Which Math Skill Matters the Most in Accounting Learning?

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Accounting has been one of the most popular business majors in the United States and is a subject that requires substantial quantitative and analytical skills. At many universities and colleges, accounting courses typically require a certain level of mathematics preparation. However, it is still unclear which branches of mathematics contribute most to students' accounting learning. We collect data on students' math ability and accounting performance to investigate the relation between three mathematics skills (arithmetic, algebra, and word problems) and accounting learning. Our results have implications on college curriculum design, showing that an emphasis should be on word problems for accounting students.

Keywords: accounting learning, mathematics, arithmetic, algebra, word problems

INTRODUCTION

Accounting has been one of the most popular business majors in the United States (Stockwell, 2014) and accounting courses are part of the curriculum for many non-accounting majors, such as business administration, economics, and other non-business majors. According to Merriam-Webster dictionary (Merriam-Webster., n.d.), accounting is defined as the system of recording and summarizing business and financial transactions and analyzing, verifying, and reporting the results. Accounting is a subject that requires substantial quantitative and analytical skills, inherent in mathematics courses. It is not rare to see that at many universities or colleges, accounting courses typically require a certain level of mathematics preparation demonstrated through math placement tests, standardized tests (e.g. ACT and SAT), and passing prerequisite college courses.

For instance, at the University of Iowa, multiple mathematics courses including Calculus I, Calculus and Matrix Algebra for Business, and Quantitative Reasoning for Business are listed as possible prerequisite courses for Managerial Accounting. Similarly, two mathematics courses, Probability and Statistics for the Engineering and Physical Sciences and Mathematical Statistics II, are listed as possible prerequisites for Accounting for Management Analysis and Control (University of Iowa, 2021). It appears to be common practice to include mathematics coursework in accounting programs. However, considering that mathematics has many branches (such as arithmetic, geometry, algebra, statistics, and calculus), it is still unclear which branches of mathematics contribute most to students' accounting learning.

This study aims to shed some light on which math skill matters the most in accounting learning. We collect data on students' math ability and accounting performance from a four-year public university in the United States. We find that, among the three mathematics skills: arithmetic, algebra, and word problems, the ability to complete word problems has a significant positive association with accounting performance. We also find that (1) although all three mathematics skills are positively associated with accounting grades individually, word problems skill is the only one remaining significantly positive when all skills are considered together and (2) Accounting/Economics students outperform Business Administration major students in math test total scores as well as in word problems scores. In addition, students' math skills and accounting final grades vary depending on gender and math courses taken in college. Our results not only have implications on college curriculum design, showing that there should be emphasis on word problems for accounting students, but may also contribute to students' decision making about how to choose a major in college that is a good fit.

The paper proceeds as follows. Section 2 reviews relevant literature and develops hypotheses. Section 3 discusses research design and data. Section 4 reports our results. Section 5 concludes this paper and offers avenues for future research.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Studies reveal factors that may influence students' accounting ability. It is commonly agreed that higher Grade Point Average (GPA) and standardized tests scores (ACT and SAT) could significantly relate to better performance in accounting courses (Fedoryshyn, O'Brien, Hintz, & Bosner, 2010; Phillips, 2015). However, there are mixed findings in the existing literature as to the effect of students' mathematics background on their accounting course performance. While some empirical studies have confirmed that better mathematics course performance significantly predicts students' performance in accounting courses (Clark & Sweeney, 1985; Yunker, Yunker, & Krull, 2009), there are also arguments of no significant association between math and accounting (Burdick & Schwartz, 1982; Fedoryshyn et al., 2010). For an example in favor, some researchers (Gist, Goedde, & Ward, 1996; Phillips, 2015) find that students' calculus study is positively linked to their accounting learning. However, Burdick and Schwatz (1982) find that algebra or calculus grades cannot predict students' performance in accounting.

