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Gender Differences in the Effects of a Utility-Value Intervention to Help Parents Motivate Adolescents in Mathematics and Science

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A foundation in science, technology, engineering, and mathematics (STEM) education is critical for students' college and career advancement, but many U.S. students fail to take advanced mathematics and science classes in high school. Research has neglected the potential role of parents in enhancing students' motivation for pursuing STEM courses. Previous research has shown that parents' values and expectations may be associated with student motivation, but little research has assessed the influence of parents on adolescents through randomized experiments. Harackiewicz, Rozek, Hulleman, and Hyde (2012) documented an increase in adolescents' STEM course-taking for students whose parents were assigned to a utility-value intervention in comparison to a control group. In this study, we examined whether that intervention was equally effective for boys and girls and examined factors that moderate and mediate the effect of the intervention on adolescent outcomes. The intervention was most effective in increasing STEM course-taking for high-achieving daughters and low-achieving sons, whereas the intervention did not help low-achieving daughters (prior achievement measured in terms of grade point average in 9th-grade STEM courses). Mediation analyses showed that changes in STEM utility value for mothers and adolescents mediated the effect of the intervention on 12th-grade STEM course-taking. These results are consistent with a model in which parents' utility value plays a causal role in affecting adolescents' achievement behavior in the STEM domain. The findings also indicate that utility-value interventions with parents can be effective for low-achieving boys and for high-achieving girls but suggest modifications in their use with low-achieving girls.

Keywords: academic motivation, educational intervention, STEM motivation, gender differences

In the United States, national education policies have focused on improving the performance of U.S. students relative to their international peers, particularly in areas related to science, technology, engineering, and mathematics (STEM; National Science Foundation [NSF], 2012). Of particular concern are students' decisions not to take advanced science and mathematics courses in high school. For example, only 35% of high school graduates have taken precalculus and only 39% have taken physics (NSF, 2012). Moreover, although gender gaps have closed for course-taking in some STEM areas, they persist in others. For example, although

girls and boys take calculus at the same rate, boys are more likely to take physics than girls are (42% vs. 36%) and are more likely to take engineering in high school (6% vs. 1%; NSF, 2012). Recently, a number of interventions have been implemented to increase STEM motivation and to close gender gaps (e.g., Harackiewicz et al., 2014; Hulleman & Harackiewicz, 2009; Miyake et al., 2010; Walton & Cohen, 2011). Here, we report on the moderators and mediators of an intervention shown to help parents motivate their adolescents to take mathematics and science courses in high school (Harackiewicz, Rozek, Hulleman, & Hyde, 2012). We probed

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whether the intervention was equally effective for boys and girls depending on their prior performance in mathematics and science courses and what factors mediated the effect of the intervention on students' STEM course-taking.

Theoretical Framework

Numerous theoretical models have been proposed to help explain student motivation and persistence in academics. One comprehensive model is Eccles's expectancy-value theory (Eccles-Parsons et al., 1983), which frames the research reported here. The expectancy-value model holds that expectations for success (expectancy) and perceived task value are direct predictors of achievement and achievement choices (e.g., Eccles-Parsons et al., 1983; Simpkins, Davis-Kean, & Eccles, 2006; Updegraff, Eccles, Barber, & O'Brien, 1996). In Eccles's model, expectancy for success is defined as how well an individual thinks he or she will do on an ensuing task (Eccles-Parsons et al., 1983). Task value consists of attainment value (how a task is related to one's identity), intrinsic value (enjoyment of the task), utility value (perceived usefulness of a task), and cost (costs to the individual of task engagement, such as what one concedes by choosing one task over others).

The expectancy-value model proposes that adolescents' perceived task values and expectations for success are the most proximal predictors of STEM-related achievement choices. Previous research supports this hypothesis, with students being more likely to choose to take mathematics and science courses when they have either high expectations for success or value for those courses or both (e.g., Eccles, Barber, Updegraff, & O'Brien, 1998; Simpkins et al., 2006; Updegraff et al., 1996; Watt, 2005; Watt, Eccles, & Durik, 2006). In addition, both expectancies and values predict classroom performance (e.g., Hulleman, Durik, Schweigert, & Harackiewicz, 2008; Watt, 2005).

Parents' Influence on Values and Expectancies

The expectancy-value model proposes that, more distally, key socializers, such as parents, play an important role in shaping adolescents' values. Previous research has found that parents' values and expectancies for success for their child are linked to adolescents' values in a variety of domains, including mathematics and science (Jodl, Michael, Malanchuk, Eccles, & Sameroff, 2001; Simpkins, Fredericks, & Eccles, 2012). Much of this research has concentrated on adolescents and their achievement motivation in STEM courses throughout middle school and high school (Riegle-Crumb & King, 2010; Watt et al., 2012). Parents' values for mathematics and science are associated with adolescents' values in mathematics and science, which, subsequently, are associated with adolescents' educational choices and outcomes (Jodl et al., 2001; Simpkins et al., 2012).

Parents' expectancies for their adolescents have also been associated with their adolescents' expectancies for success in mathematics and science and educational outcomes, and these associations are even stronger than the associations between parents' values and adolescents' outcomes (Bleeker & Jacobs, 2004; Frome & Eccles, 1998; Jacobs & Eccles, 1992; Yee & Eccles, 1988). For instance, if parents have high expectancies for their adolescents in STEM, they are more likely to have adolescents with high expectancies

and better educational outcomes in STEM courses. If parents have low expectancies, they are more likely to have adolescents with low expectancies and worse educational outcomes in STEM (Jacobs & Eccles, 1992). However, studies involving the associations between parents' and adolescents' expectations and values are typically correlational in nature and thus are unable to test for a causal effect of parents' values and expectations on adolescents' values and expectations.

Whereas multiple studies have focused on the role of parental support—such as involvement and support for autonomy—in relation to children's school outcomes (Grolnick & Ryan, 1989; Grolnick, Ryan, & Deci, 1991; Ratelle, Larose, Guay, & Sénécal, 2005; Spera, 2005), here we focus on parents' values for their child's education. Such values may be a key resource that educators can leverage to enhance student outcomes, such as STEM course-taking (Harackiewicz et al., 2012). From a process perspective, it is important to understand how parents' values are transmitted to children. Some researchers have examined the specific parental behaviors that contribute to value transmission from parents to adolescents, such as encouragement, provision of educational and other materials, and coactivity (e.g., Simpkins et al., 2012). However, parental behaviors are not the only means of value transmission. Because students' perceptions are featured heavily in the expectancy-value model, it is important to examine whether adolescents are even aware of their parents' values. If adolescents are unaware of their parents' utility-value beliefs, parents' values may have smaller effects on their adolescents' attitudes and behaviors. Such perceptions could serve as an important indicator that parental values are being communicated (Paulson & Sputa, 1996; Spera, 2006; Wood, Kurtz-Costes, & Copping, 2011).

