Best Practices in Financial Education: Incorporating Mathematics

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Objective

There is a pressing need for improved financial knowledge across the US population. Research has shown that financial education programs can be an effective solution to this problem. However, there is wide variability in the success of different education interventions, and the reasons for this heterogeneity are not yet fully understood. A crucial project is to increase our knowledge of best practices in financial education, in order to maximize the benefits participants in future courses receive.

One important dimension of this goal is understanding the role of mathematics in a high-quality personal finance course, given the well-documented correlation between mathematical knowledge and financial literacy. We present results from a study that investigates the relationship between financial learning and mathematical learning. A sample of high-school students were assessed on both financial and mathematical knowledge, before and after taking a course that combined mathematics and personal finance.

Our goal is to investigate whether there is a connection between mathematical *learning* and financial *learning*. Previous research has primarily looked at the connection between a student's mathematical knowledge or education level and their financial knowledge at a single point in time. This leaves a lot unknown about how and why the two values are connected. To shed further light on the matter, our study measures how a student's mathematical knowledge and financial knowledge *changes* over the course of a year and allows us to see how the changes are related. Analysis of the results confirms that there is a correlation between the two. This suggests that a course combining finance and mathematics is an effective approach to financial education.

Significance

The level of financial knowledge in the US is much lower than it should be, given the complex financial choices people must navigate in modern Western society. A vast body of research demonstrates the breadth and depth of this issue. The successive 'Financial Capability Surveys' (FINRA 2009, 2013, 2015) show that a large percentage of Americans are unable to answer a number of questions on central financial concepts, and display a lack of knowledge in "fundamental economic principles" (Lusardi 2011).

Of particular concern is the lack of financial knowledge in young people in the United States, given that the country is trending towards placing more individual responsibility on financial planning (Lusardi & Mitchell 2014), and technological developments promise ever more complex financial instruments will be available in the future. It has been demonstrated that most high-school and undergraduate students fail basic financial literacy tests (Hastings, Madrian & Skimmyhorn 2012; Lusardi, Mitchell & Curto 2010). Making this even more concerning is the fact that many people are making poor financial decisions and experiencing negative financial outcomes. Research indicates that the lack of financial knowledge and poor financial outcomes are connected. Higher financial literacy is connected with higher levels of wealth accumulation (Behrman, Mitchell, Soo, & Bravo 2012), with better investment portfolio diversification (Abreu & Mendes, 2010), with better 401(k) performance (Clark, Lusardi, & Mitchell 2014), and with avoidance of costly borrowing behavior (Lusardi & Tufano 2015).

As a response to this problem, there has been a growth in financial education programs across the county: from state-mandated high school courses, to on-the-job training sessions (Council of Economic

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Education, 2016). An essential research project is to assess the effectiveness of such courses. There have been a vast number of individual course studies, such that enumerating them all would be neither practical nor informative. Instead is best to look for a systematic overview.

A pair of comprehensive meta-studies by Kaiser and Menkhoff (2017, 2018) incorporated the results from a large and up-to-date range of studies. They found that, on the whole, financial education courses did have a significant impact on financial literacy. However, they also found a high level of heterogeneity in the results: some education interventions were much more effective than others.

As Kaiser and Menkhoff (2017) note, the variance in effectiveness is far from fully understood “indicating that those offering financial education measures can still learn from best practice experiences, a development that is ongoing”.

One promising area to explore is the relationship between financial knowledge and mathematical knowledge. Research shows that additional courses in *mathematics* improve later financial outcomes. Such coursework has been shown to improve creditworthiness, increase the propensity to accumulate assets, and decrease adverse financial outcomes including credit card delinquency and foreclosure (Brown, Van der Klaauw, Wen & Zafar 2016; Cole, Paulson and Shastry 2014).

Our conjecture is that mathematics can be used to improve financial education. Whether our conjecture is correct depends on the nature of the connection between mathematical knowledge and financial knowledge. There are many plausible reasons higher levels of mathematics knowledge and mathematics education could be correlated with greater financial knowledge and better financial outcomes. For example, taking more mathematics coursework may be correlated with growing up in a higher socio-economic class, reaching a higher level of education, or with earning a higher income as an adult – all things that are themselves linked to higher financial knowledge and better financial outcomes (Lusardi 2011).

Previous studies have looked at the connection between mathematics and finance at a single point in time, either comparing financial and mathematical knowledge, or financial outcomes and mathematics education, which leaves the nature of the connection open. Our goal is to investigate whether financial *learning* and mathematical *learning* are connected. If they are, it tells us that the connection between the two is not simply predetermined by background factors, but that it provides a potential tool for improvement.

