Financial Education, Mathematical Confidence, and Financial Behavior

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A significant ongoing initiative is to identify the conditions under which financial education is most effective, as it has been shown to work much better in some circumstances than others. One factor to consider is mathematical capability, as it has been linked to improved financial knowledge and financial outcomes. In this paper, we investigated one aspect of math capability: math confidence (that is, self-reported math ability). We examined how this factor interacts with financial education (measured by the number of financial education courses taken) with data from the 2018 National Financial Capability Survey (NFCS). We found that both mathematical confidence and financial education were positively associated with financial behaviors and, moreover, that the effects were largely independent rather than acting as substitutes – suggesting that future intervention work should consider both factors.

Keywords: financial behavior, financial education, financial literacy, financial wellbeing, personal finance

Financial education is a popular proposal for addressing the poor financial outcomes experienced by many adults in the U.S. (CFPB, 2017; Lusardi, 2019). However, research has shown that such programs vary dramatically in their effectiveness, in terms of producing improvement in either financial knowledge or financial behavior (Kaiser & Menkoff, 2017; Urban et al., 2015). A key question for researchers, in light of this, has been whether such education programs are in general achieving what they aim to. A set of influential meta-studies performed by Tim Kaiser and various colleagues find that, on average, financial education programs have a statistically significant positive effect (Kaiser & Menkhoff, 2017, 2018a; Kaiser et al., 2020), though the authors note that there is "significant heterogeneity" in the effects of different programs.

It is worth mentioning that these results have not been universally accepted. Willis (2021) argues that the methodology in the most recent study by Kaiser et al. (2020) is flawed. Most significantly, she notes that many of the individual studies being used in the meta-study only measure self-reported financial outcomes rather than looking at data that externally verifies an individual's financial situation — for example, asking whether an individual *feels* financially competent rather than verifying that they have in fact made good financial decisions.

Research that investigates the relationship between self-assessment and actual outcomes finds that the former does not predict the latter entirely accurately, though there is a significant correlation between the two (Dunning et. al, 2004). In particular, people tend to be overly optimistic about their own situation and abilities. Research in *financial* self-assessment backs this up (Atlas et al., 2019; Lee & Hanna, 2021; Palmer et al., 2021; Zhang & Fan, 2022). This suggests that much more needs to be done to research the extent to which financial education programs are effective, with more attention paid to the distinction between objective outcomes and self-assessment. However, given the general correlation between subjective and objective properties, the research to date provides reasonable grounds for going ahead with our project of investigating under what conditions financial education programs are most effective. The prospects of using financial education to improve outcomes are not so hopeless as to render the question moot.

A range of recent studies have aimed to address this question by comparing the effectiveness of varying pedagogical

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approaches (Drexler et al., 2014; Gibson et al., 2021; Kaiser & Menkhoff, 2018b; Lusardi et al., 2017; Skimmyhorn et al., 2016). One factor to consider, though, that has received little attention so far and merits further investigation, is the role of mathematical capability. As Hastings et al. (2012) note, there is a well-documented relationship between numeracy and financial outcomes. Individuals with such abilities also tend to have higher levels of financial literacy (Banks & Oldfield, 2007; Gerardi et al., 2010). On a larger scale, using data collected in the international PISA study on educational outcomes, Moreno-Herrero et al. (2018) find that the association between math knowledge and financial literacy is present in students around the world.

Further, taking additional courses in mathematics improves later financial results. 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 et al., 2016; Cole et al., 2014). Cole et al. (2016) find that "additional mathematics training leads to greater financial market participation, investment income, and better credit management." In addition, Goodman (2019) shows that additional math course work significantly increases later earnings, particularly among black students. This has led some to argue for mathematics education as a superior alternative to financial education (Ogden, 2019).

Before we can make a decision on this issue, though, we need to better understand the relationship between financial education and mathematical capability. It could be that they are two components of the optimal solution to improving financial outcomes, rather than mutually exclusive alternatives (Dituri et al., 2019). Because the two factors often have been taken to be in competition (Llanes, 2019), the question of how they work together has received little attention in the research literature. Our goal is to begin to address this gap in the research, focusing on a particular aspect of mathematical capability: mathematical *confidence*. We use the term "mathematical confidence" to refer to a person's self-ascribed mathematical ability.