Aside from success in mathematics courses, students' perceptions and attitudes toward mathematical ability could significantly impact accounting performance (Boateng, 2015; Du, Liang, & Schalow, 2019; Ferreira & Santoso, 2008; Lucas & Meyer, 2005; Ma, Chen, & Ampountolas, 2016). Moreover, accounting and accounting education have been evolving with more emphasis on data analytics skills, which will in turn shape students' attitudes, perceptions, and performance as they encounter data analytics skills in curriculum, professional certificate programs, and job descriptions (AICPA & NASBA, 2021). In other words, not just mathematics skills, but also student perceptions and attitudes, will always be an important element in accounting.

Combining the contradictory results regarding the importance of mathematics preparation with students' attitudes toward mathematical ability in accounting performance, it is critical to conduct more in-depth investigations. Specifically, many previous studies measure "math ability" in a general way (e.g. Zandi and Shahabi, 2012), which leaves the gap to investigate what specific math skills influence accounting performance. This study intends to shed some light on this question. As the foundation and tools for many disciplines, mathematics includes a broad range of specialties that could be utilized in various ways for different purposes. Therefore, it is reasonable to believe certain math capabilities could be particularly important in accounting learning. The results of this study will provide practical guidance on what specific math preparation will be essential for students' success in accounting courses. Additionally, knowing what specific math skills are utilized in accounting will further help accounting students appreciate the nature of accounting.

Depending on the context and complexity, accounting could employ different branches of mathematics. This study examines the most commonly used mathematics skills in accounting: arithmetic, algebra, and word problems, and attempts to establish the relationship between these skills and accounting course performance. First, arithmetic reasoning is the ability to quickly and accurately manipulate numbers. Accounting requires this ability to grasp interrelationships between numbers and perform basic arithmetic operations; thus, students' skill in arithmetic might be positively related to accounting performance. For example, Fedoryshyn et al. (2010) find a strong correlation between arithmetic reasoning skills and a student's final average in introductory accounting courses. Second, accounting employs basic algebra applications to analyze and solve financial problems that simulate the real business world (Roberts, 1997); therefore, students' skill in algebra might be positively related to their accounting performance. Collier's and McGowan's (1989) research among accounting course students indicates that the higher their pretest scores of algebra, the better their final course grades will be. Similarly, Yunker et al. (2009) establish the positive relationship between ability in an algebra course and success in an accounting course among high school students. Third, accounting is a subject based on mathematical word problems (Babalola & Abiola, 2013) that require students to solve questions in a real-life context through the application of mathematical formulas or equations (Mkhize, 2019). Here is an example of a word problem: "Let's say that you paid $115 for a textbook and your bookstore marked up the price by 25%. How much did the bookstore pay for the textbook?" Thus, it is reasonable to believe that students' skill in solving word problems might be positively related to their accounting performance.

Accounting is an applied subject with numbers as part of the language to communicate economic information. There are definitions, meanings, and boundaries behind all the numbers. Therefore, we posit that word problems solving ability may be the most important skill, since problem solving skills involve critical elements in accounting decision making, such as understanding the problem, devising a plan, carrying out the plan, and looking back to check the answer (Polya, 2004). Moreover, as accounting students are more adapted to the subject, they could be better prepared in terms of interpreting numbers under certain contexts. They may do better in word problems solving than students pursuing other majors. Taken together, this study proposes the following hypotheses:

H1a: *A student's arithmetic skill is positively associated with his/her accounting performance.*

H1b: *A student's algebra skill is positively associated with his/her accounting performance.*

H1c: *A student's skill at solving word problems is positively associated with his/her accounting performance.*

H1d: *A student's skill at solving word problems has a stronger positive association with his/her accounting performance than his/her arithmetic or algebra skill.*

H2: *Accounting major students perform better with word problems than non-accounting major students.*

RESEARCH DESIGN

Data

A growing number of colleges are phasing out standardized tests as an admissions requirement (Vigdor & Diaz, 2020). Some colleges, such as the University of Chicago, Harvard, and Cornell, have waived ACT or SAT scores. Other colleges have made the tests optional, such as the University of California system. Thus, in our study, in lieu of standardized tests, to measure students' math ability, a math test is given to accounting students at a four-year public university in the United States. There are 15 questions, distributed evenly in algebra, arithmetic, and word problems categories. The math test is provided in the Appendix. The math test is handed out during class to a total of 581 students. We receive 273 complete responses, which gives us a response rate of 47%. Students' accounting final grades and available ACT math section scores are collected as well. A short survey is also sent out to students to collect their demographic information, such as major, gender, and mathematics courses they have taken in college. We receive 217 valid responses, giving us a 37.3% response rate.

