

Selected papers presented at
the [2nd Network Gender &
STEM Conference](#), 3–5 July
2014, in Berlin, Germany

In association with



NETWORK
**GENDER
& STEM**
educational and
occupational pathways
and participation

The Role of Parental Values and Child-specific Expectations in the Science Motivation and Achievement of Adolescent Girls and Boys

Päivi Hannele Taskinen, Julia Dietrich and Bärbel Kracke

Friedrich-Schiller-Universität Jena, Germany

ABSTRACT

Expectancy-value models attach great importance to the role of parents in an adolescent's motivational development and achievement-related choices. The present study examined the relationship between the science-related values and child-specific expectations of parents, and the learning- and future-oriented motivation and the science achievement of boys and girls. The sample consisted of $N = 4188$ adolescents from the German PISA sample (51.4% girls) and their parents. Structural equation modeling revealed positive associations between the values and expectations of parents and the individual characteristics of students. The associations between the values of parents and the motivation and achievement of students were significant, but rather weak. Parental expectations for their child pursuing a science-related career were more strongly related to student variables. Our analyses also revealed that the associations between the expectations of parents and the learning motivation and achievement of students were stronger for boys than for girls. We discuss our findings with respect to the potential role of parents as socializers for the motivation, achievement, and career choices of boys and girls as well as the role of children in eliciting parental expectations.

KEYWORDS

family influence; parental values; parental expectations; motivation in science; science achievement; career aspirations in science; gender differences



The Role of Parental Values and Child-specific Expectations in the Science Motivation and Achievement of Adolescent Girls and Boys

INTRODUCTION

Parents play an important role in the academic lives of their children. Positive parenting sets a general climate for academic success, and parental involvement in school can foster the learning and achievement of students (e.g., Pomerantz, Moorman, & Litwack, 2007). However, there is a lack of studies that specify the role of parents in the motivation and achievement of boys and girls with respect to science (Harackiewicz, Rozek, Hulleman, & Hyde, 2012). While some studies have indicated the relevance of science-related activities within the family (e.g., Archer et al., 2012) and parental role models in science (e.g., Sjaastad, 2012), fewer studies have focused on the significance of parental science-related values and expectations for their child's motivation and achievement (e.g., Jodl, Michael, Malanchuk, Eccles, & Sameroff, 2001; Tenenbaum & Leaper, 2003). This study addresses this research gap by discussing the role of parental values and child-specific expectations in the motivation and achievement of adolescent girls and boys with respect to science and examining their empirical significance.

ADOLESCENTS' LEARNING MOTIVATION, ACHIEVEMENT, AND CAREER ASPIRATIONS IN SCIENCE

According to many studies conducted in Western countries, many adolescents dislike science (e.g., OECD, 2007; Sjøberg & Schreiner, 2010). This, in turn, is related to lower overall engagement in science within and outside of school (Krapp & Prenzel, 2011). Conversely, adolescents engaged in science demonstrate high learning motivation and achievement and are more likely to consider a science career. In empirical studies, these expressions of a student's commitment to science are often examined separately. We therefore take a multidimensional perspective; we focus on learning motivation, science achievement, and future-oriented motivation in terms of career aspirations.

Ability beliefs and individual interest are two crucial constructs of a student's learning motivation (e.g., Eccles, 2005). A common conceptualization for ability-related beliefs is the domain-specific academic self-concept (Marsh & Martin, 2011; for an overview, see Wigfield & Eccles, 2000). Academic self-concepts are subjective beliefs about one's abilities in specific academic domains (e.g., science). They are formed through accomplishment (or the lack thereof) or comparison with the accomplishments of significant others (Möller, Pohlmann, Köller & Marsh, 2009). Because people usually like to engage in tasks they perceive as manageable, academic self-concept in science is highly relevant for how an individual deals with science (Marsh & Martin, 2011).

Individual interests, in turn, are related to specific content or objects and are fairly stable over time (Krapp & Prenzel, 2011). Interest-based learning is strongly linked to intrinsic motivation, which is closely related to the enjoyment of learning. This implies that an individual is more involved in, and is more likely to take – or even

generate – opportunities to engage in, corresponding activities (Köller, Baumert, & Schnabel, 2001; Ryan & Deci, 2000). Therefore, one's interest in science is highly predictive of one's relationship with science.

In an academic setting, science achievement is the most apparent indicator of an adolescent's commitment to science. Achievement interacts reciprocally with a student's motivation. A high self-concept and high interest can drive achievement gains, but high achievement also makes students believe in their abilities (e.g., Möller et al., 2011) and increases their interest (Krapp & Prenzel, 2011).

An adolescent's well-developed science motivation may also be expressed in science-related career choices. Adolescents' career aspirations are understood as an indication of the motivation to become involved with specific occupational fields in the future. In the context of science-related careers, these aspirations are reasonably predictive of adolescents' actual career choices (Tai, Liu, Maltese, & Fan, 2006). In general, ability beliefs, interests, and achievement are important precursors of individuals' career aspirations and choices (Eccles, 2005; Lent, Brown & Hackett, 2000). This also applies to choices made in scientific fields (e.g., Simpkins, Davis-Kean & Eccles, 2006).

Taken together, an adolescent's commitment to and engagement with science may manifest themselves in different ways. Motivation and achievement are interrelated; learning motivation is a positive precursor of achievement, whereas high achievement is thought to result from higher learning motivation. Similarly, future-oriented motivation in science in terms of career aspirations is influenced by one's learning motivation and achievement. In the following, we explain how an adolescent's learning motivation, achievement, and career aspirations are linked to parental science-related values and child-specific expectations regarding science.

EFFECTS OF PARENTAL VALUES AND EXPECTATIONS ON ADOLESCENTS' LEARNING MOTIVATION, ACHIEVEMENT, AND CAREER ASPIRATIONS IN SCIENCE

According to the expectancy-value model of achievement-related choices, parents, teachers, and other socializers play an active role in shaping an adolescent's motivation, achievement, and career aspirations (e.g., Eccles, 2007). Children whose parents are supportive and involved in their education exhibit better learning motivation and achievement (Fan & Chen, 2001; Fan & Williams, 2009). However, parents may support their child's academic behaviors in a wide range of ways (e.g., Pomerantz et al., 2007). In this study, we focus on parental values and child-specific expectations. We examine the extent to which these factors are related to an adolescent's learning motivation, achievement, and career aspirations.