Gender Differences in Expectancies and Values

Two aspects of Eccles's model have been hypothesized to show gender differences that, in turn, may explain differences in STEM achievement: gender differences in expectancies and gender differences in values (e.g., Eccles, Wigfield, Harold, & Blumenfeld, 1993; Updegraff et al., 1996). Compared with boys, girls have lower expectancies for success in STEM domains (Yee & Eccles, 1988). This difference predicts increased enrollment in these courses for boys (Watt et al., 2012). Gender differences in expectancies for success can be influenced by socializers, especially parents. Research indicates that parents can have exaggerated expectancies for success in mathematics and science for their sons and diminished expectancies for success for their daughters (Eccles et al., 1993; Yee & Eccles, 1988).

The amount of value that boys and girls place on mathematics and science as well as the number of valued domains may influence gender differences in STEM achievement choices as well. The results are mixed on whether boys and girls differ in how much they value STEM domains, with many studies showing no gender differences in levels of STEM value (Eccles, 2009). However, there are gender differences in the number of valued domains, suggesting that women place high value on more domains (including non-STEM domains) than men do, which can lead to even high levels of STEM value being relatively less important for women (Eccles, 2007; Eccles, Barber, & Jozefowicz, 1999; Thoman, Arizaga, Smith, Story, & Soncuya, 2013). Additionally,

women, compared with men, tend to believe it is more important to make occupational sacrifices for the family and to have a job that helps people, which is one of the strongest predictors for women not pursuing STEM careers (Eccles, 2007). Men, however, are more likely to value making money and having a successful career. This difference may be especially crucial for talented girls, because they are caught between their beliefs in gender stereotypes on the one hand and their accomplishments in mathematics and science courses on the other (Eccles, 2007). Thus, high-achieving girls may shy away from enrolling in challenging STEM courses because of their belief in cultural stereotypes. Parents and other socializers, whose values are influenced by cultural stereotypes, may transmit these stereotyped beliefs to their adolescents.

Utility-Value Interventions

Recent studies have focused on understanding the particular role of utility value (UV) in achievement behaviors (Durik & Harackiewicz, 2007; Hulleman et al., 2008; Hulleman, Godes, Hendricks, & Harackiewicz, 2010; Hulleman & Harackiewicz, 2009; Kauffman & Husman, 2004; Shechter, Durik, Miyamoto, & Harackiewicz, 2011). For example, Hulleman et al. (2008) found that students' perceptions of utility value predicted achievement in both a college classroom and a high school sports camp. In another study, students who had higher utility value for their studies persisted longer and performed better than those who had lower levels (Vansteenkiste, Simons, Lens, Sheldon, & Deci, 2004).

On the basis of this correlational research, researchers have recently begun to manipulate utility value with interventions in the lab, classroom, and home (Acee & Weinstein, 2010; Durik & Harackiewicz, 2007; Harackiewicz et al., 2012; Hulleman et al., 2010; Hulleman & Harackiewicz, 2009). They have targeted utility value in particular because it is likely that perceptions of utility value can be changed with interventions. Attainment and intrinsic values are more intrinsic and therefore would be difficult for an outside entity to manipulate. Utility value, in contrast, should be amenable to change by an intervention. Studies have found that these utility value interventions cause an increase in interest and performance in the subject, including STEM topics (Durik & Harackiewicz, 2007; Hulleman et al., 2010; Hulleman & Harackiewicz, 2009; Shechter et al., 2011). Although these UV interventions have had positive effects on motivation, these effects have typically been moderated by past performance or expectations for success, which is consistent with expectancy-value theory (Nagengast et al., 2011; Trautwein et al., 2012). Individuals with high expectations for success responded most positively when told why a topic was relevant to their lives (e.g., Durik & Harackiewicz, 2007), whereas individuals with low expectations for success showed no positive response or responded negatively when given relevance (UV) information (for a review, see Durik, Hulleman, & Harackiewicz, 2013). These results suggest that it is critically important to consider the role of expectations and past performance in studies involving utility-value interventions.

Indirect Utility-Value Interventions

Based on the documented potential of UV information to promote motivation for many individuals and the associations between parents' values and their adolescent's values in correlational

research, we implemented a utility-value intervention aimed at parents (Harackiewicz et al., 2012). The ultimate goal of this intervention was to increase adolescents' STEM UV and STEM course-taking in high school. Previous research had not used randomized experiments to test the influence of parents on adolescents' utility value and achievement choices, but this study was able to evaluate the role of parents by randomly assigning them to an experimental UV intervention versus control condition. In the experimental condition, parents in an ongoing longitudinal study were given information about the relevance or usefulness (utility value) of mathematics and science for their adolescent. Parents in the control group received no information.

The results indicated that adolescents whose parents were in the intervention group took almost a semester more of mathematics and science classes during the last 2 years of high school than those whose parents were in the control group. These results indicated that parents can play a crucial role in increasing important adolescent achievement choices, such as advanced STEM course-taking. Although this intervention was effective for adolescents on average, it is important to consider the possibility that this intervention effect may vary as a function of gender and past performance, as has been observed in previous studies. It is also important to examine how this intervention worked to influence adolescents' course-taking.

The Current Study

This study goes beyond our previous evaluation of the utility-value intervention described above, to investigate for whom the intervention worked best and how it worked. The first research question asked whether gender and past performance (i.e., 9th-grade math and science grade point average) moderated the effects of the intervention. Previously, we found a main effect of the intervention on course-taking in the last 2 years of high school; later we coded past performance from high-school transcripts to use as a proxy for expectancies to test for an expectancy (prior performance) by value (intervention) interaction. Given the underrepresentation of women in many STEM fields (Halpern et al., 2007) and previously documented gender differences in expectancies and values in the STEM domain, we tested both gender and past performance as moderators of the intervention effect. Although in an earlier paper we reported that the intervention effect did not differ as a function of gender (Harackiewicz et al., 2012), we hypothesized that gender differences might emerge once we considered students' past performance. We therefore tested for an interaction among the intervention, gender, and past performance in STEM classes.

