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Is Math Literacy a Determinant of Early Financial Literacy? An Investigation Based on State of Texas Assessment of Academic Readiness

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Abstract

The Texas public school system implemented financial planning education for grades K-8 beginning in the school year of 2012-13 as a result of a mandate by the state legislature. Using the data from test assessments in financial planning literacy and basic mathematics in grade 8, this paper finds empirical support for the pedagogical decision made by the Texas Education Agency to link the new state-mandated curriculum for financial planning literacy with the mathematics curriculum. A simple linear production function estimated by least squares regression, using robust standard errors, finds that a student's financial planning literacy score increases by 0.63 percentage point for a one percentage point increase in math score, controlling for demographics.

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The 2008 Great Recession was led by the housing crisis and loan defaults (Baker, 2008). The lack of consumer literacy in financial matters is considered by many to have been a significant determinant of the housing crisis because consumers took out loans that they could not afford (Gerardi, Goette, & Meier, 2012). Lusardi and Mitchell (2014) find that U.S. high school students score about a third as high as their German counterparts in financial literacy, supporting the need for education in financial planning in the U.S. The State of Texas is among a few states which have increased their focus on early financial literacy. The Texas Legislature mandated that the Texas Education Agency (TEA) institute personal financial education starting at the kindergarten level (TEA, 2012). TEA implemented the early financial literacy initiative starting with the school year of 2012-13. This initiative includes financial education as part of the mathematics curriculum in Grades K-8. Personal Financial Literacy (PFL) is an elective that falls under social studies in Grades 9-12.

It is instructional that TEA found it appropriate to incorporate education and testing of the new financial literacy curriculum as part of Math Literacy (ML). Joseph, Kalenkoski and Lacombe (2019a), utilizing international data collected from 15-year-old students by the Organization for Economic Cooperation and Development (OECD), find a substantial and statistically significant association between PFL and ML (OECD, 2012).

The State of Texas Assessment of Academic Readiness (STAAR) provides student assessments. The current essay analyzes the STAAR data and finds a positive association, both substantive and statistically significant, between PFL and ML, holding demographic variables constant. A simple linear production function for PFL motivates the associated model. It is

estimated using least squares regression using robust standard errors. This finding should support the efforts by the TEA to attach the new PFL curriculum to ML.

Literature

The theory of human capital, advanced by Becker (1993) and Mincer (1993), postulates that workers invest in their knowledge and skills through education to increase the economic value of their labor. Given that the target is financial wellbeing, this education includes education in financial literacy. Investments in personal financial literacy not only increase the value of one's knowledge and skills to one's organization in the traditional labor markets, but they also extend to gaining productivity in managing one's household finances, savings, and small business ownership (Greenspan, A., 2002). Given the multifaceted value of financial literacy, it is worth discussing the potential processes of bringing about early financial literacy to students.

Experiential learning, advanced by Kolb (1984), is described as the process of knowledge creation through transformative experiences or learning by doing. The theory of experiential learning suggests that the basic ideas in financial literacy can be acquired at relatively young ages, with the practice of experiential learning already in place, for the core subjects in early education, specifically mathematics for its possible synergy with financial literacy. The same process can be applied to financial education, where students from Grades K to 12 can learn from the financial-planning experiences in their households through their parents. Teachers can engage the families of students with live examples of financial planning concepts, taking advantage of the opportunity to learn through the experiences surrounding the students in their homes, thus enhancing the propensity to learn financial planning concepts (Niemiec & Ryan, 2009). This allows students to develop an appreciation, gradually from Grades K to 8, of

household-financial-planning concepts such as earnings, taxes, expenditures, savings, planning for higher education, budgeting, the real cost of loans, the time value of money and elements of wealth management (PFL, 2015). This approach to learning financial planning also utilizes the pedagogical axiom of relatedness–deliver content in a way the student can relate in a familiar context (Furrer & Skinner, 2003). In many cases, this may offer parents the opportunity to refresh their understanding of the topics (McCutchen & Berninger, 2010).

