

Integrating Quantitative And Financial Literacy

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Abstract

This paper proposes that financial literacy be integrated into the current math curriculum rather than taught separately because it is an ideal subject for teaching quantitative reasoning—a skill set for which educational assessments consistently show student deficits. Some educators have argued that improvement in students' quantitative reasoning ability would improve higher-order math skills—such as algebra—and reduce the growing need for remedial college math. The personal finance problems given for teaching quantitative reasoning are examples of “obvious benefit/hidden cost” problems. These are based on studies in the interdisciplinary field of behavioural finance of consumer responses to “framing” of financial propositions. Presented in this paper are Web-based instructional resources created using the Flash programming language that illustrate examples of “obvious benefit/hidden cost” problems. Each Flash calculator provides one possible quantitative decision-frame and is accompanied by a short description that explains the reasoning. The intent is to provide instruction on how to quantify the costs and benefits of financial propositions and quantitatively compare various alternatives. These instructional resources are available for use on the Web at <http://www.ComputeGasSavings.com>, and <http://www.GoldPricingOnline.com>.

Key Words: quantitative literacy, financial literacy, personal finance, math instruction resources, behavioural finance, high school math curriculum

1. Introduction

The financial crisis of 2008-09 prompted proposals in many states to add financial literacy requirements to the high school curriculum. The new enthusiasm for instruction on personal finance presents pitfalls and opportunities for educators.

First the pitfalls: Many of the political and corporate leaders calling for additional financial literacy requirements are doing so to create a false narrative that poor consumer choices precipitated the financial crisis. While such a narrative is a convenient misdirection away from their culpability, it is completely illogical. Consumer choice did not cause companies such as Bear Stearns and Lehman Brothers to be leveraged at ratios of between 30 and 50 to 1. Normal stochastic market fluctuations can easily wipe out the equity of any company with that amount of leverage. It was folly for the executives at these companies to take on that kind of leverage, and worse for companies such as AIG to act as a facilitator by insuring such reckless financial behaviour.

The fact that the people running these companies were highly knowledgeable on financial matters proves that no amount of education can substitute for sound judgment and good character. Therefore, it is a pitfall to believe that additional instruction on personal finance at the high school level would have prevented the financial crisis, and that adding such a requirement will prevent future ones.

It is also a pitfall to continually add lists of learning outcomes to an already crowded high school curriculum in order to serve adult agendas without providing motivation for the students. Too much of the school curriculum consists of lists of facts to memorize, presented as distinct and separate from each other. There is little integration between all the lists so students often fail to see the relevance of anything that they are required to learn.

But, it is from this second pitfall that there is opportunity. Personal finance education is a laudable goal, even if the motives of many of its advocates are suspect. However, financial literacy should be integrated into the current math curriculum rather than taught separately. Such an approach would have the added benefit of showing students that math is relevant, because knowledge of math leads to personal financial gain.

This paper proposes that financial literacy be integrated into the current math curriculum rather than taught separately. It explains why this should be done and gives examples, in the form of instructional resources, of how it can be done. Personal finance is an ideal subject for teaching quantitative reasoning—a skill set for which educational assessments consistently show student deficits. Some educators have argued that improvement in students' quantitative reasoning ability would improve higher-order math skills—such as algebra—and reduce the growing need for remedial college math. The personal finance problems given for teaching quantitative reasoning are examples of what I call “obvious benefit/hidden cost” problems. These are based on studies in the interdisciplinary field of behavioural finance of consumer responses to “framing” of financial propositions.

2. Background

2.1 Systemic Failure to Prepare Students for College Level Math

Statistics compiled in 2010 by the U. S. Department of education report that for the 2003-04 academic year 34.7% of freshmen entering college needed at least one remedial course. In many instances an individual student needed more than one remedial course. The need for remedial courses in college changed little over the next four years. By the 2007-08 academic year 36.2% of freshmen entering college needed at least one remedial course (U.S. Department of Education, National Center for Education Statistics, 2010). Despite implementation in 2002 of the Elementary and Secondary Education Act (No Child Left Behind Law), that mandated testing for proficiency in reading and math, the readiness of graduating high school students for college-level studies did not improve.