Using a mediation model, the second research question asked what mechanisms accounted for the effect of the intervention on students' course-taking (see Figure 1 for the theoretical model). We hypothesized that the intervention would lead to increased STEM UV for parents, which we assessed with questionnaires given to mothers of the adolescents. This increase in mothers' STEM UV was then predicted to be associated with an increase in adolescents' perceptions of parents' STEM values and adolescents' STEM UV. To provide the strongest test of mediation, we capitalized on the longitudinal design of the original study. The outcome variable was 12th-grade STEM course-taking. Mothers' perceived STEM UV, adolescents' perceptions of parents' STEM

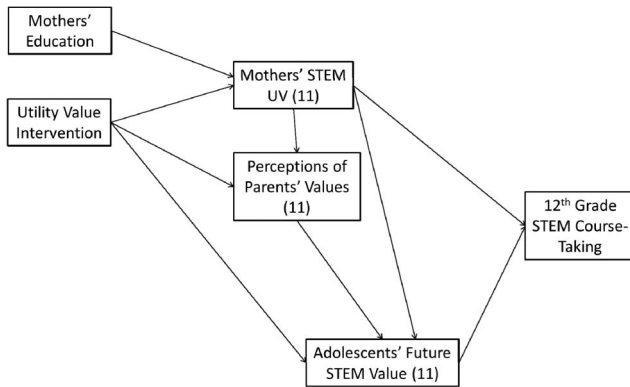


Figure 1. Theoretical model. STEM = science, technology, engineering, and mathematics; UV = utility value.

values, and adolescents' perceived STEM utility value were measured in the summer after 11th grade and therefore could be tested as mediators in the analyses of the effects of the intervention (which occurred during 10th and 11th grades) on 12th-grade STEM course-taking. These variables were predicted to mediate the effect of the intervention on 12th-grade STEM course-taking.

Method

Participants

The sample comprised families participating in the longitudinal Wisconsin Study of Families and Work (WSFW; for details on recruitment, see Hyde, Klein, Essex, & Clark, 1995). The current sample consisted of 188 adolescents (88 girls, 100 boys) and their parents who participated in a randomized experiment during high school (Harackiewicz et al., 2012). With regard to ethnicity, 90% of the adolescents were White (not of Hispanic origin), 2% were African American, 1% were Native American, and 7% were biracial or multiracial; this distribution is characteristic of the state of recruitment, in which 90% of the population is White (U.S. Census Bureau, 2006). At the time of data collection, participants attended 108 different high schools, increasing the generalizability of the findings. In 2010, the majority of adolescents (98%) had graduated from high school, and 94% reported plans to attend college or technical school. Average parents' years of education was 15.42 years ($SD = 1.92$) on a scale where 12 years is equivalent to high school graduation or GED completion.

Experimental Procedure

The intervention was implemented in October 2007 (10th grade) and again in January 2009 (11th grade). Families were followed through the teens' graduation from high school in June 2010. Families were randomly assigned to one of two experimental conditions and were blocked on gender of teen and mothers' educational level. Of these 188 families, 83 were in the experimental group and 105 were in the control group.

The intervention materials (two brochures and a website) were delivered exclusively to parents and focused on the usefulness of mathematics and science for adolescents. In particular, these ma-

terials explored potential connections between mathematics and science and current and future goals of adolescents (Harackiewicz et al., 2012). A first brochure, titled "Making Connections: Helping Your Teen Find Value in School," was sent to each household, addressed to the parents, in October of 10th grade. A second brochure, titled "Making Connections: Helping Your Teen with the Choices Ahead," was sent to each parent separately in January of 11th grade. This mailing included a letter giving them access to a dedicated, password-protected website called "Choices Ahead." Additionally, in the spring of 11th grade, parents in the experimental group were asked to complete an online questionnaire to evaluate the Choices Ahead website, which resulted in more parents visiting the website. A high percentage of parents (86%) reported using these resources, and a high percentage of adolescents (75%) reported exposure to this information. Parents in the control group did not receive any of these materials.

The 10th-grade brochure provided information about the importance or usefulness of mathematics and science in daily life and for various careers; it also provided parents with information about how to talk with adolescents about these issues. The 11th-grade brochure focused on these same themes but with different examples, and it gave greater emphasis to everyday activities (e.g., video games, cell phones) and preparation for college and careers. The 11th-grade brochure provided additional information for parents about communicating with their children about these issues and personalizing the relevance of mathematics and science for their 11th grader. The website featured clickable links to resources about STEM fields and careers. It also presented interviews with current college students who explained the usefulness of the mathematics and science courses that they had taken in high school. Parents were able to e-mail specific links from the site to their teens.

Measures

STEM courses taken in 12th grade and prior performance.

Transcripts were obtained for 181 of the 188 students in the sample and came from 108 different high schools. Receipt of transcripts did not vary due to experimental condition or gender. The remaining sample of 181 families included 47 girls and 53 boys in the control group and 39 girls and 42 boys in the intervention group. For the outcome measure, we coded transcripts for the number of semesters of mathematics and science taken during 12th grade (12th-grade STEM course-taking). (Note that Harackiewicz et al. (2012) used number of mathematics and science courses taken in 11th and 12th grades as the outcome variable. Here we used just the number taken in 12th grade, so that a mediation model could be tested with mediators measured in 11th grade.)

For the measure of prior STEM performance, we created a standardized measure of ninth-grade STEM grade point average (GPA) by individually calculating each adolescent's GPA for mathematics and science courses taken in ninth grade on a GPA scale that ranged from 0 (F) to 4.0 (A/A+). The scale distinguished between grades by one third of a grade point (e.g., A = 4.0, A- = 3.67, B+ = 3.33). The final measure was a weighted, cumulative STEM GPA from ninth grade that took into account

the number of credits each course counted to weight the course grade.

Mother's STEM utility value, adolescent's perceptions of parents' values, and adolescents' future STEM value. Questionnaires given to mothers and adolescents in the summer after 11th grade included one measure from mothers (mothers' STEM UV for their adolescent) and two adolescent measures (perceptions of parents' STEM values and adolescents' STEM value). Response rates on the questionnaires were 83% for mothers and 77% for adolescents. All measures were based on items developed by Eccles and colleagues (e.g., Eccles & Wigfield, 2002; Eccles-Parsons et al., 1983). Mothers' STEM UV was measured with four items that asked about the mother's perceptions of the utility value of mathematics and science for her adolescent (e.g., *In general, how useful will [biology] be for your teen in the future?* $\alpha = .79$). This question was asked about four STEM topics: biology, mathematics, chemistry, and physics. Responses were on a scale from 1 (*not at all useful*) to 5 (*very useful*). Fathers also reported on STEM UV for their adolescent. However, the response rate for fathers at 11th grade was only 62%, creating substantial missing data. Therefore, we used only the variable from mothers.

