International Journal of Gender, Science and Technology

NETWORK GENDER & STEM educational and occupational pathways and participation

Do Social Comparisons Matter for University Major Choices? A Longitudinal Study from a Gender Perspective

Luise von Keyserlingk[1], Michael Becker[1], Malte Jansen[2]

[1]Leibniz Institute for Research and Information in Education (DIPF), [2]Institute for Educational Quality Improvement (Institut zur Qualitätsentwicklung im Bildungswesen), Germany

ABSTRACT

In Germany, male students are largely overrepresented in STEM majors at university. Gender differences in important predictors of major choices, namely self-concept and interest in math or science, have been discussed to explain the gender gap in STEM. For both self-concept and interest, social comparisons with peers are important (big-fish-little-pond effect - BFLPE). Recent findings have further shown indirect long-term BFLPEs in high school on STEM major choice at university through students' self-concept and interest. We built on these findings and investigated if differential BFLPEs on females' and males' self-concept and interest in high school could help understand gendered enrollment processes in math-intensive university majors. We used a subsample (N = 2182) of a German longitudinal study and used data from two measurement points (T1: 12th grade; T2: two years after high school graduation). Results showed gender differences in math self-concept, math achievement, and enrollment in math intensive university majors. The BFLPE on self-concept, interest and university major choice did not differ between female and male students. These findings point not only to gender differences in the means of relevant predictors of university major choice, but also to gender similarity in the underlying processes of self-concept formation and university major choice.

KEYWORDS

big-fish-little-pond effect; university major choice; gender; longitudinal data

This journal uses Open Journal Systems 2.4.8.1, which is open source journal management and publishing software developed, supported, and freely distributed by the Public Knowledge Project under the GNU General Public License.

The Open University

Do Social Comparisons Matter for University Major Choices? A Longitudinal Study from a Gender Perspective

INTRODUCTION

Choosing a university major is an important decision for young adults' later educational and occupational pathways. In general, jobs in the STEM fields (science, technology, engineering and mathematics) provide higher salaries and lower risk for unemployment compared with jobs in other areas (U.S. Bureau of Labour Statistics, 2017). Most countries of the Organization for Economic Co-Operation and Development (OECD), however, report a gender gap in STEM fields in postsecondary education (OECD, 2018). In Germany, this gender gap is large with a ratio of about 67% male students and 33% female students in the STEM fields at university (Statistisches Bundesamt, 2018a). Like in other countries, this gap is even more pronounced in STEM majors, such as engineering (77% male students) and rather small in other STEM fields such as math, biology, chemistry, and physics (52% male students). Several explanations for this gender difference in major choice have been offered. A number of empirical studies have shown that gender differences in relevant predictors of STEM major choice, such as domain specific academic self-concepts and interests, help explain the gender gap in STEM fields (Lauermann et al., 2017; Nagy et al., 2008; Perez-Felkner et al., 2017; Watt, 2006).

Academic self-concept is a person's perception of her or his own ability in a specific academic domain, such as math or English (Bong & Skaalvik, 2003; Shavelson et al., 1976). To form these academic self-concepts, students use different sources of information. Among these, social comparisons with peers play an important role (Gore & Cross, 2014; Marsh, 1987; Marsh & Hau, 2003). Hence, students compare their own achievement in a major with the achievement of their peers to evaluate their own ability. Research on the so-called big-fish-little-pond effect has shown that being surrounded by higher-achieving peers can be detrimental for students' academic self-concept and also for students' interest because of constant upward comparisons (Marsh, 1987; Marsh & Hau, 2003; Schurtz et al., 2014). Both academic self-concept and interest are important drivers for postsecondary educational choice. In the present study, we investigate potential gender differences in social comparisons, which play an important role in the formation of students' self-concept and interest in high school. Differential effects in the formation of self-concept and interest in high school could help understand gendered enrollment processes in math-intensive majors in postsecondary education. Put differently, a stronger BFLPE in secondary school in math for girls might result in even lower math self-concept and math interest, compared to boys. This in turn could further decrease the probability that female students will enroll in math-intensive university majors.

Empirical research on university major choice

Eccles and colleagues' expectancy value theory (EEVT; Eccles, 1983; Eccles, 2009; Wigfield & Eccles, 2000) offers a comprehensive theoretical framework to explain achievement motivation and choices in educational settings. It assumes that expectations of success and subjective task values are important and proximal drivers of educational choices. Empirical findings have supported the theoretical assumptions of the EEVT for educational choices in general and also in the context of enrollment in STEM majors at university (Eccles & Wang, 2016; Guo et al., 2015; Lauermann et al., 2017; Musu-Gillette et al., 2015). Put differently, students are more likely to enroll in majors if they think they can perform well in that major (expectations of success) and if it is interesting and important to them (subjective task values).

In empirical studies, expectations of success have often been operationalized by students' academic self-concept or self-efficacy. Wigfield and Eccles (2000) have shown that both constructs are appropriate operationalizations of expectancy of success in the context of their model. In the present study, we use measures of students' academic self-concept in math. In most cases, subjective task values were measured via students' intrinsic value/interest, attainment value, or utility value (Eccles & Wang, 2016; Guo et al., 2015; Lauermann et al., 2017; Musu-Gillette et al., 2015). Eccles (1983) describes intrinsic value/interest as enjoyment one experiences when engaging in a task. Attainment value refers to the perceived importance of doing well in a task, and utility value refers to the perceived usefulness of the task for one's future. In the present study, we measured interest following a conceptualization of Krapp (2007). This measure of interest combines aspects of the intrinsic value and attainment value from the EEVT.

A gender gap in both academic self-concept and subjective task values has been identified in STEM domains. Female students report lower self-concepts in math and science than their male peers (Guo et al., 2015; Marsh et al., 2013; Nagy et al., 2008; Parker et al., 2014). Similarly, studies have shown that female students report lower interest in math compared with male students (Gaspard et al., 2015; Guo et al., 2015; Marsh et al., 2013). However, the gender differences in these psychosocial characteristics cannot be entirely explained by differences in ability or achievement in math (Hyde, 2005; Hyde et al., 1990). Following the EEVT model, these gender differences in self-concepts and interests should largely explain gender differences in choices themselves. Several researchers pointed out that these gender differences in relevant predictors of STEM major choice largely mediate the gender gap in the STEM fields (Lauermann et al., 2017; Nagy et al., 2008; Perez-Felkner et al., 2017; Watt, 2006).