Method

Our study is designed to investigate the connection between mathematical and financial knowledge in high school students. A group of students taking a course in financial mathematics completed an assessment on both math and finance before and after the course, allowing us to track their progress. The students were drawn from five US high schools that volunteered to take part in this study; the students’ placement in the course was a mandatary part of their timetable, not an elective. All five schools were title I, four of them were public schools, while one was a charter school; four of the schools were located in New York City, while one was located in the Los Angeles area, outside of the city.

Our measurement instrument was a survey which asked multiple choice questions on topics in both mathematics and finance. The assessment contained 10 math questions, covering topics in algebra and probability, and 17 questions addressing key topics in personal finance. In addition, we asked students to self-assess their confidence levels with regard to both mathematical and financial skills on a five point scale.

Students at completed this survey before and after taking a course combining mathematics and finance (we refer to these as the ‘pre-assessment’ and ‘post-assessment’ respectively). The course covered both the Jump$tart standards in financial literacy and common core standards in algebra, probability and statistics. The responses were anonymous and did not count towards the student’s grade. However, students input an ID number that could be used to match their beginning and end responses. Teachers were instructed to give students 20 to 30 minutes to complete the assessment in one sitting, with use of calculators allowed.

Results

We obtained 147 sets of pre- and post-assessment results with matching ID numbers – along with a number of responses that failed to enter matching numbers. Our focus will be on the matched results.

To begin our analysis, we'll look at overall results for the pre- and post-assessments, summarized in *table 1* (see Supporting Details).

We see that there is significant improvement across all categories of the assessment and, as a multiple of standard deviation, it is at or above the level of many successful education interventions (Lipsey & Wilson 1993).

In addition, we can check the relationship between the math and finance scores using regression analysis, where math score is the independent variable, and finance score is the dependent variable. In our model, $y = \alpha + \beta x$, where x is math score, and y is finance score. The values are given in table 2 (see Supporting Details).

As with previous research, there is a clear correlation between mathematical knowledge and financial knowledge. Also note that both the coefficient β and the degree of correlation R^2 are significantly higher in the post-assessment than in the pre-assessment.

The regression results do not tell us whether the students who made significant improvements in financial knowledge are the same ones who made significant improvements in mathematical knowledge, or if they are separate groups. To learn more, we need to look at how *individual's* scores changed over the course of the year.

For this, we compared how an individual student's improvement levels across different categories were related. The primary result is a regression, with change in math score as the independent variable and change in finance score as the independent variable.

This gives us a model of the form $y = \alpha + \beta x$, where x is change in math score and y is change finance score. This tells us that for every percentage point improvement in math score a student makes from pre- to post-assessment, our model predicts that the student's finance score will improve by β percentage points.

In line with our hypothesis, there was a statistically significant relationship, with $\beta = 0.32$ and $R^2 = 0.15$, significant at 1%. In other words, on average, for every percentage point a student's math score increased from pre- to post- assessment, their finance score increases by approximately one-third of a percentage point. Further, approximately 15% of the improvement in finance score was explained by the improvement in math score. The corresponding scatterplot and regression line are presented in *figure 1* (see Supporting Details).

To check this result for possible confounding factors, we ran a regression that included dummy variables for race and gender. The results in this case were virtually unchanged: math score was the only variable with a statistically significant coefficient. Its value in this regression was 0.28, very close to the previous result of 0.31.

As we saw above, finance and math scores were correlated in both the pre-assessment and post-assessment, but the correlation was higher in the post assessment – R^2 increased from 0.12 to 0.31. This suggests that when there was an initial disparity between a student's math score and finance score, they would tend to come closer together over the course of the year.

Conclusions/Relevance

As we discussed in the literature review, there is a great deal of research on financial education, with many conflicting results. In virtue of this, it would be unwise to jump to conclusions on the basis of a single study. However, the present results complement a large amount of previous research on the correlation between mathematical and financial knowledge and suggest that the connection persists in the context of additional *learning*.

It seems safe to conclude, therefore, that the connection between mathematics and financial literacy is genuine and that this is an important component of best practices in financial education. Further research is required to better understand the nature of the relationship and how it can be harnessed. This should be of interest to anyone concerned with maximizing the effectiveness of personal finance education.

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Supporting Details

Table 1

	Pre Assessment	Post Assessment	Change	SD	Change/SD
Total Score	44.08%	49.7%	5.65%***	12%	0.41
Finance Score	43.67%	47.99%	4.31%***	15%	0.28
Math Score	43.36%	51.85%	8.49%***	18%	0.45
Math Confidence	59.75%	62.17%	2.43%***	17%	0.14
Finance Confidence	56.12%	59.22%	3.11%***	14%	0.22

Notes: Here and throughout: * significant at 10%; **significant at 5%; *** significant at 1%

Table 2

	α	β	R^2
Pre-Assessment	0.30***	0.31***	0.14
Post-Assessment	0.21***	0.51***	0.34

Figure 1