While early financial literacy is theoretically appealing, and educational initiatives are currently in place for early financial literacy in many states including Texas, the literature has found mixed empirical results regarding the effectiveness of early financial education. On the positive side, many researchers find substantial support for early financial education to deal with the day-to-day financial planning issues of consumers (Lusardi &Mitchell, 2014; Walstad, Rebeck, & MacDonald, 2010). Defining 'financial capability' as the ability to apply knowledge in the day-to-day financial affairs of the household, Wagner (2015) finds a strong and statistically significant association between financial literacy and financial capability, using the National Financial Capability Survey (NFCS). Joseph, Kalenkoski, and Lacombe (2019b), utilizing the NFCS data, find a substantive and statistically significant association between financial literacy and state-level, real per capita GDP (GSP) and also between financial literacy and state-level, per capita income (INC) in the U.S. Joseph et al. (2019b) also find that an increase in GSP or INC by about a third may be associated with either increasing financial literacy by about 33% or about doubling the percentage of college graduates in the U.S. Financial literacy of high school graduates in Germany is 52% versus 19% of those in the U.S. (Lusardi & Mitchell, 2014). Increasing financial literacy by a more modest 33% than what is

achieved in another industrialized country (Germany) may be more economically feasible than doubling the percentage of college graduates.

As indicated above, there are also negative findings on the lack of effectiveness of early financial literacy. These come from the periodic surveys by Mandell (2008) conducted between 1997 and 2008 on behalf of JumpStart, an organization dedicated to financial literacy (Jumpstart, 1995). However, retaining a working memory of topics learned in schools has been a challenge for all subjects (Ball, Lubienski, & Mewborn, 2001), thus requiring pedagogical solutions for effective financial education as well. Even though the empirical results on early financial literacy are mixed, without such pedagogical solutions the third of the population which does not go past high school or the three-quarters of the population who do not graduate from college can be left without basic financial planning skills (USFC, 2012).

This essay examines math literacy as a determinant of early financial literacy with a simple linear production function. The association proposed in the current essay between financial literacy and math literacy is supported by the pedagogical understanding that math skills rank high in importance in phases of learning (Gagne, 1970). Math also is described as foundational to anything financial (Lusardi & Wallace, 2013).

Regarding the importance of quantitative skills to financial literacy, the assessment questions for financial literacy are mathematical (Gilliland, Melfi, & Silorskii et al., 2011; Lusardi & Wallace, 2013), using a select sample of about 500 incoming freshmen at Michigan State University, find a positive association between quantitative and financial literacies. Joseph, et al. (2019a) find a substantive and statistically significant association between math and financial literacies when analyzing OECD data collected from 15-year-old students from 19 international educational systems.

In this essay, utilizing about 124,000 observations from the Texas schools, a simple linear production function is the basis of the model associating financial and math literacies, controlling for demographics (Bowles, 1970 and Hanushek, 2008). The present analysis finds a substantive and statistically significant association between PFL and ML, holding demographic factors constant.

Data

The data for this study come from the TEA. The TEA was chartered by the Texas Legislature to teach financial planning concepts starting in kindergarten beginning in the 2012-13 school year. As part of this program, PFL is taught under the mathematics curriculum in Grades K-8. PFL is taught in social sciences in Grades 9-12 as an elective. TEA began testing students in Spring 2013 through the state's assessment of academic readiness program STAAR. STAAR testing is divided into grades 3-8 and grades 9-12, where the latter is referred to as End of the Curriculum (EOC). STAAR started testing financial concepts only in 2015-16 in Grades 3-8. The 8th grade 2015-16 testing cohort will have benefited from the PFL coursework, which would begin in the 5th grade. The 2020-21 testing cohort will benefit from the full K-8 PFL curriculum.

The financial literacy questions in the STAAR tests are rigorous. For example, one 8th-grade question requires the calculation of the ending balance given a principal amount, a compound interest rate, and term without the use of a financial calculator. There are four PFL questions included in the 56 math questions in 2016 (42 starting in 2017) for the 8th grade. The PFL questions fall under the category of Data Analysis and PFL, which has a total of nine questions, with four questions designated as PFL. The other categories preceding this are 1) Numerical Representations & Relationships, 2) Communications & Algebraic Relationships, and

3) Geometric Measurement. These three categories provide 47 questions that represent basic Math Literacy (ML). Table H gives a breakdown of the questions in these categories.

The STAAR data from 2013 through 2016 contain approximately 10 million observations. The analysis in this paper uses the 410,600 observations from the Spring 2016 (2015-16 academic year) 8^{th}-grade tests in mathematics. To maintain the privacy of students, TEA removed about 195,000 observations from classes with fewer than five students in data fields like those of demographics. This is reduced further by about 91,000 missing observations (mainly illness during testing and testing irregularity). Data are also limited to mainstream students, excluding special education students (2,005), bilingual students (607), migrant students (340), and students of extreme ages [less than 12 and greater than 14] (405). These leave about 124,000 observations for analysis. Appendix J shows the stepwise-deletion process.