The big-fish-little-pond effect (BFLPE)

When students form their academic self-concepts and interests in different domains, they use comparisons with the social context of their learning environment—that is, their classroom or school. Research on the so-called big-fish-little-pond-effect (BFLPE) has shown that students' self-concepts are related to their peer group in school, which serves as a frame of reference for social comparisons (Marsh, 1987; Marsh & Hau, 2003; Seaton et al., 2009). The BFLPE describes that given the same individual achievement level a student in a higher achieving school exhibits a lower academic self-concept than a student in a lower achieving school. This can be explained by the fact that the former student compares him or herself to higher achieving peers, whereas the latter student compares him or herself to lower achieving peers. The BFLPE has been replicated numerous times across countries, school types, and age groups and is one of the most prominent effects in educational psychology (Liem et al., 2013; Marsh, Abduljabbar et al., 2014; Marsh & Hau, 2003; Marsh, Kuyper et al., 2014; Nagengast & Marsh, 2011; Seaton et al., 2010). Some researchers have broadened the BFLPE framework and showed that social comparisons also affect students' interests and values (Cambria et al., 2017; Schurtz et al., 2014). In other words, given the same individual achievement level in math, a student in a school with a higher mean math achievement showed lower interest in math compared with a student in a school with a lower mean math achievement. Hence, students' academic self-concept, as well as students' interest are related to the achievement level of the peer group in high school (BFLPE). And both self-concept and interest are central drivers of major choice at university.

Among the extensive research on the BFLPE, a few studies investigated gender as a potential moderator of this effect. Plieninger und Dickhäuser (2013) investigated gender as a possible moderator of the BFLPE in science in secondary school with German PISA data. For girls, the BFLPE on self-concept in science was larger than for boys. Hence, girls were more affected by the BFLPE in science than were boys. The authors argued that higher levels of anxiety of girls in science and a stronger attachment to the peer group could explain the moderation effect of gender. Indeed, girls report higher levels of anxiety in science (Devine et al., 2012; Udo et al., 2004) and anxiety is a known moderator of the BFLPE (i.e., students with higher levels of anxiety are more affected by the BFLPE; Seaton et al., 2010). Furthermore, girls are more attached to their peer groups (Gorrese & Ruggieri, 2012; Ma & Huebner, 2008) and may be more oriented to social comparisons in general (Guimond et al., 2006; Guimond & Chatard, 2014). In addition, a cooperative orientation in classrooms has been shown to moderate the BFLPE (Seaton et al., 2010). Marsh et al. (2007) investigated the potential long-term impact of the BFLPE in secondary school on students' self-concept several years after graduation based on two longitudinal samples. Similarly to Plieninger and Dickhäuser (2013), they reported more pronounced BFLPEs on math self-concepts for girls. On the other hand, some results pointed to gender similarity, rather than gender differences, in the BFLPE (Loyalka et al., 2018; Marsh, Abduljabbar et al., 2014).

Overall, results of empirical research on gender differences in the BFLPE in STEM-related majors in high school are inconsistent. This warrants further research and replication in order to generate cumulative evidence on the generalizability of the BFLPE, one of the most fundamental effects in motivational research in the field of education. In addition, no previous studies examined gender differences in the BFLPE on interest rather than self-concept. With regard to implications, gender differences in effects of social comparisons on academic self-concept and interest in high school might also help to better understand gendered enrollment processes in postsecondary education STEM fields.

Previous research has shown that small long-term effects of social comparisons in secondary school (BFLPE) can affect STEM major choice at university (Keyserlingk et al., 2019). These long-term effects are mediated by students' math self-concept and math interest. Given the same individual math ability, students in higher achieving schools exhibited lower math self-concept and math interest, which in turn decreased the probability of these students to enroll in a STEM major at university. Gender differences in long-term effects of social comparisons (BFLPE) on university major choice have yet to be investigated. A stronger BFLPE in secondary school in math for girls might help explain the lower enrollment rates of girls in math-intensive university majors.

The present study

In the present study, we built on previous research on the BFLPE in the context of major choices. We focused on the findings of recent studies showing small, mediated long-term effects of social comparisons in school (BFLPE) on university major choice in STEM through students' math self-concept and math interest (Keyserlingk et al., 2019). We aimed to combine these findings with previous research on BFLPE gender differences in the science domains. First, we tested whether there are differential effects of social comparisons in school (BFLPE) on math self-concept and math interest for girls and boys. Because results on gender differences in the BFLPE have been inconsistent, both results of gender differences and gender similarity in the BFLPE on math self-concept and math interest would be plausible. If differences are found, we would expect a stronger BFLPE for female students compared to male students. These differences would align with previous research (Marsh et al., 2007; Plieninger & Dickhäuser, 2013). Second, we investigated whether these differential BFLPEs also lead to different enrollment patterns in math-intensive majors two years after graduation from secondary school.

METHODS

Sample

We used a subsample from the longitudinal large-scale study Learning Processes and Psychosocial Development in Adolescence and Young Adulthood [Bildungsverlaeufe und psychosoziale Entwickung im Jugendalter – BIJU]*.* The study was initiated by a cooperation between the Leibniz Institute for Science and Mathematics Education at Kiel University and the Max Planck Institute for Human Development in Berlin. Data collection took place in four federal states in Germany. A representative sample of each secondary school type was drawn in each state, and two classes in every sampled school were randomly sampled to participate in the study. So far, seven waves of data collection have been completed. The first wave took place in 1991, when students were in seventh grade, and the seventh wave of data collection took place in 2010. As long as students remained in secondary school, they were tested within the school setting. After graduation, they were tracked individually and tested via paper-pencil questionnaires sent to them in the mail. The BIJU study was carried out in accordance with ethical guidelines for research with human participants, and informed consent was obtained for all participants. All of the study materials and procedures were approved by the responsible ministries of education and by the ethics committee of the respective research institutions. A more detailed description of the study is given in Baumert et al.(1996).

