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Empirical Articles

It's not What You Think: Perceptions Regarding the Usefulness of Mathematics May Hinder Performance

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Abstract

The present study investigated the moderating effect of self-confidence in one's ability to learn mathematics on the relation between beliefs about its usefulness and performance. The study was conducted using a sample of college students from an urban college in the Eastern US (N = 306). Moderation was tested using hierarchical regressions as well as the Johnson-Neyman Technique. The results indicate that performance and beliefs about the usefulness of mathematics were not statistically related amongst individuals with high self-confidence, and negatively related for participants with low self-confidence. The findings suggest that teaching approaches aiming to improve student performance in mathematics by enhancing student beliefs about its usefulness, would likely be more effective if they primarily focused on increasing student self-confidence in their mathematics ability.

Keywords: performance in mathematics, perceived usefulness of mathematics, self-confidence in mathematics ability

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According to results from the latest report by the National Assessment of Educational Progress, performance in mathematics among college-ready students has remained low and stagnant for decades (U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics [NAEP], 2015). Not surprisingly, these underachievement patterns continue during the college years, and present many challenges for mathematics instructors. For many years, scholars have tried to understand underachievement in mathematics by examining aspects of the cognitive domain. Today, researchers of mathematics education and educational psychology agree that features of the affective domain are also crucial (Ashcraft & Rudig, 2012; Boaler, 2015).

In particular, scholars have examined student beliefs regarding their ability to learn mathematics, and how these beliefs influence their performance. The evidence unquestionably indicates a positive relation (Arikan, van de Vijver, & Yagmur, 2016; Ganley & Lubienski, 2016). Such perceptions regarding one's ability in mathematics have also been shown to correlate with beliefs about the usefulness of the subject (Lent, Lopez, & Bieschke, 1991). Thus, scholars have also considered the role of beliefs about the usefulness of mathematics on performance. Yet, the empirical evidence has presented mixed findings. Namely, researchers have found a positive (Marsh, Walker, & Debus, 1991), negative (Midgley, Feldlaufer, & Eccles, 1989; Sherman 1979) and spurious (Pajares & Miller, 1994) relation between perceived usefulness of mathematics and performance.

According to Fennema and Peterson (1985) such relation depends on the extent to which the individual believes he or she has control over the ability to learn the material, which has in turn been linked to self-confidence in ability (Garger, Thomas, & Jacques, 2010; Liping, 2007). Consequently, individuals with similar beliefs about the usefulness of mathematics could perform differently in the subject depending on the extent to which they feel confident in their mathematics ability. These statements suggest that self-confidence could act as a moderator in the relation between perceived usefulness of mathematics and performance. Such assertion has never been tested empirically. The purpose of this article is to present evidence of the moderating effect of self-confidence on the aforementioned relation.

Method

Data for this study were collected between the years 2015 and 2016. Participation was voluntary, and all questionnaires were completed in a research lab.

Participants and Procedure

Undergraduate students at 4-year public university in the Northeastern US, who at the time were taking at least one mathematics class, were recruited for this study. Students were asked to fill out a survey including demographic questions (e.g., gender, age, major, etc.) as well as items from psychometric scales measuring perceptions about the usefulness of mathematics in their lives, and self-confidence in their ability to learn mathematics. Participants were also asked to provide consent for the researcher to contact their course instructors at the end of the term to obtain their final course grades.

Respondents (N = 306) received extra credit (e.g., bonus points in an exam) for participating in this study. Respondents were between the ages of 18 and 43 (M = 21.70, SD = 4.26). The majority of respondents were male (62%), sophomore or above (80%), majoring in engineering (60%) and taking advanced mathematics such as calculus, differential equations or linear algebra (86%). This study and all associated procedures were approved by the Institutional Review Board of the university, and written informed consent was obtained from all participants.

