Does Math Confidence Matter? How Student Perceptions Create Barriers to Success in Economics Classes

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ABSTRACT

One of the most common obstacles in the economics classroom is facing students' disinclination to perform tasks requiring basic quantitative skills. Economics, relative to other disciplines, is particularly bridled by this challenge since mastery of economics requires sufficient mathematical proficiency to elicit anxiety and resistance in many students but is not widely regarded as math intensive enough to generate a selection effect of highly quantitative students. This paper attempts to measure undergraduate economics students' perceptions of their level of "mathiness" or mathematical abilities and anxieties and then identifies the impact of those perceptions on the students' performance in economics courses.

Introduction

At the graduate and professional levels, the field of economics is becoming increasingly quantitative. At the undergraduate level, introductory courses remain a staple in general education core curricula and enroll students of all mathematical levels. Despite its introductory nature, the basic mathematical principles of economics are still present in these courses. Thus, economics professors face a unique challenge: they are unable to avoid mathematical tools altogether as perhaps in humanities courses, nor are their students a self-selected quantitatively eager group as perhaps in STEM courses.

This dichotomy between the quantitative nature of the field and student attitudes often leads to complaints, unpreparedness, and anxiety on the part of the students. We postulate that lack of mathematical confidence is an important contributor to the occasionally negative classroom climate that arises in undergraduate economics and, perhaps, an explanatory variable for the gender gap in economics. Hence, we seek to determine if increased math confidence contributes to higher levels of economics classroom performance.

Previous work finds that perception of ability, even when not correlated with true ability, impacts confidence and success in academic settings (Everingham et al. 2013). It is important for professors who frequently encounter students with math anxiety to understand the role of mathematical confidence on performance. Understanding this role has pedagogical implications for all students, but might be especially helpful in shedding light on females' reluctance to participate in economics.

Economics education research thoroughly establishes a link between mathematical ability and performance in economics courses (Ballard and Johnson 2004; Elzinga and Melaugh 2009; Arnold and Straten 2012; Ullmer 2012) as well as gender asymmetries in economic inclination (Calkins and Welki 2006; Jensen and Owen 2001; Ashworth and Evans 1999). However, a gap in the literature remains. No

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studies yet have separated mathematical ability and mathematical confidence and examined the role of confidence.

This research expands on the existing literature to include confidence as a determinant of performance in the undergraduate economics classroom. We distinguish between math confidence and mathematical ability. Results indicate that while math ability matters for both men and women, math confidence (holding math ability constant) plays a large role in determining success in economics classes. Moreover, for women, their perceived confidence is a greater predictor of success than their actual math knowledge.

Literature Review

A clear link has been established between math ability and performance in undergraduate economics. Most studies show a significant positive relationship between math ACT/SAT scores and the Test of Understanding in College Economics (Becker 1997; Siegfried and Walstad 1998). Math ACT and SAT scores are found to be an essential determinant of performance when measuring math aptitude from a multidimensional perspective and are very important indicators of both introductory and intermediate performance (Ballard and Johnson 2004; Butler et al. 1994; Siegfried and Walstad 1998; Arnold and Straten 2012; Elzinga and Melaugh 2009; Ullmer 2012). These data seem to be robust to whether they are self-reported or administratively collected (Haley et al. 2010).

In economics, the quantitative SAT score gender differential can explain approximately 16% of the gender gap (Turner and Bowen 1999). The remaining gap is left to be explained. A clear distinction in preferences and anxiety over grades has been shown to affect some of this differential. Females are less likely than males to continue into a second economics course (Horvath et al. 1992). Females may be more responsive to poor grades and less likely to continue with the discipline if their perceived performance is weak (Rask and Tiefenthaler 2008; Horvath et al. 1992; Jensen and Owen 2001). Chizmar (2000) concludes that when controlling for grade differences the persistence gap between genders disappears.

Literature has hence shown that math ability has a significant impact in students' selection and performance in economics. Furthermore, the expectation of failing an economic class is more likely to push away female students. Our study therefore looks at the impact of math confidence on undergraduate economics classes. Level of confidence may be relevant to the current gender gap in economics and may also be affected by math placement and timing.

Swope and Schmitt (2006) find that better quantitative skills result in a higher economics final grade and Bosshardt and Manage (2011) find that math aptitude exceeds math training in importance. Schuhmann et al. (2005) find that the fundamental skills needed are the ability to solve systems of equations, compute a percentage, and interpret increases and decreases on a graph. However, the timing of when math is introduced matters. Sabot and Wakeman-Linn (1991) and Anderson et al. (1994) both find that taking calculus in high school is a significant determinant of success in college level economics. Lagerlöf and Seltzer (2009) find that remedial math programs in college do not improve outcomes in introductory economics classes for students with low math aptitude.

Confidence in the classroom can often eclipse objective ability. Engagement and attitude towards learning can be affected by anxiety (Everingham et al. 2013). Lyons and Beilock (2012) find that the math anxious tend to have the same response to anticipating math as to anticipating pain. Chipman et al. (1992) find that math anxiety measures are a much stronger determinant of future career decisions than objective test scores measuring ability. Allgood et al. (2015) finds that, at the college level, course expectations regarding math requirements affect achievement.

There are asymmetric gender and income effects of confidence on performance. Gunderson et al. (2012) confirms that girls tend to have higher anxiety than boys when it comes to mathematics. Jackson and Leffingwell (1999) finds that K-12 teacher behavior is a prime determinant of math anxiety on both genders; low confidence is more easily disseminated to students in the early years (Geist 2015). Beilock et al. (2010) find evidence that the impact of an anxious teacher is worse on female students than on male students, while Mahigir et al. (2012) find that socioeconomic class, not gender, is the biggest driver of math anxiety differences.

While confidence and ability are distinct, recognizing one's objective level of high ability may mitigate anxiety. Benedict and Hoag (2002) find proficiency measured by ACT Math score to have a negative effect on student anxiety. This may indicate that pedagogical efforts to increase mathematical skills and awareness of objective proficiency might increase confidence and thus performance in the classroom.

Therefore, our study hopes to evaluate the impact of both math ability and confidence at an undergraduate economic classroom by further teasing out results by gender.

