Numeracy
Advancing Education in Quantitative Literacy

Volume 4 | Issue 2 Article 6

2011

Quantitative Literacy at Michigan State University, 2: Connection to Financial Literacy

Dennis Gilliland
Michigan State University, gilliland@stt.msu.edu
Vince Melfi
Michigan State University, melfi@stt.msu.edu
Alla Sikorskii
Michigan State University, sikorska@msu.edu
Edward Corcoran
Michigan State University, ed.corcoran@gmail.com
Eleanor Melfi
University of Michigan, efmelfi@gmail.com

Quantitative Literacy at Michigan State University, 2: Connection to Financial Literacy

Abstract
The lack of capability of making financial decisions has been recently described for the adult United States population. A concerted effort to increase awareness of this crisis, to improve education in quantitative and financial literacy, and to simplify financial decision-making processes is critical to the solution. This paper describes a study that was undertaken to explore the relationship between quantitative literacy and financial literacy for entering college freshmen. In summer 2010, incoming freshmen to Michigan State University were assessed. Well-tested financial literacy items and validated quantitative literacy assessment instruments were administered to 531 subjects. Logistic regression models were used to assess the relationship between level of financial literacy and independent variables including quantitative literacy score, ACT mathematics score, and demographic variables including gender. The study establishes a strong positive association between quantitative literacy and financial literacy on top of the effects of the other independent variables. Adding one percent to the performance on a quantitative literacy assessment changes the odds for being at the highest level of financial literacy by a factor estimated to be 1.05. Gender is found to have a large, statistically significant effect as well with being female changing the odds by a factor estimated to be 0.49.

Keywords
financial literacy, quantitative literacy, numeracy

Cover Page Footnote
Dennis Gilliland is Professor of Statistics and Probability at Michigan State University. He is a Fellow of the American Statistical Association with current research interests in quantitative literacy, statistical inference and strategies for repeated games.

Vince Melfi is Associate Professor of Statistics and Probability and Mathematics Education, and Director of the Mathematics Education Graduate Program at Michigan State University. His current research interests include quantitative literacy and adaptive allocation in clinical trials.

Alla Sikorskii is Assistant Professor of Statistics and Probability at Michigan State University. Her research interests include quantitative literacy, methodology and measurement in health research, and stochastic processes.

Edward Corcoran is a graduate student in Mathematics Education at Michigan State University. His current research interests include quantitative literacy and undergraduate persistence in STEM majors.

Eleanor Melfi is an undergraduate student at the University of Michigan. She is studying Biochemistry and Chinese.

Introduction

Definitions of *quantitative literacy* (sometimes referred to as *numeracy*) range from simple to very broad statements. Consider a few examples:

- "Using simple mathematical concepts to solve everyday problems." Chosen by Colby-Sawyer College in its NSF-funded project to integrate quantitative literacy across its curriculum (Steele and Kilic-Bahi 2008).
- "The term *numeracy* describes the aggregate of skills, knowledge, beliefs, dispositions, and habits of mind—as well as the general communicative and problem-solving skills—that people need in order to effectively handle real-world situations or interpretative tasks with embedded mathematical or quantifiable elements" (Gal 1995).
- "Ability to formulate, evaluate, and communicate conclusions and inferences from quantitative information." "Quantitative literacy employs analytical arguments and reasoning built upon fundamental concepts and skills of mathematics, statistics, and computing" (Estry and Ferrini-Mundy 2005).

Steen (2001, p. 108) states that "numeracy is not so much about understanding abstract concepts as about applying elementary tools in sophisticated settings." Quantitative literacy (QL) builds on yet goes beyond the understandings and manipulative skills that are developed in typical mathematics, statistics or computer science courses, understandings and skills which are seen as prerequisite for other courses and for later professional use. These courses may not be focused on the development of the functional, interpretative, and communicative skills that are part of QL.

As argued in many places (e.g., Steen 2001), it is important to the nation that its citizens are quantitatively literate. Citizens and elected representatives make decisions on complex matters such as public health policy and taxes on carbon emissions. These are but two examples of areas and questions where evaluation and interpretations are largely mathematical, probabilistic, and statistical in nature. Quantitative and financial literacy are also important to the individual well-being of persons as they go about their lives. Certainly the understanding of risks and benefits of medical procedures and compound interest are of value to an individual.