Materials

Self-Confidence in Mathematics Ability and Perceived Usefulness of Mathematics

Participants completed the Confidence in Learning Mathematics, and the Mathematics Usefulness scales of the Fennema-Sherman Mathematics Attitudes Scales (FSMAS) (Fennema & Sherman, 1976) adapted for a college sample. While the Confidence scale measures a person's beliefs about their own ability to learn mathematics, the Usefulness scale measures a person's beliefs about the benefits of learning mathematics. Some sample items include "I am sure that I can learn mathematics" or "I'll need mathematics for my future work". Each scale contains 12 items measured on a 5-point Likert-scale (5 = *strongly agree* … 1 = *strongly disagree*). The FSMAS has been extensively used to gauge domain-specific perceptions toward learning mathematics, and its psychometric properties have been well documented using multiple populations. In other studies, Cronbach's alpha estimates for the measures used herein have ranged between .84 and .91 (Bringula, 2015; Ren, Green, & Smith, 2016). In this study, Cronbach's alpha estimates were .92 and .88 for the Confidence and Usefulness scales, respectively.

Student Performance

The outcome variable of interest was student performance in mathematics, which was measured on a numeric scale representing the students' average score in the class (e.g., 78%). Average scores were obtained at the end of the term from course instructors.

Results

Summary statistics for each scale, as well as Pearson and partial correlations are reported in Table 1. As shown, participants on average had performance scores, which generally translate to a letter grade of C or C+, and on average students reported moderately high levels of self-confidence and perceptions about mathematics being useful. Pearson correlations between the FSMAS scales as well as between the Confidence scale and performance were positive and significant, as expected.

Table 1

Correlations, Means and Standard Deviations for all Measures (N = 306)

Measure	1	2	r_p	*M*	*SD*
1. Class Performance	—			78.57	16.75
2. Self-Confidence scale	.22***	—	.29***	47.15	8.83
3. Usefulness scale	-.09	.42***	-.21***	50.95	7.61

Note. Pearson bi-variate correlations for all participants are presented below the diagonal. Partial correlations (r_p) between performance with each scale are presented in the third column. Means and standard deviations are presented in the last two columns. For Confidence and Usefulness scales higher scores imply higher self-confidence in mathematics ability and beliefs about mathematics as useful.
***p < .001.

Although the correlation between the Usefulness scale and performance was not significant, the partial correlation, controlling for the effect of self-confidence, was negative and significant as indicated in the third column of Table 1. This result suggests a moderating effect of self-confidence on the relation between performance and perceptions about the usefulness of mathematics.

The moderating effect of self-confidence was gauged using hierarchical regressions as suggested in the literature (Hayes, 2013). In particular, a two-stage hierarchical model was estimated. The first step included the Confidence and Usefulness scales, and the second step added their interaction. The regression models also included gender, as the literature suggests that gender differences, albeit small, may depend on the type of mathematics considered (Gherasim, Butnaru, & Mairean, 2013; Lindberg, Hyde, Petersen, & Linn, 2010). Table 2 presents the regression results.

Table 2

Hierarchical Regression Results (N = 306)

Step and predictor variable	*b*	*SE*(*b*)	β	*t*	ΔR^2	R^2
Step 1[a]					.10***	.10***
Male	-3.6	1.90	-.10	-1.89		
Self-Confidence	0.63***	0.12	.33	5.41		
Usefulness of Mathematics	-0.48***	0.15	-.22	-3.26		
Step 2[b]					.01*	.11***
Self-Confidence*Usefulness	0.02*	0.01	.83	3.66		

Note. *SE* = Robust standard error; *b* = unstandardized coefficients, β = standardized coefficients; $\Delta R^2 = R^2$ change. Females constituted the comparison group for gender. Continuous variables were mean-centered.

[a]$F(3, 302) = 11.46$. [b]$F(4, 301) = 9.35$ and ΔR^2 $F(1, 300) = 4.81$.

*$p < .05$. **$p < .01$. ***$p < .001$.

As shown, the first step of the regression confirmed the correlations presented in Table 1. Namely, the relation between performance and the Confidence scale, holding all else constant, was positive with a moderate effect size ($\eta_p^2 = .10$). In contrast, the relation between perceived usefulness of mathematics and performance, holding all else constant, was negative, but the effect size was small ($\eta_p^2 = .04$). A Wald test confirmed a significant difference between these estimates ($F(1, 4) = 20.33$, $p = .01$). No significant gender differences in performance were detected. Moderation was confirmed in the second step, as the interaction and the increment in R^2 were statistically significant.

