**Does "Mathiness" Matter? How Student Perceptions Create Barriers to Economics**

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Abstract:

One of the most common obstacles in the economics classroom is facing a student's 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 student perceptions of their level of "mathiness" or mathematical abilities and anxieties and then identifies the impact of perceptions on their performance in economics courses. The inclusion of self-identified perceptions allows this paper to build on the previous literature establishing a link between measured quantitative skills and undergraduate economic performance.

Keywords: mathematics, quantitative, economics, perceptions, anxiety

JEL codes: A12, A22

# 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 attitude 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. This work seeks 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 will frequently encounter math anxiety and resistance to understand the roll of mathematical confidence on performance. Understanding this roll will ultimately have pedagogical implications.

Economics education literature thoroughly establishes a link between mathematical ability and performance in the economics classroom (Ballard and Johnson 2004; Elzinga and Melaugh 2009; Arnold and Straton 2012; Ulmer 2012) as well as gender asymmetries in economic inclination (Calkins and Welki 2006; Jensen and Owens 2001; Ashworth and Evan

1999). However, a gap in the literature still exists. No studies yet separate mathematical ability and mathematical confidence and examine the role of confidence.

We expand 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. We find that while math ability matters for both men and women, math confidence plays a large role in women's ability to do well in economic classes. For women, their perceived confidence is a greater predictor of success then 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; Seigfried and Walsted 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, Finegin, Sigfried 1994; Sigfried and Walsted 1998; Arnold and Straton 2012; Elzinga and Melaugh 2009; Ulmer 2012). These data seem to be robust to whether they are self-reported or administratively collected (Haley, Johnson, and McGhee 2010). In economics, the SAT score gender differential can explain approximately 16% of the gender gap (Turner and Bowen 1999). The rest is explained by a clear distinction in preferences. Females are less likely than males to continue into a second economics course (Horvath, Beaudin, and Wright 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, Beaudin, and Wright, 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. Confidence levels may be relevant to the current gender gap in economics and may also be affected by math placement and timing. Swope and Schmidt (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, McGoldrick, and Burrus (2005) find that the fundamental skills needed are: ability to solve a 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, Benjamin, and Fuss (1994) both find that taking calculus in high school is a significant determinant of success in college level economics. Lagerlöf and Seltzer (2008) 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 (2012b) find that the math anxious tend to have the same response to anticipating math as to anticipating pain. Chipman, Krantz, and Silver (1991) 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. (2011) 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; low confidence is more easily disseminated to students in the early years (Geist 2015). Beilock, Gunderson, Ramirez, and Levine (2010) find evidence that the impact of an anxious teacher is worse on female students than on male students, and Mahigir and Karimi (2012) find that math anxiety is worst among those of the lowest socioeconomic status.

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. Our study therefore 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 economics classes taught at 2 regional universities: Northern Kentucky University and University of Kentucky and a liberal arts college: Young Harris College. The data represents a variety of classes, ranging from introductory level courses to upper division classes.

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 1 for the math questions). The questions were selected from SAT and ACT test banks, and reflect concepts that are covered in economics frequently.

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.

## DESCRIPTIVE STATISTICS

*Demographics*

Of the 614 students asked to complete the survey, 274 did so, for an overall participation rate of 44.6%. The participation rate by institution was 51.4%, 32.28%, and 90.24% for NKU, UK, and YHC, respectively. There were 329 non-respondents, 9 students chose to opt out and 2 students started the survey but never completed it.[2]

Table 1 contains student-level descriptive statistics. The final sample (Fall 2015) contains 274 students who completed the survey, out of which 53% are female and 47% are male. The sample is classified as 16% freshmen, 51% sophomores, 26% juniors and 6% seniors. The average student's age is 21.3 years. The sample is 78% white/non-Hispanic, 8% white/Hispanic, 7% Black, 4% Asian, and 2% other race. Approximately 17% transferred from other institutions, 65% are from within the respective institution's state, 34% are international students and 51% live on campus.

[2] NKU-70 completed, UK -130, YHC – 74 UK – 396 students enrolled NKU -136 YHC - 82

We asked students to identify what bracket of college GPA do they fall under: 0% have a college GPA between 0-0.99, 1% have a college GPA between 1-1.99, 7% have a college GPA between 2-2.49, 21% have a college GPA between 2.5-2.99, 30% have a college GPA between 3-3.49 and 40% have a college GPA between 3.5-4. All but 2% of the samples have had some sort of math course either in high school or college and approximately 50% 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 (3.377). The average final course grade is 82.37 and the average math quiz grade is 49.38. Math confidence and math ability (as measured by the quiz grade) were not correlated.