Frequently math is one of the remedial courses entering college freshmen need. The National Mathematics Advisory Council reported in 2008 that proficiency in mathematics declines during high school. For students in grade 8, 32% were proficient in math, but by grade 12 the fraction of proficient students declined to 23%. In regards to the drop in the fraction of proficient students, the final report of the Advisory Council stated: “Consistent with these findings is the vast and growing demand for remedial mathematics education among arriving students in four-year colleges and community colleges across the nation” (U.S. Department of Education, 2008).

The systemic failure of the secondary schools to adequately prepare students for college-level math is of great concern to college educators because it makes it difficult for students to major in any of the science, social science, or engineering programs. These

are all critical subject areas for our modern high-tech economy. In 2009, I wrote of my personal observations of this problem in an opinion piece: “A Math Paradox: The Widening Gap Between High School and College Math” (Ganem, 2009, *APS News*). I attributed much of the problem to teaching developmentally inappropriate math concepts throughout the K-12 curricula. Specifically, I criticized the push to teach algebra in middle school before students are developmentally ready for the concepts it requires.

A thorough, systematic study in 2009, for the state of Maryland examined the alignment among Maryland’s voluntary state curriculum for high school mathematics, the algebra I high school assessment and the Accuplacer college placement tests (Martino & Wilson, 2009). Many colleges use the Accuplacer tests to determine placement in math courses (College Board, 2011). In the study titled “Doing the Math: Are Maryland’s high school math standards adding up to college success?” Martino and Wilson reported disconnect between Maryland’s high school curriculum and the expectations for the Accuplacer test. They found that: “It is possible that the Accuplacer Arithmetic Test is the first rigorous arithmetic test that many students have ever encountered.” In characterizing this situation as “unfair” to the students, Martino and Wilson included a recommendation that: “Students should master arithmetic before they take an Algebra I course.” In their words: “Algebra can be described as a generalization of arithmetic... and it should not be formally studied without a thorough knowledge of arithmetic.”

2.2 Behavioural Finance: Framing

At the same time that our education system is failing to teach quantitative reasoning, an interdisciplinary field known as “behavioural finance” has emerged. Behavioural finance combines methods in economics and psychology with the goal of understanding how consumers make decisions in the marketplace. Classical economic theory assumed that when making decisions to buy and sell, consumers act “rationally,” meaning that they seek to maximize their financial position. However, studies in behavioural finance have shown that consumers frequently make decisions contrary to their financial best interests. Consumers are not “rational” in the sense of classical economic theory, but neither are consumer choices random. They are according to the title of one popular treatment of the field “predictably irrational” (Ariely, 2008). Of course being predictably irrational puts consumers at a great financial disadvantage in relation marketers, who are highly cognizant of the factors that trigger irrational financial decisions.

Among the many findings of behavioural finance is the role of “framing” in influencing decisions. Behavioural finance studies have shown that decision-making is highly dependent on how a financial proposition is presented or “framed.” A decision frame is “the decision maker’s conception of the acts, outcomes, and contingencies associated with a particular choice” (Tversky & Khaneman, 1981). For many financial decisions, the frame is a quantitative comparison.

Behavioural finance studies have shown that mathematically equivalent, but alternately worded quantitative comparisons result in different decisions frames, and as a result different decision outcomes. For example a “buy 1, get 1 free” offer will attract more takers than a “buy 2, get half price” offer even though the offers have identical financial outcomes. The use of the adjective “free” results in a decision frame that is different than the frame resulting from the description “half price.”

While it is easy to see that “buy 1, get 1 free” and “buy 2, get half price” are identical offers, most financial offers are more complex and require more sophisticated

quantitative analysis to understand and construct an appropriate decision frame. Consider the “zero-percent financing offers” that automobile companies use to promote sales. These promotions are highly effective because a “zero-cost” financial proposition, like the adjective “free,” is emotionally charged and resonates strongly with consumers. In fact, a study reveals an irony: consumers will pay a great deal for a product that is “free” (Shampanier, *et al.* 2007).