For adolescents' perceptions of parents' values, adolescents rated how important their parents thought mathematics and science would be in their lives with two items (e.g., *My parents think math and science are important for my life*; $\alpha = .78$). Adolescents' perception of the value of mathematics and science for their future (future STEM value) was measured with four items that focused on the current and future value of mathematics and science for themselves (e.g., *Math and science are important for my future*; $\alpha = .79$). Adolescent measures were rated on a scale from 1 (*strongly disagree*) to 7 scale (*strongly agree*).

Parents' education. In the current sample ($N = 181$), mothers averaged 15.42 years of education ($SD = 2.10$), and fathers also averaged 15.42 years of education ($SD = 2.41$). A variable of parents' average years of education ($M = 15.42$, $SD = 1.92$) was created by averaging these two variables ($r = .44$). In this paper, we use mothers' education for analyses involving mother variables and parents' education for analyses not involving mothers' reports.

Overview of Analyses

We used multiple regression followed by structural equation modeling to analyze these data in two stages. First, multiple regression was used to investigate the direct effects of the predictors on 12th-grade STEM courses taken, which was the primary outcome variable. Second, a structural equation model was estimated based on the theoretical model (see Figure 1) to examine the relationships among the predictors, mediators (mothers' UV, perceptions of parents' values, and adolescents' future STEM value), and the outcome in a single model. In this model, we tested whether the total indirect effect of the predictors on the outcome through the mediators was significant (Preacher & Hayes, 2008). Cases with missing data were included by using full information maximum likelihood methods (Arbuckle, 1996).

There were seven predictors involving the intervention and the moderators of the intervention (*base predictors*): the intervention (coded as 1 for intervention group and -1 for control group), adolescent's gender (coded 1 for boys and -1 for girls), ninth-

grade STEM GPA (measured continuously and standardized), and two- and three-way interactions (the interaction of the intervention by adolescent's gender, the interaction between the intervention and ninth-grade STEM GPA, the interaction between adolescent's gender and ninth-grade STEM GPA, and the three-way interaction among the intervention, adolescent's gender, and ninth-grade STEM GPA). Finally, we included a term to test parental education.

Results

Zero-order correlations and descriptive statistics for all variables are shown in Table 1, separately by adolescent's gender.

Multiple Regression Model of Direct Effects on Course-Taking

To address the first research question, we regressed 12th-grade STEM courses taken on the base predictors and parents' education.¹ For 12th-grade STEM courses taken, there was one significant effect: the three-way interaction among the intervention, adolescent's gender, and ninth-grade STEM GPA ($\zeta = -2.44$, $p < .05$, $\beta = -.18$).² In contrast to the main effect of the intervention reported by Harackiewicz et al. (2012), the pattern of the three-way interaction (see Figure 2) suggests that, when prior performance and gender are taken into consideration, the intervention increased course-taking for low-GPA boys ($\beta = .27$, $p < .05$) and high-GPA girls ($\beta = .22$, $p < .10$), whereas the intervention did not help low-GPA girls ($\beta = -.20$, trend toward a negative effect of the intervention) and had no effect on high-GPA boys ($\beta = -.04$). The graph of the three-way interaction in Figure 2, as for all interaction graphs in this paper, follows the convention of graphing high values at 1 SD above the mean of GPA and low values at 1 SD below the mean (Aiken & West, 1991).

Structural Equation Model

To address the second research question, we used structural equation modeling in Mplus to test whether the direct effect of the intervention (as moderated by gender and prior STEM performance) on 12th-grade STEM course-taking was mediated by indirect effects through the mediators. In the model (see Figure 1), we estimated paths from the base predictors (the intervention, gender, prior STEM performance, and their interactions) to mothers' STEM UV, perceptions of parents' values, and adolescents' future STEM value. To be consistent with previous analyses (Harackiewicz et al., 2012), we also included mothers' years of education as a predictor of mothers' STEM UV and of STEM course-taking. In accordance with the theoretical model, mothers' STEM

¹ The results remain the same if mothers' education is substituted for parents' education here. The three-way interaction is still the only significant predictor ($\zeta = -2.39$, $p < .05$, $\beta = -.18$).

² These regression analyses were repeated with STEM course-taking in 11th and 12th grades as the outcome measure, the one used in the Harackiewicz et al. (2012) paper. The results were the same, that is the three-way interaction among intervention, gender, and prior performance significantly predicted 11th- plus 12th-grade STEM course-taking. We report results in detail here only for the 12th-grade course-taking outcome, to preserve the temporal sequence for mediation analyses.

Table 1
Zero-Order Correlations and Descriptive Statistics for Major Variables by Gender

Variable	1	2	3	4	5	6	7
1. Ninth-grade STEM GPA	—	0.34**	0.36**	0.26*	0.26*	0.24*	0.18
2. Mothers' STEM UV	0.21	—	0.54**	0.39**	0.27*	0.30*	0.27*
3. Adolescents' future STEM UV	0.40**	0.52**	—	0.55**	0.34**	0.28*	0.15
4. Perceptions of parents' values	0.37**	0.39**	0.61**	—	0.15	0.25*	0.16
5. STEM courses (12th grade)	0.16	0.34**	0.36**	0.18	—	0.11	0.04
6. Parents' education	0.42**	0.15	0.10	0.17	0.26*	—	0.79**
7. Mothers' education	0.42**	0.27*	0.26*	0.34*	0.21	0.86**	—
Girls, <i>M</i> (<i>SD</i>)	3.15 (0.84)	4.08 (0.79)	5.23 (1.43)	5.75 (1.06)	3.77 (1.71)	15.35 (2.09)	15.41 (2.33)
Boys, <i>M</i> (<i>SD</i>)	2.92 (0.88)	4.11 (0.81)	5.03 (1.63)	5.62 (1.26)	3.45 (1.85)	15.48 (1.76)	15.43 (1.88)

Note. Correlations above the diagonal are for boys. Correlations below the diagonal are for girls. There were no mean differences due to gender. STEM = science, technology, engineering, and mathematics; GPA = grade point average; UV = utility value.