Study Design

The goal of this study is to discover the impact of math confidence on performance in economics courses. The data represents individuals in principles of economics classes taught at two regional universities: Northern Kentucky University and University of Kentucky, and a liberal arts college: Young Harris College. The data represents principles of economics classes only.

Data for our study come from two sources: a 10-question math ability test and a perceptions survey. Data collection began during the second week of classes after the add/drop date. A 10-question math ability test was administered to test students' math knowledge (see Appendix Table 1 for the math questions). The questions were selected from SAT and ACT test banks and reflect concepts that are frequently covered in economics (Schuhmann et al. 2005).

In addition to the math test, students completed a survey that provided information on demographics, previous economics courses, and perceptions questions regarding their level of math confidence. Table 1 provides the summary statistics for selected areas of interest. To avoid framing biases, students were given the perceptions surveys before they were aware they would be taking a math quiz.

To assess confidence, math students were asked "How confident are you in your math abilities?" and asked to rate their answers on a Likert scale where 1= not at all confident and 5= very confident.[2] Although this measure is highly subjective, and we would not expect perceptions to be ordinal from participant to participant, these questions accurately gauge exactly what we want to measure: self-perception. We expect some students to be overly confident and some under confident relative to their abilities. For this reason, we measure objective ability separately and group students according to both measures in the analysis.[3]

For the purposes of this paper, confidence is simply a measure of self-perception. It is not ordinal and cannot be compared to another students' rating of their own confidence. It is simply a means of gathering information on student beliefs in regard to their ability to perform mathematical calculations. Motivation for this measurement came from the author's own experiences with students expressing anxiety about test questions involving "math" or statements of "I can't do math." Since this is a clear trend among students, this paper attempts to examine this trend among students. When students express these sentiments, they are certainly not expressing measurable or precise statements regarding their efficacy, their definition of confidence or anxiety, or their definition of "math." Therefore, the confidence measurement in this paper is purely an attempt to gather information on self-perceptions only.

Because confidence can cover a wide range of definitions, several survey questions were included to try and capture an understanding of self-perceptions of confidence. All students were given a pre-test of ability and ability is controlled for throughout the analysis below. This is an attempt to tease about self-beliefs and perceptions versus confidence based on ability. To tease out the effect of math specific confidence instead of general academic confidence, students were also asked to rate their verbal confidence. These two variables did not have a strong correlation, indicating that math confidence is distinct from other types of academic confidence.

In attempt to distinguish what students mean when they cite nervousness about "math," participants further investigated when participants first experience a lack of confidence. Although there were some respondents stating that they have had low confidence in math as long as they could remember, and some respondents stating that they have never felt a lack of confidence, most participants stated that their confidence began to wane in the middle school years. Finally, because confidence self-perceptions are so subjective, participants were also asked to rate belief in ability and belief in own ability relative to peers. After review of all confidence measures collected, the authors selected only the variable "math confidence" to be included in the main analysis of the paper.

Performance is measured by students' final course grade. Our teaching and assessment of principles of economics was similar across the three institutions. Each instructor gave three mid-semester exams and a

[2] Other variation of questions asked in other studies to measure "I feel confident in my abilities to solve mathematics problems."

[3] To ensure we were picking up a distinct measure of math confidence, we asked students several variations of the perceptions questions regarding their overall academic confidence, math confidence, verbal confidence, and assessment of these abilities relative to others.

comprehensive final. Exams at all institutions were based on multiple choice questions derived from verified test bank questions. Exams comprised the majority of the grade (80-90%) with quizzes, homework assignments, and participation making up the remainder (10-20%). Classroom instruction was based on lecture and active learning methods.

Descriptive Statistics

Of the 1193 students asked to complete the survey, 684 did so, for an overall participation rate of 59% (we exclude the dropped students when determining our participation rate). The participation rate by institution was 67%, 53%, and 82% for NKU, UK, and YHC respectively. There were 397 non-respondents, 38 students who chose to opt out of the study, 10 students who started the survey but never completed it, 37 students who completed the survey but were missing key variables, and 27 students who dropped the course.[4]

The main differences across institutions are reflected in the class sizes. Average class sizes are 400, 50, and 30 for UK, NKU, and YHC respectively. The higher participation rate at YHC is likely due to the closer student-faculty contact due to the small class sizes and residential liberal arts environment present at this institution. Moreover, the larger the institution and class size, the smaller the participation rate for our study. The strictness of IRB standards also likely affected participation rate. YHC students were able to receive their survey directly from their instructor and use a small amount of class time to complete it. To fulfill IRB requirements at NKU and UK, the authors' colleague had to summarize the research idea to students, provide a hard copy of the consent to sign and then email the students their surveys.

To examine the possibility of participation bias, we compared our individual population class averages to our samples class averages. For UK, the population average was 80.3% and the sample average was 82.7%. For NKU the measures were 76.4% and 82.73% respectively, and for YHC 81.2% and 80.1% respectively. Given the administration method, non-participation at YHC was almost universally due to absence for a school sanctioned event the day the survey was administered. At NKU and UK, students' non-participation was due to students being absent; the reasons for their absences were not documented since attendance was incentivized by quizzes but was not mandatory. In the case of UK, several students chose to complete the survey online but did not sign the consent forms provided in class. Overall, our sample is quite representative of our population.

Table 1 contains student-level descriptive statistics. The final sample contains 684 students who completed the survey, of which 50.1% were female. Students are classified as 35% freshmen, 40% sophomores, 20% juniors and 5% seniors. The average student age is 20.8 years. The sample is 77% white/non-Hispanic, 8% white/Hispanic, 7% Black, 4% Asian, and 2% other race. Approximately 15% transferred from other institutions, 66% are from within the respective institution's state, 7% are international students and 59% live on campus.

We asked students to identify what bracket of college GPA they fall under: 0% have a college GPA between 0-0.99, 1% have a college GPA between 1-1.99, 9% have a college GPA between 2-2.49, 21% have a college GPA between 2.5-2.99, 31% have a college GPA between 3-3.49 and 38% have a college GPA between 3.5-4. All but 2% of the students have some sort of math course either in high school or college and approximately 45% of the sample work while they attend college. On average, students attempt 5-6 courses per semester.