In the case of zero-percent financing offers on automobiles, “payment” is usually in the form of a declined “rebate” on the “purchase price.” A typical advertisement will offer a choice between paying full price for a vehicle and having it financed at 0%, or paying cash for the vehicle and receiving a discount, usually in the form of a rebate. For example an advertisement for a vehicle will show a \$24,000 price with 0% financing for 5 years, or a \$4000 rebate. Of course the same offer could be presented as a \$20,000 purchase with a \$4000 pre-paid finance charge. However, the second wording, while a financially equivalent proposition, is not nearly as enticing to consumers because the “rebate,” which is perceived by consumers as a gain, has been re-labelled as a “finance charge” which is perceived by consumers as a loss (Ganem 2009, *Int. J. Sci. & Soc.*).

This gimmick is possible because marketers of automobiles are allowed to re-frame the “finance charge.” For a consumer the finance charge is the difference between the cash price for the automobile and the total amount paid after completing all payments of principal and interest on the loan. But the marketers fold the finance charge into the purchase price and then say that there is none, even though the cash customers will get it back in the form of a rebate. Folding the finance charge into the purchase price also benefits the automobile companies in another important way. Once the buyer declines the “rebate” he or she is committed to paying the full finance charge, *no matter what happens in the future*.

For example if the vehicle is totalled shortly after purchase, the buyer must pay off the loan in full for the un-rebated “purchase price.” In contrast, a buyer who paid with cash obtained from an institution that provided alternative financing for the vehicle, would pay a smaller loan off in full, and not be liable for future finance charges. There are other reasons a buyer might pay off a zero-percent loan before the scheduled completion date—title transfer because of a sale or trade-in, desire to reduce debt—and in each case there is no savings on future finance charges because those were included in the original sale. As a result, while the re-framing of the “finance charge” as a “rebate” appears to be only a semantic change designed to trigger an emotional response in the buyer, there is a negative financial consequence for the buyer. All risk that the loan will not run the full term is transferred to the buyer, because the automobile seller is assured of receiving all finance charges even if the loan is paid off early.

Folding the finance charge into the purchase price also makes it difficult for buyers to compare the cost of financing from the dealer to cost of financing from alternative sources such as banks and credit unions. The reason is that most consumers do not know how to do finance charge calculations. Without that knowledge, it is difficult for consumers to make rational decisions in the marketplace. Ganem in *The Two Headed Quarter: How to See Though Deceptive Numbers and Save Money on Everything You Buy*, (Ganem, 2007) explained how consumers can re-frame zero-percent finance offers in order to make rational comparisons. The problem is that the costs associated with alternative finance offers are usually expressed in terms of annual percentage rates

(APRs). To make rational comparisons, the rebate needs to be expressed in terms of finance charges arising of an “effective APR.”

For example, a vehicle purchased for \$24,000 with 0% financing for 5 years from a dealer would require monthly payments of \$24,000 divided by 60, or \$400. But, if the buyer chooses a \$4000 rebate in lieu of dealer financing, and instead borrows \$20,000 from a bank at an APR of 7.42%, the monthly payments would also be \$400. Therefore the \$4000 rebate (surcharge) paid to finance the vehicle through the dealer is equivalent to an effective APR of 7.42%. When shopping for a loan, the buyer should compare the APRs for alternative sources of financing to 7.42%, which is effectively the APR paid to finance through the dealer.

Notice that making a rational decision on a vehicle loan requires the consumer to have two skill sets. First, the consumer must be able to re-frame financial propositions in order to recognize that the “rebate” is a prepaid finance charge. That means the consumer must be able to remove the emotionally charged words, such as “free” or “0%,” from a sales pitch, and compare the total cost of a choice in relation to the total cost of the alternatives. Second, the consumer must be facile with numbers so that an effective APR can be computed. It is this second skill set that requires quantitative literacy. Many consumers lack the quantitative ability to calculate monthly payments on a loan given the initial principal, APR, and duration.

Readers of *The Two Headed Quarter* are taught to do “effective APR” calculations with a worksheet and look-up table provided in the book. However, I created a separate instructional resource for this problem in the form an interactive calculator created using the Flash programming language and made available on the Web at: <http://www.computegassavings.com/zeropercentsavingscalc.html>. A screen shot of the calculator with some sample numbers is shown in Figure 1.