Parental valuing of science may reveal itself on different dimensions. We investigate three aspects in this study. First, some parents may value science as important for society in general. Second, some parents may value science as important to themselves personally. Of course, many probably value science for both reasons (see Gaspard et al., 2015). Third, some parents may value science as important for their child and the child's future career.

Furthermore, parental expectations can influence a child's motivation, achievement, and career aspirations (Eccles, 2005). In fact, in prior research, child-specific expectations were closer to a child's behavior than parental values were (Eccles, 2007). We focus on the child-specific expectations of parents as the extent to which parents believe that their child will enter a career in science.

Values that parents ascribe towards science as well as their expectations of their child may guide the daily actions of families (Eccles, 2005; Schwartz, 1996). First, parents can express their values and expectations in everyday communication with their child (Jacobs & Eccles, 2000; Tenenbaum & Leaper, 2003). For example, parents may support the pursuit of a science career by setting high expectations for doing well in science courses and stressing the importance and necessity of achievement in science. Second, parents who value science highly may interact more with their child in science-related matters (e.g., discussions of scientific phenomena, visiting exhibitions, and watching science-related programs on television), which may then support their child's commitment to science (Archer et al., 2012).

With respect to values, the academic values and attitudes of parents transmit to the values and attitudes of adolescents (Gniewosz & Noack, 2012; Jodl et al., 2001). Moreover, the career expectations on the part of parents are important for a child's own career aspirations (Rimkute, Hirvonen, Tolvanen, Aunola, & Nurmi, 2011).

Taken together, expectancy-value models predict that a student's learning motivation, achievement, and career aspirations in science benefit if parents value science and have high expectations for their child. However, the strength of this relationship may vary between girls and boys because of their different experiences with science, or gender typical behavior exhibited by parents when interacting with their child. This possibility is outlined in the following section.

Gender Comparisons

Average gender differences in science motivation have been observed in many western countries (OECD, 2007). For example, large-scale studies conducted in several countries have indicated that boys tended to show interest in more diverse science fields and expressed greater general interest in science during adolescence than girls did (e.g., OECD, 2008; Sjøberg & Schreiner, 2010). Not only do adolescent girls show a lower interest in science but they also have weaker science self-concepts than boys even though the two genders demonstrate equally high achievement (OECD, 2007; Reis & Park, 2001). The future-oriented science motivation of girls also seems to be gendered even if girls and boys generally demonstrate an equal level of science competency at the end of secondary school. Despite being interested and competent in science, many young women pursue careers in other fields (Bøe, Henriksen, Lyons, & Schreiner, 2011; Brotman & Moore, 2008). Still, in some scientific fields (e.g., the life sciences), girls demonstrate the same interest and career aspirations as boys do (e.g., Krapp & Prenzel, 2011; Su & Rounds, 2015).

One presumed reason for the overall lower motivation of girls is the perceived masculinity of some science disciplines (e.g., Kessels, 2015). Because of stereotype

threat, many girls avoid scientific fields that typically require aptitude in physical sciences and advanced mathematics and which are deemed to be male-dominated (Kessels & Hannover, 2007). Many scientific fields (e.g., physics) also do not appear to respond to the occupational goals of young women, which include helping others or working in teams (e.g., Su, Rounds & Armstrong, 2009). The limited number of female role models in science (Cheryan, Siy, Vichayapai, Drury & Kim, 2011) and the negative image that peer groups have of girls or women who like science (Hannover & Kessels, 2004) leads to stereotypes about scientists and science subjects at school that are detrimental to the development of learning motivation or career interest in girls. In this situation, parents may have an important role in a girl's motivation for science. They may express their high expectations or positive values about science. These could support girls with an interest in science to counteract existing stereotypes (e.g., Kessels, 2015). Accordingly, associations between parental values and expectations may be stronger in girls than in boys.

Overall, parental values or expectations are thought to be conveyed in social interactions with their children (e.g, Eccles, 2015). However, research indicates that gender-typical beliefs influence how parents interact with their children (Eccles, Freedman-Doan, Frome, Jacobs, & Yoon, 2000). In the context of science, parents believe that science is less interesting and more difficult for girls than it is for boys (Tenenbaum & Leaper, 2003). This, in turn, could mean that parents less frequently interact with their daughters on science matters even if they themselves highly value science and find it interesting. Associations between parental values and expectations may therefore be stronger in boys than girls.

Research Questions

This study aimed to investigate the associations between parental values and expectations and an adolescent's learning motivation, achievement, and career aspirations in science. We formulated two hypotheses:

- 1) Parental values and expectations will equally influence an adolescent's learning motivation, achievement, and career aspirations in science.
- 2) Parental expectations will be more strongly related to adolescents' learning motivation, achievement and career intentions than parental values.

Finally, we investigate whether parental values and expectations will be more relevant for boys or girls with respect to learning motivation, achievement, and career aspirations in science.

METHOD

Participants

The international survey Programme for International Student Assessment (PISA) provides international options to supplement the age-based sampling of 15-year-old students on which the international comparison is based. In the 2006 survey, Germany took the option of a parental survey as well as an additional grade-based sampling (random sampling of entire ninth grade classes). We used this additional data for the analysis.

Because we focused on the aspirations of students to pursue an academic science-related career, we included classes with access to higher education (classes in the highest educational track "Gymnasium"; for general information about the German school system, see Wölfel & Heineck, 2012). Our final sample consisted of $N = 4188$ ninth-graders (51.4% female) and their parents. For each family, there was only one parental questionnaire. The parental questionnaire was completed by 2371 mothers, 558 fathers, and 32 other persons (other family members), and 548 parents completed the questionnaire together. Altogether, a parental questionnaire was available for 3509 students (84% of the total sample). In general, the parents were well educated. In many families, at least one parent had a university degree (57.7 %). In 9.0% of the families, neither the mother nor father had a high school diploma. Such a high family education level is typical for children attending "Gymnasiums" in Germany.

Measures

The current analysis was based on eight variables related to the science motivation and achievement of students, and parental values and expectations from international PISA questionnaires. The motivation of adolescents was measured by three scales related to a student's learning motivation in science and science-related career aspirations. Their achievement was measured by a standardized test. Parental values and expectations were measured by four scales.