The importance of financial literacy (FL) to the individual well-being of persons is established through a series of recent studies. Banks and Oldfield (2007) established a strong positive association between financial literacy and wealth while controlling for other variables in a large sample of persons 50 years of age and older. Other researchers have established strong associations of financial literacy with decision-making and outcomes: Lusardi and Mitchell (2006) with savings for retirement; van Rooij et al. (2007) with stock market participation; and Gerardi et al. (2010) with defaults and payment delinquency for homeowners with subprime mortgages. Lusardi et al. (2008) surveyed young persons ages 23 through 28 with three financial literacy questions and they "found that most young adults are not well equipped to make financial decisions." Lusardi (2010) states: "The findings from the National Survey paint a troubling picture of the current state of financial capability in the U.S. adult population." A concerted effort to improve education in quantitative and financial literacy and to simplify financial decision-making processes is critical.

The broad definitions of quantitative literacy capture some aspects of financial literacy. However, the latter is built on an understanding of economic terms that may not be a part of a K−12 education. In 2009, the Council for Economics Education completed a survey of the state of economic, personal finance, and entrepreneurship education in the fifty states and the District of Columbia. It found that while all states and the District of Columbia included economics in their educational standards, only 19 states tested student knowledge in economics. Additionally, 21 states required high school students to take an economics course. Personal finance is included in the standards of 44 states and is tested in nine. Courses in personal finance or economics courses including personal finance content are required at the high school level in 13 states. Nineteen states included entrepreneurship in their standards, but only four required it to be included in a high school course (Council for Economics Education 2009).

Despite the inclusion of personal financial literacy in the curricula of many states, there is evidence that high school students lack personal financial literacy. Since 1997, the Jump$tart Coalition for Personal Financial Literacy has surveyed the financial literacy of high school students every two years. In 2008, they found that high school students achieved an average of 48.3 on their assessment, the lowest score to date. In addition, students who took a personal financial literacy course did no better than those who had not. 2008 was also the first year that the Jump$tart Coalition surveyed college students. In contrast to high school students, college students averaged 62.2 percent on the assessment with average scores increasing with each year in college (Mandell 2008).

In this paper, quantitative literacy is operationalized through scores on the three forms of the QL assessment found in Appendix A of the companion paper by Sikorskii et al. (2011), where their development and validation are reported. The instruments (forms) are called Basic, General, and Advanced, reflecting differences in, for example, the amount of reasoning versus procedural fluency being assessed. Most of the items deployed on the three instruments assess QL at the prerequisite level for post-secondary education. The Basic QL instrument has 17 QL items; over two years of testing, the subjects were 59% correct in responding to these items. The General and Advanced QL instruments each contain 14 QL items; over two years of testing the subjects were about 46% correct in responding to the items on each of these instruments. These instruments were, for this study, supplemented with FL questions.

Financial literacy level is defined through performance on the five items taken from the English Longitudinal Study of Aging (ELSA) and used by Banks and Oldfield (2007) and Gerardi et al. (2010) to group subjects into four levels of financial literacy. These items were chosen because of their use in the cited research that ties financial literacy to the financial well-being of individuals.

In the next section, we describe the assessment process and the subjects of the study. This is followed with sections containing the results of the quantitative literacy assessments, the results of the financial literacy assessments, and the findings from the study of their relationship. We close with conclusions and final remarks.

Assessment Process and the Sample

Incoming freshmen to Michigan State University attended a 2010 summer academic orientation program in 20 groups of about 350 students each. A QL assessment was administered to a subset of each group of students. For three of the groups, the assessment instrument included open-ended FL items along with the well-tested, multiple-choice QL items.