The dependent variable in this study is PFL, which is the percentage of correct answers to the four PFL questions. The key independent variable in this analysis is ML, measured by the percentage of responses to 47 basic math questions that are correct. Demographic variables are included in the analysis as controls. These include gender, age, participation in Career & Vocational and Gifted & Talented programs, being at-risk of graduating from high school and being economically disadvantaged. Table E3.1 presents the descriptive statistics for the variables used in the analysis.

(Suggested Space for Table 1)

Model

The model to be estimated is motivated by a simple linear production function for financial literacy and is given by:

$$PFL_i = \beta_0 + \beta_1 ML_i + \beta_2 G_i + \beta_3 C_i + \beta_4 T_i + \beta_5 E_i + \beta_{6\,Ri} + \beta_7 D_{LMi} + \beta_8 D_{MHi} + \beta_9 N_{Bi} + \beta_{10} N_{Hi} + \beta_{11} N_{Oi} + \beta_{12} A_{13i} + \beta_{13} A_{14i} + \varepsilon \quad (1)$$

where PFL is Personal Finance Literacy and ML is for Math Literacy, both measured on a continuous scale from 0 to 100%. This is followed by dichotomous variables such as G for gender (male for 1, otherwise 0 for female), C for Career & Vocational Elective (1 for participation, otherwise 0 for non-participation), T for Gifted & Talented (1 for participation in the program, otherwise 0 for non-participation), E for English Remedial Needs (1 when identified for remedial needs, otherwise 0 for non-identification), and R for at-risk of graduation (1 when designated as at-risk, otherwise 0 for non-designation). Two dummies for economic disadvantage are included, one for Low-Medium Economic Disadvantage (D_{LM}) and the other for Medium-High Economic Disadvantage (D_{MH}). Economically Sound is the omitted category. Three dummies for race/ethnicity also are included. These are Black who are not Hispanic/Latino (N_B), Hispanic/Latino (N_H), and Other (N_O). White, who is not Hispanic/Latino, is the omitted category. There also are two age dummies included, one for age 13 (A_{13}) and the other for age 14 (A_{14}). Age 12 is the omitted category. The β's are the coefficients to be estimated. The term ε stands for unexplained factors and follows the normal distribution. Least squares regression is employed to estimate this model, and robust standard errors are calculated.

The coefficient β_1 for ML is expected to be associated positively with PFL as ML is a critical component of all financial computations (Lusardi & Wallace, 2013). The remaining independent variables serve primarily as control variables for demographics and educational considerations. The effect of being male, β_2, is undetermined. Lachance and Mazzocco (2016) report on opposing findings in the literature regarding gender differences in math skills in the early school years. Their longitudinal study finds no gender difference in math skills. A meta-

analysis by Hyde, Fennema, and Lamon (1990) finds no advantage in math skills for males; if anything, they find an advantage for females.

The coefficient β_3, the effect of being in a Career & Vocational program, is expected to be associated positively with PFL under the theory of experiential learning (Kolb, 1984). The coefficient β_4, the effect of being in the Gifted & Talented program, by definition, is associated positively with literacy in general. The coefficient β_5, the effect of being identified for English Remedial Needs, is expected to be associated negatively with PFL. Such deficiency should impede learning any subject where English is the language of instruction. The coefficient β_6, the effect of being at risk of not graduating, by definition, is expected to be associated negatively with financial planning test scores.

The coefficients β_7 and β_8, the effects of being economically disadvantaged at low-medium and medium-high levels respectively, are expected to be associated negatively with learning because child development is influenced 50-70% by the environment (Jenson, 2009). The coefficients β_9, the effect of being Black who is not Hispanic/Latino, and β_{10}, the effect of being Hispanic/Latino, are at a disadvantage compared to being White who are not Hispanic/Latino. The coefficient β_{11} for the category of being Other (Asian, Pacific Islander, American Indian, or of two or more races) who are not Hispanic/Latino, are advantaged compared to being White who is not Hispanic/Latino. These socio-economic factors apply to education in general (Hanushek, 2010 and Haycock, 2001).

The coefficients β_{12} and β_{13}, the effect of higher ages 13 and 14 relative to age 12, is expected to be associated positively with education in general due to incremental maturity (maturational theory, referred to as Relative Age Effect - RAE) (Navarro, García-Rubio, &

Olivares (2015). Such an advantage may not persist as students advance to higher grades (Cascio & Schanzenbach, 2016).