Students were asked to respond to the question "How confident are you with your overall mathematic abilities?" by using a Likert scale rating where 1=not at all confident and 5= very confident. Students on average were fairly confident in their math ability (3.434). The average final course grade is 82.52 and the average math quiz grade is 51.98. Math confidence and math ability (as measured by the quiz grade) were not correlated.

For further analysis, we replicate Allgood and Walstad (2016) for more a detailed understanding. Having two key math variables, we split each measure in terms of high and low categories. The math ability (quiz) measure is split using the mean of the composite score. Any student with a score greater than the mean of 51.98 is placed in the "High Ability" (53%) category and the rest in the "Low Ability" category.

[4] The following provides the breakdown by institution: Total Enrolled: NKU - 215, UK – 848, YHC – 130. Completion (Lower Level Classes): NKU – 140, UK – 437, YHC – 107.

Table 1: Descriptive Statistics

	All		NKU		UK		YHC	
Variable	**Mean**	Std. Dev	**Mean**	Std. Dev	**Mean**	Std. Dev	**Mean**	Std. Dev
Final Course Grade	**82.520**	9.848	**83.745**	9.518	**82.730**	9.319	**80.093**	11.861
Math Quiz Grade	**51.982**	21.245	**53.571**	22.507	**53.918**	20.833	**41.700**	18.149
Math Confidence	**3.434**	1.056	**3.688**	0.995	**3.387**	1.098	**3.299**	0.903
Age	**20.814**	2.260	**21.938**	2.836	**20.382**	2.098	**21.122**	1.419
HS GPA	**3.615**	1.194	**3.554**	0.577	**3.654**	1.359	**3.491**	0.414
Semester Classes	**5.136**	0.753	**5.119**	0.723	**5.123**	0.770	**5.206**	0.723
Female	**0.501**	0.500	**0.464**	0.501	**0.517**	0.500	**0.486**	0.502
Male	**0.497**	0.500	**0.529**	0.501	**0.483**	0.500	**0.514**	0.502
White/Non Hispanic	**0.774**	0.419	**0.793**	0.407	**0.765**	0.425	**0.785**	0.413
White/Hispanic	**0.086**	0.281	**0.037**	0.190	**0.090**	0.287	**0.131**	0.339
Black	**0.077**	0.267	**0.104**	0.306	**0.071**	0.258	**0.065**	0.248
Asian	**0.044**	0.205	**0.052**	0.223	**0.052**	0.223	**0.000**	0.000
Other Race	**0.020**	0.139	**0.015**	0.121	**0.021**	0.145	**0.019**	0.136
Transfer	**0.150**	0.358	**0.261**	0.441	**0.131**	0.338	**0.084**	0.279
Instate	**0.656**	0.475	**0.706**	0.457	**0.615**	0.487	**0.757**	0.431
International Student	**0.069**	0.254	**0.080**	0.272	**0.048**	0.215	**0.142**	0.350
On Campus	**0.587**	0.493	**0.284**	0.452	**0.597**	0.491	**0.925**	0.264
Private School	**0.215**	0.411	**0.224**	0.418	**0.233**	0.423	**0.131**	0.339
First Economc Class	**0.707**	0.455	**0.470**	0.501	**0.844**	0.364	**0.467**	0.501
College GPA (0-0.99)								
College GPA (between 1-1.99)	**0.014**	0.116	0	0	**0.019**	0.137	**0.009**	0.097
College GPA (between 2-2.49)	**0.091**	0.288	**0.067**	0.251	**0.102**	0.304	**0.075**	0.264
College GPA (between 2.5-2.99)	**0.206**	0.405	**0.216**	0.413	**0.193**	0.395	**0.243**	0.431
College GPA (between 3-3.49)	**0.307**	0.462	**0.276**	0.449	**0.331**	0.471	**0.252**	0.436
College GPA (between 3.5-4)	**0.383**	0.486	**0.440**	0.498	**0.355**	0.479	**0.421**	0.496
Job	**0.452**	0.498	**0.754**	0.432	**0.373**	0.484	**0.383**	0.488
Math	**0.984**	0.126	**0.986**	0.119	**0.982**	0.134	**0.991**	0.097
Freshman	**0.351**	0.477	**0.022**	0.146	**0.530**	0.500	**0.047**	0.212
Sophmore	**0.401**	0.490	**0.522**	0.501	**0.297**	0.458	**0.664**	0.475
Junior	**0.202**	0.402	**0.312**	0.465	**0.154**	0.362	**0.252**	0.436
Senior	**0.047**	0.212	**0.145**	0.353	**0.018**	0.135	**0.037**	0.191
Spring	**0.613**	0.488	**0.500**	0.502	**0.703**	0.458	**0.393**	0.491
Total # of Students	684		140		437		107	
Percent of students	100%		20%		64%		16%	

Similarly, the confidence self-ratings were split as "High Confidence" (48%) for those who responded with a "4" or "5" and "Low Confidence" (52%) for those who responded with a "1", "2", or "3". We then created for math perception groups: a) High Ability and High Confidence (32%) (b) High Ability and Low Confidence (21%) (c) Low Ability and High Confidence (17%) (d) Low Ability and Low Confidence (30%). Table 2 provides a more detailed descriptive of these variables by institution and gender.

We find several similarities and differences among students at the three institutions.[5] There are similarities in the average ages between the three institutions (range from 20.3 to 21.93). We find that there are more men in the NKU (52.9%) and YHC (51.4%) sample (compared UK (48.3%)). The majority of the students at all 3 institutions are white (more than 75%). While black students account for the next largest race proportion at NKU, Hispanics represent the next largest group at UK and YHC.

All three institutions have a large in-state student base. The YHC sample (92.5%) has a large number of students who live on campus followed by UK (59.7%). Only 28% of NKU sample live on campus. There is a big variation between the samples in relation to working: almost 75% of the NKU sample work compared to 37% at UK and 38% at YHC.

We find a noticeable difference in class standings between UK and the other institutions. At UK, the sample is heavily weighted towards freshmen and sophomores. At the other two campuses, the sample is heavily weighted towards sophomores and juniors. Other interesting observations include massive differences between the institutions on whether the current class is the students' first economic class. More

[5] We tested the differences between the means of the characteristics with each institution and with the overall average as well. There were some statistically significant (5% level) differences for some covariates. These t-stats are available upon request. By surveying institutions with different student bodies, we hope to gain insight from a diversity of attitudes and perceptions from different students and different institutions.

students have had prior economics at UK than YHC and NKU. Students at NKU were more confident about their math ability and perceived math aptitude when compared to UK and YHC. Students from NKU and UK received higher final grades and math quiz scores compared to YHC.