To address our research questions, we used data from two measurement points: one year before graduation from secondary school, when students were in 12th grade (T1; 1997), and two years after graduation, when students already enrolled at university (T2; 2000/01). In 12th grade, N = 6652 students participated in the data collection and N = 3008 students participated in later waves of the BIJU study. The large reduction of the sample size can be explained by the design of the study. Data collection in 12th grade (N = 6652) took place in high school. Trained instructors went to classrooms and students worked on the surveys and tests in class during regular school hours. In later waves of the study, participants received a questionnaire via mail. Participants completed the surveys and sent them back via mail. Even though incentives and several reminder letters were used in an attempt to keep participation high, the questionnaire return rate was considerably lower than in the school context, which led to a decrease in sample size. Students who continued participating in the study after graduating high school were similar to students who dropped out. Both groups of students had similar math achievement scores, math grades, and math self-concepts in 12th grade. More women than men continued in the study. In the present study, we only included students (a) for whom data was available at both waves and (b) who enrolled at university after graduating from secondary school, resulting in a sample size of N = 2182 students from 93 secondary schools. 59% of the sample was female.

Instruments

Enrollment in a math-intensive university major

Two years after graduation from high school (T2), students were asked in an open-ended question format which major they were currently enrolled in at university. The majors were coded according to the classification of university majors of the German Federal Statistical Office (Statistisches Bundesamt, 2018b). We then classified the majors into four categories, indicating the level of math required in each major (1 = *no math required*, 2 = *some math required*, 3 = *moderate math required*, 4 = *intensive math required*). Hereby, we followed the categorization used by Musu-Gillette et al. (2015) and Umarji et al. (2018) and adapted it to the German university majors. The categorization of the majors can be found in Table 1. In the analyses, this math-intensity variable was treated as continuous.

Table 1: *Categorization of majors at university along the level of math required in the majors*

no math (1)	some math (2)	moderate math (3)	intensive math (4)
humanities	political science	economics	mathematics
linguistic sciences	sociology	chemistry	physics, astronomy
cultural studies	psychology	pharmacy	engineering
sports	education	biology	
art	law	geosciences	
music	medicine	architecture	
		computer sciences	

Math achievement
We assessed achievement in 12th grade math with standardized and curriculum-validated tests. The items originally came from the First International Mathematics Study (FIMS), the Second International Mathematics Study (SIMS), the Third International Mathematics Study (TIMS), and the "Schulleistungsstudie" ("Academic achievement study") conducted by the Max Planck Institute for Human Development in Berlin (Baumert et al., 1996). In order to use a latent modelling approach that controls for measurement error, the 25 achievement test items were divided into three parcels of 8 or 9 items each. We used sum scores of correct answers in each parcel as indicators to model a latent factor of individual math achievement. In subsequent analyses, we used individual math achievement, as well as school-level math achievement, as independent variables. To obtain an achievement measure at the school-level, we aggregated the sum scores of each parcel at the school-level and used them as indicators to model a latent factor of school-level math achievement (latent-manifest modeling approach; Marsh et al., 2009). To avoid overestimating school-level math achievement, we aggregated the variables at the school-level before selecting our subsample, which was comprised of only students who enrolled in university after graduating.

Math self-concept
Math self-concept was measured at T1 with five items originally developed by Jerusalem (1984) and Jopt (1978). Students responded to the items on a 4-point Likert-type scale, ranging from 1 = *strongly agree* to 4 = *strongly disagree*. An example item is "Nobody is perfect—but I am just not good at math." Higher scores indicate a more positive math self-concept. Cronbach's α was satisfactory (α = .86).

Math interest
Math interest was assessed at T1 with five items based on the conceptualization of interest by Krapp et al. (1992). Students responded to the items on a 4-point Likert-type scale, ranging from 1 = *strongly agree* to 4 = *strongly disagree*. Example items are "I really have fun solving mathematical problems" and "For me personally, it is important to be a good mathematician." All items were recoded so that higher scores represented greater interest in math. Cronbach's α was satisfactory (T1: α = .84). This measure of interest combines aspects of the intrinsic value and attainment value from the EEVT.

Gender
Participants reported their gender at T1. Female gender was coded 0 and male gender was coded 1.

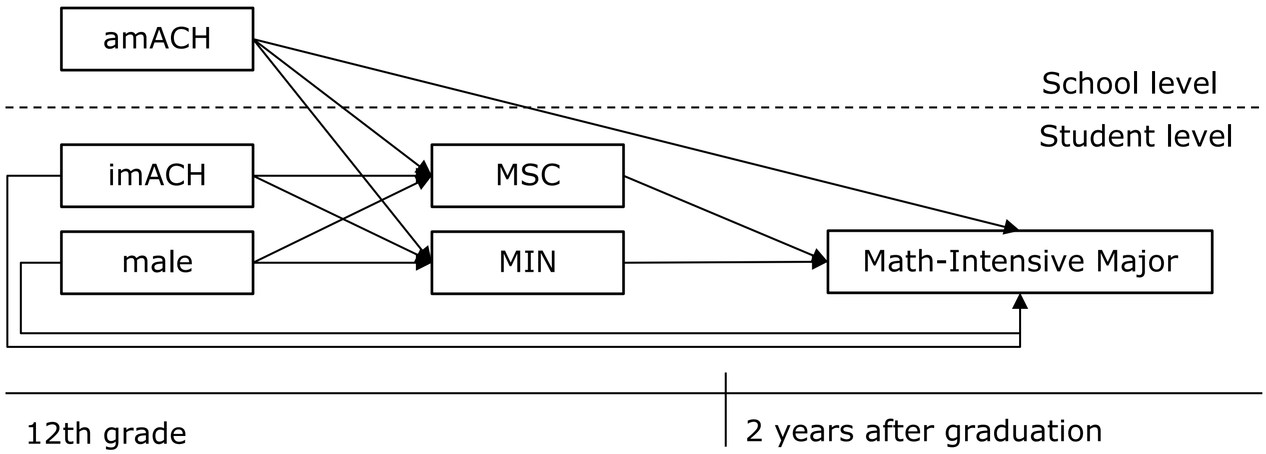
Statistical analyses
To estimate the long-term effects of student composition in high school on university major choice, we estimated latent-manifest multilevel models (Marsh et al., 2009) using the Mplus software (Muthèn & Muthèn, 1998-2012). In the first step, we used a confirmatory factor analysis to specify a multilevel-measurement model including math self-concept, math interest, and math achievement with a two-level structure. The model fulfilled Hu und Bentler's (1999) criteria of good model fit (RMSEA = .042, CFI = .966, TLI = .960, and SRMR = .031). Factor loadings of the items measuring math self-concept and math interest were