Research Question and Hypotheses

This paper investigates the interaction of mathematical confidence and financial education in connection with financial outcomes. If either factor made the other redundant, we would expect to see the positive associations of one diminished in the presence of the other — so that financial education acts as a *substitute* for mathematics confidence, and *vice-versa*. If they are not in competition, then the benefits might be *independent*, each unaffected by the presence of the other; or they might even be *complements* so that the benefits of both together exceed the sum of the benefits of each individually. In examining this issue, we propose to look at the following two hypotheses:

> **H1**: Financial education and mathematics confidence do not act as substitutes in their associations with financial outcomes.
>
> **H2**: The associations between financial education and mathematics confidence with financial outcomes are complementary.

There is good theoretical reason to think these two hypotheses might prove correct. Making effective financial decisions throughout life requires possessing a range of concepts from both personal finance (e.g., assets and interest) and mathematics (e.g., exponents and probability) (Lusardi, 2012). It's plausible that each family of concepts must be learned independently: One cannot infer the financial concepts from the mathematical or *vice versa*. Therefore, adding sufficient capacity in the one area cannot eliminate the need for it in the other. For someone with high math confidence, taking a financial education course should still increase their exposure to financial concepts and thus improve their financial decision making. Similarly, for someone taking a financial education course, increasing their math confidence should increase their willingness to make crucial calculations relevant to financial decisions, leading to improved outcomes. Therefore, there is *prima facie* reason to find H1 plausible.

One might further think that mathematical confidence builds the kind of facility in critical analysis required to apply financial concepts effectively, so that it enhances the effects of financial education — making the two complementary, in line with H2 (Agarwal & Mazumder, 2013). In addition, fundamental research in education and learning shows that we learn and retain information better when it is part of an interconnected body of knowledge, constituting a deep conceptual understanding, rather than an unconnected list of superficial facts (Brown et al., 2014). Combining mathematical confidence and financial knowledge would seem a plausible candidate for creating this kind of interconnected web of concepts, both because increased math confidence might increase a person's comfort transferring their math *knowledge* into a new setting and also because, as research shows, higher levels of math confidence are generally correlated with higher levels of math knowledge (Fagerlin et al., 2007).

Methods

Data

This investigation will be based on data from the 2018 National Financial Capability Survey (FINRA IEF, 2019). Significantly, this dataset has been the basis of recent research on the effectiveness of financial education conducted by Walstad and Wagner (2019) and Xiao and Porto (2021). This allows us to build on existing models, designed to measure the associations between financial education and financial outcomes. Crucially for our purposes, the survey provides a question on mathematical confidence (that is, self-reported mathematical capability), asking respondents to answer the following question on a scale of 1–7: "How strongly do you agree or disagree with the following statements? I am pretty good at math". This is the only variable included in the survey that relates directly to mathematics. Again, it is a self-assessment; however, such measures have been widely used in mathematics education research and have been shown to be generally reliable indicators of math knowledge (Fagerlin et al., 2007).

The new contribution provided by our study will be adding a measure of mathematical confidence based on this question and measuring the interaction between financial education and math confidence.

Variables

In order to get a useful framework for our analysis, we must restrict our focus to a few key variables. We will look for questions that target specific financial behaviors of particular financial significance, following the approach of Walstad and Wagner (2019). The authors aimed to find financial behaviors measured in the dataset that one will likely take if one is financially knowledgeable and appropriately motivated and likely not take otherwise. Crucially, these are behaviors that do not require significant financial resources to enact. Following Walstad and Wagner (2019), we use four measures: (1) *Emergency*: Assesses whether subject has ever set aside an emergency fund; (2) *Savings*: Assesses whether subject has a savings account; (3) *Investment*: Assesses whether subject has non-retirement investments; (4) *Retirement*: Assesses whether subject has calculated retirement needs. We took the sum of behaviors enacted as an additional outcome variable.

We also followed Walstad and Wagner (2019) in using the number of financial education courses taken as an explanatory variable in our model; this variable is an integer between 0 and 3. Respondents were asked not just if they took a financial education course, but at what periods in their life they did so: high school, college, and employment. Given that we are looking at interaction effects, this variable is particularly significant for our purposes since it allows us to see whether extra financial education yields diminishing returns when combined with high levels of mathematics confidence.