[Insert Table 1 here.]

For further analysis, we replicate Allgood & Walstad (2015) for a 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 49.38 is placed in the "High Ability" (57%) category and the rest in the "Low Ability" category.

Similarly, the confidence self-ratings were split as "High Confidence" (47%) for those who responded with a "4" or "5" and "Low Confidence" for those responded with a "1", "2" or "3". We then created for math perception groups: a) High Ability and High Confidence (31%) (b) High Ability (26%) and Low Confidence (c) Low Ability and High Confidence (16%) (d)

Low Ability and Low Confidence (28%). Table 3 provides a more detailed descriptive of these variables by institution and gender.

[Insert Table 3 here.]

We find several similarities and differences amongst students at the three institutions.[3] There is not much difference in the average ages between the three institutions (range from 21.0 to 22.06). We find that there are more men in the YHC sample (52.7%) compared to NKU (44.9%) and UK (43.8%). The majority of the students at all 3 institutions are white (more than three-fourths). While black students account for the next largest race proportion at NKU, Asians represent the next largest group at UK and Hispanics represent the next largest group at YHC.

NKU has a large in-state student base, likely due to its classification as a regional school. YHC sample also has at least 70% of their students from within the state. The YHC sample has a large number of students who live on campus followed by UK. Only 27% of NKU sample live on campus. There is a big variation between the samples in relation to working: almost 80% of the NKU sample work compared to 39% at UK and 44% 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 current class is students' first economic class. More students have had prior Economics at UK than YHC and NKU. There were no statistical mean differences in the perceived math aptitude variable across

[3] 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 survey institutions with different student bodies, we hope to gain insight from a diversity of attitudes and perceptions from different students and different institutions.

the institutions. However, students at NKU were more confident about their math ability when compared to UK and YHC. Students from NKU and UK received higher final grades and math quiz scores compared to YHC.

## 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:

$$Final\ Grade_{ij} = \beta_0 + \beta_1 X_j + \beta_2 M_j + \epsilon_j$$

where $X_j$ is a set of individual specific control variables, and $\varepsilon_j$ is the stochastic error term. Subscripts indicate student $i$ in course $j$. This is a standard education production function. We are interested in the impact of the standard variables measured in baseline model. We are also interested in $M_j$, 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.

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.[4]

## RESULTS

This section tests the impact of math confidence controlling for mathematical ability on in undergraduate economics. The general regression model attempts to explain final grade in economics classes as a function of math ability, math confidence, and educational outcome variables. After considering duplicates and incomplete math quizzes and survey responses, the total number of observations is reduced to 260.

Table 4 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 1.5 percentage point increase in the overall course grade. Math confidence is positively associated with performance for the whole sample, even when controlling for given levels of

[4] 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 of these regressions are reported in tables 3-5 of the appendix.

ability.

Splitting the sample by gender shows that confidence, when controlling for given levels of abilities is only a significant factor for females. When controlling for confidence, the marginal effect of ability for males only in specification 4 is twice as high as the marginal effect for females in specification 5. These results suggest that confidence may be the greater factor driving females where ability may be the greater factor driving males.

In the above specifications math confidence entered the regressions as a categorical variable (1 through 5 with 5 being the highest levels of confidence.) Because there is reason to believe that the difference between a rating of 1 and 2 and 2 and 3 is not the demonstratively the same, 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-nuetral, 2- not confident, or 1-not at all confident were placed in the "low confidence category." Regressions were reran replacing the measure of math confidence. All results hold as before. Results of these regressions can be found in Table 2 of the appendix.

As expected, students' cumulative GPA is also positively correlated with student performance within class for every specification. Specification (1), (3) and (4) found some race effect where Asians performed overall worse than White non-Hispanic students. Sophomores performed worse than freshman by at least 4-5 percentage points (this variable was insignificant in specification 2). 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 for this 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.

[Insert Table 4 here.]

To further gain a deeper understanding of the impact of math ability and confidence on success in economics courses, we follow the direction of Allgood and Walsted (2015) 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 5 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 previous results. Those with high ability and low confidence perform better than those with low ability and low confidence, yet the marginal affect 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 affect was significant for women only suggesting that for women with weak math skills confidence is a key factor in success.

[Insert Table 5 here.]