constrained to be equal across both levels. Sum scores of the three parcels of the math achievement test were used as indicators to model a latent factor of individual math achievement. Sum scores of each parcel were aggregated at the school-level and used as indicators for a latent factor of school-level mean achievement. Scores were aggregated at the school-level before the subsample of this study was drawn to avoid overestimation of the school-level achievement. We tested further for measurement invariance across female and male students. We concluded that the models were invariant if the fit of the model with metric invariance (i.e., same factor loadings across female and male students) and the model with scalar invariance (i.e., same factor loadings and intercepts across female and male students) did not differ by more than |.01| on the CFI or .015 on the RMSEA (Chen, 2007). Models fulfilled these criteria of scalar invariance (see Table 2).

Table 2: *Invariance testing for math self-concept, math interest, and math achievement across female and male students.*

Model	χ^2	df	*p*	RMSEA	CFI	TLI	SRMR	Δ RMSEA	Δ CFI
configural invariance	423294	118	<.001	0.049	0.972	0.963	0.032		
metric invariance	449100	128	<.001	0.048	0.970	0.964	0.037	0.001	0.002
scalar invariance	539065	138	<.001	0.052	0.963	0.958	0.039	-0.004	0.007

We estimated two models to investigate long-term effects of the BFLPE on major choice and potential gender differences. In Model 1, we estimated the effects of individual math achievement, school mean math achievement, and gender on students' math self-concept, math interest and the math intensity of their chosen major. We also estimated the effects of math self-concept and math interest on enrollment in a math-intensive university major. This also allowed us to examine mediated long-term effects of the BFLPE on major choice through math self-concept and math interest. We estimated the mediated effect by using the IND command in the option MODEL INDIRECT in Mplus. To estimate the BFLPEs on math self-concept, math interest, and enrollment in a math-intensive university major, we used the latent-manifest modelling approach described by Marsh et al. (2009). Scores of individual achievement were centered at the group mean. To calculate the coefficient of the BFLPE on students' math self-concept (i.e., the contextual effect), we subtracted effects of individual math achievement on math self-concept (i.e., the within effect) from the effects of school-level mean math achievement on math self-concept (i.e., the between effect). This contextual effect can be interpreted as the effect of school mean math achievement (social comparison) on students' math self-concept after controlling for individual math achievement. We used the same method to obtain the BFLPE on students' math interest and students' university major choice. Figure 1 shows a conceptual representation of the estimated model.



amACH = school mean math achievement. imACH = individual math achievement. ieACH = individual English achievement. MSC = math self-concept. MIN = math interest.

Figure 1. Estimated paths of individual achievement in math, gender, and school-level mean achievement in math on math self-concept, interest in math, and the choice of a math-intensive major at university.

In Model 2, we addressed the question of whether the BFLPE differed between girls and boys. Hence, this model was of central interest in the present study. We used the same procedure described by Marsh et al. (2009) and Plieninger and Dickhäuser (2013), and included a cross-level interaction between gender and school-average achievement. Thereby, we checked if gender moderated the BFLPE on math self-concept, math interest, and enrollment in a math-intensive university major, and we separately calculated the BFLPEs for female and male students. The Mplus syntax for Model 2 can be found in the appendix.

Treatment of missing data

The missing rates of all variables in the subsample were comparatively low. The amount of missing data for the items measuring math self-concept and math interest was 2%. The missing rate in the math achievement test was even lower (1%). We used the full information maximum likelihood approach (FIML) to address the missing data. This model-based approach results in unbiased parameter estimation when data are missing at random (MAR) and is preferable to traditional approaches (e.g., listwise or pairwise deletion) because no observations are deleted, therefore leaving the statistical power unaffected (Enders, 2010). Consequently, the risk of biased estimates remains low.

RESULTS

Descriptive statistics showed that girls scored lower in math self-concept (girls: M = 2.70, SD =0.76; boys: M = 3.00, SD = 0.72; d = .40) and math interest (girls: M = 2.26, SD = 0.70; boys: M = 2.41, SD = 0.70; d = .21) than their male peers. Furthermore, in general boys enrolled in more math-intensive university majors than girls (girls: M = 2.32, SD = 0.86; boys: M = 2.9, SD = 0.90; d = .66; see Table 3).

Table 3: *Descriptive statistics of math achievement, math self-concept, math interest, and enrollment in a math-intensive university major for girls and boys*

	Girls (N=1312)	Boys (N=870)	
	M (SD)	*M (SD)*	*d*
math achievement	3.44 (1.2)	4.01 (1.5)	.43
math self-concept	2.70 (.76)	3.00 (.72)	.40
math interest	2.26 (.70)	2.41 (.70)	.02
math intensiveness of university major	2.32 (.86)	2.90 (.90)	.66

Note. M = mean; SD = standard deviation; d = Cohen's d.

Results of Model 1 (see Table 4) showed individual math achievement to be a positive predictor of students' math self-concept (β = .40, *SE* = .02, p < .05), students' interest in math (β = .40, *SE* = .02, p < .05), and enrollment in a math-intensive university major (β = .09, *SE* = .05, p < .05). Also, math self-concept and math interest were positive predictors of enrollment in a math-intensive university major (math self-concept: β = .23, *SE* = .07, p < .05; math interest: β = .20, *SE* = .05, p < .05).