We use the response to the mathematical confidence question as an additional explanatory variable, taking an integer value between 1 and 7. Since we are interested in the combined effects of math confidence and financial education — whether they have independent influence, complement each other, or act as substitutes — we add an interaction variable $x_1 \bullet x_2$, where x_1 is the variable for financial education and x_2 is the variable for math confidence.

We introduce several controls to our model; these cover demographic factors such as gender, race, age group, income, education level, and census region. We treat each response option as a dummy variable. A full list of the variables in our model is provided in Table 1.

Analyses

Given that the outcome variables are binary, we follow Walstad and Wagner (2019) in using probit regression to produce predicted results between 0 and 1. We include all variables used in the survey weighting as controls so we don't have to weight the regression analysis, reducing the standard errors in our results. This gives a model of the form: $p = \Phi\ (\beta ixi)$, where p represents the probability that the dependent variable has value 1; Φ is the standard normal distribution function; xi is a vector of the explanatory variables and βi is the vector of coefficients. Note that this provides four structurally similar models: one for each of the outcome variables outlined above. For total behaviors, we use linear regression.

TABLE 1. Variable Key

Name	Description	Value	Survey Source
Explanatory Variables			
Math Con	Measure of subjective mathematical confidence	Integer between 0 and 7	M1_2
Finance	Total number of finance education course taken	Integer between 0 and 3	M21_1, M21_2_2015, and M21_3
Math*Fin	Interaction variable: Product of value of Math Con variable and Finance variable	Integer between 0 and 21	M1_2, M21_1, M21_2_2015, and M21_3
Outcome Variables			
Emergency	Assesses whether subject has every set aside an emergency fund	Dummy variable	J5
Savings	Assesses whether subject has a savings account	Dummy variable	B2
Investment	Assesses whether subject has non-retirement investments	Dummy variable	B14
Retirement	Assesses whether subject has calculated retirement needs	Dummy variable	J8/J9
Behaviors	Assesses total behaviors exhibited	Integer between 0 and 4	Sum of Emergency, Savings, Investment and Retirement values
Control Variables			
Female	Subject is female	Dummy (reference male)	A3
Minority	Subject belongs to a minority group	Dummy (reference non-minority)	A4A_new_w
Married	Subject is married	Dummy (reference not married)	A6
No HS	Subject did not complete high school	Dummy (reference graduate degree)	A5_2015
High School	Subject completed high school	Dummy (reference graduate degree)	A5_2015
Some College	Subject attended some college	Dummy (reference graduate degree)	A5_2015
Associate's	Subject has associate degree	Dummy (reference graduate degree)	A5_2015
Bachelor's	Subject has bachelor's degree	Dummy (reference graduate degree)	A5_2015
Children	Subject has children	Dummy (reference no children)	A11
Military	Subject's family is or was in military	Dummy	AM21
< $25k	Income is below $25k	Dummy (reference income 150k+)	A8
$25−50k	Income is $25–50k	Dummy (reference income 150k+)	A8
$50−75k	Income is $50–75k	Dummy (reference income 150k+)	A8
$75−150	Income is $75–150	Dummy (reference income 150k+)	A8
New England	Subject lives in census region	Dummy (reference Pacific)	CENSUSDIV
Mid Atlantic	Subject lives in census region	Dummy (reference Pacific)	CENSUSDIV
East North Central	Subject lives in census region	Dummy (reference Pacific)	CENSUSDIV
West North Central	Subject lives in census region	Dummy (reference Pacific)	CENSUSDIV
South Atlantic	Subject lives in census region	Dummy (reference Pacific)	CENSUSDIV
East South Central	Subject lives in census region	Dummy (reference Pacific)	CENSUSDIV
West South Central	Subject lives in census region	Dummy (reference Pacific)	CENSUSDIV
Mountain	Subject lives in census region	Dummy (reference Pacific)	CENSUSDIV

In addition to the overall regression results, we also apply the model to the 18–24 and 25–34 age groups separately to compare these results to those of the entire dataset. Walstad and Wagner (2019) note that these age groups are the ones most likely to be affected by the recent increased focus on financial education, and so they deserve specific focus. Further, our exploratory data analysis revealed that a disproportionate number of respondents with a military background received multiple financial education courses and that this might have a significant influence on results. To test the effect of this, we also apply our model to the dataset with such respondents excluded.