The instruments were administered after dinner, during a 45-minute session, to subjects in a large lecture hall. Students were seated by about 6:35 pm. The next five minutes were used to explain the study. The assessment instruments were distributed by about 6:40 pm and students were instructed to write their names and university-assigned identification numbers on the instruments and the answer sheet used for capturing answers to the multiple-choice items. Then there was an explanation of the first question. The first question asked these human subjects to choose between “consenting” or “not consenting.” The choice “consenting” allowed the researchers to use the student’s assessment results anonymously in publications and to query the student’s record as maintained in the university’s Student Information System (SIS).[1] About 93% (531 out of 572) of the incoming students consented across the three sessions where the financial literacy items were included. Most students were finished with the assessment within 25 minutes; these students remained quietly in their seats until all papers were called for at about 7:10 pm. Calculators were not allowed.

Tables 1 and 2 report demographic and covariate information for our consenting subjects (n = 531) and for all consenting subjects who took either

[1] The SIS maintains the record of demographic variables such as gender and ethnicity, and academic variables such as ACT scores, SAT scores, high school class rank, intended major, etc.

scientific reasoning or *quantitative literacy* assessments in summer 2010 (*n* = 5,001).

Table 1
Demographic Characteristics of the Sample Subjects

	All 2010 SR and QL subjects (n = 5,001)	***FL sample (n = 531)***	***FL Basic QL (n = 149)***	***FL Gen QL (n = 193)***	***FL Adv QL (n = 189)***
	***n* (%)**	***n* (%)**	***n* (%)**	***n* (%)**	***n* (%)**
Race and Ethnicity					
Caucasian/White non-Hispanic	4019 (80.3)	444 (83.6)	125 (83.9)	161 (83.4)	158 (83.6)
Black non-Hispanic	338 (6.8)	19 (3.6)	6 (4.0)	4 (2.1)	9 (4.8)
Hispanic	218 (4.4)	14 (2.6)	5 (3.4)	4 (2.1)	5 (2.7)
Asian	202 (4.0)	25 (4.7)	8 (5.4)	8 (4.2)	9 (4.8)
Native American	23 (0.5)	4 (0.8)	0 (0.0)	2 (1.0)	2 (1.1)
Other	111 (2.2)	15 (2.8)	3 (2.0)	11 (5.7)	1 (0.5)
Refused or missing	109 (1.8)	10 (1.9)	2 (1.3)	3 (1.6)	5 (2.7)
Gender					
Female	2723 (54.9)	309 (58.2)	97 (65.1)	99 (51.3)	113 (59.8)
Male	2238 (44.8)	217 (40.9)	50 (33.6)	92 (47.7)	75 (39.7)
Refused or missing	42 (0.8)	5 (0.9)	2 (1.3)	2 (1.0)	1 (0.5)

**SR* = scientific reasoning

Table 2.
Academic Characteristics of the Sample Subjects

	All 2010 SR and QL subjects (n = 5,001)	***FL sample (n = 531)***	***FL Basic QL (n = 149)***	***FL Gen QL (n = 193)***	***FL Adv QL (n = 189)***
	Mean (SD)	**Mean (SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**
High school GPA	3.62 (0.33)	3.65 (0.30)	3.66 (0.26)	3.63 (0.30)	3.65 (0.32)
Best ACT English score	25.51 (4.45)	25.70 (4.10)	25.91 (3.93)	25.98 (4.28)	25.23 (4.03)
Best ACT Reading score	25.87 (4.83)	25.90 (4.74)	26.30 (4.66)	25.98 (4.77)	25.49 (4.75)
Best ACT Science score	25.15 (3.78)	25.15 (3.68)	25.29 (3.62)	25.41 (3.88)	24.77 (3.49)
Best ACT Math score	25.32 (4.29)	25.42 (3.91)	25.52 (3.72)	25.70 (4.02)	25.06 (3.94)
Best ACT Writing score	24.61 (3.68)	24.76 (3.38)	24.95 (3.32)	25.12 (3.41)	24.25 (3.35)
Best ACT Composite score	25.62 (3.53)	25.70 (3.22)	25.90 (3.14)	25.93 (3.37)	25.29 (3.11)
QL Basic score (17 items)	–	–	9.71 (2.96)	–	–
QL General score (14 items)	–	–	–	6.99 (2.96)	–
QL Advanced score (14 items)	–	–	–	–	6.47 (2.82)

**SR* = scientific reasoning, SD = standard deviation

Quantitative Literacy Assessment Results

The Basic QL instrument, the General QL instrument, and the Advanced QL instrument were administered in the three separate sessions. Table 3 reports five-number summaries and means for scores on these instruments for the 531 subjects in the study.