Our results consistently show mathematical ability matters for both men and women.

However, for women 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 be careful to pay attention to 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 greatly across institutions and generated a relatively low overall response rate. One concern with is the issue of selection bias. Given the low response rate and the high average final score of 82%, it is reasonable to assume that the samples biases toward more motivated 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.

## 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 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 method of teaching may not be natural to economic educators, since most educators receive no formal training in pedagogical methods. Our findings reinforce the need for educational training for economic educators. Knowledge of the subject is not sufficient to help increase student learning of economics.

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Table 1: Descriptive Statistics

| | All | | NKU | | UK | | YHC | |
|---|---|---|---|---|---|---|---|---|
| Variable | **Mean** | Std. Dev | **Mean** | Std. Dev | **Mean** | Std. Dev | **Mean** | Std. Dev |
| Final Course Grade | **82.372** | 11.642 | **83.043** | 10.338 | **84.731** | 9.029 | **77.595** | 15.110 |
| Math Quiz Grade | **49.380** | 21.905 | **50.000** | 21.400 | **55.077** | 22.178 | **38.784** | 17.900 |
| Age | **21.304** | 2.618 | **22.016** | 2.646 | **21.000** | 3.080 | **21.203** | 1.355 |
| HS GPA | **4.201** | 7.326 | **3.572** | 0.413 | **4.287** | 7.811 | **4.633** | 9.561 |
| Semester Hours | **5.112** | 0.809 | **5.091** | 0.717 | **5.070** | 0.932 | **5.203** | 0.641 |
| Math Aptitude | **3.496** | 0.966 | **3.671** | 0.912 | **3.431** | 1.071 | **3.446** | 0.796 |
| Math Ability - Confidence | **3.377** | 1.095 | **3.686** | 1.071 | **3.215** | 1.181 | **3.370** | 0.890 |
| Female | **0.535** | 0.500 | **0.551** | 0.501 | **0.562** | 0.498 | **0.473** | 0.503 |
| Male | **0.465** | 0.500 | **0.449** | 0.501 | **0.438** | 0.498 | **0.527** | 0.503 |
| White/Non Hispanic | **0.783** | 0.413 | **0.803** | 0.401 | **0.764** | 0.426 | **0.797** | 0.405 |
| White/Hispanic | **0.079** | 0.270 | **0.045** | 0.210 | **0.079** | 0.270 | **0.108** | 0.313 |
| Black | **0.075** | 0.264 | **0.106** | 0.310 | **0.063** | 0.244 | **0.068** | 0.253 |
| Asian | **0.041** | 0.199 | **0.030** | 0.173 | **0.071** | 0.258 | **0.000** | 0.000 |
| Other Race | **0.022** | 0.148 | **0.015** | 0.123 | **0.024** | 0.152 | **0.027** | 0.163 |
| Transfer | **0.169** | 0.376 | **0.275** | 0.450 | **0.155** | 0.363 | **0.095** | 0.295 |
| Instate | **0.651** | 0.478 | **0.701** | 0.461 | **0.563** | 0.498 | **0.757** | 0.432 |
| International Student | **0.092** | 0.290 | **0.087** | 0.284 | **0.085** | 0.280 | **0.110** | 0.315 |
| On Campus | **0.513** | 0.501 | **0.277** | 0.451 | **0.414** | 0.494 | **0.892** | 0.313 |
| Private School | **0.206** | 0.405 | **0.227** | 0.422 | **0.236** | 0.426 | **0.135** | 0.344 |
| First Economc Class | **0.284** | 0.452 | **0.455** | 0.502 | **0.156** | 0.365 | **0.351** | 0.481 |
| College GPA (0-0.99) | **0.000** | 0.000 | **0.000** | 0.000 | **0.000** | 0.000 | **0.000** | 0.000 |
| College GPA (between 1-1.99) | **0.007** | 0.086 | **0.000** | 0.000 | **0.008** | 0.089 | **0.014** | 0.116 |
| College GPA (between 2-2.49) | **0.075** | 0.264 | **0.091** | 0.290 | **0.063** | 0.244 | **0.081** | 0.275 |
| College GPA (between 2.5-2.99) | **0.210** | 0.408 | **0.227** | 0.422 | **0.197** | 0.399 | **0.216** | 0.414 |
| College GPA (between 3-3.49) | **0.303** | 0.461 | **0.227** | 0.422 | **0.346** | 0.478 | **0.297** | 0.460 |
| College GPA (between 3.5-4) | **0.404** | 0.492 | **0.455** | 0.502 | **0.386** | 0.489 | **0.392** | 0.492 |
| Job | **0.503** | 0.501 | **0.788** | 0.412 | **0.391** | 0.490 | **0.446** | 0.500 |
| Math | **0.978** | 0.147 | **0.986** | 0.120 | **0.969** | 0.173 | **0.986** | 0.116 |
| Freshman | **0.162** | 0.369 | **0.000** | 0.000 | **0.310** | 0.464 | **0.054** | 0.228 |
| Sophmore | **0.515** | 0.501 | **0.580** | 0.497 | **0.434** | 0.498 | **0.595** | 0.494 |
| Junior | **0.261** | 0.440 | **0.319** | 0.469 | **0.225** | 0.419 | **0.270** | 0.447 |
| Senior | **0.063** | 0.243 | **0.101** | 0.304 | **0.031** | 0.174 | **0.081** | 0.275 |
| Total # of Students | 274 | | 70 | | 130 | | 74 | |
| Percent of students | 100% | | 26% | | 47% | | 27% | |