Except where otherwise noted, the response format in the questionnaires was a four-point rating scale ranging from "strongly agree" to "strongly disagree." Details about the science test, the questionnaires, and the testing procedures are available in the OECD publications about PISA 2006 (e.g., OECD 2007, 2009).

Adolescents' interest in science. An adolescent's interest in learning about science and enjoyment of science-related activities were measured using five items (e.g., "I like reading about science" or "I am interested in learning about science"; Cronbach's $\alpha = .92$). The scale is conceptually related to intrinsic learning motivation (Levesque, Copeland, Pattie, & Deci, 2010).

Adolescents' science self-concept. Science self-concept was measured by an adolescent's beliefs about her/his own abilities in school science, using six items (e.g., "I learn school science topics quickly" or "Learning advanced school science topics would be easy for me"; Cronbach's $\alpha = .90$).

Adolescents' science achievement. An adolescent's science achievement was measured using the regular standardized PISA 2006 science test. This test measured the science competency in terms of "the capacity of students to identify scientific issues, explain phenomena scientifically and use scientific evidence as they encounter, interpret, solve and make decisions in life situations involving science and technology" (OECD, 2007, p. 33). The estimates of achievement are plausible values based on item response models (OECD, 2009).

Adolescents' career aspirations in science. Future-oriented science motivation was measured by an adolescent's expectations of pursuing tertiary studies in science

and working in academic science-related careers, with five items such as "I would like to study science after school" or "I would like to work on science projects as an adult" (Cronbach's $\alpha=.91$).

Parental perceptions of the societal value of science. The societal importance of science measured the extent to which parents valued the contribution of science and technology to improving conditions of life with five items (e.g., "Advances in science and technology usually improve people's living conditions" or "Science is important for helping us to understand the natural world"; Cronbach's $\alpha=.77$).

Parental perceptions of the personal value of science. One scale also measured the extent to which science is of personal value (four items). Items for this scale included "There are many opportunities for me to use science in my everyday life" or "Science is very relevant to me" (Cronbach's $\alpha=.77$).

Parental valuing of science for the child's future. One scale also focused on the extent to which parents value science as beneficial for their child's future (e.g., "Most jobs today require some scientific knowledge and skills" or "It is an advantage in the job market to have good scientific knowledge and skills"; Cronbach's $\alpha=.86$).

Parental expectations of the child's career aspirations in science. Parents were asked about their expectations for their child's career. The scale measured the expectations that parents had about their child pursuing a scientific career. The scale had five items and a binary response format (yes/no). Items included "Does your child show an interest in working in a science-related career?" or "Do you expect your child will go into a science-related career?" (Cronbach's $\alpha=.86$).

Analysis

We used structural equation modeling to test the latent associations between the variables. We first examined the quality of the measurement models for student and parent variables. We then examined the first hypothesis by inspecting latent correlations between parental and student variables. To address the second hypotheses, we conducted step-wise latent regression analyses. We first entered parental values as predictors for student outcomes (Model 1). We then included parental expectations to explore the relative importance of parental variables (Model 2).

Finally, to examine parental effects on boys and girls, we used multi-group modeling to test whether associations between parent and student variables differed by gender (Asparouhov & Muthén, 2012). In the multi-group model, factor loadings, item intercepts, factor variances, and covariances were kept equal across genders so that differences in regression coefficients could be interpreted meaningfully. Differences were tested using the likelihood ratio test for complex data. We compared a model in which regression coefficients were kept equal across groups (one-group model) with a model in which we allowed the free estimation of regression coefficients across groups (multi-group model). We successively tested for possible gender differences. First, we compared the one-group model and the

multi-group model for Model 1. Whenever we found no difference between boys and girls in this first step, in the next step, we estimated the effects of parental values for boys and girls together (comparison for Model 2). We did this separately for every dependent variable. Finally, we also present a comprehensive path model that simultaneously considers parental variables, student motivation, achievement, and career aspirations in a single model. This model also includes the gender differences identified in earlier analysis steps.

Analyses were carried out with the Mplus 7.1 software (Muthén & Muthén, 2012) using MLR estimation (maximum likelihood with robust standard errors). The complex structure of survey data was taken into account by using survey weights and stratification. This procedure corrects standard errors, which would be biased if the nesting of students in classrooms and schools was ignored. The models tested involved categorical data for parental expectations. Therefore, no descriptive fit indices were available for these models. Where applicable, we report Chi-square model fit information, although these are inflated given the large sample size.

We present standardized parameter estimates in which a coefficient of 1 indicates that an increase of one standard deviation in the independent variable will result in an increase of one standard deviation in the dependent variable. The coefficients in the model can therefore be interpreted as standardized regression coefficients (β) in regression models.

RESULTS

Measurement Models

We first examined the quality of the measurement models separately for parent and student variables. The measurement model for student variables had an excellent fit to the data: $\chi^2(99) = 1022.223$, RMSEA = .047, CFI = .977, TLI = .972, SRMR = .020. It revealed that a student's interest, self-concept, achievement, and career aspirations are distinct constructs (Table 1).

The measurement model for parent variables, which involved a categorical latent variable for parental expectation, fits the data well: Pearson $\chi^2(7) = 99.434$; Likelihood Ratio $\chi^2(7) = 359.376$. This model showed that parental ratings of the societal and personal importance of science were highly correlated ($r = .79$, $p < .001$). To prevent suppression problems in the regression models, we also tested a second-order factor structure (Figure 1). To identify the model, the loading of societal importance on the second-order factor *general importance* was fixed to 1. The fit of the second-order measurement model was: Pearson $\chi^2(7) = 99.706$; Likelihood Ratio $\chi^2(7) = 360.395$.

We then continued our analyses with three parent variables as predictors i.e., general values (societal and personal values), values for the child's future, and expectations.

Associations between Parental Values and Expectations, and Adolescents' Interest, Self-Concept, Achievement, and Career Aspirations

Before focusing on our hypotheses, we examined the correlations between parental variables (Table 1). The different parental values were strongly associated with each other ($r = .52$). The child-specific expectations of parents were moderately correlated to parental values ($r = .32$). The correlation analysis also indicated strong associations among the motivational variables of students (Table 1; $r = .54$ to $r = .68$), which is in line with existing research. A student's achievement in science was only moderately related to other student variables ($r = .27$ to $r = .34$).