Results

Descriptive Statistics

A comprehensive summary of the descriptive data is available from the corresponding author upon request. Some particular items are worth noting, though, with regard to our key explanatory variables. First, with regard to the number of financial education courses taken, the distribution of responses is highly skewed. Around 80% of respondents had taken no courses in financial education, with the rest taking between one and three courses. This should not come as a great surprise, given that financial education has not in general been a part of compulsory education. However, the irregular nature of the distribution should be kept in mind when interpreting the results, as any benefits found to be associated with taking multiple courses would be experienced only by a small fraction of the population. For this reason, we will also look at the distribution of outcome variables graphically, rather than relying on regression results alone, to ensure a coefficient has not been altered dramatically by a small number of extreme results.

It is also notable that the math confidence responses are higher (a mean score of 5.5 out of 7) than might be expected, given the phenomena of "math anxiety" that is often thought to be prevalent in the U.S. In particular, very few respondents picked between one and three. To understand this, recall that the precise question asks respondents whether they agree that they are "pretty good at math," which implies they are not being asked about an advanced level of mathematical skill. We believe the goal here was to assess respondents' confidence in everyday mathematics so the question was phrased this way to make sure responses weren't skewed low based on advanced math courses respondents may have encountered at school. As noted in the survey administrators own report, a high level of math confidence did not always correspond to a high level of applied math knowledge. Many respondents who gave themselves a "7" in math capability, answered the financial literacy questions with a mathematics component incorrectly (Lin et al., 2019). In addition, on the 7-point scale, only points 1, 4 and 7 were labeled, which may explain the "jump" in frequency of responses from 3 to 4. For these reasons, when analyzing trends at the granular level, it will be best to focus on responses between 4 and 7 since there are potentially confounding factors in the move from 3 to 4.

Bar Charts of the Number of Financial Behavior by Financial Education and Math Confidence

A sense of the strength of the associations is provided by Figures 1–2, which show the individual relationship between math and financial education respectively and total financial behaviors taken (without controls). This shows that the patterns are fairly uniform, despite the aforementioned skewed distributions of the explanatory variables.

Multiple Regression Results

Turning to the regression analysis, complete results for the total sample are displayed in Table 2, while key results for the subsamples are displayed in Table 3 (complete results for the subsamples are available from the corresponding author upon request). The first takeaway from these results is that both mathematical confidence and financial education have

Figure 1. Bar chart for math confidence and actions taken.

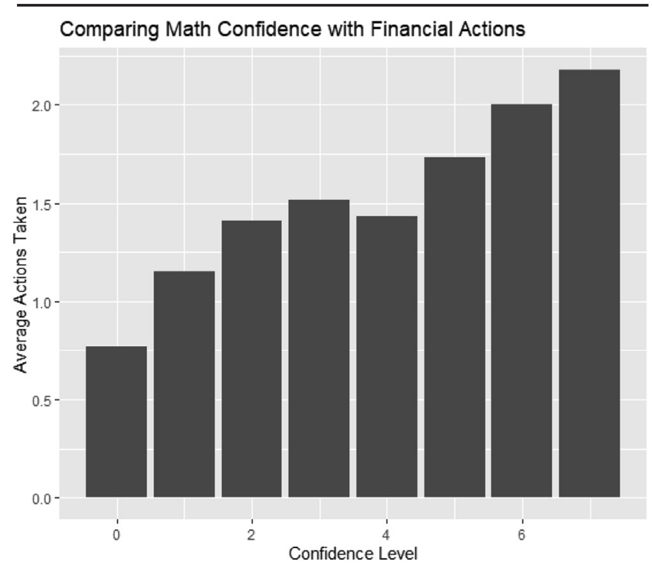
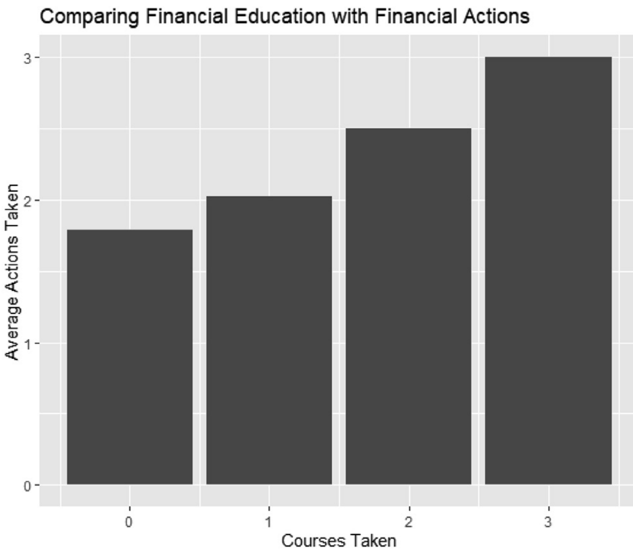


