were no statistically significant differences (belief in success:  $p = 0.361$ ;  $M_{\text{Science}} = 9.24$ ;  $M_{\text{No Science}} = 9.43$ ; financial security:  $p = 0.137$ ;  $M_{\text{Science}} = 6.12$ ;  $M_{\text{No Science}} = 6.52$ ). Further, the mean value of the non-science students regarding the impact of female significant others (mother, female friends, female relatives) was significantly higher than in the group of the science students ( $p < 0.001^{***}$ ;  $M_{\text{Science}} = 4.72$ ;  $M_{\text{No Science}} = 5.45$ ). We did not detect significant differences in the impact of male significant others ( $p = 0.440$ ;  $M_{\text{Science}} = 4.63$ ;  $M_{\text{No Science}} = 4.77$ ).

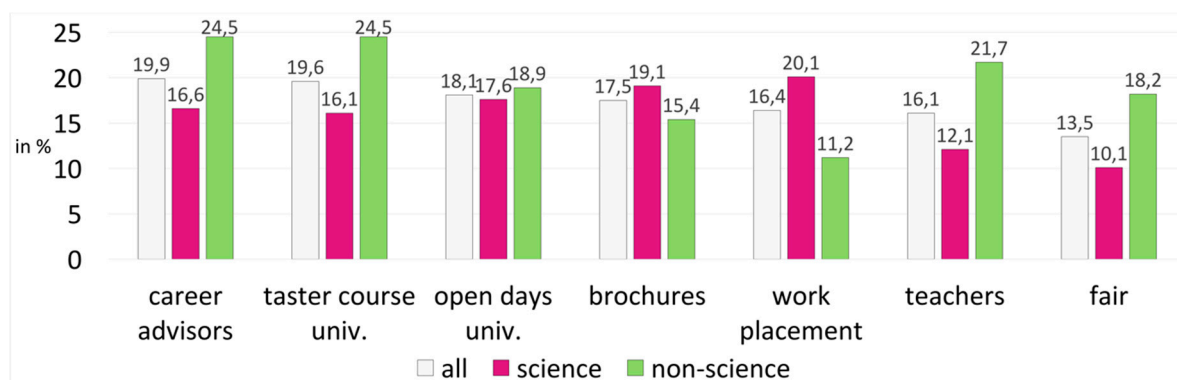
This tendency of the non-science students to agree more strongly with the items can be either (i) a substantive difference or (ii) a different response behavior. The first option would mean that non-science students have stronger reasons for their course choices than science students. The second option would mean that the differences lie in response behavior only, i.e., the non-science students in this sample had a stronger tendency to agree with items in general. The issue cannot be resolved in this analysis. Yet, the students' responses to the open question about "other reasons" suggested that several non-science students reflect on their choice from a political point of view. For example, one student added that he or she had chosen his or her course "in order to abolish sexism and racism". Another student stated that one reason for his or her choice for political science was "to examine and reconsider my attitudes". No such statement could be found among the science students. We interpret this as a hint towards some substantial differences. Yet, this hypothesis would need a closer examination that our data did not allow for.

The sample of the university students was dominated by female students without migration background. We, therefore, could not conduct the same analyses as in the sample of the secondary school students when it comes to preferred sources for vocational orientation in science. We investigated the sources the students had used. Irrespective of their course choice, the most popular options were homepages (53.2%), friends (50.6%), open days at university (44.7%), teachers (44.4%), work placements (44.4%), and female family members (43.9%). We then analyzed differences between science and non-science students using Pearson's  $\chi^2$  test. We found some significant differences with the type of university course. This was the case for homepages  $\chi^2(1) = 5.74, p = 0.017^*$ , friends  $\chi^2(1) = 8.98, p = 0.003^{**}$ , teachers  $\chi^2(1) = 6.50, p = 0.011^*$ , female family members  $\chi^2(1) = 18.14, p < 0.000^{***}$ , fairs  $\chi^2(1) = 22.82, p < 0.000^{***}$ , Girls'/Boys' Day  $\chi^2(1) = 12.15, p < 0.000^{***}$ , and work placements  $\chi^2(1) = 39.38, p < 0.000^{***}$ . Here, the type of university course the students had chosen (science/non-science) was associated with the sources they had used. Among the science students, the odds of having used the source in vocational orientation were higher regarding teachers (1.76; CI<sub>95%</sub> 1.11, 2.81), fairs (4.40; CI<sub>95%</sub> 2.26, 9.16), and Girls'/Boys' Day (3.44; CI<sub>95%</sub> 1.62, 8.00). The odds were lower regarding homepages (0.59; CI<sub>95%</sub> 0.37, 0.93), friends (0.52; CI<sub>95%</sub> 0.32, 0.82), female family members (0.39; CI<sub>95%</sub> 0.24, 0.62), and work placements (0.24; CI<sub>95%</sub> 0.15, 0.39). No significant associations could be found for brochures  $\chi^2(1) = 1.94, p = 0.163$ , serials and movies  $\chi^2(1) = 2.56, p = 0.110$ , online video platforms  $\chi^2(1) = 0.01, p = 0.924$ , career advisors  $\chi^2(1) = 0.16, p = 0.684$ , male family members  $\chi^2(1) = 3.21, p = 0.073$ , company tours  $\chi^2(1) = 1.10, p = 0.294$ , open days at university  $\chi^2(1) = 0.43, p = 0.512$ , taster courses at university  $\chi^2(1) = 0.15, p = 0.697$ , and other activities at university  $\chi^2(1) = 2.44, p = 0.118$ .