Table 3

Descriptive Statistics for QL Score for the Three Sessions

	n	*Min*	Q_1	Q_2	Q_3	*Max*	*Mean*
Basic QL	149	2/17	8/17	9/17	12/17	17/17	9.7/17 (57.2%)
General QL	189	1/14	5/14	7/14	9/14	14/14	7.0/14 (50.0%)
Advanced QL	193	1/14	4/14	6/14	8/14	14/14	6.5/14 (46.4%)

Financial Literacy Assessment Results

We assessed FL with questions written with "financial" contexts in an attempt to capture what Lusardi and Mitchell (2009) refer to as the capacity to handle *basic financial literacy* concepts. In our study, financial literacy was assessed by adding six open-ended questions to the ends of the QL instruments. The first FL question asked for the change that would come from the purchase of an 85-cent item with a one dollar bill. Virtually all subjects responded correctly, and this item was removed from consideration in all analyses. The other five FL items used in our analyses and the percentages of correct responses for each of them are as follows.

F1. In a sale, a shop is selling all items at half price. Before the sale, a sofa costs $300. How much will it cost in the sale? (98.5% correct)

F2. If the chance of getting a disease is 10 percent, how many people out of 1,000 would be expected to get the disease? (92.6% correct)

F3. A second hand car dealer is selling a car for $6,000. This is two-thirds of what it cost new. How much did the car cost new? (79.4% correct)

F4. If 5 people all have the winning numbers in the lottery and the prize is $2 million, how much will each of them get? (76.0% correct)

F5. Say you have $200 in a savings account. The account earns ten percent interest per year, compounded yearly.[2] How much will you have in the account at the end of two years? (39.8% correct)

---

[2] The wording *compounded yearly* does not appear in the statement of this item in the other studies we have cited. Pretesting this item on some college students exposed the fact that some tried to use the (continuous) Annual Percentage Rate. The wording was added to remove ambiguity in the statement of the item.

Following Banks and Oldfield (2007) and others, we use responses to these five items to define four levels of financial literacy. The definitions of the Financial Literacy Levels are reported in Table 4. These definitions were used in Gerardi et al. (2010) as well as Banks and Oldfield (2007). In our application, the classification *incorrect* includes *wrong answer* and *no answer*.

Table 4

Definitions of the Financial Literacy Levels

Level 1 (*Least Financially Literate*)	Incorrect on F1–F3 or correct on F1 and incorrect on F2–F4
Level 2	Subjects not falling in Groups 1, 3 or 4
Level 3	Correct on F1–F4 and incorrect on F5
Level 4 (*Most Financially Literate*)	Correct on F1–F5

Table 5 reports the distribution of our incoming freshmen subjects across the Financial Literacy Levels. For comparisons, the distributions of subjects in the Banks and Oldfield (2007) study and the Gerardi et al. (2010) study are reported. The comparisons are hardly meaningful without taking into account the particulars of the subjects and data collection techniques. The Banks and Oldfield data were drawn from the 2002 wave of the English Longitudinal Study of Aging. The subjects were persons 50 years of age or older as of February 29, 2002. The Gerardi et al. subjects were persons in the United States holding subprime mortgages on their homes in summer 2008; apparently the subjects were interviewed over the telephone.

Table 5

Distributions of Subjects across Financial Literacy Levels

	Level 1	*Level 2*	*Level 3*	*Level 4*
Incoming Freshmen (2010)	2.3%	36.9%	29.8%	31.1%
Banks and Oldfield (2007)	16.2%	46.5%	26.1%	11.2%
Gerardi et al. (2010)	15.6%	53.9%	17.1%	13.3%

Quantitative and Financial Literacy Relationship

In all subsequent tabulations and analyses of the incoming freshmen, FL Level 1 and FL Level 2 subjects are aggregated and the resulting group named FL Level 2*. We see that a subject is in FL Level 2* if and only if the subject was incorrect on one or more of the items F1 through F4. FL Level 3 subjects were correct on items F1 through F4 and missed F5; FL Level 4 subjects were correct on all five items F1 through F5.