Table 2: Actual Ability and Perceived Confidence

	All		NKU		UK		YHC	
Variable	**Mean**	Std. Dev	**Mean**	Std. Dev	**Mean**	Std. Dev	**Mean**	Std. Dev
High Math Ability	**0.53**	0.50	**0.54**	0.50	**0.57**	0.50	**0.39**	0.49
High Confidence	**0.48**	0.50	**0.61**	0.49	**0.46**	0.50	**0.40**	0.49
High Ability & High Confidence	**0.32**	0.47	**0.36**	0.48	**0.33**	0.47	**0.20**	0.40
High Ability & Low Confidence	**0.21**	0.41	**0.17**	0.38	**0.23**	0.42	**0.20**	0.40
Low Ability & High Confidence	**0.17**	0.37	**0.24**	0.43	**0.13**	0.34	**0.21**	0.41
Low Ability & Low Confidence	**0.30**	0.46	**0.22**	0.42	**0.30**	0.46	**0.40**	0.49

Methodology

Our main evaluation criterion is the final course grade (Final Grade in percentages) calculated without any curve (un-curved). Thus, the dependent variable is measured on a 0 to 100 scale. The baseline ordinary least squares (OLS) regression specification is:

$$Final\ Grade_{ij} = \beta_0 + \beta_1 MA_1 + \beta_2 MC_2 + \beta_3 X_3 + \cdots . + \beta_n X_n + \varepsilon$$

where X is a set of individual specific control variables and ε_j is the stochastic error term. This is a standard education production function. Our key variables of interests are: MA and $MC,$ our new measures of math ability and math confidence. The measure of math confidence is collected through the survey conducted at the beginning of the semester and math ability through the math quiz administered during the second week of classes as explained in our data section.[6]

For our choice of control variables, we relied primarily on the educational outcomes literature. The set of control variables includes demographic characteristics (age, race, gender, academic standing), dummy variables for whether or not the individual attended a private high school, whether the student is taking economics for the first time, whether the student is an international student, whether the students transferred to the institution, the self-reported number of hours worked per week, number of courses taken by the students during the semester, the total number of high-school and college math courses the student has taken, and self-reported cumulative college GPA.[7]

[6] For robustness checks we reran the model replacing math confidence with perceived math aptitude. To determine this key variable student were asked not about their confidence levels but about how well their abilities rank in relation to their peers. Results were robust to wording of the perception question and can be found in Tables 3 and 4 of the Appendix.

[7] For robustness checks the general specification of the regression was rerun with a different dependent variable. Final exam score replaced final course average. Initial thinking was that the cumulative final exam would be a better measure of performance as it only measures knowledge and does not include any non-test grade factors. However, after close examination of final exam scores, they did not correlate with previous exam scores. Possibly, this is due to students focusing on other exams during exam week, sleeplessness, discouragement, lack of motivation for students who are already earning good grades in the course, and other factors. Results can be provided upon requests.

Results

This section tests the impact of math confidence controlling for mathematical ability in undergraduate economics. The general regression model attempts to explain the final grade in economics classes as a function of math ability, math confidence, and educational outcome variables. After considering duplicates, incomplete math quizzes and survey responses, and students who registered for upper level classes, the total number of observations is reduced to 684.

Table 3 displays the results for the initial regression specification. Iteration 1 adds math ability only to the control vector of education outcomes variables. Iteration 2 adds math confidence only. Iteration 3 includes both math ability and math confidence. Iterations 4 and 5 are a replication of iteration 3 for males and females respectively.

In every specification, math ability is significant and positive. This finding is consistent with previous literature: stronger math skills increase economic performance. Holding all else constant, scoring one additional correct question on the SAT based math quiz is associated with a 1.2 percentage point increase in the overall course grade on average. Math confidence is positively associated with performance for the whole sample, even when controlling for given levels of ability. Splitting the sample by gender shows that confidence, when controlling for given levels of abilities, is a significant factor in success.[8]

As expected, students' cumulative GPA is also positively correlated with student performance within class for every specification. Specification (1), (2), (3) and (4) found some race effect where Black students performed overall worse than White non-Hispanic students. Juniors performed better than freshman by at least 2-5 percentage points as evident by specification (2) and (5) (this variable was insignificant in specification 1, 3 & 5). Lastly, students at YHC scored lower than students at UK for all 5 specifications. More interesting in our results is that the number of math courses taken is statistically insignificant in all specifications. Perhaps this is because math ability is controlled for in the regressions. Another explanation is that the number of math classes is not necessarily a good measure of their math ability. A better measure to indicate their ability or the quality of their consumption of math would be the highest level of math class taken.

To gain a deeper understanding of the impact of math ability and confidence on success in economics courses, we follow the direction of Allgood and Walstad (2016) and split students in four categories: (a) High Ability and High Confidence (b) High Ability and Low Confidence (c) Low Ability and High Confidence (d) Low Ability and Low Confidence. This provides a much cleaner understanding as it provides an estimate on performance based on the direction of movement from high to low math ability and math confidence. Using Low Ability and Low Confidence as a comparison group, we test to see how other groups perform. Table 4 provides the analysis for the full sample and then broken down for male and female, respectively.

Intuitively, individuals with high mathematical ability and high mathematical confidence perform the best out of the comparison groups. This result is consistent with previous results. Those with high ability and low confidence perform better than those with low ability and low confidence, yet the marginal effect is not as great as the group with both high ability and high confidence, suggesting that confidence still matters even among individuals with high levels of achievements. Among those with low ability and high confidence, the marginal effect was only significant for women, suggesting that confidence is a key factor in success for women with weak math skills.