In the next step, we wanted to find the sources through which the students would have liked to receive more information on jobs in science. Irrespective of their course choice, the students' favorite options were career advisors, taster courses, open days at university, brochures, work placements, and discussions with their teachers (Figure 2). Then we analyzed differences between the science and the non-science students using Pearson's  $\chi^2$  test. For some types of sources, the  $\chi^2$  test could not be conducted because the minimum expected frequency was very low (< 5). This was the case for friends, female family members, and male family members. Here, the absolute number of students who would have liked more vocational orientation was too low to be analyzed.

Among the remaining variables, we found some significant associations with the type of university course. This was the case for homepages  $\chi^2(1) = 4.22, p = 0.040^*$ , teachers  $\chi^2(1) = 5.70, p = 0.017^*$ , fairs  $\chi^2(1) = 4.73, p = 0.030^*$ , company tours  $\chi^2(1) = 7.63, p = 0.006^{**}$ , and work placements  $\chi^2(1) = 4.83, p = 0.028^*$  in science jobs. Among the natural science students, the odds of wishing for more vocational orientation were higher regarding homepages (7.17; CI<sub>95%</sub> 0.98, 5.20), company tours (3.17; CI<sub>95%</sub> 1.30, 8.87), and work placements (1.99; CI<sub>95%</sub> 1.03, 4.00). The odds were lower regarding teachers (-0.49; CI<sub>95%</sub> 0.26, 0.92) and fairs (0.50; CI<sub>95%</sub> 0.25, 0.99). No significant associations could be found for brochures  $\chi^2(1) = 0.79, p = 0.373$ , series and movies  $\chi^2(1) = 1.03, p = 0.311$ , online video platforms  $\chi^2(1) = 2.29, p = 0.130$ , career advisors  $\chi^2(1) = 3.25, p = 0.071$ , Girls'/Boys' days  $\chi^2(1) = 0.22, p = 0.641$ , open days at university  $\chi^2(1) = 0.094, p = 0.759$ , taster courses at university  $\chi^2(1) = 3.72, p = 0.054$ ,

and other vocational orientation activities at university  $\chi^2(1) = 0.35, p = 0.556$ . Here, the students' wishes seemed not to differ between the groups.



**Figure 2.** Sources the university students would have liked to use more in terms of their vocational orientation for science. Mean values for the most frequently selected sources.

In summary, study 2 shows that science and non-science university students' reasons for choosing their courses were very much alike. They did not show different patterns in their reasons, but their answers differed in strength only. This could indicate that the non-science students see stronger reasons for their course choice although this remains a hypothetical statement. Regarding the sources the students had used and those they would have liked to use more, some trends became visible. In general, career advisors, taster courses, open days at university, brochures, work placements, and discussion with teachers were the sources the students wished for most. In both groups, vocational orientation through professionals and institutions seemed to be most requested. In contrast, orientation in private life through family and friends seemed not to play such a pivotal role.

## 6. Discussion and Conclusions

The goal of this research was to establish the behavior and needs of students in their vocational orientation regarding science. We were interested in the views of both (1) secondary school students who had not yet chosen a career path and (2) the retrospective view of university students about what had been helpful in their vocational orientation phase in school. Regarding the secondary school students, we did not find differences in science aspirations between males and females in secondary schools (Q1a). This confirms the findings of DeWitt and colleagues [37]. Further, migration background did not make a difference, which contrasts with the findings of DeWitt and colleagues [37]. This could be explained by the different composition of the group of minority students in Germany. However, this would require further investigations. Further, we did not find differences in their need for information about science jobs (Q1b). This indicates that, in general, the students in all groups have a similar interest in science jobs. This contrasts the findings from the literature [3], stating that females and students from ethnic minorities show lower science aspirations. Maybe the logic of the 'doing/being divide' (many students like doing science but especially females and young people belonging to ethnic minorities show low science aspirations—they cannot imagine *being* a scientist) needs to be stretched further, i.e., maybe a considerable number of female and minority students in Germany can envision themselves as scientists but there are other obstacles that limit their actual representation in science professions.