For each regression, the assumption of normality of residuals was verified using cutoff values of 2 for skewness and 7 for kurtosis as suggested by West, Finch, and Curran (1995). Homoscedasticity for the error terms was tested using the Breusch-Pagan test for heteroskedasticity (Breusch & Pagan, 1979), but not confirmed. Therefore, robust standard errors were computed using the Huber-White sandwich estimator (Freedman, 2006). Finally, all variance inflation factors were below 2, indicating that multicollinearity did not cause estimation problems.

The Johnson-Neyman (J-N) technique (Hayes, 2013) estimated the relation between the mathematics Usefulness scale and performance, conditional on values of the Confidence scale, and identified the values of the Confidence scale where such relation was statistically significant (i.e., $p < .05$). Figure 1 plots the estimated effects obtained via the J-N technique. Specifically, Figure 1 shows the changes in the magnitude and significance of the relation between the Uselfulness scale and performance as a function of differences in self-confidence.

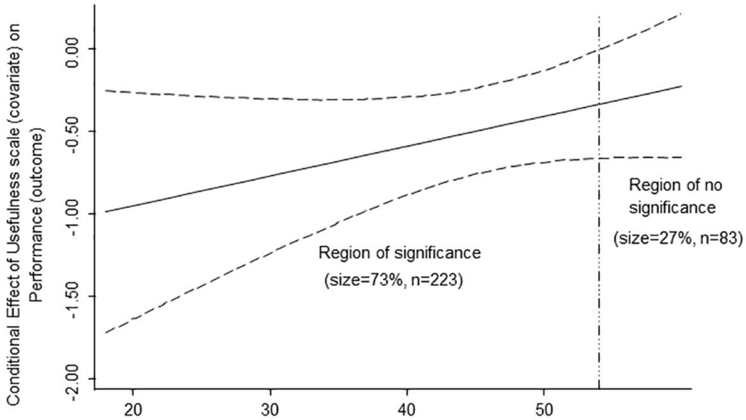

Figure 1. Johnson-Neyman calculated effects of perceptions about the usefulness of mathematics on performance moderated by self-confidence in mathematics ability.

Note. The dashed vertical line marks the region of significance for the effect of the usefulness scale (covariate) on performance (outcome) by scores of the self-confidence scale (moderator). The value of the self-confidence scale that demarcated the region of significance was 54. For self-confidence scores ≥ 54, the relation between the usefulness scale and performance was not statistically significant ($p \geq 0.5$). The dashed horizontal lines label the lower and upper 95% confidence bands.

According to Figure 1, the relation between the Usefulness scale and performance was negative and significant only among individuals with low self-confidence scores, and the negative effect decreased in magnitude with increments of the Confidence scale. For individuals with self-confidence scores of 54 or above (i.e., 0.78 *SD* above the mean), the effect was not significant at the 95% confidence level. The majority of respondents (73%) had self-confidence scores below 54 and thus, fell within the region of significance.

Discussion and Conclusion

This study analyzed the relation between perceptions about the usefulness of mathematics and performance, moderated by self-confidence in mathematics ability. Hierarchical regressions, followed by the Johnson-Neyman technique, were conducted using data from 306 undergraduate students at a 4-year college in the Northeastern US. The relation between performance and beliefs about the usefulness of mathematics was negative for individuals with low levels of self-confidence. For individuals with high levels of self-confidence, said relation was not significant. The effect sizes found were small, and the results may have been influenced by intricacies of the sample. Therefore, these analyses should be verified through replication in future studies. In addition, future studies should consider mathematics anxiety and motivation, two prevalent affective factors that are related to performance (Chang & Beilock, 2016; Wang et al., 2015) and not considered in this study.

The practical effect of this study however, is potentially large as it relates to the use of affective approaches to teaching mathematics. Mathematics instructors are often advised to highlight the usefulness of the material (Posamentier & Krulik, 2011). The results presented here suggest that teaching approaches aiming to improve student engagement and consequently math performance by highlighting the practicality of the material, should also consider improving student self-confidence in their ability. Otherwise, they may have unintended effects such as lower performance, or no changes in performance at all. Such emphasis is vital in the case of remedial courses where, due to past performance, student self-confidence is diminished (Ganley & Lubienski, 2016).

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Competing Interests

The author has declared that no competing interests exist.

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Ethics Approval

This study and all associated procedures were approved by the Institutional Review Board of the university, and written informed consent was obtained from all participants.

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