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[8] In the above specifications math confidence entered the regressions as a categorical variable (1 through 5 with 5 being the highest level of confidence.) Because there is reason to believe that the difference between a rating of 1 and 2 and 2 and 3 is not demonstratively the same, the analysis is repeated changing math confidence into a dichotomous variable. Respondents answering they were 4-confident or 5-very confident were given placed into the "high confidence" category. Respondents were answered 3-neutral, 2- not confident, or 1-not at all confident were placed in the "low confidence" category. A similar math variable was created to differentiate between "High Ability" and "Low Ability." Students whose score on the math quiz was greater than the mean were placed in the "High Ability Category" and those who scored below the mean were placed in the "Low Ability Category." Regressions were re-estimated replacing the measure of math confidence and math ability with the variables created as explained above. All results hold as before. However, in this scenario, confidence does matter for male students and the ability co-efficient are much closer for both male and female students. Results of these regressions can be found in Table 2 of the appendix.

Table 3: Results Using Composite Scores and Self-Rating Confidence Responses

VARIABLES	(1) Final Grade	(2) Final Grade	(3) Final Grade	(4) Final Grade (M)	(5) Final Grade (F)
Math Quiz	0.12***		0.11***	0.08***	0.13***
	(0.02)		(0.02)	(0.02)	(0.03)
Math Confidence		1.64***	1.13***	1.12***	0.89***
		(0.32)	(0.33)	(0.43)	(0.52)
Male	1.93***	2.66***	1.51***		
	(0.68)	(0.68)	(0.68)		
Age	-0.04	-0.08	0.03	0.05	0.04
	(0.18)	(0.19)	(0.18)	(0.26)	(0.27)
White (Hispanic)	-0.94	-0.68	-0.80	-1.48	-0.80
	(1.16)	(1.16)	(1.16)	(1.35)	(1.98)
Black	-2.92***	-4.23***	-3.15***	-5.50***	-1.90
	(1.26)	(1.25)	(1.25)	(1.80)	(1.79)
Asian	-2.28	-1.85	-2.03	-4.51***	-0.67
	(1.73)	(1.75)	(1.72)	(2.57)	(2.39)
Other Race	1.09	0.25	1.20	1.64	-0.06
	(2.31)	(2.28)	(2.29)	(2.48)	(4.53)
Sophomore	0.32	0.44	0.63	1.30	-0.35
	(0.88)	(0.89)	(0.85)	(1.13)	(1.34)
Junior	1.34	1.93***	1.62	4.56***	-1.28
	(1.13)	(1.11)	(1.11)	(1.45)	(1.79)
Senior	1.71	1.00	1.28	1.54	1.76
	(1.92)	(1.91)	(1.91)	(2.22)	(3.61)
Private School	-0.49	-0.16	-0.33	-1.04	0.08
	(0.80)	(0.81)	(0.80)	(0.97)	(1.30)
Job	-1.09	-1.20***	-0.90	-1.10	-0.95
	(0.69)	(0.69)	(0.68)	(0.90)	(1.04)
First Time Econ	-2.16***	-2.75***	-2.04***	-2.42***	-2.50***
	(0.78)	(0.78)	(0.77)	(1.00)	(1.19)
Number of Courses	0.47	0.67	0.36	0.58	0.18
	(0.45)	(0.45)	(0.44)	(0.60)	(0.68)
International Student	-0.22	-0.39	-0.46	-0.94	0.24
	(1.55)	(1.51)	(1.54)	(2.10)	(2.34)
Transfer	-1.54	-2.14***	-1.46	-2.56***	-0.72
	(1.03)	(1.02)	(1.02)	(1.21)	(1.84)
# of Math Classes	-2.02	-3.26	-3.32	-3.29	-4.88
	(3.17)	(3.25)	(3.16)	(4.36)	(4.72)
Cumulative GPA	3.87***	4.05***	3.77***	3.26***	4.17***
	(0.33)	(0.33)	(0.33)	(0.39)	(0.55)
NKU	-0.09	-0.65	-0.47	-3.09***	1.43
	(0.97)	(0.99)	(0.97)	(1.24)	(1.53)
YHC	-3.37***	-4.72***	-3.27***	-4.32***	-3.10***
	(1.08)	(1.06)	(1.06)	(1.39)	(1.68)
Spring	-1.00	-1.19***		-1.31	-0.76
	(0.71)	(0.71)		(0.90)	(1.09)
Constant	55.67***	55.81***	53.02***	57.95***	52.97***
	(5.71)	(5.79)	(5.68)	(8.17)	(8.35)
Observations	616	642	615	301	313
R-squared	0.37	0.34	0.38	0.46	0.36
Prob > F-Stat	0.00	0.00	0.00	0.00	0.00

Standard errors in parentheses, * p<0.10, ** p<0.05, *** p<0.01

Table 4: Results Using Categorical Groups: High to Low Ability and Confidence

VARIABLES	(1) Final Grade	(2) Final Grade (M)	(3) Final Grade (F)
High Ability and High Confidence	6.19***	5.23***	6.27***
	(0.83)	(1.10)	(1.30)
High Ability and Low Confidence	4.29***	3.63***	4.49***
	(0.91)	(1.24)	(1.38)
Low Ability and High Confidence	2.64***	1.14	3.26***
	(0.98)	(1.34)	(1.46)
Male	2.19***		
	(0.66)		
Age	-0.04	0.03	-0.04
	(0.18)	(0.26)	(0.27)
White (Hispanic)	-0.55	-1.31	-0.34
	(1.14)	(1.32)	(1.97)
Black	-3.63***	-5.36***	-2.69
	(1.23)	(1.82)	(1.73)
Asian	-2.01	-4.84***	-0.15
	(1.71)	(2.52)	(2.40)
Other Race	-0.19	1.49	-1.88
	(2.23)	(2.51)	(4.15)
Sophomore	0.42	1.57	-0.45
	(0.87)	(1.13)	(1.34)
Junior	1.49	4.63***	-1.17
	(1.09)	(1.39)	(1.76)
Senior	1.40	2.30	0.70
	(1.87)	(2.18)	(3.46)
Private School	-0.15	-0.98	0.24
	(0.79)	(0.97)	(1.28)
Job	-1.27***	-1.20	-1.46
	(0.68)	(0.88)	(1.04)
First Time Econ	-2.36***	-2.65***	-2.48***
	(0.77)	(1.00)	(1.19)
Number of Courses	0.63	0.89	0.43
	(0.44)	(0.59)	(0.67)
International Student	-0.46	-0.35	0.16
	(1.49)	(2.00)	(2.28)
Transfer	-1.56	-2.75***	-0.65
	(1.01)	(1.20)	(1.81)
# of Math Classes	-2.55	-2.48	-4.69
	(3.19)	(4.38)	(4.74)
Cumulative GPA	4.06***	3.53***	4.51***
	(0.32)	(0.38)	(0.54)
NKU	-0.11	-2.66***	1.65
	(0.97)	(1.24)	(1.52)
YHC	-3.65***	-4.10***	-3.71***
	(1.05)	(1.36)	(1.64)
Spring	-0.57	-0.75	-0.33
	(0.70)	(0.91)	(1.08)
Constant	56.97***	59.34***	57.51***
	(5.66)	(8.05)	(8.25)
Observations	643	315	327
R-squared	0.37	0.44	0.34
Prob > F-Stat	0.00	0.00	0.00