Auto Financing Savings

Cost without rebate (dollars):

Cost with rebate (dollars):

Loan term (years):

Reduced financing (APR*):

Alternate financing (APR*):

Compute

Monthly Payment: (reduced APR)

Monthly Payment: (alternate APR)

Difference:

* APR = annual percentage rate


 **The Two Headed Quarter**
How to See Through Deceptive Numbers

Figure 1: Screen shot of the Automobile Financing calculator with a sample calculation shown. In this example the monthly payment for a \$24,000 loan with a 0% APR for 5 years is compared to the monthly payment on a \$20,000 loan with a 7.0% APR for 5

years. The difference of \$ –4.00 shows that in comparison to the 0% APR offer from the dealer, it would save \$4 per month to take the \$4000 rebate and finance the \$20,000 balance with a 7.0% APR loan from another lender.

3. Quantitative Framing

3.1 Obvious Benefit/Hidden Cost Problems

The problem of choosing between the 0% financing option or the rebate can be generalized. It is an example of a more general class of financial propositions I call “obvious benefit/hidden cost” problems. It is possible to construct an infinite number of these kinds of problems. Consider these financial propositions:

- I have a coupon to save \$5 on any size purchase at a store 20 miles away. I need to buy a \$15 calculator. Should I make the trip? Suppose I need a \$125 jacket instead. Would that change my decision?
- On my street, gas sells for \$3.95 per gallon. If I drive to the next town 15 miles away it sells for \$3.85 per gallon. Should I make the trip?
- At a neighbourhood cash-for-gold party, I’ve been offered \$700 for a gold chain that I no longer wear. Should I sell it?
- My wife who is currently an “at home” mom is considering an offer for a clerical job at an office downtown that pays \$12 per hour. How much will this help the family finances?

The answers to these questions are not as obvious as they appear, because there is both a benefit and a cost associated with each choice. It is easy to see the benefit, but it takes further reflection to understand the costs. Determining whether the benefit is more than the cost requires quantitative analysis of the precise circumstances, which means that there are no pat-answers to the questions. There are also multiple approaches to construct quantitative comparisons for framing each of these decisions.

I have created Web-based instructional resources for each of the four questions above, along with other similar questions, using the Flash programming language. Each Flash calculator provides one possible quantitative decision-frame and is accompanied by a short article that explains the reasoning. These solutions are by no means unique. The intent is to provoke thought on how to quantify the costs and benefits for each alternative and compare them.

3.2 Overview of Instructional Resources

Here is a brief overview of the calculators for the four financial propositions just stated. Links to all the resources presented are at <http://www.ComputeGasSavings.com> and <http://www.GoldPricingOnline.com>.

3.2.1 Driving to another store to use a coupon

In a study by Amos Tversky and Daniel Kahneman (1981) 68% of the subjects said that they would drive 20 minutes to save \$5 on a \$15 purchase, but only 29% would drive 20 minutes to save \$5 on a \$125 purchase. Of course an identical financial proposition is: Would you drive 20 minutes to save \$5? Depending on individual circumstances there can be multiple costs associated with a 20-minute drive. In the calculator I constructed, I

stated the problem in terms of a distance instead of a time. The only cost considered is the gas used for the total distance traveled (roundtrip). If gas costs \$3.50 per gallon, for a car that gets 25 miles to the gallon, a 40-mile roundtrip requires \$5.60 for the gas alone. The total savings would be \$-0.60, meaning that the choice to use the coupon results in a net loss of 60 cents.

Total Savings

Miles per gallon:


Cost per gallon (dollars):

Discount (dollars):

Distance (miles):

Compute

Total Savings: \$ -0.60



The Two Headed Quarter
How to See Through Deceptive Numbers

Figure 2: Screen shot of the Total Savings calculator with a sample calculation shown. In this example the store is 20 miles away, which requires a 40-mile roundtrip. Given the 25-mile per gallon fuel efficiency and \$3.50 cost per gallon for the gas, the fuel cost for the roundtrip is \$5.60. The total discount is \$5.00 so the net savings is \$-0.60, which indicates a loss.

