



South County High School– Team #4187, Lorton,
Virginia

Coach: Daniel Southard

Students: Alex Coppeans, Brian King, Trung Nguyen,
Peter Wang, James Wang

M3 Challenge Sixth Place Team, First Honorable Mention Team Prize: \$2,500

***Note: This cover sheet has been added by SIAM to identify the winning team after judging was completed. Any identifying information other than team # on an M3 Challenge submission is a rules violation.

***Note: This paper underwent a light edit by SIAM staff prior to posting.

Moody's Mega Math Challenge 2015

STEM Sells: What is higher education really worth?

Team 4187

3-1-2015

Executive Summary:

Dear Administrators of <#INSERT SCHOOL NAME>,

Your seniors are about to embark on a lifelong journey in which they will meet many trials and tribulations. Many of them have discovered that college will be their compass and sextant as they sail the oceans of prosperity. However, any navigation system takes time and effort to learn how to use. Similarly, college has many costs, both obvious and implicit, the calculation of which can be mentally taxing and exhausting. This model uses tried and true techniques, as well as concrete mathematics, to provide the pinpoint guidance of a GPS system. Instead of tirelessly looking over FAFSAs, financial aid websites, and other resources to determine the cost of a college education, students and parents alike can use this model, the figures calculated, and the lessons learned to plan their own path through the sinuous labyrinth that is our higher education system. Using an eclectic variety of mathematical and financial techniques, we have created a model that prices, values, and ranks the many rivers (college choices) that make up the watershed of higher education. Unlike many other naïve models and algorithms used to navigate these treacherous waters, our model takes into account the fact that money tomorrow is worth less than money today. These effects add up substantially at interest rates seen in the stock market. We have simply applied the corrective lens of discounting to the telescope of financial planning. Much like removing a kaleidoscope from one's eye instantly clears the vision, our model leads to unorthodox conclusions. Did you know that a high school student who decides to enter the workforce creates more value than a student who chooses to pursue an associate's degree? Assuming returns stay at historical levels, a student is far better off working and saving the money that would otherwise be spent on an associate's degree and investing it. We used average statistics to determine a baseline for the college costs, after which we deducted financial aid using an Estimated Financial Contribution calculator. We generally recommend that students enroll in a STEM program in college; occupations in that field pay the most and were ranked the highest. If it is truly not a student's calling, we recommend a 4-year degree program. If that is not acceptable, no degree is the best choice of action for most; the associate's degree program was found to be expensive and value destroying. However, this report is also very general - it analyzes the world's oceans, but every river, stream, and lake is different. Averages can only represent the whole. Not all students have equal aptitudes at STEM. Some may even choose not to pursue post-secondary education. Not everyone is willing to invest in the stock market to gain the returns assumed in this report. While flawed, this report will take you on a journey through winding and sometimes strenuous mathematics, colorful formulas, and strange numbers to see the reality of college financing. Good luck, and have fun!

Sincerely, Team 4187

Table of Contents

Introduction.....	4
Part 1: The Costs of College.....	5
Part 2: The Costs and Benefits of a STEM Education...	14
Part 3: The Real Value of a Job.....	20
Conclusion.....	24
References.....	27

1: Introduction

1.1 Background

In 2013, 7 out of 10 adults graduated from public and nonprofit colleges with an average of \$28,400 in student loan debt (24, "State by State Data"). As state funding for colleges has decreased dramatically in the recent past years, higher education has become less affordable and more difficult for students and their families to access. However, President Obama's Council of Advisors on Science and Technology (PCAST) requests that more STEM professionals be produced in the next few decades, a demand impeded by the rising costs of college. Additionally, financial illiteracy is widespread among today's youth. It is important to make sure that they can get information about the financial, personal, and career value of their education choices in simple, easy-to-understand terms.

1.2 Problem Restatement

College is not cheap; the average cost of a public 4 year university is around \$19,000 (25, "Tuition Costs"), raising an inevitable question for many high school students: Is college worth it?

1. Determine how much an individual student will pay for an undergraduate degree, taking into consideration President Obama's recent suggestion to make two years of community college free.
2. Assuming that a college graduate's earning potential and financial stability are all that matters, create a model that contrasts the liability and rewards of STEM vs. non-STEM jobs.
3. Taking account factors that influence quality of life, such as income, benefits, job security, etc., develop a ranking model that would help high school students plan their educational choices.

1.3 Global Assumptions

1.3.1 Introduction

Generally, we used assumptions that pertain to most people and simplified the thinking process. The one major assumption we made is that people are completely rational; they maximize personal utility. Without this assumption, we would delve into the abyss of psychology. Another assumption we made regarding the financial aspect was a fixed interest rate based on historical data, because it fluctuates and is difficult to predict.