Standard errors in parentheses, * p<0.10, ** p<0.05, *** p<0.01

Our results consistently show that mathematical ability matters for both men and women. For women, however, confidence also plays a role. Women with higher confidence do better than women with lower confidence, holding all else constant. Results indicate that confidence in students has a positive impact on their class performance. From a pedagogical perspective, spending time combating math disinclination and building confidence is important. Such pedagogy can help attract more female students to the economics discipline. It is important for future research to discover how to build mathematical confidence in students. This research should note the differences in math anxieties between the genders.

Limitations

All sample collection followed institution specific Institutional Review Board standards. Due to differences in school culture and IRB requirements, response rates varied across institutions and generated variation in overall response rate. One concern with this is the issue of participation bias. Although this does not seem to be the case for UK and YHC, the difference in the sample and population means for NKU seems to indicate that high achieving students were more likely to participate than low performing students. Although a negative for study, we believe this helps support our findings. Our study shows that even for motivated students, ability and confidence matters. We believe these factors could have a much bigger impact for the low motivated students with ability and confidence concerns.

Other concerns that may influence the overall significance of the research are issues that are typical in survey datasets. More importantly, the issue of omitted variables. We feel the variables we collect from our students are sufficient for a standard education production function. With the data as is, it is highly doubtful that any of the econometric techniques would be feasible in solving the issue. A common method to use is an Instrumental Variable (IV) approach or even a matching technique. With our data and sample, these are highly unlikely. A robustness check using high school GPA rather than college GPA to control for ability and for any endogeneity issues is also estimated and results hold. We use the typical education production function (Emerson and Taylor 2004) and insert math confidence as a determinant of outcome. Our approach falls in line with other research examining the determinants of success in the economics classroom.

Conclusion

The determinants of what helps students succeed in economics courses and the economics major has received a lot of attention. We examine the impact of both objective math ability and perceived math confidence on student learning outcomes. Due to the mathematical nature of economics, it is presumed that math proficiency is positively correlated with success at the introductory level courses and in the major. We find that students' current quantitative aptitude does impact student-learning outcomes positively. Furthermore, student confidence in their math abilities is a large predictor of their success in economics relative to their actual math ability. While we find positive associations between confidence and performance for the whole sample, further investigation reveals that this effect is being driven by females only.

The implication of these findings affects the way economics is taught. To help increase student learning of economics, instructors need to devote some effort to encouraging, motivating, and building mathematical confidence, especially for female students. This gives way to further research. What is the best way to increase math confidence? Do these approaches need to differ by gender? Would this increase in mathematical confidence have further positive effects on the educational process? If math differences are present between genders and math ability and math confidence contribute to success in economics, our findings may also have implications in explaining the gender gap in economics and eventually seeking to close it as well.

Furthermore, the educational psychology literature distinguishes between many self-belief concepts but two of them are more relevant to this paper--confidence and self-efficacy. The two are interrelated, but self-efficacy is a domain-specific construct, which refers to beliefs about one's ability to perform specific tasks. Confidence is a more general personality trait that refers to one's belief about one's self-worth and likelihood of success. In recent years, distinction between confidence and self-efficacy has increasingly been made in some business/economics literature. To measure efficacy, one could survey students on 3-5 questions asking about a student's belief in performing specific tasks in algebra or geometry that would be useful in an economics course. Self-efficacy matters in the math literature and should also matter in Economics. The trick is to be able to separate the impacts of each.

It is a common assumption among economic educators that students are anxious about the math and graphing component in economics courses. Our study was motivated by this thought and looked to possibly explain a reason for the lower numbers of female economics majors. This study is new to the field of economics. Our hope is that this will kick-start more in-depth discussion on students' math confidence or efficacy on students' success in economics courses.

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APPENDIX

Appendix Table 1: Math Quiz

Quiz 1

Student Instructions: you have 15 minutes to take the following quiz. No calculators or other electronic devices are allowed. Please indicate your answer for each question on the blank provided beside each question number. Make sure to include your student ID on your scantron.

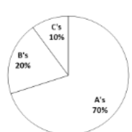
___ 1. A special lottery is to be held to select the student who will live in the only deluxe room in a dormitory. There are 100 seniors, 150 juniors, and 200 sophomores who applied. Each senior's name is placed in the lottery 3 times, each junior's name 2 times, and each sophomore's name 1 time. What is the probability that a senior's name will be chosen?

A. 1/8
B. 2/9
C. 2/7
D. 3/8
E. 1/2

___ 2. A car averages 27 miles per gallon. If gas costs $4.04 per gallon, which of the following is closest to how much the gas would cost for this car to travel 2,727 typical miles?

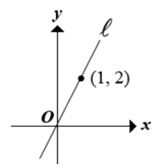
A. $ 44.44
B. $109.08
C. $118.80
D. $408.04
E. $444.40

___ 3. The distribution of Jamal's high school grades by percentage of course credits is given in the circle graph below. What is Jamal's grade point average if each A is worth 4 points; each B is worth 3 points; and each C is worth 2 points?



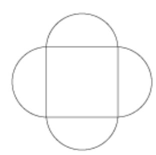
A. 3.0
B. 3.4
C. 3.6
D. 3.7
E. Cannot be determined from the given information

___ 4. In the x y-coordinate plane below, line contains the points (0, 0) and (1, 2). If line (not shown) contains the point (0, 0) and is perpendicular to , what is an equation of ?