Table 2: Correlation Table

| | Actual Aptitude (Math Quiz) | Perceived Math Aptitude | Math Confidence |
|---|---|---|---|
| Actual Aptitude | 1 | | |
| Perceived Math Aptitude | 0.3387 | 1 | |
| Math Confidence | 0.32 | 0.8532 | 1 |

Table 3: 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 | **0.566** | 0.497 | **0.557** | 0.500 | **0.685** | 0.466 | **0.365** | 0.485 |
| High Confidence | **0.467** | 0.500 | **0.614** | 0.490 | **0.400** | 0.492 | **0.446** | 0.500 |
| High Ability & High Confidence | **0.310** | 0.463 | **0.386** | 0.490 | **0.346** | 0.478 | **0.176** | 0.383 |
| High Ability & Low Confidence | **0.255** | 0.437 | **0.171** | 0.380 | **0.338** | 0.475 | **0.189** | 0.394 |
| Low Ability & High Confidence | **0.157** | 0.364 | **0.229** | 0.423 | **0.054** | 0.227 | **0.270** | 0.447 |
| Low Ability & Low Confidence | **0.277** | 0.449 | **0.214** | 0.413 | **0.262** | 0.441 | **0.365** | 0.485 |

| | Low Confidence | High Confidence | |
|---|---|---|---|
| Low Ability | 18% | 14% | Men |
| High Ability | 28% | 40% | |

| | Low Confidence | High Confidence | |
|---|---|---|---|
| Low Ability | 36% | 17% | Women |
| High Ability | 23% | 24% | |