Nonparametric Tests

Due to violation of normal distribution in certain groups in our data, to test hypothesis two, Kruskal-Wallis test and Dunn test are chosen to examine whether there is any difference in math performance between different majors. Based on previous research, gender (Jacobs & Eccles, 1985; Miller & Bichsel, 2004; Rodríguez, Regueiro, Piñeiro, Estévez, & Valle, 2020) and math courses taken in college (Johnson & Kuennen, 2006) are also considered as group variables. Thus, Wilcoxon test, Kruskal-Wallis test, and Dunn test are used to explore whether there is any difference in math performance between females and males, and between students who have taken different mathematics courses in college.

Multivariate Regressions

Multivariate regressions are chosen to test hypothesis one, which investigates the relation between mathematics skills and accounting learning.

Dependent Variable

Accounting final grade on a 100-point scale is the dependent variable in our multivariate regression models.

Test Variable

Algebra, arithmetic, and word problems, as well as the comprehensive math ability measured by the sum of the three, are the test variables in our multivariate regression models.

Control Variables

Based on previous research, four control variables are included in our regression models. Gender (Rebele, Stout, & Hassell, 1991; Reed & Holley, 1989; Wally-Dima & Mbekomize, 2013), major (Shotweel, 1999), mathematics courses taken in college (Gist et al., 1996; Phillips, 2015), and high school accounting exposure are included in the models as control variables.

Model Specification

$$final\_grade = algebra + gender + major + math\_college + accthighschool \tag{1}$$

$$final\_grade = arithmetic + gender + major + math\_college + accthighschool \tag{2}$$

$$final\_grade = word + gender + major + math\_college + accthighschool \tag{3}$$

$$final\_grade = algebra + arithmetic + word + gender + major + math\_college \\ + accthighschool \tag{4}$$

RESULTS

Descriptive Statistics

Two-hundred and seventeen valid demographic surveys are collected. As presented in Table 1, 102 (47%) of the respondents are business administration major students, 23 (11%) are accounting students, 8 (4%) are economics students, and 84 (39%) are non-business students. Female students account for 47% (101), while male students account for 53% (116). Approximately half of the respondents have taken a calculus course in college, and approximately a quarter of them have taken Elementary Statistical Methods in college. In this study, we also give students a math test in class and use that grade as a proxy for their math ability. Students who perform better on the math test tend to have more positive attitudes toward math, which is consistent with the results obtained using ACT math scores (Du at el., 2019). As shown in Table 2, the average accounting final grade is around 79.98 and the average math test score is 9.71 out of 16 (i.e., 60.7%). The average scores for the arithmetic section, the algebra section, and the word problems section are 4.34 out of 6 (i.e., 72.3%), 1.75 out of 4 (i.e., 43.8%), and 3.61 out of 6 (i.e., 60.2%), respectively.

TABLE 1
DEMOGRAPHIC STATISTICS

Variable	N	N = 217[1]
Major	217	
Accounting		23 (11%)
Business Administration		102 (47%)
Economics		8 (3.7%)
Non-business		84 (39%)
Gender	217	
Female		101 (47%)
Male		116 (53%)
Math Taken in College	217	
Calculus		110 (51%)
Elementary Statistical Methods		56 (26%)
Other		51 (24%)

[1]n (%)

TABLE 2
GRADE SUMMARY STATISTICS

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Median	Pctl(75)	Max
Accounting Final Grade	273	79.98	11.73	38.92	73.81	80.78	88	100
ACT Math Score	219	22.43	4	13	19	23	25	32
Math Test Total Score	273	9.71	2.80	2	8	10	11.5	16
Math Test Arithmetic Score	273	4.34	1.34	1	3	5	5	6
Math Test Algebra Score	273	1.75	0.98	0	1	1.5	2	4
Math Test Word Problems Score	273	3.61	1.46	0	3	4	5	6