Furthermore, there were significant but rather small correlations between parental values and an adolescent's motivation or achievement ($r = .12$ to $r = .18$). The relations between parental expectations and student variables were clearly stronger ($r = .29$ to $r = .60$).

Table 1 *Correlations between parental variables*

	1.	2.	3.	4.	5.	6.	7.
1. Parents: general importance of science	1						
2. Parents: value of science for the child's future	.523	1					
3. Parents: Expectations of the child's career aspirations in science	.318	.387	1				
4. Student: interest in science	.141	.154	.454	1			
5. Student: science self-concept	.154	.165	.394	.604	1		
6. Student: career aspirations in science	.176	.176	.604	.679	.544	1	
7. Student: achievement	.121	.142	.286	.336	.318	.269	1
<i>SD</i>	0.35	0.57	0.29	0.73	0.58	0.88	82.9

Note. $N = 4,188$. All correlations are significant ($p < .001$). Latent means fixed at zero. *SD* = standard deviation.

Our first hypothesis was that parental values and expectations would be positively related to an adolescent's learning motivation, achievement, and career aspirations with respect to science. As Model 1 (Table 2) shows, both variables explained student interest, self-concept, achievement, and career aspirations. Still, the associations were consistently small ($\beta = .07$ to $\beta = .16$), and parental values explained only 3 to 5% of the variance in student outcomes.

The second hypothesis predicted that parental expectations would be more strongly related to an adolescent's learning motivation, achievement, and career aspirations

than parental values. The results of Model 2 (Table 2) revealed that a parent's child-specific expectations were more strongly related to student outcome than values. We found strong associations of parental expectations with a child's career aspirations ($\beta = .63$), moderate to strong associations with student motivation ($\beta = .41$ to $\beta = .63$), and a moderate association with a student's science achievement ($\beta = .30$). In this model, the amount of explained variance in student outcomes increased to 10

Gender Comparisons

Before testing gender differences concerning the role of parental beliefs, we examined whether the average level of interest, self-concept, achievement, and career aspiration differed by gender. We therefore conducted a regression analysis with latent motivational constructs as dependent variables and gender as an independent (manifest) variable. The mean value for all latent constructs was set to zero, as is common in latent variable models. When entering gender into the regression, the beta coefficient reflects the differences between girls (coded 0) and boys (coded 1). The standard deviations of student variables were $SD_{\text{interest}} = 0.73$, $SD_{\text{self-concept}} = 0.33$, $SD_{\text{career aspirations}} = 0.78$. The results of these models indicated that boys had a slightly higher interest in science ($\beta = .13$, $\beta = .18$, $p < .001$) and a higher self-concept than girls ($\beta = .26$, $\beta = .22$, $p < .001$). Correspondingly, girls did not pursue careers in scientific fields as often as boys did ($\beta = .25$, $\beta = .14$, $p < .001$). In another model, we performed a regression of student achievement, which was measured as a manifest variable, on the gender of students. On average, the students reached the fourth competency level (of six) with an average mean value of 561 points ($SD = 83$). (for further information on competency levels, refer to OECD, 2007.) The analysis showed that boys performed slightly better than girls ($B = 11$, $\beta = .07$, $p < .001$).

We then focused on the relevance of parental values and expectations for the learning motivation, achievement, and career aspirations of girls and boys regarding science. Table 3 presents the results of the multi-group models. In Model 1, we found a significant difference between the self-concept of boys and girls in science only. When parents valued science as important in general, boys showed a significantly higher self-concept than girls did ($\Delta\beta = .17$). In terms of other motivational characteristics and achievement, there were no gender differences concerning the role of parental values.

Furthermore, as Model 2 shows, parental expectations were more strongly related to the interest, self-concept, and achievement of boys than it was to that of girls ($\Delta\beta$ s = .11 to .18). In contrast, the high expectations of parents predicted career aspirations in science equally well for boys and girls ($\Delta\beta = .04$). In general, parents had higher expectations of their daughters ($M = 0.27$) than they did of their sons ($M = 0.00$).

Table 2. Latent regression models predicting student science motivation and achievement by parental values and expectations (standardized coefficients)

	Interest in science		Science self-concept		Career aspirations in science		Science achievement	
	Mod1	Mod2	Mod1	Mod2	Mod1	Mod2	Mod1	Mod2
PARENT VARIABLES								
General value of science	.141	(.026)	.141	(.048)	.163	(.016)	.097	(.025)
Value of science for the child's future	.071	(-.049)	.081	(-.019)	.073	-.086	.084	(.010)
Expectations of the child's career aspirations in science	-	.480	-	.409	-	.630	-	.295
R ²	.036	.224	.041	.177	.045	.368	.025	.096

Note. Not-significant coefficients are parenthesized. Other effects are significant ($p < .05$).

Table 3. Multi-group latent regression model predicting student science motivation and achievement by parental values and expectations separately for each gender (standardized coefficients)

	Interest in science		Science self-concept		Career aspirations in science		Science achievement	
	Mod1	Mod2	Mod1	Mod2	Mod1	Mod2	Mod1	Mod2
GIRLS								
PARENT VARIABLES								
General value of science	.091	(.030)	<u>.083</u>	<u>(.017)</u>	.128	(.020)	.074	(.028)
Value of science for the child's future	.089	-.054	.101	(.034)	.072	(-.092)	.069	(.007)
Expectations of the child's career aspirations in science	-	<u>.418</u>	-	<u>.332</u>	-	.603	-	<u>.198</u>
BOYS								
PARENT VARIABLES								
General value of science	.214	(.028)	<u>.249</u>	<u>.100</u>	.218	(.019)	.132	(.026)
Value of science for the child's future	(.020)	-.051	(.008)	-.094	(.044)	-.089	.083	(.007)
Expectations of the child's career aspirations in science	-	<u>.523</u>	-	<u>.443</u>	-	.640	-	<u>.378</u>
Loglikelihood difference	5.49	15.04	9.84	14.93	3.86	3.35	3.08	24.83
df	2	1	2	1	2	1	2	1
p	.064	<.001	.007	.002	.145	.067	.995	<.001

Note. Not-significant coefficients are parenthesized. Other effects are significant at $p < .05$. Significant gender difference are underlined.