Table 4: 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 | 0.15*** | | 0.13*** | 0.18*** | 0.09*** |
| | (0.03) | | (0.03) | (0.05) | (0.04) |
| Math Confidence | | 1.96*** | 1.22*** | 0.44 | 1.31*** |
| | | (0.60) | (0.60) | (1.05) | (0.75) |
| Male | 2.18*** | 3.08*** | 1.84 | | |
| | (1.25) | (1.25) | (1.25) | | |
| Age | -0.19 | -0.29 | -0.16 | 0.18 | -0.18 |
| | (0.27) | (0.27) | (0.26) | (0.55) | (0.30) |
| White (Hispanic) | -0.95 | -0.04 | -0.61 | -3.79 | 3.24 |
| | (2.18) | (2.22) | (2.16) | (3.41) | (2.90) |
| Black | -0.68 | -1.77 | -0.62 | -2.34 | -1.26 |
| | (2.30) | (2.34) | (2.28) | (4.54) | (2.57) |
| Asian | -7.80*** | -4.95 | -6.76*** | -15.31*** | -3.65 |
| | (3.46) | (3.55) | (3.47) | (6.46) | (4.21) |
| Other Race | 3.79 | 4.27 | 4.23 | 9.92 | 2.04 |
| | (3.87) | (3.96) | (3.84) | (6.11) | (5.37) |
| Sophomore | -1.76 | -2.48 | -1.89 | 0.17 | -3.32 |
| | (1.84) | (1.88) | (1.82) | (3.06) | (2.36) |
| Junior | 0.49 | 0.75 | 0.37 | 2.82 | -1.66 |
| | (2.06) | (2.10) | (2.04) | (3.15) | (2.95) |
| Senior | -1.70 | -4.43 | -4.44 | -6.27 | 9.07 |
| | (3.12) | (3.35) | (3.24) | (4.62) | (5.79) |
| Private School | -1.23 | -1.10 | -0.89 | -2.52 | 0.97 |
| | (1.58) | (1.62) | (1.57) | (2.52) | (2.02) |
| Job | -0.76 | -1.22 | -0.84 | 0.88 | -1.75 |
| | (1.26) | (1.29) | (1.25) | (2.25) | (1.58) |
| First Time Econ | 1.18 | 1.41 | 1.14 | 0.19 | 1.32 |
| | (1.37) | (1.40) | (1.36) | (2.20) | (1.77) |
| Number of Courses | 0.51 | 0.25 | 0.39 | 2.01 | -0.81 |
| | (0.77) | (0.79) | (0.77) | (1.31) | (0.97) |
| International Student | -0.34 | -1.37 | -1.08 | 3.54 | -1.45 |
| | (2.44) | (2.51) | (2.43) | (4.29) | (3.14) |
| Transfer | -2.25 | -2.25 | -1.70 | -2.56 | -3.02 |
| | (1.81) | (1.85) | (1.80) | (2.91) | (2.48) |
| # of Math Classes | -2.02 | -4.01 | -2.86 | -5.70 | -1.50 |
| | (4.49) | (4.59) | (4.45) | (8.00) | (5.67) |
| Cumulative GPA | 4.08*** | 4.37*** | 3.87*** | 3.16*** | 4.81*** |
| | (0.63) | (0.64) | (0.63) | (0.98) | (0.87) |
| NKU | 0.70 | -0.33 | 0.22 | -2.21 | 0.92 |
| | (1.66) | (1.72) | (1.67) | (2.80) | (2.09) |
| YHC | -4.92*** | -7.57*** | -5.35*** | -6.60*** | -4.74*** |
| | (1.61) | (1.56) | (1.60) | (2.71) | (2.06) |
| Constant | 59.18*** | 64.62*** | 58.37*** | 51.30*** | 60.61*** |
| | (9.21) | (9.30) | (9.13) | (17.24) | (10.86) |
| Observations | 260 | 259 | 259 | 119 | 140 |
| R-squared | 0.41 | 0.38 | 0.42 | 0.50 | 0.45 |

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

Table 5: 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 | 7.94*** | 10.57*** | 6.51*** |
| | (1.64) | (3.11) | (2.00) |
| High Ability and Low Confidence | 6.50*** | 9.98*** | 4.11*** |
| | (1.68) | (3.11) | (2.04) |
| Low Ability and High Confidence | 6.22*** | 5.36 | 5.47*** |
| | (1.90) | (3.63) | (2.31) |
| Male | 2.45*** | | |
| | (1.24) | | |
| Age | -0.16 | 0.36 | -0.22 |
| | (0.27) | (0.57) | (0.30) |
| White (Hispanic) | -0.88 | -3.99 | 3.15 |
| | (2.18) | (3.55) | (2.96) |
| Black | -2.22 | -3.28 | -2.43 |
| | (2.30) | (4.63) | (2.58) |
| Asian | -5.75 | -11.59*** | -3.16 |
| | (3.51) | (6.60) | (4.21) |
| Other Race | 4.46 | 11.09*** | 1.64 |
| | (3.88) | (6.29) | (5.37) |
| Sophomore | -2.13 | -0.80 | -3.24 |
| | (1.84) | (3.13) | (2.36) |
| Junior | 0.28 | 2.09 | -1.69 |
| | (2.05) | (3.27) | (2.94) |
| Senior | -2.64 | -4.94 | 8.72 |
| | (3.15) | (4.49) | (5.77) |
| Private School | -1.18 | -2.66 | 0.35 |
| | (1.58) | (2.65) | (2.05) |
| Job | -0.20 | 2.23 | -1.60 |
| | (1.27) | (2.34) | (1.58) |
| First Time Econ | 1.24 | 0.79 | 1.36 |
| | (1.38) | (2.26) | (1.78) |
| Number of Courses | 0.62 | 2.55*** | -0.69 |
| | (0.77) | (1.37) | (0.98) |
| International Student | -1.11 | 2.20 | -0.78 |
| | (2.47) | (4.57) | (3.14) |
| Transfer | -2.50 | -3.10 | -3.36 |
| | (1.80) | (2.95) | (2.48) |
| # of Math Classes | -1.97 | -4.71 | -1.08 |
| | (4.49) | (8.30) | (5.75) |
| Cumulative GPA | 4.23*** | 3.45*** | 5.06*** |
| | (0.64) | (1.01) | (0.88) |
| NKU | -0.35 | -2.24 | 0.23 |
| | (1.68) | (2.88) | (2.10) |
| YHC | -6.29*** | -6.85*** | -5.48*** |
| | (1.58) | (2.77) | (2.02) |
| Constant | 59.95*** | 45.75*** | 64.58*** |
| | (9.20) | (17.92) | (10.91) |
| Observations | 260 | 120 | 140 |
| R-squared | 0.42 | 0.48 | 0.45 |