Math Ability Difference by Gender, Major, and Math Course Taken in College

Table 3 presents the nonparametric tests results. The group sizes are uneven when dividing the students by majors. In our sample, Accounting, Economics, and Business Administration majors share the common business core requirements. Most Accounting and Economics major students double major in Business by selecting a couple more electives in Business. Hence, we combine Accounting major and Economics major students into one group, Accounting/Economics, to alleviate the uneven group sizes problem. Table 3 Panel A reports the Kruskal-Wallis test results for different majors, which indicate math test score ($p = 0.020$) and word problem score ($p = 0.032$) are significantly different among various majors. From the Dunn test results reported in Table 3 Panel B, it can be seen that Accounting/Economics students outperform Business Administration major students in math test total score ($p = 0.016$). As far as word problem skill, Accounting/Economics students outperform Business Administration major students ($p = 0.031$) and non-Business students ($p = 0.049$). Hypothesis two is supported. Table 3 Panel C reports the Wilcoxon test results for gender. The difference between females and males in word problems skill is statistically significant at 0.1 level (p = 0.053). Table 3 Panel D reports the Kruskal-Wallis test results for students that have taken different math courses in college. The results indicate students' math test score and word problems score differ among students who have taken calculus and those who have not. As shown in Table 3 Panel E Dunn test results, students who have taken a calculus course in college outperform those who have not in math test total score (p = 0.037) and word problems skill (p = 0.012). These differences are both statistically significant at 0.05 level.

TABLE 3
NONPARAMETRIC TESTS RESULTS

	Contrast	Statistic	p.adj
Panel A: Major – Kruskal-Wallis Test			
Math Test Score	Major	7.840	0.020
Arithmetic Score	Major	3.320	0.190
Algebra Score	Major	3.061	0.217
Word Problems Score	Major	6.907	0.032
Panel B: Major – Dunn Test			
Math Test Score	Accounting/Economics-Business	-2.788	0.016
	Accounting/Economics-Non-business	-1.853	0.128
	Business-Non-business	1.197	0.231
Arithmetic Score	Accounting/Economics-Business	-1.524	0.383
	Accounting/Economics-Non-business	-0.425	0.671
	Business-Non-business	1.460	0.383
Algebra Score	Accounting/Economics-Business	-1.368	0.406
	Accounting/Economics-Non-business	-0.248	0.803
	Business-Non-business	1.493	0.406
Word Problems Score	Accounting/Economics-Business	-2.570	0.031
	Accounting/Economics-Non-business	-2.250	0.049
	Business-Non-business	0.361	0.718
Panel C: Gender – Wilcoxon Test			
Math Test Score	Male-Female	5584	0.551
Arithmetic Score	Male-Female	6029	0.705
Algebra Score	Male-Female	6161.5	0.490
Word Problems Score	Male-Female	4988	0.053
Panel D: College Math Taken – Kruskal-Wallis Test			
Math Test Score	College Math Taken	6.447	0.040
Arithmetic Score	College Math Taken	0.649	0.773
Algebra Score	College Math Taken	2.930	0.231

Word Problems Score	College Math Taken	8.340	0.015
Panel E: College Math Taken – Dunn Test			
Math Test Score	Calculus-Elementary Statistical Methods	-1.200	0.461
	Calculus-Other	-2.507	0.037
	Elementary Statistical Methods-Other	-1.177	0.461
Arithmetic Score	Calculus-Elementary Statistical Methods	-0.143	0.886
	Calculus-Other	-0.796	0.426
	Elementary Statistical Methods-Other	-0.576	0.565
Algebra Score	Calculus-Elementary Statistical Methods	-1.366	0.466
	Calculus-Other	-1.421	0.466
	Elementary Statistical Methods-Other	-0.085	0.932
Word Problems Score	Calculus-Elementary Statistical Methods	-1.204	0.270
	Calculus-Other	-2.874	0.012
	Elementary Statistical Methods-Other	-1.495	0.270

Correlation Analysis

Table 4 presents a correlation table for the dependent variable, test variables and control variables we use in our regression models. A student's ACT math score, math test score and the word problems score are all positively associated with his/her accounting final grade at 0.3 or higher. Arithmetic and algebra scores are both positively associated with his/her accounting final grade as well and the correlation coefficients are 0.18 and 0.19, respectively. Hence, hypotheses 1a, 1b, and 1c are preliminarily verified. The math test score and the word section score are both positively associated with ACT math score at around 0.5, which indicates the math test captures the students' math ability well.