Results

The least squares regression estimates of equation (1) with robust standard errors are presented in Table E3. 2. Math Literacy (ML) is statistically significant at a 1% level. PFL is estimated to increase by a score of 0.63 unit for every unit increase in ML score, all other variables held constant

(Suggested Space for Table 2)

The effect of the control variable Gender shows that males have 2.55 percentage points higher PFL scores compared to females. This effect of 2.6% percentage points compares to the PFL mean PFL score of 57% and hence not considered materially significant. This situation applies to the other control variables also as discussed below. The effect of participation in a Career & Vocational program is a higher 0.78 PFL score. The effect of being in a Gifted & Talented program is a 4.48 higher PFL score. The effect of being in an English Remedial program is a lower PFL score by 1.32 percentage points. The effect of being at-risk of not graduating is to lower the PFL score by 2.75 percentage points.

The effect of being economically disadvantaged at a Low-Medium level vs. the reference of Economically Sound is a lower PFL score by 0.87 percentage points. The effect of being economically disadvantaged at a Medium-High level vs. the reference of Economically Sound is a lower PFL score by 2.2 percentage points. The effect of Black, non-Hispanic/Latino, vs. White, non-Hispanic/Latino, as a reference is a lower PFL score by 3.12 percentage points. The effect of Hispanic/Latino, vs. White, non-Hispanic/Latino, as a reference is a lower PFL score by 2.18 percentage points. The effect of Other Ethnicity (predominantly Asian), non-Hispanic/Latino,

vs. White, non-Hispanic/Latino, is a 4.26 higher PFL score. The effect of age 13 years is a lower PFL score by 2.23 percentage points vs. 12 years. The effect of age 14 years is a lower PFL score by 2.62 percentage points vs. 12 years of age.

The negative association of age with PFL is not consistent with the idea of the Relative Age Effect in learning. However, the literature suggests that this advantage may not be universal, as mentioned earlier. A recent study shows that relative age advantage in mathematics is present through the 3rd grade in Germany but reverses by the 8th grade (Thoren, Heinig, & Brunner, 2016).

Overall, the quantitative significance of the control variables is relatively small as the effects on PFL are for a full switch (0% to 100%) between the states of these categorical variables. The most significant impact on PFL is the effect of changing from White, non-Hispanic/Latino, to Other (predominantly Asian), an increase of 4.3 percentage points in PFL, given the mean PFL score is 57%.

Conclusions

Financial literacy has been a concern for the Texas educational policymakers who made the directive to incorporate Personal Financial Literacy (PFL) into the curriculum starting in kindergarten, beginning with the 2012-13 school year. TEA incorporated financial planning topics into math lessons. This offers an opportunity in the current essay to examine the association between PFL and Math Literacy (ML) to guide educational policy makers on how best to create financial planning literacy.

This essay finds that financial literacy is associated with substantively and positively with math literacy, controlling for demographics. The marginal effect of ML on PFL is 0.63

percentage point. This is based on utilizing 8th grade (mainly 13-year-old) students in Texas public schools in 2016 as part of the state's assessments of academic readiness program STAAR.

The analysis in this essay is consistent with prior analysis by Joseph (2017), utilizing 2012 data on 15-year-old students from 19 international educational systems, including the U.S., generated by the OECD. The current study associated with Texas public schools also finds a substantially positive and statistically significant association between financial literacy and math literacy, controlling for the demographic factors.

This paper may provide support for the initiatives taken in 2012 in the Texas Public Schools to promote early financial literacy through math curriculum in Grades K-8. A longitudinal study to assess progress in financial planning literacy in Grades K-8 should be considered in 2020-21 when the first kindergarten cohort from 2012-13 reaches Grade 8. This longitudinal study may include Grade 12 in 2024-25.

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Appendix A

Map of Texas STAAR Tests

Texas STAAR Tests - Map of Math Questions (Focus: 8th Grade)

Reporting Category	Standards	**Questions by Grades** - 2017												**2016**	
		3	Q's	4	Q's	5	Q's	6	Q's	7	Q's	8	Q's	8	Q's
1	Readiness	4		3		2		4		2		1		2	
Numerical	Supporting	10	8	10	9	4	6	11	10	5	6	3	4	6	5
Representation	Total	14		13		6		15		7		4		8	
2	Readiness	5		5		6		6		5		5		3	
Communicatio	Supporting	9	13	7	11	9	17	11	15	7	15	9	16	2	22
ns & Algebraic	Total	14		12		15		17		12		14		5	
3	Readiness	3		4		3		3		4		5		1	
Geometric	Supporting	6	7	7	10	5	9	3	6	5	12	9	15	5	20
Measurement	Total	9		11		8		6		9		14		6	
4	Readiness	1		1		1		3		2		2		3	
Data Analysis	Supporting	6	4	4	4	6	4	10	7	8	7	6	7	4	9
& PFL	Total	7		5		7		13		10		8		7	
	Readiness	13		13		12		16		13		13		11	34-36
	Supporting	31		28		24		35		25		27		22	20-22
	Total Qis.		32		34		36		38		40		42		56
	Mult Choice		29		31		33		34		36		38		52
	Griddablle		3		3		3		4		4		4		4