All statistical analyses reported here treat FL as a categorical variable. The methods include the contingency table chi-square test for independence, and the chi-square tests based on the difference of deviances in binary and in polytomous logistic regression models. The first-mentioned chi-square test assesses the association of two categorical variables; the second assesses the contribution of independent variables to regression models. In the binary case, the response variable is membership in FL Level 4 or not, and, in the polytomous case, the response variable is FL at three levels. We use of the term *statistically significant* when the *p*-value of the test statistic is less than 0.05. Hosmer and Lemeshow (2000) provide background for the methods used in the analyses.

Recall that one and only one of the three QL instruments was administered in each of the three assessment sessions. In each session, the QL items were followed with the same open-ended FL items. This raises the question as to whether the distribution of subjects across FL levels is dependent on the form of the QL instrument used to assess QL. A cross-tabulation of FL level and QL form (Table 6) shows no statistically significant association for the two variables (chi-square *p*-value = 0.49). In other words, the association of financial literacy level and the particular set of QL items that preceded the FL items is not statistically significant.

Table 6

Cross-tabulation of QL Form and FL Level

	*FL Level 2**	*FL Level 3*	*FL Level 4*	*Total*
Basic QL	63 (42.3%)	39 (26.2%)	47 (31.5%)	149 (100.0%)
General QL	75 (39.7%)	62 (32.8%)	52 (27.5%)	189 (100.0%)
Advanced QL	70 (36.3%)	57 (29.5%)	66 (34.2%)	193 (100.0%)
Total	208 (39.2%)	158 (29.8%)	165 (31.1%)	501 (100.0%)

The average QL score percent is 40.9% for FL Level 2* subjects, 48.7% for FL Level 3 subjects, and 64.8% for FL Level 4 subjects. The large average QL score percent for FL Level 4 subjects illustrates the discrimination power that the FL item on compound interest (F5) has in regard to quantitative literacy.

Binary logistic regression models were fit to assess the relationship of being in FL Level 4 to QL score percent and other independent variables (see Tables 1 and 2). The numerical independent variables used in the analyses were QL percent score, Math placement score (a university assessment used for placing in-coming students in mathematics courses), ACT Composite score (best), and ACT Math score (best). Categorical independent variables were Gender, Race, Intended major (STEM[3] or not), and QL Form (three levels). We included QL Form in fitting the full model to the data to adjust for any possible form effects

[3] STEM refers to Science, Technology, Engineering or Mathematics, as used in National Center for Education Statistics publications. We used the NSF classification of majors discussed in Chen (2009), which uses a degree classification scheme described in Morgan and Hunt (2002).

even though the above chi-square contingency table analysis suggests that there is little pairwise association of FL level and QL form. The pairwise interactions of possible interest and capable of estimation with our data were Gender with QL Form, Gender with Intended major, Gender with the four continuous variables and the pairwise interaction of QL Form and QL percent score. These interactions were included in the full model first fit to the data. The chi-square test based on difference of deviances showed the set of pairwise interactions not to be statistically significant (p-value = 0.42). A parsimonious model was then derived by eliminating the variables one-at-a-time based on largest p-value until only variables with p-values less than 0.05 remained. This led to the reduced model with fitted regression equation

$$LogOdds(FL\ Level\ \mathbf{4}) = -5.923 - 0.710 * Indicator\ for\ Female + 0.116 * ACT\ Math + 0.046 * QL\ Percent$$

where the p-values of the three coefficients are 0.002, 0.002 and < 0.001, respectively (last column of Table 7). The chi-square test based on difference of deviances showed the set of main effects that were eliminated not to be statistically significant (p-value = 0.99). There is multicollinearity among the independent variables yet the coefficients of the three surviving variables remained stable across the series of reduced models. In the fit of the full additive model, the coefficients for the three surviving terms were −0.735, 0.108 and 0.056, respectively.

Table 7 gives the results of the analysis in terms of estimates of odds ratios (OR), and the lower (LB) and upper (UB) 95% confidence bounds for the ratios.