* $p < .05$. ** $p < .01$.

UV was an additional predictor of perceptions of parents' values and adolescents' future STEM value. Furthermore, perception of parents' values was a predictor of adolescents' future STEM value. Additionally, paths were estimated from the base predictors, mothers' STEM UV, and adolescents' future STEM value to 12th-grade STEM courses taken. Thus, by examining the indirect effects of the base predictors through the mediators to STEM course-taking, this model tested whether the intervention, as moderated by GPA and adolescent's gender, influenced STEM course-taking through mothers' STEM UV, adolescents' perceptions of parents' values, and adolescents' future STEM value. Because this is a saturated model, it does not allow for a meaningful test of model fit.

Overall, the model accounted for 16.8% of the variance in 12th-grade STEM course-taking, 13.9% of the variance in mothers' STEM UV, 26.7% of the variance in perceptions of parents' values, and 50.8% of the variance in adolescents' future STEM value. See Figure 3 for the path models showing these results.

Effects on mothers' STEM UV. The base predictors and years of mothers' education were used to predict mothers' STEM

UV. There was a nearly significant effect of ninth-grade STEM GPA ($z = 1.94, p = .06, \beta = .17$) showing a trend for mothers to perceive more STEM utility value when their adolescent had a higher ninth-grade STEM GPA. In addition, the predicted three-way interaction among the intervention, adolescent's gender, and ninth-grade STEM GPA was significant ($z = -1.96, p = .05, \beta = -.16$); it is graphed in Panel A of Figure 4. The pattern of this interaction effect is similar to the one for the course-taking outcome in the multiple regression analysis (see Figure 2). Finally, mothers' education was a significant predictor of mothers' STEM UV ($z = 2.32, p < .05, \beta = .20$), such that mothers with more years of education showed higher levels of STEM UV.³

Effects on perceptions of parents' values. The base predictors and mothers' STEM UV were used to predict adolescents' perceptions of parents' values. There were significant effects of ninth-grade STEM GPA ($z = 2.64, p < .05, \beta = .23$), such that parents were perceived as seeing the value of STEM course-taking more when the adolescent had a higher STEM GPA. The two-way interaction between adolescent's gender and the intervention was significant ($z = 2.41, p < .05, \beta = .19$), suggesting that the intervention increased boys' perceptions of parents' values and decreased girls' perceptions of parents' values; however, this two-way interaction was qualified by the three-way interaction among the intervention, adolescent's gender, and ninth-grade STEM GPA, which was nearly significant ($z = -1.89, p = .06, \beta = -.17$). The pattern of the interaction is similar to the one for course-taking; in particular, the intervention appeared to decrease low-GPA girls' perceptions of their parents' values for them (see Figure 3, Panel A, and Figure 4, Panel B). That is, low-GPA girls in the intervention group perceived a lack of support for STEM from their parents. Finally, mothers' STEM UV was a significant predictor of adolescents' perceptions of parents' values ($z = 3.70, p < .01, \beta = .29$), such that mothers with higher levels of STEM UV tended to have adolescents with higher levels of perceptions of parents' values.

Effects on adolescents' future STEM value. The base predictors, mothers' STEM UV, and perceptions of parents' values

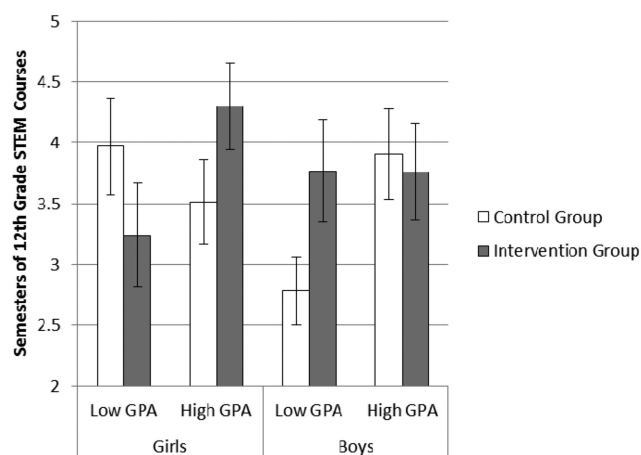
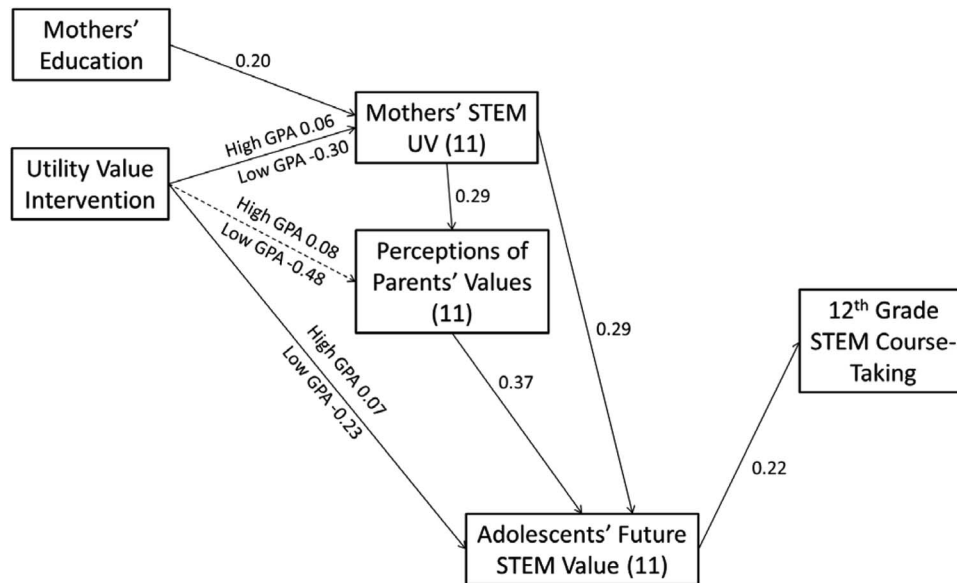


Figure 2. Direct effects of the intervention, adolescent's gender, and ninth-grade STEM GPA on STEM course-taking (12th grade). Predicted values were generated for high (1 *SD* above the mean) and low (−1 *SD*) ninth-grade STEM GPA from the multiple regression models. Error bars represent ± 1 *SEM*. STEM = science, technology, engineering, and mathematics; GPA = grade point average; *SEM* = standard error of the mean.