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

# 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.*

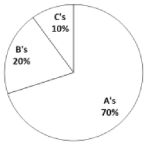
___ 1. A special lottery is to be held to select the student who will live in the only deluxe room in a dormitory. There are 100 seniors, 150 juniors, and 200 sophomores who applied. Each senior's name is placed in the lottery 3 times, each junior's name 2 times, and each sophomore's name 1 time. What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

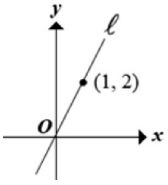
A. $ 44.44
B. $109.08
C. $118.80
D. $408.04
E. $444.40

___ 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?



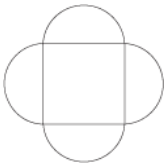

A. 3.0
B. 3.4
C. 3.6
D. 3.7
E. Cannot be determined from the given information

___ 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. · = − $\frac{1}{2}$ · + 1
C. · = − ·
D. · = − · + 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

## Appendix Table 1: Math Quiz Continued

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

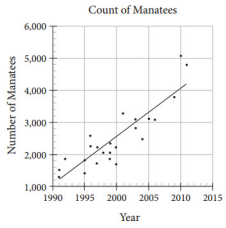
9. A survey was conducted among a randomly chosen sample of U.S. citizens about U.S. voter participation in the November 2012 presidential election. The table below displays a summary of the survey results. According to the table, for which age group did the greatest percentage of people report that 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 | 5.33*** | | 4.55*** | 7.84*** | 2.92*** |
| | (1.34) | | (1.35) | (2.43) | (1.59) |
| High Confidence | | 4.37*** | 3.46*** | 2.11 | 3.94*** |
| | | (1.27) | (1.27) | (2.13) | (1.63) |
| Male | 2.66*** | 3.43*** | 2.44*** | | |
| | (1.26) | (1.23) | (1.24) | | |
| Age | -0.21 | -0.30 | -0.18 | 0.35 | -0.23 |
| | (0.27) | (0.27) | (0.27) | (0.57) | (0.30) |
| White (Hispanic) | -0.91 | -0.15 | -0.63 | -4.46 | 3.73 |
| | (2.21) | (2.23) | (2.18) | (3.52) | (2.89) |
| Black | -1.51 | -2.23 | -1.74 | -3.28 | -2.06 |
| | (2.33) | (2.34) | (2.30) | (4.63) | (2.55) |
| Asian | -7.27*** | -4.17 | -5.38 | -11.20*** | -3.19 |
| | (3.51) | (3.58) | (3.53) | (6.60) | (4.21) |
| Other Race | 3.37 | 4.93 | 4.51 | 10.56*** | 2.03 |
| | (3.93) | (3.98) | (3.90) | (6.28) | (5.35) |
| Sophomore | -1.92 | -2.51 | -2.06 | -0.73 | -3.29 |
| | (1.87) | (1.88) | (1.85) | (3.14) | (2.36) |
| Junior | 0.57 | 0.75 | 0.44 | 2.56 | -1.79 |
| | (2.09) | (2.11) | (2.06) | (3.24) | (2.94) |
| Senior | -0.81 | -2.59 | -2.40 | -4.39 | 8.69 |
| | (3.16) | (3.24) | (3.17) | (4.47) | (5.77) |
| Private School | -1.44 | -1.19 | -1.10 | -3.23 | 0.69 |
| | (1.60) | (1.62) | (1.59) | (2.60) | (2.01) |
| Job | -0.48 | -0.88 | -0.29 | 1.97 | -1.62 |
| | (1.29) | (1.29) | (1.28) | (2.33) | (1.57) |
| First Time Econ | 1.39 | 1.63 | 1.54 | 1.02 | 1.57 |
| | (1.39) | (1.40) | (1.38) | (2.25) | (1.76) |
| Number of Courses | 0.66 | 0.34 | 0.55 | 2.49*** | -0.81 |
| | (0.79) | (0.79) | (0.78) | (1.37) | (0.97) |
| International Student | 0.41 | -1.55 | -0.77 | 3.33 | -1.05 |
| | (2.48) | (2.52) | (2.48) | (4.46) | (3.12) |
| Transfer | -2.63 | -2.85 | -2.46 | -3.33 | -3.19 |
| | (1.83) | (1.84) | (1.81) | (2.94) | (2.47) |
| # of Math Classes | -1.71 | -3.64 | -2.51 | -3.71 | -1.97 |
| | (4.56) | (4.59) | (4.51) | (8.26) | (5.66) |
| Cumulative GPA | 4.23*** | 4.51*** | 4.07*** | 3.37*** | 4.89*** |
| | (0.64) | (0.63) | (0.63) | (1.00) | (0.86) |
| NKU | 0.50 | -0.50 | -0.27 | -2.45 | 0.46 |
| | (1.69) | (1.72) | (1.69) | (2.88) | (2.08) |
| YHC | -5.84*** | -7.38*** | -6.01*** | -6.68*** | -5.20*** |
| | (1.60) | (1.56) | (1.58) | (2.77) | (1.99) |
| Constant | 61.95*** | 67.44*** | 62.38*** | 46.76*** | 67.13*** |
| | (9.29) | (9.24) | (9.17) | (17.91) | (10.56) |
| Observations | 260 | 260 | 260 | 120 | 140 |
| R-squared | 0.39 | 0.38 | 0.41 | 0.47 | 0.45 |