Table 7
Fitted Odds Ratios for Binary Logistic Regression

Independent Variable		*Estimate*	*95% LB*	*95% UB*	*p-value*
QL Score %		1.05	1.03	1.06	< 0.001
Best ACT Math		1.12	1.05	1.21	0.002
Gender	**Female**	0.49	0.31	0.77	0.002
	Male	referent	•	•	•

QL score percent is statistically significant. An increment of 1% in QL score percent changes the odds for being in FL Level 4 by an estimated factor of 1.05. An increment of 1 point in the ACT Math score multiplies the odds for being in FL Group 4 by an estimated factor of 1.12. Gender has a large, statistically significant effect as well.

The fitted binary model may be best understood using *probability* rather than *log odds*, that is, using *Prob*(*FL Level* **4**) rather than *LogOdds*(*FL Level* **4**) where

$$Prob(FL\ Level\ \mathbf{4}) = \frac{e^{LogOdds(FL\ Level\ 4)}}{1 + e^{LogOdds(FL\ Level\ 4)}}.$$

Consider a female subject with QL score percent 50% and ACT Math score 26. For this hypothetical subject, the fitted *log odds* for being at FL Level 4 is

$$LogOdds(FL\ Level\ \mathbf{4}) = -5.923 - 0.710 * 1 + 0.116 * 26 + 0.046 * 50 = -1.317$$

which leads to the *probability*

$$Prob(FL\ Level\ \mathbf{4}) = \frac{e^{-1.317}}{1 + e^{-1.317}} = 0.21.$$

For a male, the *Indicator for Female* variable is 0. The estimates for a male with QL score percent 50% and ACT Math score 26 are *LogOdds*(*FL Level* **4**) = −0.607 and *Prob*(*FL Level* **4**) = 0.35. Table 8 gives an array of the estimated probabilities for various combinations of gender, ACT Math score and QL score percent.

Table 8

Estimated Probabilities for being at FL Level 4

	ACT Math Score 24			***ACT Math Score 26***			***ACT Math Score 28***		
QL Score	**40%**	**50%**	**60%**	**40%**	**50%**	**60%**	**40%**	**50%**	**60%**
Female	0.12	0.17	0.25	0.14	0.21	0.30	0.18	0.25	0.35
Male	0.21	0.30	0.40	0.25	0.35	0.46	0.30	0.41	0.52

To investigate the three levels of financial literacy more fully, a polytomous logistic regression model was fit to relate probabilities for all three financial literacy categories (FL level 2*, FL level 3, FL level 4) to independent variables including QL score percent, ACT Math score, race, and gender using SAS, Version 9.2. Table 9 contains the results in regard to estimates for the comparisons FL Level 3 versus FL Level 2*, FL Level 4 versus FL Level 2* and FL Level 4 versus FL Level 3. Fitted odds ratios are reported for all independent variables that are statistically significant in at least one of the comparisons.

Table 9 shows that only QL score percent is a significant predictor for FL Level 3 versus FL Level 2*; that is, in discriminating between Levels 3 and 2* of FL, QL score percent matters over and above gender and ACT Math score, which are not statistically significant. On the other hand, QL score percent, ACT Math score and gender are statistically significant for FL Level 4 versus FL Level 2*. When we compare FL Level 4 versus FL Group 3, QL score percent and gender are statistically significant predictors, but ACT Math score is not. The effects of QL score percent remain significant after the stringent Bonferroni adjustment for multiple comparisons, that is, the *p*-values are less than 0.05/3 = 0.017.

Table 9

Fitted Odds Ratios for Polytomous Logistic Regression

Independent Variable	*Level*	**Odds Ratios FL Level 3 v. FL Level 2***			
		Est.	***95% LB***	***95% UB***	***p-value***
QL Score (%)		1.03	1.009	1.042	0.002
Best ACT Math		1.08	0.999	1.158	0.054
Gender	**Female**	1.22	0.742	2.003	0.434
	Male	referent	•	•	•
		Odds Ratios FL Level 4 v. FL Level 2*			
		Est.	***95% LB***	***95% UB***	***p-value***
QL Score (%)		1.06	1.045	1.082	< 0.0001
Best ACT Math		1.16	1.068	1.263	0.0005
Gender	**Female**	0.56	0.329	0.937	< 0.0001
	Male	referent	•	•	•
		Odds Ratios FL Level 4 v. FL Level 3			
		Est.	***95% LB***	***95% UB***	***p-value***
QL Score (%)		1.04	1.020	1.054	< 0.0001
Best ACT Math		1.08	0.996	1.170	0.0621
Gender	**Female**	0.46	0.274	0.757	0.0024
	Male	referent	•	•	•