³ The model was also tested using parents' education instead of mothers' education, and the results for the overall model did not change; however, parents' education was a nonsignificant predictor of mothers' STEM UV ($z = 1.77, p > .05, \beta = .15$).

A. Intervention Effects for Girls



B. Intervention Effects for Boys

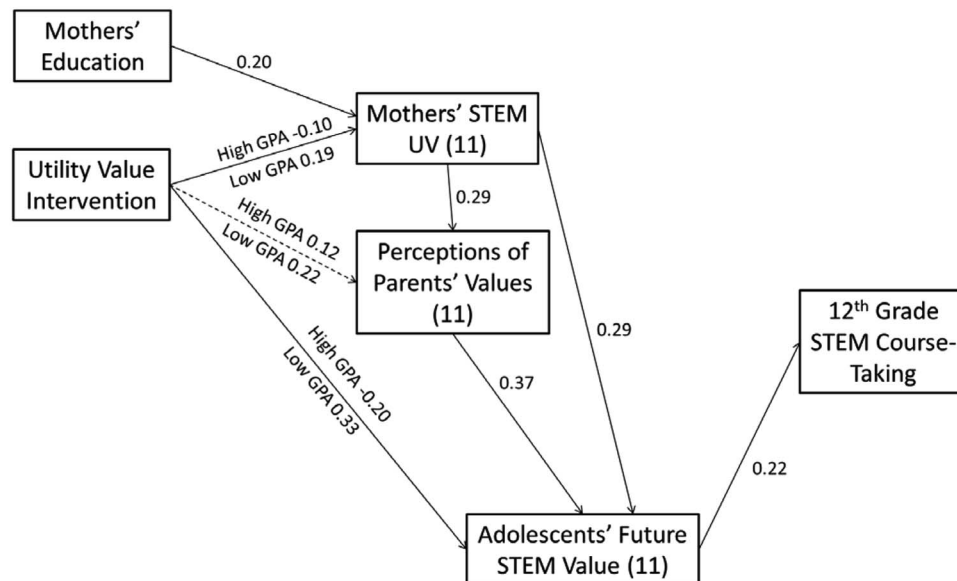


Figure 3. Empirical path model. Only significant paths are shown. The effect of the intervention on STEM course-taking in 12th grade differs by gender and ninth-grade STEM GPA and is mediated by mother's utility value (UV), perceptions of parents' values, and adolescents' future STEM value. The different intervention effects are shown (A) for girls and (B) for boys. Dashed line indicates $p = .06$ (the three-way interaction involving the intervention to perceptions of parents' values). STEM = science, technology, engineering, and mathematics; GPA = grade point average.

were used to predict adolescents' future STEM value (see Figure 3). The three-way interaction among the intervention, adolescent's gender, and ninth-grade STEM GPA was significant, as predicted ($z = -2.85, p < .05, \beta = -.21$). The three-way interaction is shown in Panel C of Figure 4; the pattern of the interaction is also

similar to the one for STEM course-taking and suggests that the intervention increased adolescents' future STEM value particularly for low-GPA boys. The effect of mothers' STEM UV was significant ($z = 4.35, p < .01, \beta = .29$); higher levels of mothers' STEM UV predicted higher levels of adolescents' future STEM

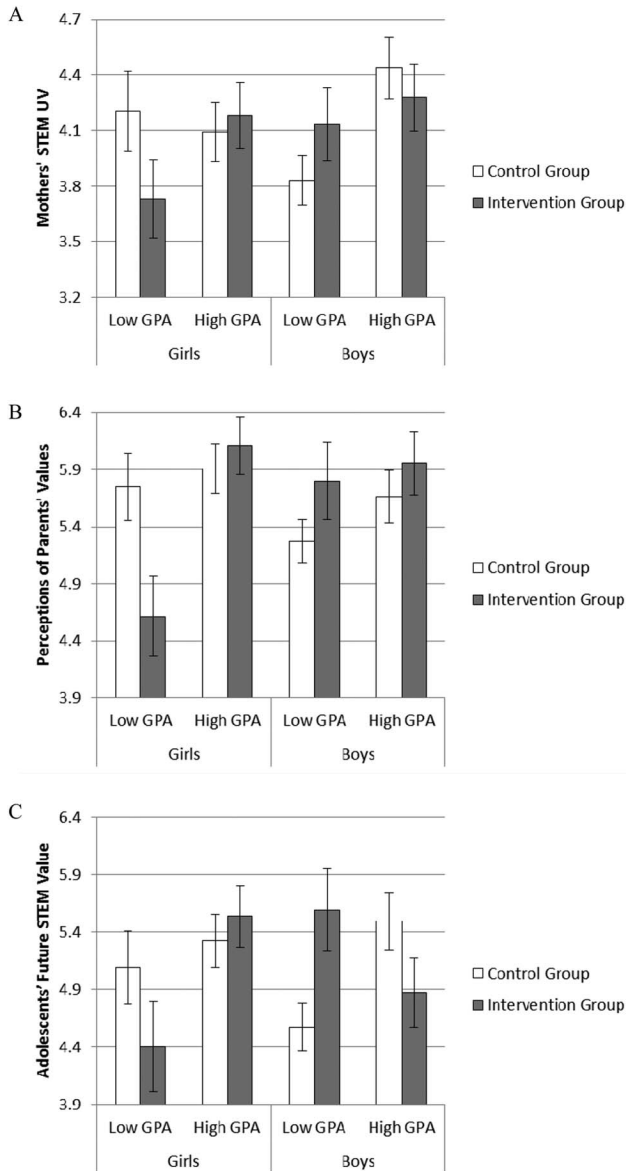


Figure 4. Direct effects of the intervention, child gender, and ninth-grade STEM GPA on the hypothesized mediators: (A) mothers' STEM UV, (B) perceptions of parents' values, and (C) adolescents' STEM utility value. Predicted values were generated for high (1 *SD* above the mean) and low (−1 *SD*) ninth-grade STEM GPA from the multiple regression models. For (A) the range of possible values is 1 to 5. For (B and C) the range of possible values is 1 to 7. Error bars represent ± 1 *SEM*. STEM = science, technology, engineering, and mathematics; GPA = grade point average; UV = utility value; *SEM* = standard error of the mean.

value. Perceptions of parents' values was a significant predictor as well ($z = 5.36, p < .01, \beta = .37$); higher levels of perceptions of parents' values predicted higher levels of adolescents' future STEM value.