Their preferences in vocational orientation do differ (Q1c/d). As expected, online video platforms, fictional movies, and series play an important role in vocational orientation. This confirms the findings in the literature [32]. The use of these videos depends on gender and cultural background. The existing video formats regarding science seem to appeal most to males without migration background. One possible way to reach the other groups would be to experiment with different

video formats that give female students and students with migration background more room for identification. For example, science channels of young female scientists and young scientists with migration background could be more appealing to these groups e.g., [53]. In addition, showing different approaches to science could be interesting. For example, taking up discussions in society or the social relevance of science see also [54] in online videos could appeal to female students. We believe that online video platforms are promising social media for vocational orientation, especially if the video formats are adapted to the respective target groups.

Established formats should not be neglected either. This is especially true if one aims at a more equal representation of women and men with all cultural backgrounds in science. For females with a migration background, the teacher seems to play a pivotal role. Many of them wish for more advice from him or her, maybe because science teachers are professionals in their field and also a person they know personally. In vocational orientation, it could be fruitful to build this kind of personal but at the same time professional relation—be it through social media, teachers, or other advisors. Proximity and professionalism seem to be key factors in this group. Further, building contacts with the university is important for young women irrespective of their cultural background.

The study with the university students shows that students of science and non-science subjects do not differ significantly in the values for their course choices in Eccles' model [9]. Interest and attainment values are much more important than utility values to all students (Q2a). This confirms the findings from the literature [39]. Further, this study confirms our assumption that vocational orientation in science through online video platforms and fictional series and movies is a recent trend (Q2b/c). For university students, they were far less important than in the group of secondary school students. The fact that these students attribute less importance to family members and friends is most probably due to their age. These students expressed their wishes in a retrospective view as adults who are less dependent on their families than adolescents.

The present research shows that not all students prefer the same kind of vocational orientation regarding science. While science aspirations and the need for information seem to be comparably strong among female and male students with and without a migration background, the way they want to learn about careers in science differs. These findings are applicable to interventions for vocational orientation in science. We encourage researchers and practitioners to reflect on their target group and its specific needs before planning an intervention. This could enhance the effectiveness of vocational orientation programs.

In particular, we deduce from the findings from this investigation that there might be a need for videos for vocational orientation in science which are adapted to young women and students with migration background. The young women stated that online videos are not so important for their vocational orientation. This could be the case either because they do not like online videos in vocational orientation in general, or because the existing videos do not appeal to young women and their science identities. We do not believe that young women do not like online videos in vocational orientation. Rather, looking at the science and technology YouTubers in the German language, we see a domination by male YouTubers who mostly embrace a nerdy science identity e.g., [55]—an identity that is very alien to young women. Given this quite male-dominated field on YouTube, we believe this sector could open promising possibilities in vocational orientation in science. Further, vocational orientation in science could benefit from measures that combine proximity and professionalism. In particular, young women with a migration background could be reached this way. A broad range of options could fulfill these criteria, ranging from adequate YouTube channels with protagonists these students can identify with or be it through direct contacts between the secondary school students and young scientists from university.

Based on the findings from this study, we designed an intervention on vocational orientation in science, targeting females with migration background [6]. This intervention takes place in public spaces and is based on a coaching conducted by young university students who act as role models. They engage in personal conversations on careers in science and science aspirations. In addition to the

coaching, short videos portraying young female professionals who talk about their personal experiences with working in science and technology were produced. These videos were diffused on Instagram in order to reach the target group. Further, we designed and tested a card game for vocational orientation in science and technology that can be played in class or at home between a student and a parent. This intervention is based on the finding that relatives play an important role in career orientation [32]. The card game aims to engage the parent and the student in a conversation about science careers in order to create social support for the student when considering careers in science.

Since this study is partly exploratory, it is limited in several regards. We now have information about which sources students do or do not use for vocational orientation in science and which sources they prefer. What we do not know, however, are the reasons for their vocational orientation behavior and their preferences. This paves the way for further research which could help to further understand how female students with migration background could best be supported in their vocational orientation in science. In particular, qualitative data could be insightful for understanding these students' situation. For instance, understanding the experiences the students have with certain sources of information and their desire to further use these sources or not could be insightful. Here, a multitude of patterns and causal relationships are possible which could provide insight into the specific needs regarding particular sources of information. Further, we cannot entirely differentiate between the students' activities and needs in terms of general vocational orientation and aspects that are specific for science-related vocational orientation.

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