Figure 2. Bar chart for financial education and actions taken.



a statistically significant positive coefficient for all financial behaviors of interest when looking at the dataset as a whole. When looking at the younger age groups, the results are more mixed. There is a statistically significant correlation between mathematical confidence and outcome in all cases in the 18–24 and 25–34 groups. For financial education, there is no statistically significant relationship in the 18–24 group for any outcome variable; for the 25–34 group, there is a significant value for the investment, retirement, and total behaviors outcomes only. Note, though, that in almost all cases, the coefficient for financial education has a positive value, despite failing to meet the 5% threshold for statistical significance. In addition, there are no noteworthy differences in results between the dataset as a whole and with military members excluded. Finally, there was no significant value found for the interaction variable in any of the models.

TABLE 2. Regression Results for Entire Data Set

	Emergency	Savings	Investment	Retirement	Behaviors
(Intercept)	0.92***	1.40***	0.76***	0.35***	3.11***
	(0.06)	(0.07)	(0.06)	(0.06)	(0.05)
Math Con	0.08***	0.07***	0.05***	0.08***	0.09***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)
Finance	0.15**	0.16**	0.18**	0.20***	0.21***
	(0.05)	(0.06)	(0.06)	(0.05)	(0.04)
Math*Fin	−0.00	−0.00	0.00	0.00	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Female	−0.10***	0.04*	−0.20***	−0.08***	−0.11***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)
Minority	0.02	−0.07***	−0.08***	−0.01	−0.05**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
18−24	−0.49***	−0.21***	−0.40***	−0.43***	−0.49***
	(0.03)	(0.04)	(0.04)	(0.03)	(0.03)
25−34	−0.56***	−0.33***	−0.43***	−0.34***	−0.53***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)
35−44	−0.68***	−0.38***	−0.55***	−0.33***	−0.62***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)
45−54	−0.68***	−0.43***	−0.53***	−0.28***	−0.61***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)
55−64	−0.33***	−0.18***	−0.26***	−0.01	−0.24***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)
Married	0.08***	0.08***	−0.04*	0.09***	0.07***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
No HS	−0.54***	−0.82***	−0.77***	−0.70***	−0.80***

TABLE 2. Regression Results for Entire Data Set *(Continued)*

	Emergency	Savings	Investment	Retirement	Behaviors
	(0.07)	(0.06)	(0.08)	(0.07)	(0.05)
High School	-0.24^{***}	-0.32^{***}	-0.41^{***}	-0.35^{***}	-0.43^{***}
	(0.03)	(0.04)	(0.03)	(0.03)	(0.02)
Some College	-0.29^{***}	-0.19^{***}	-0.35^{***}	-0.24^{***}	-0.35^{***}
	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)
Associate's	-0.20^{***}	-0.13^{**}	-0.35^{***}	-0.20^{***}	-0.29^{***}
	(0.03)	(0.04)	(0.04)	(0.03)	(0.03)
Bachelor's	−0.01	−0.00	-0.10^{***}	-0.10^{***}	-0.07^{**}
	(0.03)	(0.04)	(0.03)	(0.03)	(0.02)
Children	-0.21^{***}	-0.16^{***}	-0.05^{*}	0.00	-0.13^{***}
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Military	0.19^{***}	0.06	0.23^{***}	0.21^{***}	0.23^{***}
	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)
Income < \$25k	-1.33^{***}	-1.21^{***}	-1.44^{***}	-1.13^{***}	-1.64^{***}
	(0.04)	(0.05)	(0.04)	(0.04)	(0.03)
\$25−50k	-0.91^{***}	-0.71^{***}	-1.01^{***}	-0.74^{***}	-1.10^{***}
	(0.04)	(0.05)	(0.04)	(0.04)	(0.03)
\$50−75k	-0.61^{***}	-0.41^{***}	-0.73^{***}	-0.49^{***}	-0.72^{***}
	(0.04)	(0.05)	(0.04)	(0.04)	(0.03)
\$75−150	-0.33^{***}	-0.13^{**}	-0.39^{***}	-0.21^{***}	-0.33^{***}
	(0.04)	(0.05)	(0.04)	(0.04)	(0.03)
New England	-0.08^{*}	−0.04	-0.07^{*}	-0.10^{**}	-0.09^{***}
	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)
Mid Atlantic	−0.02	-0.21^{***}	−0.04	−0.04	-0.09^{**}
	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)
East North Central	−0.03	-0.17^{***}	-0.12^{***}	-0.09^{*}	-0.12^{***}
	(0.03)	(0.04)	(0.04)	(0.03)	(0.03)
West North Central	-0.07^{*}	−0.06	−0.05	0.01	−0.05
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
South Atlantic	-0.06^{*}	-0.13^{***}	-0.08^{**}	−0.03	-0.09^{***}
	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)
East South Central	−0.03	-0.25^{***}	-0.15^{***}	−0.06	-0.14^{***}
	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)
West South Central	-0.08^{*}	-0.30^{***}	-0.10^{*}	−0.03	-0.15^{***}
	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)
Mountain	−0.02	−0.04	−0.05	0.02	−0.02
	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)
N	27091	27091	27091	27091	27091
AIC	31430.57	26305.58	28550.12	31868.87	81365.47
BIC	31684.98	26560.00	28804.53	32123.29	81628.10
Pseudo R2	0.27	0.25	0.27	0.25	0.37