In our study of the relationship of QL and FL, the effect of gender has surfaced. Breaking out the results for the five FL items by gender we find that the items had these percentages correct by (males, females): F1 (96.3%, 100%), F2 (95.9%, 90.6%), F3 (87.6%, 74.1%), F4 (81.6%, 72.8%), and F5 (60.8%, 25.9%). The differences are statistically significant based on *p*-values from the chi-square test (Fisher Exact test for item F1) for two-by-two contingency tables.

Conclusions and Final Remarks

Among the $n = 531$ subjects, 31.1% are at FL Level 4, the most financially literate level. Binary logistic regression models for membership in FL Level 4 were fit to the data. Among the independent variables, only QL score percent, ACT Math score, and gender have statistically significant effects.

Financial literacy and QL score percent have a strong, positive association on top of the effects of ACT Math score and gender. This positive association may not be surprising. After all, financial literacy is a type of numeracy and the FL and

QL data for a subject were generated by an assessment taken in one short session while the ACT Math score came from a separate test situation. The strength of the association is somewhat surprising along with its persistence in models that adjust for ACT Math score and other independent variables. The large gender effect persists after controlling for QL score percent, ACT Math score, and other independent variables.

Comparing simple percentages, 47.9% of the male subjects were at FL Level 4 compared to 19.7% for female subjects, a very large gender difference in financial literacy. The direction of the gender difference agrees with those reported for items in other studies. The percentages of correct answers to a simple compound interest question were reported for (males, females) as (74.7%, 61.9%) in Lusardi (2008) and as (81.3%, 57.9%) in Lusardi and Mitchell (2009). In a survey of young persons, there were three financial literacy questions labeled Interest Rate, Inflation, and Risk; the percentages correct for (males, females) were (82.2%, 76.7%), (60.1%, 53.3%), and (53.3%. 40.1%), respectively (Lusardi et al. 2008). Banks and Oldfield (2007) report statistically significant gender effects as well. In our study, the five FL questions had these percentages correct by (males, females): F1 (96.3%, 100%), F2 (95.9%, 90.6%), F3 (87.6%, 74.1%), F4 (81.6%, 72.8%), and F5 (60.8%, 25.9%). Females outperformed males on item F1 that concerns the sale price of a sofa. Males outperformed females by a large margin on item F5 that concerns compound interest. Performance on item F5 is used to define the highest level of financial literacy, FL Level 4. The gender differences in performance on items F1 and F5 serve to remind the reader of the sensitivity of definitions of level of financial literacy to the items used in that definition.

With the polytomous logistic regression analyses, QL score percent is statistically significant in distinguishing between FL Level 3 and FL Level 2*, between FL Level 4 and FL Level 2*, and between FL Level 4 and FL Level 3. ACT Math score is statistically significant only in distinguishing between the highest and lowest levels of financial literacy, FL Level 4 and FL Level 2*. Gender has a large and statistically significant effect for the comparisons between the highest level FL Level 4 and the two lower levels but not the comparison of FL Level 3 and FL Level 2* where the definitions of level do not depend upon performance on the compound interest item.

The research reported in this paper will be followed in summer 2011 with another study of the relationship of quantitative literacy and financial literacy and gender differences. In 2011−12, there will be follow-up on subjects who entered the university in Fall 2008 and in Fall 2009. Performance on QL and FL items will be compared to responses obtained in assessments in the summers preceding the fall entrances into classes. We expect that the results will inform decisions on course content and university requirements in mathematics and statistics as well as decisions on integrating more QL content into courses across all disciplines.

Acknowledgments

Support for this research came from the Quantitative Literacy Project, Office of the Provost, Michigan State University. The authors thank Andrew Miller, the referees, and the editor for their many useful suggestions. The authors take responsibility for any deficiencies remaining in the paper.