A. $= -\frac{1}{2}$
B. $= -\frac{1}{2} \quad + 1$
C. $= -$
D. $= - \quad + 2$
E. $= - 2$

___ 5. The geometric figure shown below consists of a square and 4 semicircles. The diameters of the semicircles are the sides of the square, and each diameter is 10 centimeters long. Which of the following is the closest approximation of the total area, in square centimeters, of this geometric figure?



A. 100
B. 160
C. 260
D. 400
E. 730

___ 6. A DVD player with a list price of $100 is marked down 30%. If John gets an employee discount of 20% off the sale price, how much does John pay for the DVD player?

A. $86.00
B. $77.60
C. $56.00
D. $50.00
E. $44.00

7. Based on the system of equations below, what is the value of the product *xy*?

$$4x - y = 3y + 7$$
$$x + 8y = 4$$

A. – 3/2
B. 1/4
C. 1/2
D. 11/9

8. What value of x satisfies both of the equations below?

$$|4x - 7| = 5$$
$$|3 - 8x| = 1$$

Please record your answer: x = _____
A. ¼
B. ½
C. 3
D. 5

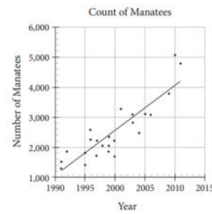
9. A survey was conducted among a randomly chosen sample of U.S. citizens about U.S. voter participation in the November 2012 presidential election. The table below displays a summary of the survey results. According to the table, for which age group did the greatest percentage of people report that they had voted?

Reported Voting by Age (in thousands)

	VOTED	DID NOT VOTE	NO RESPONSE	TOTAL
18- to 34-year-olds	30,329	23,211	9,468	63,008
35- to 54-year-olds	47,085	17,721	9,476	74,282
55- to 74-year-olds	43,075	10,092	6,831	59,998
People 75 years old and over	12,459	3,508	1,827	17,794
Total	132,948	54,532	27,602	215,082

A. 18- to 34-year-olds
B. 35- to 54-year-olds
C. 55- to 74-year-olds
D. People 75 years old and over

10. The scatterplot below shows counts of Florida manatees, a type of sea mammal, from 1991 to 2011. Based on the line of best fit to the data shown, which of the following values is closest to the average yearly increase in the number of manatees?



A. 0.75
B. 75
C. 150
D. 750

Appendix Table 2: Results Using Two Categorical Groups: High vs. Low Ability & High vs. Low Confidence

VARIABLES	(1) Final Grade	(2) Final Grade	(3) Final Grade	(4) Final Grade (M)	(5) Final Grade (F)
High Math Ability	4.50***		3.95***	3.86***	3.85***
	(0.67)		(0.68)	(0.88)	(1.05)
High Confidence		3.17***	2.24***	1.42***	2.56***
		(0.67)	(0.67)	(0.84)	(1.07)
Male	2.41***	2.90***	2.18***		
	(0.67)	(0.67)	(0.66)		
Age	-0.09	-0.11	-0.05	0.03	-0.04
	(0.18)	(0.19)	(0.18)	(0.26)	(0.27)
White (Hispanic)	-0.62	-0.73	-0.54	-1.29	-0.20
	(1.15)	(1.17)	(1.14)	(1.32)	(1.96)
Black	-3.49***	-4.17***	-3.57***	-5.40***	-2.63
	(1.23)	(1.25)	(1.22)	(1.81)	(1.73)
Asian	-2.30	-1.81	-1.96	-4.91***	-0.15
	(1.72)	(1.75)	(1.71)	(2.51)	(2.39)
Other Race	-0.44	0.34	-0.16	1.50	-1.62
	(2.25)	(2.29)	(2.23)	(2.50)	(4.13)
Sophomore	0.28	0.56	0.38	1.60	-0.50
	(0.87)	(0.89)	(0.87)	(1.12)	(1.34)
Junior	1.32	2.18***	1.47	4.63***	-1.17
	(1.10)	(1.11)	(1.09)	(1.39)	(1.76)
Senior	1.69	1.48	1.37	2.34	0.77
	(1.88)	(1.91)	(1.86)	(2.17)	(3.46)
Private School	-0.27	-0.21	-0.15	-0.95	0.32
	(0.79)	(0.81)	(0.79)	(0.96)	(1.27)
Job	-1.29***	-1.30***	-1.25***	-1.20	-1.43
	(0.68)	(0.69)	(0.68)	(0.88)	(1.03)
First Time Econ	-2.36***	-2.69***	-2.37***	-2.64***	-2.52***
	(0.77)	(0.79)	(0.77)	(0.99)	(1.18)
Number of Courses	0.71	0.69	0.62	0.90	0.41
	(0.44)	(0.45)	(0.44)	(0.59)	(0.67)
International Student	-0.02	-0.52	-0.38	-0.43	0.16
	(1.49)	(1.52)	(1.48)	(1.98)	(2.28)
Transfer	-1.59	-2.36***	-1.56	-2.75***	-0.70
	(1.02)	(1.02)	(1.01)	(1.20)	(1.81)
# of Math Classes	-1.64	-3.19	-2.56	-2.59	-4.90
	(3.20)	(3.26)	(3.18)	(4.36)	(4.73)
Cumulative GPA	4.12***	4.14***	4.05***	3.54***	4.49***
	(0.32)	(0.33)	(0.32)	(0.38)	(0.54)
NKU	0.31	-0.53	-0.07	-2.68***	1.73
	(0.97)	(0.99)	(0.97)	(1.24)	(1.51)
YHC	-3.65***	-4.68***	-3.62***	-4.11***	-3.63***
	(1.06)	(1.06)	(1.05)	(1.36)	(1.63)
Spring	-0.50	-1.08	-0.58	-0.74	-0.33
	(0.71)	(0.71)	(0.70)	(0.91)	(1.08)
Constant	56.99***	59.75***	57.30***	59.14***	58.12***
	(5.67)	(5.75)	(5.63)	(8.00)	(8.20)
Observations	643	643	643	315	327
R-squared	0.36	0.33	0.37	0.44	0.34

Standard errors in parentheses, * p<0.10, ** p<0.05, *** p<0.01

Appendix Table 3: Results Using Composite Scores and Self-Rating Aptitude Responses