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 | 0.15*** | | 0.14*** | 0.22*** | 0.10*** |
| | (0.03) | | (0.03) | (0.05) | (0.04) |
| Perceived Math Aptitude | | 1.60*** | 0.63 | -1.74 | 1.82*** |
| | | (0.69) | (0.71) | (1.24) | (0.87) |
| Male | 2.18*** | 3.28*** | 2.02 | | |
| | (1.25) | (1.27) | (1.26) | | |
| Age | -0.19 | -0.33 | -0.19 | 0.29 | -0.15 |
| | (0.27) | (0.27) | (0.27) | (0.56) | (0.30) |
| White (Hispanic) | -0.95 | -0.25 | -0.85 | -4.12 | 3.48 |
| | (2.18) | (2.26) | (2.18) | (3.43) | (2.89) |
| Black | -0.68 | -2.10 | -0.79 | -4.00 | -1.53 |
| | (2.30) | (2.37) | (2.31) | (4.56) | (2.57) |
| Asian | -7.80*** | -4.89 | -7.13*** | -18.23*** | -2.87 |
| | (3.46) | (3.63) | (3.54) | (6.51) | (4.23) |
| Other Race | 3.79 | 4.03 | 3.98 | 10.28*** | 2.13 |
| | (3.87) | (4.02) | (3.88) | (6.14) | (5.34) |
| Sophomore | -1.76 | -2.26 | -1.74 | 0.58 | -3.07 |
| | (1.84) | (1.91) | (1.84) | (3.05) | (2.36) |
| Junior | 0.49 | 1.32 | 0.65 | 3.30 | -1.05 |
| | (2.06) | (2.14) | (2.07) | (3.13) | (2.97) |
| Senior | -1.70 | -1.76 | -2.12 | -2.11 | 9.91*** |
| | (3.12) | (3.27) | (3.15) | (4.37) | (5.70) |
| Private School | -1.23 | -1.37 | -1.14 | -3.63 | 0.86 |
| | (1.58) | (1.64) | (1.59) | (2.54) | (2.01) |
| Job | -0.76 | -1.24 | -0.77 | 0.79 | -1.76 |
| | (1.26) | (1.30) | (1.26) | (2.26) | (1.57) |
| First Time Econ | 1.18 | 1.58 | 1.25 | -0.15 | 1.38 |
| | (1.37) | (1.42) | (1.38) | (2.23) | (1.76) |
| Number of Courses | 0.51 | 0.29 | 0.45 | 2.06 | -0.97 |
| | (0.77) | (0.80) | (0.78) | (1.32) | (0.98) |
| International Student | -0.34 | -0.72 | -0.55 | 4.28 | -1.36 |
| | (2.44) | (2.54) | (2.45) | (4.26) | (3.10) |
| Transfer | -2.25 | -2.56 | -2.07 | -3.82 | -2.51 |
| | (1.81) | (1.88) | (1.82) | (2.89) | (2.48) |
| # of Math Classes | -2.02 | -3.75 | -2.43 | -5.97 | -1.79 |
| | (4.49) | (4.66) | (4.51) | (8.06) | (5.65) |
| Cumulative GPA | 4.08*** | 4.49*** | 3.99*** | 3.39*** | 4.72*** |
| | (0.63) | (0.65) | (0.64) | (0.99) | (0.87) |
| NKU | 0.70 | 0.01 | 0.49 | -1.77 | 1.10 |
| | (1.66) | (1.73) | (1.68) | (2.83) | (2.05) |
| YHC | -4.92*** | -7.32*** | -5.02*** | -6.37*** | -4.66*** |
| | (1.61) | (1.58) | (1.62) | (2.72) | (2.04) |
| Constant | 59.18*** | 64.84*** | 58.47*** | 54.32*** | 59.12*** |
| | (9.21) | (9.46) | (9.25) | (17.21) | (10.84) |
| Observations | 260 | 260 | 260 | 120 | 140 |
| R-squared | 0.41 | 0.36 | 0.41 | 0.49 | 0.45 |