References

Banks, J. and Z. Oldfield. 2007. Understanding pensions: Cognitive function, numerical ability and retirement saving. *Fiscal Studies* 28 (2): 143−170. http://dx.doi.org/10.1111/j.1475-5890.2007.00052.x

Chen, X. 2009. *Students who study science, technology, engineering, and mathematics (STEM) in postsecondary education*. NCES Report 2009−161, http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2009161 (accessed May 28, 2011).

Council for Economics Education. December 2009. *Survey of the States: Economic, Personal Finance & Entrepreneurship Education in Our Nation's Schools in 2009*. New York.

Estry, D. W. and J. Ferrini-Mundy. 2005. Quantitative Literacy Task Force: Final Report and Recommendations. Michigan State University.

Gal, I. 1995. Big picture: What does "Numeracy" mean?. *GED Items*, ISSN 0896-0518, 12 (4). http://mathforum.org/teachers/adult.ed/articles/gal.html (accessed May 28, 2011).

Gerardi, K., L. Goette, and S. Meier. 2010. Financial literacy and subprime mortgage delinquency: Evidence for a survey matched to administrative data. Working Paper, Federal Reserve Board, Atlanta, April 1.

Hosmer D. W. and S. Lemeshow. 2000. *Applied logistic regression*, 2nd ed. New York: John Wiley and Sons. http://dx.doi.org/10.1002/0471722146

Lusardi, A. 2008. Financial literacy: An essential tool for informed consumer choice? (Woking paper UCC08-11). http://www.jchs.harvard.edu/publications/finance/understanding_consumer_credit/papers/ucc08-11_lusardi.pdf (accessed May 28, 2011).

________. 2010. Americans' financial capability. Report prepared for the Financial Crisis Inquiry Commission, February 26. http://fcic-static.law.stanford.edu/cdn_media/fcic-testimony/2010-0226-Lusardi.pdf (accessed May 28, 2011).

Lusardi, A. and O. Mitchell. 2006. Financial literacy and planning: Implications for retirement wellbeing. Pension Research Council Working Paper 1, The

Wharton School. http://www.dartmouth.edu/~alusardi/Papers/FinancialLiteracy.pdf (accessed May 28, 2011).

________. 2009. How ordinary consumers make complex economic decisions: Financial literacy and retirement readiness. National Bureau of Economic Research Working Paper No. 15350. http://www.nber.org/papers/w15350.pdf (accessed May 28, 2011).

Lusardi, A., O. Mitchell and V. Curto. 2008. Financial literacy among the young. University of Michigan Retirement Research Center Working Paper 2008-191. http://deepblue.lib.umich.edu/bitstream/2027.42/64131/1/wp191.pdf (accessed May 28, 2011).

Mandell, L. 2008. *The financial literacy of young American adults: Results of the 2008 National Jump$tart Coalition Survey of High School Seniors and College Students*. Washington, DC: The Jump$tart Coalition for Personal Financial Literacy.

Morgan, R. L., and E. S. Hunt. 2002. *Classification of instructional programs*: 2000 edition. NCES Report 2002−165. http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2002165 (accessed May 28, 2011).

Sikorskii, A., V. Melfi, D. Gilliland, J. Kaplan, and S. Ahn. 2011. Quantitative literacy at Michigan State University: Development and initial evaluation of the assessment. *Numeracy* 4 (2): Article 5. http://dx.doi.org/10.5038/1936-4660.4.2.5

Steele, B. and S. Kilic-Bahi. 2008. Quantitative literacy across the curriculum: A case study, *Numeracy*, 1 (2): Article 3. http://dx.doi.org/10.5038/1936-4660.1.2.3

Steen, L. A. 2001. Embracing numeracy. In *Mathematics and democracy*, ed. L. A. Steen, 107−116. Princeton, NJ: National Council on Education and the Disciplines.

van Rooij, M., A. Lusardi, and R. Alessie. 2007. Financial literacy and stock market participation. National Bureau of Economic Research Working Paper No. W13565. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1024979## (accessed May 28, 2011)