3.2.2 Driving to find cheaper gas

In the Baltimore metro area, gas is often \$0.10 cheaper in suburban areas 15 miles from the city. But will the drive result in any savings? This is a variation of the first question, but because the gas itself is the purchase, the tank size must be one of the inputs. This calculator frames the comparison in terms of a savings per gallon if you make the drive to station with the cheaper gas. For example, if a car with a 16-gallon tank that gets 30 mile per gallon travels 15 miles (30 miles roundtrip) to purchase gas at \$3.85 per gallon instead of \$3.95 locally, the net savings is -\$0.14 per gallon. The negative sign means that it is costing the driver 14 cents more per gallon (\$4.09) rather than 10 cents less. The reason is that the round trip cost \$3.85 for the one gallon of gas needed, which amounts to an extra payment of \$3.85 divided by 16 gallons, or \$0.24 for each gallon purchased.

Gas Savings

Tank Size (gallons):

Miles per gallon:


Cost local (dollars):

Cost away (dollars):

Distance (miles):

Compute

Savings per Gallon:



The Two Headed Quarter
How to See Through Deceptive Numbers

Figure 3: Screen shot of the Gas Savings calculator with a sample calculation shown. In this example the low-price gas station is 15 miles away, which requires a 30-mile roundtrip. Given the 30-mile per gallon fuel efficiency and \$3.85 cost per gallon at the low-price station, the fuel cost for the roundtrip is \$3.85. For a 16-gallon tank this cost averages to \$3.85 divided by 16, or \$0.24 per gallon. The savings per gallon on the purchase is \$3.95 – \$3.85, or \$0.10. Therefore the net savings per gallon is \$–0.14, which indicates a loss.

3.2.3 Cash for gold offers

The rapid increase in the price of gold has resulted in stashes of old, unworn jewellery becoming a valuable treasure trove for many people. Companies have arisen to exploit the demand for exchanging gold for cash. However, an investigation conducted by the Consumerist.com, a consumer advocacy group, found that some companies paid only 11-29% of actual value of the gold (Popkin, 2010). These consumer losses are unnecessary because unlike gemstones, that require an expert assessment of quality to price, gold is priced by weight and purity only. The problem for many gold owners is that the units for weight (troy ounces) and purity (carats) are unfamiliar, and unit conversions are beyond their quantitative abilities. However, anyone with a standard scale for measuring postage or food portions can determine the value of gold in jewellery. Pure gold is rated as 24 carat, which means that the fraction of gold for any piece less than 24-carat is the number of carats divided by 24. Therefore the common 14-carat alloy is 14/24, or 0.583 gold. An imperial ounce, which is the unit a postal scales uses, is 0.91 troy ounce. Therefore if a 14-carat gold chain weighs 1.5 imperial ounce on a postal scale, its gold value is 1.5 imperial ounce x 0.91 troy ounce/imperial ounce x 0.583 x price of gold per troy ounce. At the time of this writing gold is priced at \$1800 per troy ounce, so the chain contains about \$1432 worth of gold. As generous as a \$700 offer might appear for an unworn piece of jewellery, it undervalues the gold content by \$732.

Gold Jewelry Pricing

Weight (oz):

Purity (carats):

Gold (dollars/oz troy):

Gold value


 The Two Headed Quarter
How to See Through Deceptive Numbers and
Save Money on Everything You Buy

Figure 4: Screen shot of the Gold Pricing Jewellery calculator with a sample calculation shown. In this example the value of the gold content for a 14-carat, 1.5 imperial ounce piece of jewellery is determined based on a market price of \$1800 per troy ounce for gold.

3.2.4 Two wage earners in a household

The adage about the “need to spend money in order to make money” is well known to any couple with children. Daycare and commuting costs can easily offset any financial benefit obtained by having both parents work outside the home. The cost/benefit analysis for this scenario is more complex than the previous examples and allows for multiple solutions. The major expenses required for a parent to work include: gas, daycare, payroll taxes, work-related expenses (lunches, clothes, supplies) and depending on circumstances, federal taxes and state taxes.