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$.

TABLE 3. Key Values From Data Subsets

	Emergency	Savings	Investment	Retirement	Behaviors
Age 18–24					
Math Conf	0.05***	0.05***	0.04*	0.06***	0.06***
FinEd	0.16	0.10	0.24	0.01	0.14
Math*Fin	0.00	0.01	−0.01	0.04	0.02
Age 25−34					
Math Conf	0.09***	0.09***	0.10***	0.09***	0.11***
FinEd	0.12	−0.01	0.26*	0.29**	0.23**
Math*Fin	0.01	0.03	−0.00	−0.01	0.00
No Military					
Math Conf	0.08***	0.07***	0.05***	0.08***	0.08***
FinEd	0.19**	0.23***	0.18**	0.21**	0.24***
Math*Fin	−0.01	−0.02	−0.01	−0.00	−0.01

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$.

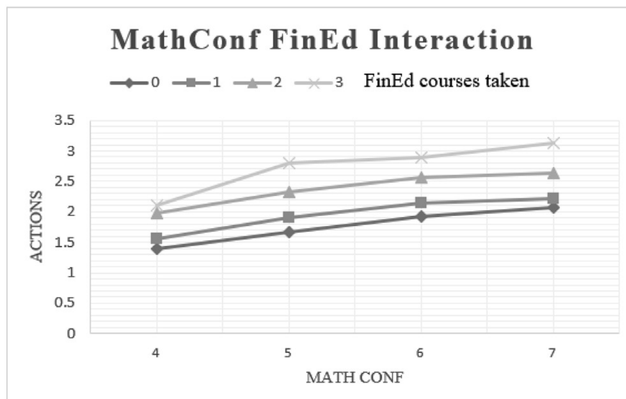
These results provide strong evidence in favor of the claim that mathematical confidence and financial education are both beneficial when it comes to improving financial behavior.

Charts on Interactions between Financial Education and Math Confidence on Financial Behavior

In addition, our results show that the benefits associated with the two factors appear to be independent, as no statistically significant interaction coefficients were found. This issue bears further exploration, though, since, as Lewontin (1974) shows, there is often more to interaction between *x1* and *x2* than can be captured by the coefficient for $x_1 \bullet x_2$ in a regression model. To see this, we need to examine how the outcome value changes when one variable changes (in this case mathematical confidence) while the other (in this case financial education) is held fixed at various values — this is what Lewontin (1974) refers to as the "norm of reaction" (See Marley-Payne, 2021 for further discussion in the context of education). These results are displayed in Figure 3.

If the two variables were completely independent, then all the lines on the chart would have the same slope at all points. We see that this is not the case. However, there is no systematic variation in the slopes. In addition, the slopes of all lines are positive at all points, and values are greater for higher numbers of financial education courses taken at all points. This shows that there is no substitution effect at work that makes higher levels of financial education or mathematical confidence *counter-productive*.