Effects on 12th-grade STEM course-taking. The base predictors, mothers' STEM UV, adolescents' future STEM value, and mothers' years of education were used to predict 12th-grade STEM course-taking.⁴ There was a significant effect of adoles-

cents' future STEM UV ($z = 2.18, p < .05, \beta = .22$). Higher levels of adolescents' future STEM value predicted more 12th-grade STEM courses taken, for both boys and girls.

Indirect effects and mediation. In the structural equation model, we hypothesized that the base predictors (specifically the three-way interaction) would influence 12th-grade STEM course-taking through the mediators, so the direct effects of the base predictors to 12th-grade STEM course-taking shown in the direct effects model should be reduced in a model containing the mediators; additionally, there should be significant indirect effects of the three-way interaction through the mediators to 12th-grade STEM course-taking. We hypothesized that the mediation would work in a specific way; that is, the three-way interaction should predict mothers' STEM UV, perceptions of parents' values, and adolescents' future STEM UV. Mothers' STEM UV should predict perceptions of parents' values and adolescents' future STEM UV, and perceptions of parents' values should predict adolescents' future STEM UV. Additionally, we specified that mothers' STEM UV and adolescents' future STEM value would predict STEM course-taking. Using procedures described by Preacher and Hayes (2008), we tested the total indirect effect of the intervention through the three mediators, as well as the specific indirect effect of mothers' STEM UV through adolescents' perceptions of parents' values and adolescents' future STEM UV.

Therefore, two indirect pathways were tested in order to test for the indirect effect of the three-way interaction on 12th-grade STEM course-taking as well as the indirect effect of mothers' STEM UV on 12th-grade STEM course-taking. For the first, we tested whether the three-way interaction had a significant total indirect effect on 12th-grade STEM course-taking through the three mediators and found support for this hypothesis ($z = -2.40, p < .05$). Therefore, the intervention, as moderated by adolescent's gender and ninth-grade STEM GPA, had a significant total indirect effect on course-taking through the mediating variables: mothers' STEM UV, perceptions of parents' values, and adolescents' future STEM value. Additionally, the model with the mediators reduced the direct effects of the predicted three-way interaction on 12th-grade STEM course-taking (direct effect, $\beta = -0.18, p < .05$; with mediators in the model, $\beta = -0.09, ns$).

For the second, we tested for the specific indirect effect of mothers' STEM UV to 12th-grade STEM course-taking through perceptions of parents' values and adolescents' future STEM value. Results indicated a significant specific indirect effect ($z = 2.06, p < .05$). This indicated that mothers' STEM UV had a significant specific indirect effect on 12th-grade STEM course-taking through perceptions of parents' values and adolescents' future STEM value.

Discussion

To address concerns about low rates of adolescents taking advanced STEM courses in high school in the United States, we implemented an intervention, based in expectancy-value theory, with parents of adolescents (Harackiewicz et al., 2012). In the results reported here, we examined whether the intervention was differentially effective for girls compared with boys in the context

⁴ The analyses were repeated using parents' education instead of mothers' education. Findings remained unchanged.

of past performance and what factors mediated the effects of the intervention on course-taking. In response to the first research question, the results from multiple regression analysis indicated that the intervention increased STEM course-taking in 12th grade for girls who had done well in ninth-grade STEM courses (high GPA) and for boys who had not done well (low GPA). However, the intervention did not increase course-taking for low-GPA girls (trending toward a negative effect), and it had no effect for high-GPA boys. The absence of an effect for high-GPA boys is most likely due to a ceiling effect on the measure of number of STEM courses taken in 12th grade.

In regard to the second research question, mediation analyses suggested that these intervention effects (specifically the three-way interaction among the intervention, gender, and prior STEM performance) occurred through changes in both mother and adolescent variables. The intervention was targeted exclusively at parents, so we predicted and found that the intervention increased mothers' STEM utility value for their adolescents. The intervention also led adolescents to perceive higher levels of parental STEM values and increased adolescents' future STEM value, and the changes in mothers' STEM utility value contributed to these changes in adolescent variables. Overall, the effect of the intervention on high-school STEM course-taking was mediated by the effects of the intervention on mothers' STEM utility value and adolescents' STEM utility value. This suggests that parents' utility value does indeed influence adolescents' utility value and achievement behavior.

Considerable support for Eccles's expectancy-value theory has been amassed through correlational and longitudinal research, but experimental support has been lacking. One strength of an experimental approach to this theory is that researchers can assess the causal effect of task values on achievement motivation and behavior. In particular, when studying families, an association has been shown between parents' beliefs and their children's beliefs and achievement-related behaviors (e.g., Chhin, Bleeker, & Jacobs, 2008), but the direction of the effect has been unclear. To explore whether parents' values could influence adolescents' values, we experimentally manipulated parents' utility value through a randomized intervention to assess the causal impact of parents' beliefs on their children's beliefs and behaviors (Harackiewicz et al., 2012). Although the original study showed that an increase in adolescents' STEM course-taking over the final 2 years of high school occurred as a result of this intervention, mediation analyses of this effect were not conducted.

Processes Underlying Intervention Effects

In the current paper, we examined the hypothesis that the intervention worked by changing parents' and adolescents' STEM utility value. We found support for this hypothesis. In our previous paper (Harackiewicz et al., 2012), the results indicated that the intervention affected mothers' STEM utility value, which provides crucial support that this utility value intervention for parents had its intended effect. In the current analyses, this increase in mothers' STEM utility value was related to an increase in adolescents' perceptions of how much their parents valued STEM for them and also adolescents' future STEM value. Thus, both mothers and adolescents had increased perceptions of STEM value due to the intervention. Because the intervention was targeted exclusively at

parents, it is reasonable to conclude that adolescents were influenced by their parents.

Two paths in Figure 3 warrant additional discussion. First, the direct path (specifically the three-way interaction among the intervention, gender, and prior STEM performance) from the intervention to adolescents' perceptions of their parents' values was significant, above and beyond the indirect path through mothers' STEM utility value. That is, the intervention appeared to have some effect on adolescents' perceptions beyond the effect it had on mothers' STEM UV for them. This might involve a process such as a mother sharing the intervention website with her adolescent while not expressing her beliefs in the value of STEM. Second, the direct path from mothers' STEM UV to adolescents' future STEM value was significant, beyond the indirect effect through adolescents' perceptions of their parents' values. This effect might involve some changes in mothers' behavior that are not consciously perceived by the adolescent but that nonetheless have an effect.