The calculator to compute actual take home pay computes the cost of gas per day (given the distance to work, vehicle efficiency, and price of gas), the after tax earnings per day (given federal and state tax rates), and the “real earnings per day” (given the daily cost of the gas, taxes, daycare and other work-related expenses). For a relatively low-wage \$12 per hour, 8 hour per day job (\$25,000 per year), the costs of going to work can consume almost all the earnings. For the example shown in Figure 5, it is assumed that the worker is a spouse providing a second income and must pay federal taxes at a 15% rate because the primary wage earner elevates the couple into this higher tax bracket. For the following inputs: 18 miles distance to work, 25 mile per gallon vehicle efficiency, \$3.50 per gallon of gas, \$35 per day for daycare, \$10 per day for work-related costs, 15% federal tax rate, and 5% state tax rate, a \$12 per hour job brings home less than \$20 per day (\$19.41). It would require only a small rise in the price of daycare (an additional child) and/or the price of gas to make the “real earnings per day” a negative value.


Daily Take Home Pay	
Distance to work (miles):	18
Miles per gallon:	25
Cost per gallon (dollars):	3.50
Cost of daycare (dollars):	35
Work-related costs (dollars):	10
Federal tax rate (%):	15
State tax rate (%):	5
Social Security/Medicare (%):	7.65
Daily pay (dollars):	96
Compute	
Cost of gas per day:	\$ 5.04
After tax earnings per day:	\$ 69.46
Real earnings per day:	\$ 19.42
 The Two Headed Quarter <i>How to See Through Deceptive Numbers</i>	

Figure 5: Screen shot of the Daily Take Home Pay calculator with a sample calculation shown. In this example the net daily earnings is calculated for a \$96 per day job (\$12 per hour for 8 hours). It is assumed that the wage earner is part of a married couple in the United States with a primary wage earner already earning enough to be in the 15% federal income tax bracket. Therefore deductions for federal, state, and payroll taxes result in a paycheck for \$69.46. The \$5.04 daily cost of gas to commute to the job is determined from the distance, fuel efficiency, and price per gallon. After subtracting the taxes, gas costs, and daycare and other reasonable work-related costs the wage earner is left with \$19.42—about \$2.43 per hour.

When the benefit of a second income is framed in terms of the real earnings per day, it might prompt a couple in this situation to look for \$20 per day of savings in the family budget, rather than deal with hassle of a second job. It is also possible that there are benefits of a second job that have not been accounted for in this model. Without a continuity of work history future earnings could be negatively affected. The “real take-home pay” calculator, and in fact all the calculators shown account only for the present-costs associated with an action. Future costs are not modeled, although more elaborate models could be constructed that quantify future costs. For example, the vehicle-financing calculator could calculate a return on investment of the rebate.

Work outside the home could also impact mental health in a positive manner by connecting an otherwise isolated parent to other groups of adults. Daily pay is quantifiable benefit, but other benefits of a job might not be quantifiable. In other words, the “numbers” might not tell the entire story, which is an important point worthy of discussion in any lesson on quantitative methods.

4. Heuristics

All economic decisions have present and future costs associated with the available options that are in addition to the prices. However, many consumers focus only on the price, and do not quantify and compare the total costs (present and future). Marketers

often take advantage of this mental blind spot by manipulating prices in order to hide total costs. Even without external pressures, consumers can spend more than they save when chasing lower prices, and not be aware of the true costs of their actions.

The point of this paper is not to turn every economic decision into an elaborate math problem because that would be impractical. Heuristics, that is experienced-based strategies, are necessary for decision-making. Without heuristics it would become impossible to act in a timely manner on any decision. The real world is simply too complex for an exhaustive analysis of all possible consequences for each option. However, all heuristics have inherent flaws, and it benefits the user to be aware of the flaws.