VARIABLES	(1) Final Grade	(2) Final Grade	(3) Final Grade	(4) Final Grade (M)	(5) Final Grade (F)
Math Quiz	0.12***		0.11***	0.08***	0.13***
	(0.02)		(0.02)	(0.02)	(0.03)
Perceived Math Aptitude		1.81***	1.23***	1.06***	1.09***
		(0.36)	(0.37)	(0.48)	(0.57)
Male	1.93***	2.70***	1.55***		
	(0.68)	(0.67)	(0.68)		
Age	-0.04	-0.11	0.01	0.01	0.05
	(0.18)	(0.19)	(0.18)	(0.26)	(0.27)
White (Hispanic)	-0.94	-0.86	-0.92	-1.54	-0.97
	(1.16)	(1.16)	(1.15)	(1.35)	(1.97)
Black	-2.92***	-4.28***	-3.16***	-5.36***	-2.00
	(1.26)	(1.25)	(1.25)	(1.81)	(1.79)
Asian	-2.28	-1.73	-1.95	-4.32***	-0.67
	(1.73)	(1.75)	(1.72)	(2.58)	(2.38)
Other Race	1.09	0.30	1.23	1.80	-0.08
	(2.31)	(2.28)	(2.29)	(2.48)	(4.52)
Sophomore	0.32	0.51	0.66	1.52	-0.40
	(0.88)	(0.89)	(0.85)	(1.13)	(1.33)
Junior	1.34	2.14***	1.71	4.80***	-1.19
	(1.13)	(1.11)	(1.11)	(1.44)	(1.78)
Senior	1.71	1.34	1.50	1.95	1.80
	(1.92)	(1.91)	(1.90)	(2.22)	(3.60)
Private School	-0.49	-0.09	-0.28	-0.94	0.00
	(0.80)	(0.81)	(0.80)	(0.98)	(1.28)
Job	-1.09	-1.12	-0.87	-1.10	-0.92
	(0.69)	(0.69)	(0.68)	(0.91)	(1.04)
First Time Econ	-2.16***	-2.75***	-2.08***	-2.41***	-2.58***
	(0.78)	(0.78)	(0.77)	(1.01)	(1.19)
Number of Courses	0.47	0.67	0.37	0.61	0.15
	(0.45)	(0.45)	(0.44)	(0.60)	(0.68)
International Student	-0.22	0.05	-0.13	-0.62	0.52
	(1.55)	(1.51)	(1.53)	(2.11)	(2.32)
Transfer	-1.54	-2.04***	-1.36	-2.68***	-0.53
	(1.03)	(1.03)	(1.02)	(1.21)	(1.83)
# of Math Classes	-2.02	-3.18	-3.18	-3.10	-4.94
	(3.17)	(3.25)	(3.16)	(4.37)	(4.70)
Cumulative GPA	3.87***	3.97***	3.71***	3.25***	4.09***
	(0.33)	(0.33)	(0.33)	(0.39)	(0.55)
NKU	-0.09	-0.43	-0.35	-3.11***	1.62
	(0.97)	(0.98)	(0.97)	(1.25)	(1.50)
YHC	-3.37***	-4.72***	-3.25***	-4.39***	-3.07***
	(1.08)	(1.06)	(1.06)	(1.39)	(1.67)
Spring	-1.00	-1.02		-1.14	-0.75
	(0.71)	(0.71)		(0.91)	(1.08)
Constant	55.67***	55.75***	52.87***	58.14***	52.48***
	(5.71)	(5.79)	(5.68)	(8.22)	(8.34)
Observations	616	643	616	301	314
R-squared	0.37	0.34	0.38	0.45	0.36

Standard errors in parentheses, * p<0.10, ** p<0.05, *** p<0.01

Appendix Table 4: Results Using Categorical Groups: High to Low Actual and Perceived Ability

VARIABLES	(1) Final Grade	(2) Final Grade (M)	(3) Final Grade (F)
High Ability and Perceived High Aptitude	4.99***	3.77***	5.50***
	(0.78)	(1.02)	(1.24)
High Ability and Perceived Low Aptitude	2.91***	3.03***	2.37
	(1.33)	(1.77)	(2.03)
Low Ability and Perceived High Aptitude	1.41	-0.08	2.40***
	(0.93)	(1.25)	(1.39)
Male	2.48***		
	(0.67)		
Age	-0.11	-0.06	-0.05
	(0.18)	(0.26)	(0.27)
White (Hispanic)	-0.93	-1.73	-0.56
	(1.15)	(1.34)	(1.98)
Black	-3.83***	-5.50***	-3.14***
	(1.24)	(1.86)	(1.75)
Asian	-1.90	-4.89***	-0.15
	(1.74)	(2.60)	(2.42)
Other Race	0.13	1.20	-0.35
	(2.26)	(2.55)	(4.17)
Sophomore	0.37	1.53	-0.52
	(0.88)	(1.14)	(1.34)
Junior	1.62	4.72***	-0.94
	(1.11)	(1.42)	(1.76)
Senior	1.54	2.18	1.83
	(1.89)	(2.21)	(3.49)
Private School	-0.16	-0.97	0.15
	(0.80)	(0.99)	(1.29)
Job	-1.00	-0.99	-1.27
	(0.69)	(0.91)	(1.05)
First Time Econ	-2.53***	-2.66***	-2.81***
	(0.78)	(1.02)	(1.20)
Number of Courses	0.73***	0.93	0.45
	(0.44)	(0.60)	(0.68)
International Student	0.22	0.20	0.46
	(1.50)	(2.01)	(2.31)
Transfer	-1.63	-2.71***	-1.16
	(1.02)	(1.23)	(1.81)
# of Math Classes	-2.27	-1.79	-5.11
	(3.24)	(4.43)	(4.90)
Cumulative GPA	3.95***	3.47***	4.41***
	(0.33)	(0.39)	(0.55)
NKU	0.06	-2.48***	1.90
	(0.98)	(1.27)	(1.51)
YHC	-3.82***	-4.29***	-3.81***
	(1.07)	(1.41)	(1.65)
Spring	-0.16	-0.25	-0.08
	(0.78)	(1.05)	(1.17)
Constant	58.41***	61.35***	58.83***
	(5.78)	(8.15)	(8.51)
Observations	643	315	327
R-squared	0.35	0.43	0.33

Standard errors in parentheses, * $p<0.10$, ** $p<0.05$, *** $p<0.01$