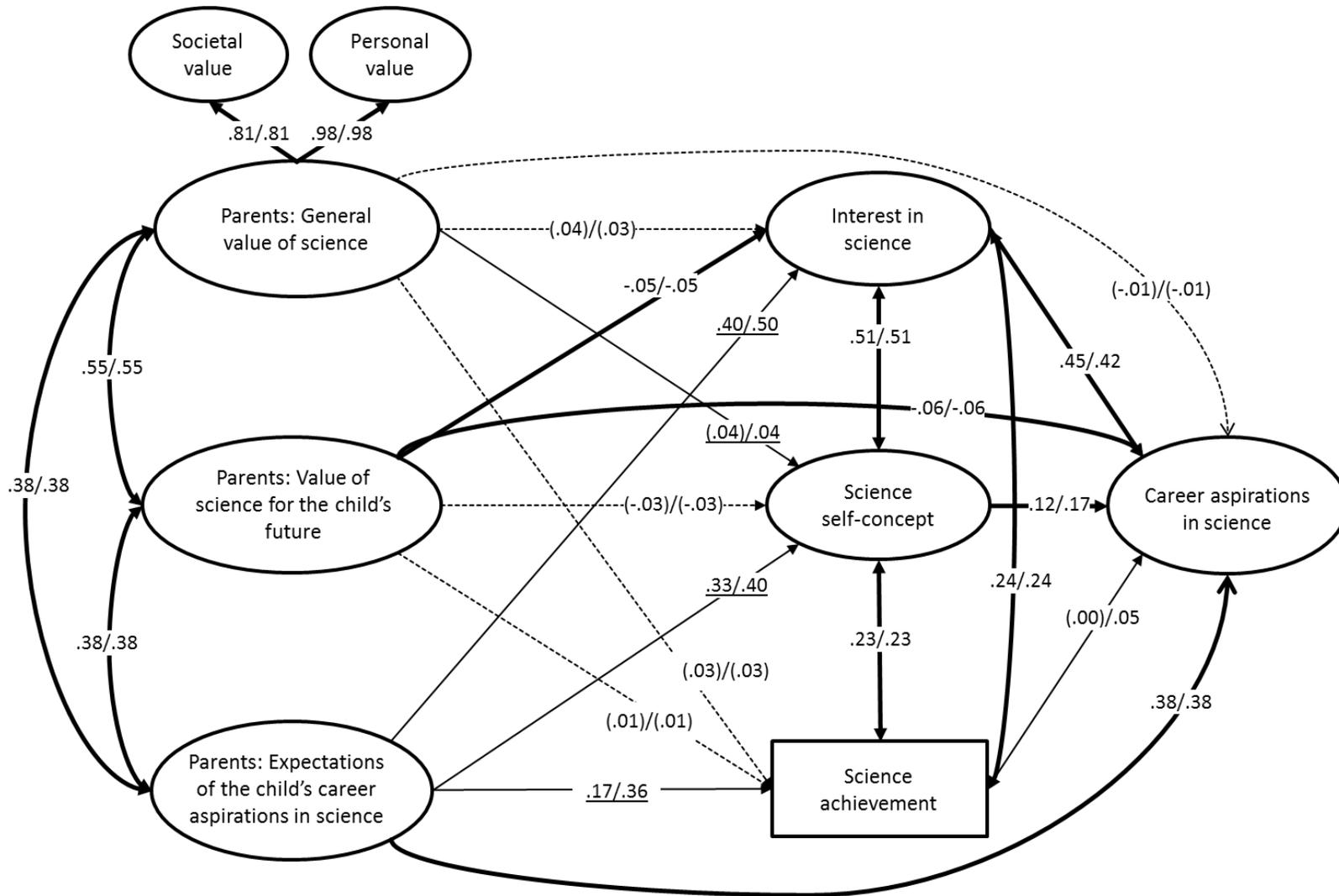


Figure 1. Overall multi-group path model. Shown is the structural model with coefficients for girls/boys. Non-significant coefficients are parenthesized. Other effects are significant at $p < .05$. Significant gender differences are underlined.

In the gender-specific models, most effects of parental values did not persist when the levels of parental expectations were controlled for. This means that with respect to the motivation of both boys and girls, parental expectations for a child's career aspirations in science are more important than parental values are. However, parental values did have a significant relationship with the self-concept of boys even when the level of parental expectations were taken into account ($\beta = .10$).

Overall model

Because the learning motivation and achievement of students are interrelated and are understood as precursors of a student's career aspirations, we estimated an additional model in order to account for these relationships. We estimated the path model depicted in Figure 1. This model fitted the data well: Pearson $\chi^2 (7) = 99.434$; Likelihood Ratio $\chi^2 (7) = 359.376$. Student interest in science was most strongly associated with career aspirations (Figure 1). Both girls and boys expressing higher interest in science more often aspired to careers in science ($\beta_{\text{girls}} = .45$, $\beta_{\text{boys}} = .42$). The science self-concept ($\beta_{\text{girls}} = .12$, $\beta_{\text{boys}} = .17$) and achievement ($\beta_s = .24$) of boys and girls were also indicators for higher career aspirations in science. Focusing on parental variables, parental expectations about their child's career in science also predicted the career aspirations of boys and girls in science even when the level of individual interest, self-concept, and achievement were taken into account ($\beta_s = .38$).

DISCUSSION

To date, the investigation of a student's commitment to science has mainly focused on school and teaching influences (e.g., Taskinen, Schütte, & Prenzel, 2013). In this study, we explored parental effects, thereby expanding upon previous studies (e.g., Jodl et al., 2001; Tenenbaum & Leaper, 2003). Situated within expectancy-value models (e.g., Eccles, 2005), our study investigated the extent to which parental values and child-specific expectations relate to an adolescent's learning motivation, achievement, and career aspirations in science. To explore the associations between parental and child variables, we used parent and student information from a representative sample of ninth-grade students, gathered for the PISA study. As expected, our findings revealed that both the values and child-specific expectations of parents were positively associated with an adolescent's commitment to science.