These findings support the theoretical assumptions of the EEVT. Boys had higher math self-concept (β = .10, *SE* = .02, p < .05), than girls and were more likely to enroll in more math-intensive university majors (β = .41, *SE* = .04, p < .05). Gender was not a statistically significant predictor of math interest. This means that scores in math interest did not differ systematically between boys and girls. Social comparisons with the peer group (BFLPE) affected both students' math self-concept (β = -.35, *SE* = .03, p < .05) and math interest (β = -.34, *SE* = .03, p < .05). Hence, given the same individual ability, students in higher achieving peer groups exhibited lower math self-concept and math interest. The BFLPE, however, had no direct impact on enrollment in math-intensive university majors. But indirect long-term effects of the BFLPE mediated through students' math self-concept and interest occurred. Put differently, the BFLPE negatively affected students' math self-concept and math interest in school, which in turn decreased the probability that these students enrolled in math-intensive majors. So far, the results are consistent with the findings of previous studies (Keyserlingk et al., 2019).

Table 4
Doubly latent two-level model to estimate the BFLPE on students' math self-concept*, math interest, and enrollment in a math-intensive university major*

	Model 1														
	DV: math self-concept					DV: math interest					DV: math-intensive major				
variable	*b*	*(S.E.)*		*CI*		*b*	*(S.E.)*		*CI*		*b*	*(S.E.)*		*CI*	
within															
Individual math achievement	.40	(.02)	**	.36	.45	.40	(.02)	**	.35	.45	.09	(.05)	*	.01	.19
Math self-concept											.23	(.07)	**	.09	.36
Math interest											.20	(.05)	**	.10	.31
Male	.10	(.02)	**	.06	.15	-.01	(.03)		-.05	.05	.41	(.04)	**	.33	.49
between															
School-level math achievement	.05	(.02)	**	.01	.1	.06	(.03)	**	.02	.11	.09	(.03)	**	.03	.16
new parameters															
BFLPE	-.35	(.03)	**	-.41	-.29	-.34	(.03)	**	-.40	-.27	.00	(.06)		-.12	.11
ind MSC											-.08	(.02)	**	-.13	-.03
ind MIN											-.07	(.02)	**	-.11	-.03

Note. DV = dependent variable; *b* = regression coefficient; *S.E.* = standard error; *CI* = confidence interval; BFLPE = big-fish-little-pond effect; ind MSC = indirect effect of school-level mean math achievement on enrollment in a math-intensive university major through students' math self-concept; ind MIN = indirect effect of school-level mean math achievement on enrollment in a math-intensive university major through students' math interest. See also Keyserlingk et al. (2019)
* $p < .05$. ** $p < .01$.

Table 5
Latent-manifest two-level model to estimate the BFLPE on students' math self-concept, math interest, and enrollment in a math-intensive university major, and moderating effects of gender

	Model 2														
	DV: math self-concept					DV: math interest					DV: math-intensive major				
variable	*b*	*S.E.*		*CI*		*b*	*S.E.*		*CI*		*b*	*S.E.*		*CI*	
within															
Individual math achievement	.41	(.02)	**	.36	.46	.40	(.02)	**	.35	.44	.09	(.04)	*	.01	.18
Math self-concept											.22	(.07)	**	.09	.36
Math interest											.21	(.06)	**	.10	.31
male	.10	(.03)	**	.05	.15	-.01	(.03)		-.06	.05	.40	(.04)	**	.33	.48
between															
School-level math achievement	.06	(.03)	*	.01	.12	.05	(.03)		-.01	.12	.044	(.04)		-.03	.13
cross-level interactions	-.01	(.04)		-.08	.06	.02	(.05)		-.07	.11	.12	(.06)		-.03	.13
new parameters															
female BFLPE	-.35	(.04)	**	-.42	-.28	-.34	(.04)	**	-.42	-.27	-.05	(.06)		-.16	.06
female ind MSC											-.08	(.02)	**	-.13	-.03
female ind MIN											-.07	(.02)	**	-.11	-.03
male BFLPE	-.36	(.04)	**	-.44	-.28	-.32	(.04)	**	-.40	-.23	.07	(.07)		-.06	.21
male ind MSC											.08	(.03)	**	-.13	-.03
male ind MIN											-.06	(.02)	**	-.11	-.03

Note. DV = dependent variable; *b* = regression coefficient; *S.E.* = standard error; *CI* = confidence interval; BFLPE = big-fish-little-pond effect; ind MSC = indirect effect of school-level mean math achievement on enrollment in a math-intensive university major through students' math self-concept; ind MIN = indirect effect of school-level mean math achievement on enrollment in a math-intensive university major through students' math interest.
* $p < .05$. ** $p < .01$.

We broadened the analyses in Model 2 (see Table 5) and investigated the moderating effect of gender on the BFLPE on math self-concept, math interest, and university major choice. Results revealed no statistically significant cross-level interactions between gender and average achievement in the prediction of math self-concept (β = -.01, *SE* = .04, *p* > .05), math interest (β = .03, *SE* = .04, *p* > .05), or enrollment in math-intensive university majors (β = .12, *SE* = .06, *p* > .05). Hence, the relation of school-level mean achievement and math self-concept, math interest or enrollment in a math-intensive university major did not differ substantially between girls and boys. In this model, we calculated the BFLPEs separately for girls and boys. Results showed statistically significant BFLPEs on math self-concept and math interest of similar sizes for girls and boys. Further, the long-term BFLPE on enrollment in a math-intensive major was small and fully mediated by students' math self-concepts and math interests. No gender differences occurred in the long-term BFLPE on university major choice.

DISCUSSION

The results of our study pointed to gender differences in students' math self-concept, even after individual math achievement was controlled. Hence, girls evaluated their own math achievement more critically than boys did. However, differences in social comparison mechanisms (i.e., in the strength of the BFLPE) between girls and boys were not present and thus do not seem to have much power to explain the gender gap in students' math self-concepts. These results differed from the findings of Marsh et al. (2007) and Plieninger and Dickhäuser (2013), who reported more pronounced BFLPEs for girls on their academic self-concept in math and science. Instead, our findings support previous findings on gender similarity in the BFLPE (Loyalka et al., 2018; Marsh, Abduljabbar et al., 2014).

Similarly, our findings revealed no gender differences in the long-term BFLPE on university major choice. Our findings showed small long-term BFLPEs on enrollment in STEM and math-intensive university majors that were fully mediated through students' math self-concepts and math interests. This pattern of results occurred for girls and boys alike. Hence, differences in the BFLPE could not help to explain why boys were more likely to enroll in STEM majors at university than girls.