TABLE 4
CORRELATION

	Accounting Final Grade	ACT Math Score	Math Test Score	Arithmetic Score	Algebra Score
Accounting Final Grade					
ACT Math Score	0.38***				
Math Test Score	0.31***	0.46***			
Arithmetic Score	0.18*	0.32***	0.79***		
Algebra Score	0.19*	0.21**	0.70***	0.39***	
Word Problems Score	0.32***	0.49***	0.76***	0.33***	0.34***

Arithmetic, Algebra, Word Problems, and Accounting Grade

Table 5 presents the regression results. The VIF values for all five models are below 2, which indicates no significant multicollinearity problem exists. As shown in Table 5, columns (1), (2), and (3), arithmetic score, algebra score, and word problems score, are all positively associated with accounting final grade at 0.01 significance level, except arithmetic, which is statistically significant at 0.05 level. The results confirm hypotheses H1a, H1b, and H1c. Table 5 column (4) reports the results when arithmetic, algebra, and word problems scores are all included in a regression model. The results indicate that word problems have the strongest positive association among the three math skills with accounting final grade and this is statistically significant at 0.01 level. Hence, hypothesis 1d is supported. Female students on average have higher accounting final grades, compared with male students. Accounting and Economics students outperform Business Administration major and non-Business major students in accounting. In line with previous research (Gist et al., 1996; Phillips, 2015), students who have taken a calculus course in college report higher accounting final grades than those who have not. Students who have taken any accounting courses in high school outperform students who have not. When we consider the math test total score, instead of three individual measures, this is significantly positively associated with accounting final grade, which is consistent with results reported in prior research (Clark & Sweeney, 1985; Yunker et al., 2009).

TABLE 5
REGRESSION RESULTS

	Dependent variable:				
	Accounting Final Grade				
	(1)	(2)	(3)	(4)	(5)
Algebra Score	2.069***			1.108	
	(0.678)			(0.737)	
Arithmetic Score		1.110**		0.331	
		(0.509)		(0.536)	
Word Problems Score			2.049***	1.689***	
			(0.478)	(0.514)	
Math Test Score					1.045***
					(0.239)
Gender-Male	-2.013	-2.028	-2.766**	-2.558*	-2.295*
	(1.353)	(1.367)	(1.333)	(1.333)	(1.323)
Major-Business	-4.213**	-4.199**	-3.546*	-3.365*	-3.432*
	(1.966)	(1.993)	(1.938)	(1.937)	(1.938)
Major-NonBusiness	-3.191	-3.099	-2.579	-2.728	-2.892
	(2.155)	(2.177)	(2.114)	(2.108)	(2.108)
MathTaken-Statistics	-2.461	-2.788*	-2.153	-2.005	-2.177
	(1.643)	(1.655)	(1.613)	(1.610)	(1.610)
MathTaken-Other	-4.658**	-4.838***	-4.038**	-3.810**	-3.943**
	(1.821)	(1.839)	(1.796)	(1.794)	(1.796)
AcctHighSchool-Yes	3.818**	3.182**	3.488**	3.507**	3.270**
	(1.537)	(1.563)	(1.505)	(1.517)	(1.504)
Constant	82.588***	81.621***	78.604***	76.285***	75.677***
	(2.408)	(3.089)	(2.717)	(3.267)	(3.191)
Observations	217	217	217	217	217
R^2	0.139	0.121	0.174	0.187	0.176
Adjusted R^2	0.110	0.091	0.146	0.152	0.149
Residual Std. Error	9.793 (df = 209)	9.897 (df = 209)	9.596 (df = 209)	9.561 (df = 207)	9.581 (df = 209)
F Statistic	4.827*** (df = 7; 209)	4.102*** (df = 7; 209)	6.272*** (df = 7; 209)	5.302*** (df = 9; 207)	6.383*** (df = 7; 209)

*p<0.1; **p<0.05; ***p<0.01
Note: AcctHighSchool indicates if a student has taken any accounting courses in high school.