In the present study, we were able to differentiate between different value facets. Our findings not only suggest that it is relevant that parents evaluate science as important for working life in general but also that they consider science as important for themselves and for society. However, the overall relationship between parental values and student characteristics was relatively weak. One reason may be socialization in the family. Research suggests that a high interparental value agreement will facilitate the transmission of academic values between parents and their children (Gniewosz & Noack, 2012). Because parents often differ in their views about science, it seems plausible to find small effects. In this study, either the mother or the father (or even both together) filled in the family questionnaire, which precluded examining interparental value agreement. This is obviously a

general limitation of the parental data used. In future studies, the operationalization of parental values could focus on the aspects of family values.

In this study, parental values did not appear to be as important as parental expectations. This is in line with the expectancy-value model of Eccles (2005), which posits that child-specific beliefs mediate between the general values and beliefs of parents, and the outcome of students. Parental expectations were relatively strongly related to their child's learning motivation. This is consistent with previous research, which suggests that learning motivation can be influenced by parents (Eccles, Wigfield, Harold, & Blumenfeld, 1993). However, individual motivation and achievement seemed to be as important for a student's commitment in science as parental expectations were. Assuming that parents form their expectations based on their perceptions of the child's motivation and achievement, this is plausible.

We also found that an adolescent's career aspirations were strongly linked to parental expectations (i.e., their child pursuing a career in science). When interpreting this result, it should be mentioned that we measured expectations differently than in many other studies focusing on the expectancy-value model. In the context of the PISA study, the measure is more about awareness of a child's career aspirations than expectations of the child's success. This could be responsible for the high association we found. The high relationship between a) parental expectations (measured by items such as "Does your child show an interest in working in a science-related career?") and b) an adolescent's career aspirations (measured by items such as "I would like to work on science projects as an adult") may reflect that parents are aware of their child's career aspirations. This would be positive because parents could act more intentionally under this condition. Parents may explicitly support the pursuit of a science career e.g., by setting high expectations for doing well or by providing their children with diverse stimulating learning situations in science. However, a student's existing high motivation and achievement may elicit parental expectations of a future career in science. Supporting this argument, several studies have documented the evocative influence of younger children on the beliefs and behaviors of their parents (e.g., Gniewosz, Eccles, & Noack, 2015; Silinskas, Niemi, Lerkkanen, & Nurmi, 2012). The directionality of this association cannot be inferred from the present cross-sectional analysis, however.

This study also focused on gender differences with respect to the role of parental values and expectations. In the cases in which we found gender differences, the associations between parental and student variables were higher for boys. This applied even when the level of individual motivation was taken into account. This could be an indicator of gender-specific socialization processes in the family, which support boys' learning motivation and achievement more strongly than girls'. Gendered socialization (Eccles & Alfeld, 2007) may lead parents to more strongly react and provide more encouragement to their sons through positive communication about science and specific activities. If parents actually do provide boys with more encouragement, as some studies have shown (e.g., Tenenbaum & Leaper, 2003), girls are likely to experience difficulty in developing a sense of

efficacy and interest in science in the family environment. Again, a major shortcoming of this study was its cross-sectional design. We cannot exactly specify how parental socialization affects the development of girls and boys. The potential evocative influence of students on their parents is also one explanation that should be taken into account when interpreting the gender differences found in this study. Finally, parents had the same career expectations for both genders when the child's motivation and career aspirations were taken into account. This result is positive because it may reflect that parents do not directly discourage girls from pursuing science-related careers (at least not any more than boys). Assuming that parents form their expectations based on their perceptions of the child's achievement and learning motivation, this is plausible.

Future directions and conclusions

Taken together, the findings and limitations of the present study indicate a number of future research directions. The process variables within families merit further attention. First, process-focused research could examine how parents verbally interact with their children in science contexts. For example, parents who value science or think science is important for their child's future may positively discuss science with their child, which may thus enhance the child's perception of the value of science and ultimately their motivation (Harackiewicz et al., 2012). Moreover, if children internalize the importance of science for their occupational future through positive discussions, their motivation and achievement could be augmented (Deci et al., 1991). In discussions about science, parents may also send out positive signals about science-related occupations because many adolescents do not have a clear conception of science-related occupations and form negative stereotypes about the work of scientists (Bennett & Hogarth, 2009).

Second, future research could involve concrete science-related activities initiated by parents. Such activities may be more directly relevant to the development of a child's learning motivation, achievement, and career aspirations than value transmission in the family is (Jodl et al., 2001; Tenenbaum & Leaper, 2003). Parents who attach more significance to science probably interact more with their children in scientific contexts; they not only provide them with opportunities to reflect on and enhance their interest in science but also give them feedback about their progress, thereby strengthening beliefs about one's ability to succeed in science (Harackiewicz et al., 2012; Şenler & Sungur, 2009). It is possible that parental expectations are more frequently implemented in concrete, child-specific actions. For example, parents who expect their child to pursue science-related activities may provide various learning materials, which should foster learning and may stimulate their child's interest (Alexander, Johnson & Kelley, 2012). Parents may positively affect the motivation of girls, who usually have less experience with science (Aschbacher, Li & Roth, 2010).

Parents may, however, hold similar values and expectations but still interact differently with their daughters and their sons. In order to differentiate between the gender-specific actions of parents, it is important to focus on the concrete interactions of parents and their children (e.g., Tenenbaum & Leaper, 2003). Such

research would enable a more precise examination of how the motivation and achievement of boys and girls evolve in families.

In conclusion, parents may have an important role in encouraging a student's learning motivation, achievement, and career aspirations. Various parental beliefs and expectations as well as support in the form of discussion or activities may be important for a student's commitment – particularly in science – because there are manifold barriers to motivational development in science. For example, teachers do not have enough time to stimulate everyone's interest in science (Kobarg et al., 2011). Science is also not a preferred subject of adolescents – not even for those who are highly adept in this area (e.g., Schreiner & Sjøberg, 2007; Taskinen, 2010). In general, adolescents tend to underestimate their scientific aptitude because they view science as a difficult subject (Osborne et al., 2003; Shanahan & Nieswandt, 2011). Gender-specific stereotypes also weaken the commitment of girls to science. These domain-specific barriers do not apply to the same extent to non-scientific domains such as languages. From the individual's point of view, this situation is unfavorable because many adolescents – especially many talented girls – cannot realize their potentials in scientific fields. Our findings indicate that parents may be a resource for enhancing the commitment of boys and girls to science.