Overall, this finding points to gender differences in the mean of relevant predictors of university major choice in the STEM fields, but to gender similarity in the underlying mechanisms of self-concept formation and major choice. Some recent studies on gender differences in STEM participation reported similar findings (Guo et al., 2015; Perez-Felkner et al., 2017): Gender differences in ability beliefs, values in math, and enrollment in STEM majors were statistically significant and in favor of boys. Gender differences in enrollment for STEM majors were partly mediated through students' ability beliefs and values. However, no interaction effects of gender and ability beliefs or values were found in the context of STEM major choice, pointing to the same underlying mechanisms of course choice for boys and girls. These findings support the gender similarity hypothesis by Hyde (2005), about high similarity in most psychological variables across gender.

Limitations and future outlook

Findings on gender differences in the BFLPE in math and science are inconsistent. Our findings point to gender similarities, rather than to gender differences. Authors of previous studies suggested that anxiety and relatedness to the peer group could moderate a potential gender effect in the BFLPE (i.e., stronger BFLPEs for girls). Future research could focus on these moderators more directly to deepen the understanding of potential gender differences in the BFLPE. In the present study, this was not feasible because neither anxiety in math or science, nor relatedness to the peer group, was assessed in the BIJU data. Further, we used school-level mean achievement to estimate the BFLPE. Research on the local dominance effect (Marsh, Kuyper et al., 2014; Zell & Alicke, 2010) has shown that students are more likely to compare themselves with closer frames of references (e.g., classes) rather than with wider frames of references (e.g., schools). In addition, some results indicate that girls are more likely to engage in social comparisons with female peers, whereas boys tend to compare themselves to male peers (Thijs et al., 2010). In particular, in the context of gender differences, a promising approach for future research would be to investigate which local frame of reference boys and girls use when they engage in social comparisons in school.

Ideally, future studies could also employ sociometric questions on social ties within a classroom (e.g., friendships) and/or ask students explicitly to whom they compare themselves. It should be noted, however, that the very salient frame of reference for the BFLPE is the classroom as teacher-assigned grades also given and compared within classes. The few studies that compared the BFLPE with an effect of friends' achievement (Wouters et al., 2013) or that examined the BFLPE in addition to specific social comparisons to individual peers (Huguet et al., 2009) showed that the BFLPE, i.e. the negative effect of the classroom average, persisted in these conditions and could not be fully explained by smaller frames of reference.

Finally, a lack of power to detect a small moderation effect of the BFLPE by gender might be a limitation of our study. Even though the power to investigate the BFLPE on math self-concept, math interest and university major choice was high for the subgroups of boys and girls. As a robustness check, we estimated the cross-level interaction effect of gender and the BFLPE on students' math self-concept and math interest in cross-sectional analyses with all students who participated in data collection in 12th grade (N = 6439 students). The pattern of results was the same when the larger sample was used. The BFLPE on students' math self-concept and math interest was of similar size for girls and boys. The cross-level interaction effect of gender was not statistically significant.

CONCLUSION

In the present study we combined three important research paradigms: 1) research on the big-fish-little-pond effect about the relevance of the social learning environment for students' self-concept formation, 2) research on Eccles et al.'s Expectancy Value Theory about educational choices that are driven by students' expectations and values, and 3) research on gender differences in STEM-related major and career choices. By combining these paradigms, we investigated if gender differences in the formation of students' self-concept and interest in high school can help explain gendered enrollment patterns in math-intensive majors in post-secondary education. Our results revealed no gender differences in the BFLPE on math self-concept, math interest, or university major choice. Instead, the BFLPE on math self-concept and math interest were of similar size for girls and boys in secondary school. Also, the indirect long-term impact of the BFLPE on major choice through these variables did not differ across gender. Our findings point to gender differences in the means of relevant predictors of university major choice. However, underlying processes of self-concept formation, interest, and university major choice were highly similar between boys and girls.

REFERENCES

Baumert, J., Roeder, P., Gruehn, S., Heyn, S., Köller, O. & Rimmele, R. (1996). Bildungsverläufe und psychosoziale Entwicklung im Jugendhalter. In K.-P. Treumann, G. Neubauer, R. Möller & J. Abel (Hg.), *Methoden und Anwendungen empirischer pädagogischer Forschung* (S. 170–180). Waxmann.

Bong, M. & Skaalvik, E. (2003). Academic self-concept and self-efficacy: How different are they really? *Educational Psychology Review*, *15* (1).

Cambria, J., Brandt, H., Nagengast, B. & Trautwein, U. (2017). Frame of reference effects on values in mathematics: Evidence from German secondary school students. *ZDM*, *49* (3), 435–447. https://doi.org/10.1007/s11858-017-0841-0

Chen, F. F. (2007). Sensitivity of goodness of fit indexes to lack of measurement invariance. *Structural Equation Modeling: A Multidisciplinary Journal*, *14* (3), 464–504. https://doi.org/10.1080/10705510701301834

Devine, A., Fawcett, K., Szűcs, D. & Dowker, A. (2012). Gender differences in mathematics anxiety and the relation to mathematics performance while controlling for test anxiety. *Behavioral and brain functions: 8*,(33). https://doi.org/10.1186/1744-9081-8-33

Eccles, J. (1983). Expectancies, values, and academic behavior. In J. T. Spence (Hg.), *A series of books in psychology. Achievement and achievement motives: Psychological and sociological approaches* (S. 75–146). Freeman.

Eccles, J. (2009). Who am I and what am I going to do with my life? Personal and collective identities as motivators of action. *Educational Psychologist*, *44* (2), 78–89. https://doi.org/10.1080/00461520902832368

Eccles, J. S. & Wang, M.-T. (2016). What motivates females and males to pursue careers in mathematics and science? *International Journal of Behavioral Development*, *40* (2), 100–106. https://doi.org/10.1177/0165025415616201

Enders, C. K. (2010). *Applied missing data analysis*. *Methodology in the social sciences*. Guilford Press.