Note: The Texas Education Agency was directed to reduce the number of test questions for the STAAR tests starting 2017 as directed by the Texas Legislature

Appendix B

Deletion of Observations from STAAR Data

Stepwise Deletion of Observations from STAAR Data

Observations - Type		Observations
Total observations:		410,600
Dropped:		
Students in Response groups <5		194,603
Missing Obs. Under Math		90,369
Other*	85,409	
No information available	3,507	
Absent	1,779	
Students flagged for missing I.D.		111
Migrant students		340
Bilingual		607
Special Ed students		2,005
Remaining observations, if no overlap		123,172
Undeclared gender		1
Obs. in analysis, before clearing extreme ages		124,424
Obs. in extreme ages outside <12-13-14 >		405
Obs. in analysis:		**124,019**

* Illness during testing, Testing Irregularities

Source: STAAR Tests - Grade 8, March 2016. Texas Education Agency.

Tables

Table 1

Summary Statistics: Financial Literacy, Math Literacy and Demographics, Based on Texas Educational System

Descriptive Statistics - Association between Financial Literacy and Math Literacy

Variables	Mean	Std. Dev.	Min	Max
Financial Literacy (FL) Score	57.122	25.636	0	100
Basic Math Literacy (ML) Score	60.261	18.778	0	100
Gender (Female omitted)	0.488	0.500	0	1
In Vocational Elective Program	0.237	0.425	0	1
In Gifted/Talented Program	0.048	0.213	0	1
In English Remedial Program	0.105	0.307	0	1
At-risk of Not Graduating	0.486	0.500	0	1
Economical Disadvantage				
(Economically Sound omitted)				
Economically Disadvantaged : Low-Medium	0.450	0.498	0	1
Economically Disadvantaged: Medium-High	0.111	0.314	0	1
Race/Ethnicity (White omitted)				
Black	0.101	0.302	0	1
Hispanic/Latio (Regrdless of Race)	0.561	0.496	0	1
Other (Mainly Asians)	0.018	0.134	0	1
Age (12 years omitted)				
Age - 13 years	0.833	0.373	0	1
Age - 14 years	0.076	0.264	0	1

Number of Observations = 124,019

Note. FPL & ML are on a continuous scale 0-100%. All other variables are discrete.

Source: STAAR Tests - Grade 8, March 2016. Texas Education Agency.

Table 2

Regression Results of Financial Literacy on Math Literacy

Simple Linear Production Function Estimates

Dependent Variable: Financial Literacy (FPL)

	Coeff-icient	Robust Std. Error		t	95% Conf.	Interval
Math Literacy (ML)	0.632	0.0040	***	157.08	0.62	0.64
Gender (Female omitted)	2.553	0.1229	***	20.77	2.31	2.79
In Career & Vocational Program	0.782	0.1438	***	5.44	0.50	1.06
In Gifted/Talented Program	4.476	0.2783	***	16.08	3.93	5.02
In English Remedial Program	-1.322	0.2258	***	-5.86	-1.76	-0.88
At-risk of Not Graduating	-2.749	0.1612	***	-17.05	-3.07	-2.43
Economical Disadvantage						
(Economically Sound omitted)						
Economically Disadvantaged: Low-Mediu	-0.864	0.1797	***	-4.81	-1.22	-0.51
Economically Disadvantaged: Medium-Hi	-2.197	0.2473	***	-8.88	-2.68	-1.71
Race/Ethnicity (White omitted)						
Black	-3.125	0.2555	***	-12.23	-3.63	-2.62
Hispanic/Latino (Regardless of Race)	-2.178	0.1811	***	-12.03	-2.53	-1.82
Other (Mainly Asians)	4.259	0.4065	***	10.48	3.46	5.06
Age (12 years omitted)						
Age - 13 years	-2.228	0.2233	***	-9.98	-2.67	-1.79
Constant	23.020	0.3816	***	60.33	22.27	23.77

Statistical Significance Levels: ***1*, **5%, *10%

Measures of Model Fit: R-sq. with Robust Std. Errors = 0.302

Observations, N = 124,019

Note. FPL & ML are on a continuous scale 0-100%. All other variables are discrete

Source: STAAR Tests - Grade 8, March 2016. Texas Education Agency