REFERENCES

- Alexander, J. M., Johnson, K. E., & Kelley, K. (2012). Longitudinal analysis of the relations between opportunities to learn about science and the development of interests related to science. *Science Education*, 96(5), 763-786.
- Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2012). Science aspirations, capital, and family habitus: How families shape children's engagement and identification with science. *American Educational Research Journal*, 49, 881-908. doi: 10.3102/0002831211433290
- Aschbacher, P. R., Li, E., & Roth, E. J. (2010). Is science me? High school students' identities, participation and aspirations in science, engineering, and medicine. *Journal of Research in Science Teaching*, 47(5), 564-582.
- Asparouhov, T. & Muthén, B. (2012). Multiple group multilevel analysis. Mplus Web Notes: No. 16. November 15, 2012. Available online: <http://www.statmodel.com/examples/webnotes/webnote16.pdf>
- Bennett, J., & Hogarth, S. (2009). "Would you want to talk to a scientist at a party"? :High school students' attitudes to school science and to science. *International Journal of Science Education*, 31, 1975-1998.
- Bøe, M. V., Henriksen, E. K., Lyons, T., & Schreiner, C. (2011). Participation in science and technology: young people's achievement-related choices in late-modern societies. *Studies in Science Education*, 47, 37-72. doi: 10.1080/03057267.2011.549621

- Brotman, J. S., & Moore, F. M. (2008). Girls and science: A review of four themes in the science education literature. *Journal of Research in Science Teaching*, 45, 971-1002. doi: 10.1002/tea.20241
- Cheryan, S., Siy, J. O., Vichayapai, M., Drury, B. J., & Kim, S. (2011). Do female and male role models who embody STEM stereotypes hinder women's anticipated success in STEM? *Social Psychological and Personality Science*, 2, 656-664. doi: 10.1177/1948550611405218
- Deci, E. L., Vallerand, R. J., Pelletier, L. G., & Ryan, R. M. (1991). Motivation and education: The self determination perspective. *Educational Psychologist*, 26, 325-346. doi: 10.1207/s15326985ep2603&4_6
- Eccles, J. S. (2005). Subjective task value and the Eccles et al. model of achievement-related choices. In A. J. Elliot & C. S. Dweck (Eds.), *Handbook of Competence and Motivation* (pp. 105-121). New York: The Guilford Press.
- Eccles, J. S. (2007). Families, schools, and developing achievement-related motivations and engagement. In J. E. Grusec & P. D. Hastings (Eds.), *Handbook of Socialization. Theory and Research* (pp. 665-691). New York: The Guilford Press.
- Eccles, J. S. (2015). Gendered Socialization of STEM Interests in the Family. *International Journal of Gender, Science and Technology*, 7, 116-132.
- Eccles, J. S., & Alfeld, C. (2007). Not you! Not here! Not now! In R. K. Silbereisen & R. M. Lerner (Eds.), *Approaches to Positive Youth Development* (pp. 133-156). Thousand Oaks, CA: SAGE Publications.
- Eccles, J. S., Freedman-Doan, C., Frome, P., Jacobs, J. E., & Yoon, K. S. (2000). Gender-role socialization in the family: A longitudinal approach. In T. Eckes & H. M. Trautner (Eds.), *The Developmental Social Psychology of Gender* (pp. 330-360). Mahwah, NJ: Lawrence Erlbaum Associates.
- Eccles, J., Wigfield, A., Harold, R. D., & Blumenfeld, P. (1993). Age and gender differences in children's self- and task perceptions during elementary school. *Child Development*, 64, 830-847.
- Fan, W., & Williams, C. M. (2009). The effects of parental involvement on students' academic self-efficacy, engagement and intrinsic motivation. *Educational Psychology*, 30, 53-74. doi: 10.1080/01443410903353302
- Fan, X., & Chen, M. (2001). Parental involvement and students' academic achievement: A meta-analysis. *Educational Psychology Review*, 13, 1-22.
- 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*. Advance online publication. <http://dx.doi.org/10.1037/edu0000003>
- Gniewosz, B., Eccles, J. S., & Noack, P. (2015). Early adolescents' development of academic self-concept and intrinsic task value: The role of contextual feedback. *Journal of Research on Adolescence* 25, 459-473. DOI: 10.1111/jora.12140

- Gniewosz, B., & Noack, P. (2012). The role of between-parent values agreement in parent-to-child transmission of academic values. *Journal of Adolescence*, 35, 809-821. doi: <http://dx.doi.org/10.1016/j.adolescence.2011.11.007>
- Hannover, B., & Kessels, U. (2004). Self-to-prototype matching as a strategy for making academic choices. Why high school students do not like math and science. *Learning and Instruction*, 14, 51-67.
- Harackiewicz, J. M., Rozek, C. S., Hulleman, C. S., & Hyde, J. S. (2012). Helping parents to motivate adolescents in mathematics and science: An experimental test of a utility-value intervention. *Psychological Science*, 23, 899-906. doi: 10.1177/0956797611435530
- Jacobs, J. E., & Eccles, J. S. (2000). Parents, task values, and real-life achievement-related choices. In C. Sansone & J. M. Harackiewicz (Eds.), *Intrinsic and extrinsic motivation: The search for optimal motivation and performance* (pp. 405-439). San Diego: Academic Press, Inc.
- Jodl, K. M., Michael, A., Malanchuk, O., Eccles, J. S., & Sameroff, A. (2001). Parents' roles in shaping early adolescents' occupational aspirations. *Child Development*, 72, 1247-1266. doi: 10.1111/1467-8624.00345
- Kessels, U. (2015): Bridging the gap by enhancing the fit: How stereotypes about STEM clash with stereotypes about girls. *International Journal of Gender, Science and Technology*, 7, 280-296
- Kessels, U., & Hannover, B. (2007). How the image of maths and science affects the development of academic interests. In M. Prenzel (Ed.), *Studies on the Educational Quality of Schools. The Final Report on the DFG Priority Programm* (pp. 283-297). Münster: Waxmann.
- Kobarg, M., Prenzel, M., Seidel, T., Walker, M., McCrae, B., Cresswell, J., & Wittwer, J. (2011). *An International Comparison of Science Teaching and Learning. Further Results from PISA 2006*. Münster: Waxmann.
- Köller, O., Baumert, J., & Schnabel, K. (2001). Does interest matter? The relationship between academic interest and achievement in mathematics. *Journal for Research in Mathematics Education*, 32, 448-470.
- Krapp, A., & Prenzel, M. (2011). Research on interest in science: Theories, methods, and findings. *International Journal of Science Education*, 33, 27-50. doi: 10.1080/09500693.2010.518645
- Lent, R. W., Brown, S. D., & Hackett, G. (2000). Contextual supports and barriers to career choice: A social cognitive analysis. *Journal of Counseling Psychology*, 47, 36-49.
- Levesque, C., Copeland, K. J., Pattie, M. D., & Deci, E. L. (2010). Intrinsic and extrinsic motivation. In P. Peterson, E. Baker & B. McGaw (Eds.), *International Encyclopedia of Education* (3 edn., pp. 618-623). Oxford: Elsevier.
- Marsh, H. W., & Martin, A. J. (2011). Academic self-concept and academic achievement: Relations and causal ordering. *British Journal of Educational Psychology*, 81, 59-77.