Gaspard, H., Dicke, A.-L., Flunger, B., Schreier, B., Häfner, I., Trautwein, U. & Nagengast, B. (2015). More value through greater differentiation: Gender differences in value beliefs about math. *Journal of Educational Psychology*, *107* (3), 663–677. https://doi.org/10.1037/edu0000003

Gore, J. S. & Cross, S. E. (2014). Who am I becoming? A theoretical framework for understanding self-concept change. *Self and Identity*, *13* (6), 740–764. https://doi.org/10.1080/15298868.2014.933712

Gorrese, A. & Ruggieri, R. (2012). Peer Attachment: A Meta-analytic Review of Gender and Age Differences and Associations with Parent Attachment. *Journal of Youth and Adolescence*, *41* (5), 650–672. https://doi.org/10.1007/s10964-012-9759-6

Guimond, S. & Chatard, A. (2014). Basic principles of social comparison: Does gender matter? In Z. Križan & F. X. Gibbons (Hg.), *Communal Functions of Social Comparison* (S. 205–251). Cambridge University Press.

Guimond, S., Chatard, A., Martinot, D., Crisp, R. J. & Redersdorff, S. (2006). Social comparison, self-stereotyping, and gender differences in self-construals. *Journal of Personality and Social Psychology*, *90* (2), 221–242. https://doi.org/10.1037/0022-3514.90.2.221

Guo, J., Parker, P. D., Marsh, H. W. & Morin, A. J. S. (2015). Achievement, motivation, and educational choices: A longitudinal study of expectancy and value using a multiplicative perspective. *Developmental Psychology*, *51* (8), 1163–1176. https://doi.org/10.1037/a0039440

Hu, L.-t. & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6* (1), 1–55. https://doi.org/10.1080/10705519909540118

Huguet, P., Dumas, F., Marsh, H., Wheeler, L., Seaton, M., Nezlek, J., Suls, J. & Régner, I. (2009). Clarifying the role of social comparison in the big-fish-little-pond effect (BFLPE): An integrative study. *Journal of Personality and Social Psychology*, *97* (1), 156–170. https://doi.org/10.1037/a0015558

Hyde, J. S., Fennema, E. & Lamon, S. J. (1990). Gender differences in mathematics performance: A meta-analysis. *Psychological bulletin*, *107* (2), 139–155.

Hyde, J. S. (2005). The gender similarities hypothesis. *The American psychologist*, *60* (6), 581–592. https://doi.org/10.1037/0003-066X.60.6.581

Jerusalem, M. (1984). *Selbstbezogene Kognitionen in schulischen Bezugsgruppen: Eine Längsschnittstudie (Band 1).*

Jopt, U.-J. (1978). *Selbstkonzept und Ursachenerklärung in der Schule: Zur Attribuierung von Schulleistungen (1. Aufl.)*. Kamp.

Keyserlingk, L. von, Becker, M., Jansen, M. & Maaz, K. (2019). Leaving the pond—Choosing an ocean: Effects of student composition on STEM major choices at university. *Journal of Educational Psychology.* Advance online publication. https://doi.org/10.1037/edu0000378

Krapp, A. (2007). An educational–psychological conceptualisation of interest. *International Journal for Educational and Vocational Guidance*, *7* (1), 5–21. https://doi.org/10.1007/s10775-007-9113-9

Krapp, A., Hidi, S. & Renninger, K. A. (1992). Interest, learning, and development. In K. A. Renninger, S. Hidi & A. Krapp (Hg.), *The role of interest in learning and development.* Psychology Press, Taylor & Francis Group. 3-25

Lauermann, F., Tsai, Y.-M. & Eccles, J. S. (2017). Math-related career aspirations and choices within Eccles et al.'s expectancy-value theory of achievement-related behaviors. *Developmental Psychology*, *53* (8), 1540–1559. https://doi.org/10.1037/dev0000367

Liem, G. A. D., Marsh, H. W., Martin, A. J., McInerney, D. M. & Yeung, A. S. (2013). The big-fish-little-pond effect and a national policy of within-school ability streaming: Alternative frames of reference. *American Educational Research Journal*, *50* (2), 326–370. https://doi.org/10.3102/0002831212464511

Loyalka, P., Zakharov, A. & Kuzmina, Y. (2018). Catching the Big Fish in the Little Pond Effect: Evidence from 33 Countries and Regions. *Comparative Education Review*, *62* (4), 542–564. https://doi.org/10.1086/699672

Ma, C. Q. & Huebner, E. S. (2008). Attachment relationships and adolescents' life satisfaction: Some relationships matter more to girls than boys. *Psychology in the Schools*, *45* (2), 177–190. https://doi.org/10.1002/pits.20288

Marsh, H. W. (1987). The big-fish-little-pond effect on academic self-concept. *Journal of Educational Psychology*, *79* (3), 280–296.

Marsh, H. W., Abduljabbar, A. S., Parker, P. D., Morin, A. J. S., Abdelfattah, F. & Nagengast, B. (2014). The big-fish-little-pond effect in mathematics: A cross-cultural comparison of U.S. and Saudi Arabian TIMSS responses. *Journal of Cross-Cultural Psychology*, *45* (5), 777–804. https://doi.org/10.1177/0022022113519858

Marsh, H. W., Trautwein, U., Lüdtke, O., Baumert, J. & Köller, O. (2007). The big-fish-little-pond effect: Persistent negative effects of selective high schools on self-concept after graduation. *American Educational Research Journal*, *44* (3), 631–669. https://doi.org/10.3102/0002831207306728

Marsh, H. W., Abduljabbar, A. S., Abu-Hilal, M. M., Morin, A. J. S., Abdelfattah, F., Leung, K. C., Xu, M. K., Nagengast, B. & Parker, P. (2013). Factorial, convergent, and discriminant validity of timss math and science motivation measures: A comparison of Arab and Anglo-Saxon countries. *Journal of Educational Psychology*, *105* (1), 108–128. https://doi.org/10.1037/a0029907

Marsh, H. W. & Hau, K.-T. (2003). Big-fish-little-pond effect on academic self-concept: A cross-cultural (26-country) test of the negative effects of academically selective schools. *American Psychologist*, *58* (5), 364–376. https://doi.org/10.1037/0003-066X.58.5.364