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

Appendix Table 5: 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 Ability | 7.46*** | 7.01*** | 8.13*** |
| | (1.64) | (2.97) | (1.92) |
| High Ability and Perceived Low Ability | 5.43*** | 7.40*** | 3.90*** |
| | (1.75) | (3.15) | (2.00) |
| Low Ability and Perceived High Ability | 3.86*** | -2.51 | 7.49*** |
| | (1.88) | (3.58) | (2.08) |
| Male | 2.46*** | | |
| | (1.25) | | |
| Age | -0.23 | 0.42 | -0.23 |
| | (0.27) | (0.58) | (0.29) |
| White (Hispanic) | -0.87 | -4.68 | 3.01 |
| | (2.20) | (3.57) | (2.80) |
| Black | -2.25 | -3.54 | -3.41 |
| | (2.35) | (4.69) | (2.52) |
| Asian | -5.97*** | -13.64*** | -2.68 |
| | (3.55) | (6.59) | (4.05) |
| Other Race | 4.26 | 9.68 | 2.59 |
| | (3.93) | (6.36) | (5.16) |
| Sophomore | -1.87 | -0.34 | -3.16 |
| | (1.86) | (3.14) | (2.28) |
| Junior | 0.94 | 2.88 | -0.87 |
| | (2.08) | (3.25) | (2.85) |
| Senior | -1.69 | -2.61 | 10.63*** |
| | (3.16) | (4.42) | (5.50) |
| Private School | -1.25 | -4.12 | 0.69 |
| | (1.60) | (2.62) | (1.97) |
| Job | -0.49 | 1.39 | -1.94 |
| | (1.28) | (2.37) | (1.52) |
| First Time Econ | 1.64 | 0.78 | 1.84 |
| | (1.40) | (2.30) | (1.71) |
| Number of Courses | 0.63 | 2.36*** | -0.84 |
| | (0.78) | (1.38) | (0.94) |
| International Student | -0.19 | 4.33 | -1.54 |
| | (2.47) | (4.39) | (3.03) |
| Transfer | -2.30 | -4.06 | -2.67 |
| | (1.82) | (2.95) | (2.38) |
| # of Math Classes | -2.14 | -4.04 | -2.09 |
| | (4.55) | (8.35) | (5.55) |
| Cumulative GPA | 4.10*** | 3.57*** | 4.84*** |
| | (0.64) | (1.02) | (0.84) |
| NKU | 0.39 | -2.22 | 1.23 |
| | (1.68) | (2.91) | (1.97) |
| YHC | -5.88*** | -6.96*** | -4.98*** |
| | (1.59) | (2.78) | (1.93) |
| Constant | 61.88*** | 47.55*** | 65.76*** |
| | (9.30) | (18.03) | (10.43) |
| Observations | 260 | 120 | 140 |
| R-squared | 0.40 | 0.47 | 0.49 |

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

| Confidence | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Low | High | | | | |
| Ability | Low | 28%/18%/36% | 16%/14%/17% | | Whole/Men/Women | | |
| | High | 26%/28%/23% | 31%/40%/24% | | | | |
| | | | | | | | |

*is there a citation for women underestimating their abilities more than men?

*is there a way to fix this pedologically? Because actual ability doesn't seem to matter