- Möller, J., Pohlmann, B., Köller, O., & Marsh, H. W. (2009). A meta-analytic path analysis of the internal/external frame of reference model of academic achievement and academic self-concept. *Review of Educational Research, 79*, 1129-1167.
- Möller, J., Retelsdorf, J., Köller, O., & Marsh, H. W. (2011). The reciprocal I/E model: An integration of models of relations between academic achievement and self-concept. *American Educational Research Journal, 48*, 1315-1346.
- Muthén, L. K., & Muthén, B. O. (2012). *Mplus User's Guide* (7th edn.). Los Angeles, CA: Muthén & Muthén.
- OECD (2007). *PISA 2006: Science competencies for tomorrow's world*. Paris: OECD.
- OECD (2008). *Encouraging student interest in science and technology studies*. Paris: OECD.
- OECD (2009). *PISA 2006. Technical report*. Paris: OECD.
- Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education, 25*, 1049-1079.
- Pomerantz, E., Moorman, E., & Litwack, S. D. (2007). The how, whom, and why of parents' involvement in children's academic lives: More is not always better. *Review of Educational Research, 77*, 373-410.
- Reis, S. M., & Park, S. (2001). Gender differences in high-achieving students in math and science. *Journal for the Education of the Gifted, 25*, 52-73.
- Rimkute, L., Hirvonen, R., Tolvanen, A., Aunola, K., & Nurmi, J.-E. (2011). Parents' role in adolescents' educational expectations. *Scandinavian Journal of Educational Research, 56*, 571-590. doi: 10.1080/00313831.2011.621133
- Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology, 25*, 54-67.
- Schreiner, C., & Sjøberg, S. (2007). Science education and youth's identity construction - two incompatible projects? In D. Corrigan, J. Dillon & R. Gunstone (Eds.), *The Re-emergence of Values in Science Education* (pp. 231-247). Rotterdam: Sense Publishers.
- Schwartz, S. H. (1996). Value priorities and behavior: applying a theory of integrated value systems. In C. Seligman, J. M. Olson, & M. P. Zanna (Eds.), *The Psychology of Values* (pp. 1-24). Mahwah, NJ: Lawrence Erlbaum Associates.
- Şenler, B., & Sungur, S. (2009). Parental influences on students' self-concept, task value beliefs and achievement in science. *The Spanish Journal of Psychology, 12*, 106-117.
- Shanahan, M.-C., & Nieswandt, M. (2011). Science student role: Evidence of social structural norms specific to school science. *Journal of Research in Science Teaching, 48*(4), 367-395. doi: 10.1002/tea.20406

Silinskas, G., Niemi, P., Lerkkanen, M. K., & Nurmi, J. E. (2012). Children's poor academic performance evokes parental homework assistance – but does it help? *International Journal of Behavioral Development, 37*, 44–56.

Simpkins, S. D., Davis-Kean, P. E., & Eccles, J. S. (2006). Math and science motivation: A longitudinal examination of the links between choices and beliefs. *Developmental Psychology, 42*, 70-83.

Sjaastad, J. (2012). Sources of inspiration: The role of significant persons in young people's choice of science in higher education. *International Journal of Science Education, 34*, 1615-1636. doi: 10.1080/09500693.2011.590543

Sjøberg, S., & Schreiner, C. (2010). *The ROSE project. An overview and key findings*. Retrieved from: <http://roseproject.no>

Su, R., & Rounds, J. (2015). All STEM fields are not created equal: People and things interest explain gender disparities across STEM fields. *Frontiers in Psychology, 2/2015*.

Su, R., Rounds, J., & Armstrong, P. I. (2009). Men and things, women and people: A meta-analysis of sex differences in interests. *Psychological Bulletin, 135*, 859-884.

Tai, R. H., Liu, C. Q., Maltese, A. V., & Fan, X. (2006). Planning early for careers in science. *Science, 312*, 1143-1144.

Taskinen, P. H. (2010). *Naturwissenschaften als zukünftiges Berufsfeld für Schülerinnen und Schüler mit hoher naturwissenschaftlicher und mathematischer Kompetenz: Eine Untersuchung von Bedingungen für Berufserwartungen. [Future careers in sciences for students with high science and mathematics competencies - A study examining the determining factors.]* Kiel: Universität Kiel.

Taskinen, P. H., Schütte, K., & Prenzel, M. (2013). Adolescents' motivation to select an academic science-related career: The role of school factors, individual interest and science self-concept. *Educational Research and Evaluation, 19*(8), 717-733. doi: 10.1080/13803611.2013.853620

Tenenbaum, H. T., & Leaper, C. (2003). Parent-child conversations about science: The socialization of gender inequities? *Developmental Psychology, 39*(1), 34-37.

Wigfield, A., & Eccles, J. S. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology, 25*, 68–81.

Wölfel, O., & Heineck, G. (2012). Parental risk attitudes and children's secondary school track choice. *Economics of Education Review, 31*, 727-743. doi: 10.1016/j.econedurev.2012.05.0