Moderation by Gender and Prior Performance

In this paper we also considered whether the intervention, which had an overall positive main effect on course-taking, might be differentially effective based on the adolescent's gender and prior STEM performance. The results indicated that, in fact, adolescents' prior STEM grades moderated the effect of the utility value intervention differently for girls and boys. The intervention had positive effects on STEM course-taking for low-GPA boys and high-GPA girls, but it had no effect (trending toward a negative effect) for low-GPA girls and had no effect for high-GPA boys.

Why were low-GPA girls not helped by the intervention when low-GPA boys were helped by it? The measure of prior performance, ninth-grade STEM GPA, should be linked tightly to both mothers' and adolescents' expectations for future success in STEM and has been used as a proxy for expectations in previous utility intervention research (Hulleman et al., 2010). Yet, research shows that parents are more likely to have inflated expectancies for success for boys in this domain in comparison to girls (Eccles, Jacobs, & Harold, 1990; Gunderson, Ramirez, Levine, & Beilock, 2012; Jacobs, Davis-Kean, Bleeker, Eccles, & Malanchuk, 2005; Yee & Eccles, 1988). Thus, parents may assess all boys as capable of success in STEM, even if they have had low grades in school. Therefore, even low-GPA boys may benefit from a utility-value intervention targeted at parents, because parents will still deem them capable of succeeding. Boys with higher prior STEM achievement did not benefit from the intervention, probably due to a ceiling effect in the number of semesters of mathematics and science taken during 12th grade. That is, their STEM course-taking was constrained by factors such as the number of class periods in the day and requirements that they take non-STEM courses. Positive effects of the intervention for high-GPA boys might be revealed in situations with fewer constraints (e.g., in college).

For girls, low STEM GPA may create low expectations for success—both for the girl and her mother—that negate the beneficial effects of the UV intervention; even if parents see the value of STEM, their low expectations for success for their low-GPA daughters mean that parents have low STEM aspirations for them, rendering the utility value of STEM irrelevant. These effects are consistent with the predicted effects in Eccles's expectancy-value theory. Moreover, they are consistent with past research showing

that UV interventions are less effective for those with low expectations for success (e.g., Durik & Harackiewicz, 2007).

In addition, girls and their mothers observe the unbalanced gender composition of many adult occupations (Ridgeway, 2011), which may contribute to the findings. Whereas girls with a high STEM GPA may aspire to traditionally masculine careers requiring substantial mathematics and science and be responsive to the intervention, girls with a low STEM GPA may see no reason to consider such aspirations and, simultaneously, may be drawn to traditionally feminine careers such as child-care worker (95% female, Bureau of Labor Statistics, 2011) or elementary- or middle-school teacher (82% female), which appear to require little mathematics and science (Beilock, Gunderson, Ramirez, & Levine, 2010). Moreover, if parents share these beliefs, they may not encourage their daughters to pursue STEM careers. This interpretation is supported by the relatively low level of parental valuing of STEM that low-GPA girls reported (see Figure 4, Panel B). On balance, then, girls with low prior STEM performance may have little interest in STEM courses and careers and receive little encouragement from parents, despite the intervention, while simultaneously experiencing a strong pull toward traditionally female careers that appear to require little mathematics and science and where they feel that they “belong” (Thoman et al., 2013).

It will be important for future interventions to take into account the role of expectancies in designing utility-value interventions that will be successful for all students. Recent research has shown that, although the interactive effects of expectancy and value are mixed, this interaction does occur in some studies (Nagengast et al., 2011; Trautwein et al., 2012). This intervention was in the STEM domain, so it is likely that both parents’ and adolescents’ expectancies would be affected not only by prior achievement but also by the adolescent’s gender. Future interventions may be strengthened by the inclusion of information that enhances not only perceptions of utility value but also expectations for success.

Limitations and Directions for Future Research

Several limitations should be kept in mind when interpreting these results. First, the sample was representative of the state of Wisconsin but not racially diverse, so future research should extend these findings to more diverse groups. Previous studies have shown that the effects of utility-value interventions are consistent across racial groups (Hulleman & Harackiewicz, 2009), suggesting that our results would extend to more diverse contexts. Additionally, although the sample size was sufficiently large to have the power to detect the intervention effects, future studies would benefit from scaling up the intervention to larger samples.

Second, although the utility-value intervention affected mothers’ and adolescents’ perceptions of utility value and adolescents’ course-taking behavior, we do not have measures of the precise interpersonal processes by which these increases in mothers’ utility value changed adolescents’ attitudes. Correlational research has shown that these effects may be explained through a variety of parental behaviors, such as modeling, encouragement, and coactivity (e.g., Simpkins et al., 2012). Future studies could also assess these behaviors to understand how parents’ perceptions of utility value result in behavioral change that affects their children. It is likely that parents use a variety of methods and behaviors to influence their children, so understanding which behaviors are

most effective will make an important contribution to future research. We believe that future studies may also benefit from using measures of adolescents’ perceptions of their parents’ values as we did here, because that measure can capture the effect of a variety of parental behaviors.

Third, this utility-value intervention (and much of the correlational research based on expectancy-value theory) was conducted within a specific domain, STEM. Therefore, we cannot assume that these intervention results would generalize to non-STEM domains, and future research should extend these findings to other domains. Previous research has shown that the relationships between utility value and achievement behavior do extend to non-STEM domains (e.g., Jodl et al., 2001), so the intervention effects should also generalize, but this will need to be tested in future studies.

Finally, although the utility-value intervention had effects that differed due to gender and prior achievement, it is important to recognize that, on average, this intervention had substantial positive effects on STEM course-taking (Harackiewicz et al., 2012). Future studies may modify this intervention to make it more effective, but it had generally positive effects on a key educational outcome needed to enhance STEM preparation. Therefore, we can recommend this intervention as having positive effects and also recommend taking into account expectancies for success to make it more effective in future research.

Implications

Several implications flow from these results. The findings indicate that parents are a resource—a largely untapped one—that may be used to enhance STEM motivation of adolescents. There is room to increase how much parents value STEM for their adolescents, and changes in parents’ utility value can affect adolescents’ beliefs and behavior. Therefore, parents—in addition to teachers and curriculum—may be used to increase students’ STEM preparation and motivation. Future utility-value interventions should also attend to issues of expectations for success, particularly in regard to gender gaps in STEM.

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