Figure 3. Math confidence and financial education interaction.



Discussions, Limitations, and Implications

The key takeaway from these results is that that the two factors associated with improved financial outcomes we have been considering, math confidence and financial education, are not in competition: In general, however well a person does in the one area, there are still benefits associated with improving in the other. In research to date, supporters of financial education have generally ignored the role that mathematical confidence may play in further improving financial outcomes, while financial education sceptics have viewed improving mathematical capability generally (including math confidence) as a superior *alternative*. This paper shows how the two approaches miss an important middle ground which suggests that math confidence and financial education can work together.

Based on these findings, we can see that our hypotheses are partially validated. For H1, the results were supportive of the hypothesis. A graphical representation of the interaction confirmed this, suggesting that even if the two independent variables were not entirely independent, they were not acting as substitutes in any systematic way. H2 on the other hand was not supported by the results. Since we did not find any statistically significant *positive* values for the interaction coefficient in any of the regression models, there is no evidence that the two factors act as complements.

A point worth discussing is that, though the positive effects of mathematics confidence were consistent, the results of financial education were more mixed. Of particular note was the general lack of significant results for the 18–24 range. This should not lead us to jump to the conclusion that the financial education that members of this group received was less effective than that received by other groups. This subset of the data is especially messy, which may underlie the lack of significance. First of all, the group covers a smaller age-range – seven years, rather than 10 years — and the sample size is correspondingly smaller too. Second, the difference in situation across the age group is particularly extreme. The group includes high school seniors, college students (either full-time or part-time), and people who have been working full-time for up to six years. These factors will all have a massive influence on the measured financial behavior and cannot be fully controlled for in our model. Finally, the coefficients, though failing to meet the threshold for statistical significance, were consistently positive, making it plausible that the data available simply lacked the power to detect positive associations definitively.

Limitations

A limitation with the present study, mentioned above, is that given the observational nature of this study, there may be selection bias in who takes financial education courses, particularly when we consider those taking *multiple* courses. Care should be taken, therefore, before drawing any conclusions on what causal relationship there might be between financial education and financial outcomes on the basis of this study.

It must also be noted that the outcome measures are self-reported, so as discussed above, there is a possibility of inaccuracy. However, respondents were self-reporting on specific actions rather than trying to make a vague holistic self-assessment or attitudinal measure, unlike those receiving Willis' (2021) harshest criticism. Therefore, it is reasonable to take them as generally reliable, unless there is particular reason to think otherwise in this case.

Another limitation concerns the mathematical confidence variable. Though the dataset provides a wealth of information on financial education, financial situation, and financial knowledge, the information on respondents' mathematical capacity is limited. As discussed, there is only a single question that asks for a self-assessment of mathematical capability, and this leaves much unknown. Key additional factors are respondents' objective level of mathematical knowledge, their level of mathematics education, and the relevance of math to their career.

Ideally, we would use equivalent math and finance variables, for example, looking at the interaction between math education and financial education, or math knowledge and financial knowledge. This would allow us to more fully assess the comparative benefits of each approach to improving financial outcomes. We could then address head-on the question of whether one or the other should be prioritized, or if they should be pursued in conjunction with each other. As was mentioned above, such data is not available in the NFCS dataset nor, to the best of our knowledge, is it available in any other comparable dataset on financial outcomes. This is because information on math knowledge and math education is not a priority for those collecting data on financial matters. However, our results show the relevance of math education to the interests and goals of such work.

Further, as discussed above, there is good theoretical reason to think that mathematical and financial concepts are both required for optimal financial decision making. It seems plausible, therefore, that mathematical and financial *education* would both improve financial outcomes. Confirming this would be especially valuable, given that it would point to ways in which educational interventions could best aid financial outcomes. Taken together, these considerations suggest that gathering further data that looks at the interrelationship between finance and math education and knowledge at a higher level of resolution would be a worthwhile endeavor and one we hope future research will undertake.

Implications for Practitioners

These results show that consumer financial counselors, planners, and educators should attend to mathematical confidence when attempting to improve financial behavior. The study confirms that financial education is associated with improved financial behavior, but also suggests that higher mathematical confidence is associated with additional improvements. Practitioners may want to look for ways to boost the math confidence of their clients and students.

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