CONCLUSION AND DISCUSSION

In this study, we collect data on accounting students' mathematics skills and accounting performance and conduct nonparametric tests and multivariate regression analyses to examine the relation between mathematics skills and accounting learning. We find (1) although all three mathematics skills are positively associated with accounting grade individually, word problems skill is the only one that remains significantly positive when all skills are considered together and (2) Accounting/Economics students outperform Business Administration major students in math test total scores as well as in word problems scores. We also find that male students outperform female students in solving word problems and students who have taken a calculus course in college outperform those who have not in the math test total score and the word problems score. In addition, students who have taken calculus perform better in accounting than students who have taken other math courses besides calculus and Elementary Statistic Methods, such as Intermediate Algebra, Algebra for Pre-Calculus, and Mathematics for the Social and Management Sciences.

Despite the fact that many universities and colleges require students to take mathematics courses before they take specific accounting courses, we cannot speak to how much is necessary for them to successfully study accounting courses. This study points out that mathematics, and in particular calculus, has an overall positive impact on students' accounting learning. However, among the three areas of mathematics skills (arithmetic, algebra, and word problems), the degree of influence on their accounting learning varies. Students' ability to solve word problems has the highest level of positive influence on their accounting learning. This finding has several implications: first, colleges and universities may wish to ascertain students' ability to solve word problems. For example, if previous data is unavailable to measure students' ability to solve word problems, colleges and universities may design a test to do so. The test result may be used to advise students to choose proper majors. For the students who are strong in word problems, an accounting major could be a possible good fit. For the students who do not perform well on word problems, accounting may not be a good choice. Second, students can also use this finding to help them decide if accounting would be a proper major for them. Third, students may not need to learn all the math content currently required in prerequisites for their accounting courses. Colleges and universities may redesign their mathematics courses for accounting courses (and possibly for other subjects as well) to fit the accounting students' needs (for example, a short course with a focus on word problems). If this approach is difficult to implement, a focus on word problems may be addressed briefly in the beginning of the accounting courses. Moreover, given the positive association between taking a calculus course and accounting performance, making calculus a required prerequisite, instead of an optional one, might better prepare students for accounting courses.

The limitations of this study indicate potential directions for future research. Regarding the representativeness of the samples, there could be some dispute regarding the generalization of the proposed model to other universities and subjects. Future research could replicate this study at other institutions to test the external validity of our results. In addition, the data of math ability was collected at a single point in time; therefore, the study findings may not rule out all alternatives. Future research can adopt a longitudinal design, with math ability tested at the beginning and the end of an accounting course, to investigate the relation between math ability and accounting performance.

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APPENDIX

Math Test

1. Calculate the problems without a calculator.
81.43-27.9
45.39+17.86
26.5×43.4
948.24 ÷ 12
$\frac{3}{11}+\frac{5}{7}=$

(Leave the result in the form of a fraction).
Calculators are allowed for questions 2-8.

2. Calculate:
$180-75\div 5$

3. Factor completely
$6x^2-xy-y^2$

4. Simplify the following expression:
$\frac{2x^2 3x-2}{2x^2-5x-3}$

5. Solve the quadratic equation:
$3x^2-4x+1=0$

6. If $4X-12=24$, then $X=$

7. Tom deposited $200 as principle into a bank with an interest of 4% compounded annually. What is the balance after 2 years?

8. A new cellphone costs $800 at T&T store. During the Black Friday, there is a 30% discount, what is the price of the cellphone after the discount?

9. Tom works for a company with an hourly rate of $24.79. His boss informed him that starting next month, he will get an 8% increase of his hourly rate. How much he will earn per hour next month? (Round the nearest hundredth).

10. A store reduced the price of a computer by 20% and sold it for $2400. How much did the computer originally sell for?

11. Let's say that you paid $115 for a textbook and your bookstore marked up the price by 25%. How much did the bookstore pay for the textbook?

12. If equity is $300,000 and liabilities are $192,000, then assets = _____________.
(Hint: equity=assets-liabilities)