Marsh, H. W., Kuyper, H., Morin, A. J.S., Parker, P. D. & Seaton, M. (2014). Big-fish-little-pond social comparison and local dominance effects: Integrating new statistical models, methodology, design, theory and substantive implications. *Learning and Instruction*, *33*, 50–66. https://doi.org/10.1016/j.learninstruc.2014.04.002

Marsh, H. W., Lüdtke, O., Robitzsch, A., Trautwein, U., Asparouhov, T., Muthén, B. & Nagengast, B. (2009). Doubly-Latent Models of School Contextual Effects:

Integrating Multilevel and Structural Equation Approaches to Control Measurement and Sampling Error. *Multivariate behavioral research*, *44* (6), 764–802. https://doi.org/10.1080/00273170903333665

Musu-Gillette, L. E., Wigfield, A., Harring, J. R. & Eccles, J. S. (2015). Trajectories of change in students' self-concepts of ability and values in math and college major choice. *Educational Research and Evaluation*, *21* (4), 343–370. https://doi.org/10.1080/13803611.2015.1057161

Muthèn, L. K. & Muthèn, B. O. (1998-2012). *Mplus (Version 7)*. Muthén & Muthén. Los Angeles, CA.

Nagengast, B. & Marsh, H. W. (2011). The negative effect of school-average ability on science self-concept in the UK, the UK countries and the world: The big-fish-little-pond-effect for PISA 2006. *Educational Psychology*, *31* (5), 629–656. https://doi.org/10.1080/01443410.2011.586416

Nagy, G., Garrett, J., Trautwein, U., Cortina, K. S., Baumert, J. & Eccles, J. S. (2008). Gendered high school course selection as a precursor of gendered careers: The mediating role of self-concept and intrinsic value. In H. M. G. Watt & J. S. Eccles (Hg.), *Gender and occupational outcomes: Longitudinal assessments of individual, social, and cultural influences* (1. Aufl., S. 115–143). American Psychological Association. https://doi.org/10.1037/11706-004

OECD. (2018). *Education at a glance 2018: OECD indicators*. OECD Publishing. https://doi.org/10.1787/eag-2018-en

Parker, P., Nagy, G., Trautwein, U. & Lüdtke, O. (2014). Predicting career aspirations and university majors from academic ability and self-concept. In I. Schoon & J. S. Eccles (Hg.), *Gender differences in aspirations and attainment: A life course perspective* (S. 224–246). Cambridge University Press. https://doi.org/10.1017/CBO9781139128933.015

Perez-Felkner, L., Nix, S. & Thomas, K. (2017). Gendered pathways: How mathematics ability beliefs shape secondary and postsecondary course and degree field choices. *Frontiers in psychology*, *8*, (386.), 1-11. https://doi.org/10.3389/fpsyg.2017.00386

Plieninger, H. & Dickhäuser, O. (2013). The female fish is more responsive: Gender moderates the BFLPE in the domain of science. *Educational Psychology*, *35* (2), 213–227. https://doi.org/10.1080/01443410.2013.814197

Schurtz, I. M., Pfost, M., Nagengast, B. & Artelt, C. (2014). Impact of social and dimensional comparisons on student's mathematical and English subject-interest at the beginning of secondary school. *Learning and Instruction*, *34*, 32–41. https://doi.org/10.1016/j.learninstruc.2014.08.001

Seaton, M., Marsh, H. W. & Craven, R. G. (2010). Big-Fish-Little-Pond Effect: Generalizability and moderation - two sides of the same coin. *American Educational Research Journal*, *47* (2), 390–433. https://doi.org/10.3102/0002831209350493

Seaton, M., Marsh, H. W. & Craven, R. G. (2009). Earning its place as a pan-human theory: Universality of the big-fish-little-pond effect across 41 culturally and economically diverse countries. *Journal of Educational Psychology*, *101* (2), 403–419. https://doi.org/10.1037/a0013838

Shavelson, R. J., Hubner, J. J. & Stanton, G. C. (1976). Self-Concept: Validation of Construct Interpretations. *Review of Educational Research*, *46* (3), 407–441. https://doi.org/10.3102/00346543046003407

Statistisches Bundesamt. (2018a). *Studierende an Hochschulen - Fächersystematik: Fachserie 11, Reihe 4.1, WS 2016/17.*

Statistisches Bundesamt. (2018b). *Studierende an Hochschulen - Fächersystematik: Fachserie 11, Reihe 4.1, WS 2016/17.*

Thijs, J., Verkuyten, M. & Helmond, P. (2010). A Further Examination of the Big-Fish–Little-Pond Effect. *Sociology of Education*, *83* (4), 333–345. https://doi.org/10.1177/0038040710383521

U.S. Bureau of Labour Statistics. (2017). *STEM occupations: Past, present, and future.* U.S Bureau of Labour Statitics.

Udo, M. K., Ramsey, G. P. & Mallow, J. V. (2004). Science Anxiety and Gender in Students Taking General Education Science Courses. *Journal of Science Education and Technology*, *13* (4), 435–446. https://doi.org/10.1007/s10956-004-1465-z

Umarji, O., McPartlan, P. & Eccles, J. (2018). Patterns of math and English self-concepts as motivation for college major selection. *Contemporary Educational Psychology*, *53*, 146–158. https://doi.org/10.1016/j.cedpsych.2018.03.004

Watt, H. M. G. (2006). The role of motivation in gendered educational and occupational trajectories related to maths. *Educational Research and Evaluation*, *12* (4), 305–322. https://doi.org/10.1080/13803610600765562

Wigfield & Eccles (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology*, *25* (1), 68–81. https://doi.org/10.1006/ceps.1999.1015

Wouters, S., Colpin, H., van Damme, J., Laet, S. de & Verschueren, K. (2013). Early adolescents' academic self-concept formation: Do classmates or friends matter most? *Learning and Individual Differences*, *27*, 193–200. https://doi.org/10.1016/j.lindif.2013.09.002

Zell, E. & Alicke, M. D. (2010). The local dominance effect in self-evaluation: evidence and explanations. *Personality and social psychology review : an official journal of the Society for Personality and Social Psychology, Inc*, *14* (4), 368–384. https://doi.org/10.1177/1088868310366144