For buying decisions, the most widely used heuristic is the price comparison. This paper has illustrated some flaws in the price comparison heuristic and some quantitative models for improving it. These models prompt the consumer to consider and quantify costs in addition to the prices and compare the total costs for the available options, not just the prices. While it might be impractical to analyze every buying decision in this manner, for large purchases—houses, cars, loans, insurance retirement plans—a quantitative analysis that re-frames the available options could result in choices that offer substantial savings.

The fact that the quantitative frame for a financial choice influences the decision has led Thaler (Thaler, 1980; Thaler, 1985) to propose a theory of “mental accounting.” He argues that just as companies perform accounting by putting money into separate categories, people have their own “mental” categories for tracking income and expenses. Framing affects choice because it determines the “mental” account for the expense or income. Even though in principle all dollars a person owns are equal, the dollars spent on the gas used driving to a store are in a different mental account than the purchases made at the store. As a result, people compare gas prices and purchase prices separately and do not consider possible relationships between the two. The same is true for the purchase price of a vehicle and the finance charges. These are assigned different mental accounts, even though these expenses are rarely completely separable.

Mental accounting is not necessarily bad. In fact it can be useful if it operates in a way to achieve financial goals. Many people have change jars to save for vacations and special purchases. Rationally, it would be easier to write out a single check to pay for a vacation. But, a large amount of cash drawn from a checking account and loose change left over after small purchases are in different mental accounts. The former is thought of as a substantial loss, while the latter is thought of as found money. As a result emptying loose change into a jar at the end of each day is a psychologically painless way of accumulating money for a vacation or special purchase.

5. Algebra

The examples of obvious benefit/hidden cost problems provided can be solved using quantitative methods only. The four standard operations of arithmetic—addition, subtraction, multiplication, and division—are all that is needed. However, in order to create the Web-based calculators the problems must be generalized. An algebraic solution to the problems must be obtained and then translated into a programming language. If students were asked to solve specific examples for each kind of problem, multiple times, they would soon see the patterns. If they repeatedly calculate commuting costs by

dividing the distance in miles by the miles per gallon and then multiply by the cost per gallon, it becomes apparent that the procedure can be summarized by an algebraic formula.

But, algebra is more than just formulas. It's greatest advantage is the ability to solve for unknowns in an equation. Any of the quantities in an algebraic formula can be isolated, which means that there are multiple statements of the same problem. For example, the question: "Do you save money by driving to a store 20 miles away to use a \$5 coupon?" can be reformulated as: "What is the furthest distance (break-even distance) you should drive to use a \$5 coupon?" Once the answer to one of these questions is formulated algebraically, it is easier for students to understand that the solutions to both problems arise from the same algebraic formulas. Only the known and unknown quantities have been switched. Formalizing the quantitative analysis leads to a natural understanding of algebra. Students can then be challenged to generate additional re-statements of the same problem such as: If you drive to a store 20 miles away to use a coupon, what is the minimum value that coupon has to be worth for you to break-even?

6. Summary

Schools devote enormous time and resources to teaching math that will never be used as an adult. However, little effort is spent teaching quantitative reasoning, which is invaluable in navigating the crowded and confusing adult marketplace. Even future scientists and engineers would, in many instances, would be better served by mastering quantitative reasoning skills before learning algebra, trigonometry, and calculus. Scientists and engineers routinely use quantitative methods in their work to strip away complexity, and answer fundamental questions about the costs, limits, and sustainability of processes under study.

This paper presented instructional resources for integrating financial literacy into the current math curriculum rather than teaching it separately. The resources focus on the use of quantitative thinking to re-frame common financial decisions. The advantages to this approach are that students learn that math is relevant to personal finance and that algebra arises naturally from quantitative thinking. These resources have not yet been deployed in a secondary education setting. Rather, the creation of these resources is intended as a call to action to encourage improved education in quantitative methods. Links to all the resources presented are at <http://www.ComputeGasSavings.com>, and <http://www.GoldPricingOnline.com>.

These are just a few examples of how quantitative skills can be deployed to address personal finance issues in a fun, relevant, and interactive way. It is my intent to prompt educators to re-think how math and financial literacy are taught. Math is often one of the most difficult subjects for students to master because they don't see the relevance and as a result, are not motivated. I hope to change the way students and educators think about math and change their motivations.

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