1.3.2 Assumptions

1. All earnings are discounted using a fixed interest rate to the present. This interest rate will be the average earned on a retirement account, which

represents a savings account. The net present value (NPV) of different degrees will be stated. This makes sense, as all earnings are either saved or spent. The decision to spend money will take into account the present value of the money (which includes future returns) and determine whether instant gratification is worth forgoing the future income stream from the wealth spent. This assumption is not necessarily true, as many prefer to leave their money uninvested, but since it is assumed people are rational, in the model, all money is invested to the maximum extent if unused.

2. All people are rational and time-consistent; that is, they make the same decisions in the present as in the future. This assumption is not completely valid, as many do not account for returns in the far future, but is reasonable as everyone seeks to maximize their wealth and happiness.

1.4 Techniques Used

1.4.1 Basics of Finance: Time Value of Money

Since compound interest increases the amount of money received in the future when it is invested, any future payments must be discounted to the present, because time is money. This is reflected in the prevailing return on capital offered by the stock market. On average, this rate has been 9.6% since 1926 (26, "Vanguard Portfolio Allocation Models"). All values, unless indicated otherwise, as in Part 1, are discounted to the present, which is just after high school graduation. The formulas for the computation of the time value of money are given along the way.

1.4.2 Basics of Calculus: Integration and Differentiation

Integration is used to sum complicated formulas. The key assumption here is that the difference imposed by assuming a continuous variation instead of a discrete variation is negligible.

2. Part 1: Costs of College

2.1. Analysis of the Problem

College costs are rising quickly today. Newer generations of students must now take into account the costs of higher education in accordance with their life goals and values. Additionally, a bachelor's degree no longer guarantees financial security in the competitive labor market today. Costs and income during the college stay are inextricably tied. Students are now expected to bear part of the financial burden of college. As such, we included the income of the student in our calculations. Other factors included the expected contribution of the family during the college stay and the

average cost of college in the United States. These values can be used to determine need-based financial aid, which often takes the form of loans. A percentage of loans as part of financial aid is necessary to determine long-term costs. All values are presented in the dollars of the year of graduation; this is because student loan payments start.

2.2 Background Information / Assumptions

The average income of a college student is \$14,400 (6, “College Student Spending Average”), including parental help and part-time jobs. The average college savings account contains approximately \$15,400 (10, Hill). Since the average age of maternity is 43.4 years old, the age of the oldest parent was assumed to be 45. The average wealth per adult (parent) was \$44,900 (15, Luhby) in 2014. The incomes per *household* were \$35,000; \$75,000; and \$125,000. Using the “Quick EFC” calculator, the Estimated Financial Contribution (EFC) per family per student was calculated. An additional assumption is that anyone who finishes college in more than four years finishes in the sixth year and that anyone who finishes college in less than or equal to four years finishes in the fourth year. The Stafford loan interest rate is 4.66% (12, “Interest Rates and Fees”), and the average annualized historical stock market return is 9.60% (from 1926-2008) (26, “Vanguard Portfolio Allocation Models”). All costs are given in terms of dollars immediately after the student finishes college. We also made the assumption that all families could pay their EFCs, which are calculated with that aspect in mind. An important thing to note is that “cost” is used in two ways in this section. We will refer to “total cost” as what the college receives in a check, while “total family/personal cost” is what gets passed on to the student and his/her family.

2.3 Estimated Financial Contributions

The EFCs were calculated with the “Quick EFC” calculator using the average values for the input parameters (8, “FinAid”).

Type of Family	Income	EFC
1 Parent / 1 Child	\$35,000	\$8,978
1 Parent / 1 Child	\$75,000	\$25,590
1 Parent / 1 Child	\$125,000	\$41,114
2 Parents / 3 Children	\$35,000	\$3,694
2 Parents / 3 Children	\$75,000	\$11,163
2 Parents / 3 Children	\$125,000	\$16,460

2.4 College Composition

73% of students who went to college in 2011 went to public institutions. 25% went to private ones (20, O'Shaughnessy).

2.5 Costs of College

2.5.1 Time Spent in College

First, to calculate the cost of college, we must calculate the average time that a student will spend acquiring a 4-year bachelor's degree. We exclude the people who drop out of college because we'll assume that everyone who is considering college will complete it (if he expected to drop out, he would not go to college). 58% of four-year college students finished their four-year degree within 6 years. 38% finished within 4 years. Remember the initial assumption that they will all graduate in either of two years. We use the equation

$$T = \sum_{i=0}^n [i \times D(i)]$$

where T is time in college, $R(n)$ is percent retained in year n starting at year 0 for the first year of college, and $D(n)$ is percent graduating in year n . Note that this is equal to $1 - R(n)$.

Table of Values for $D(n)$

n	$D(n)$
0	0.0%
1	0.0%
2	0.0%
3	38.0%
4	0.0%
5	20.0% (58.0% - 38.0%)

Thus, the time is given as the weighted average of the time spent in college using graduation rates as the weighting:

Evaluating T , we obtain 4.68 years as the average time spent by a 4-year degree student in a 4-year college. This number is also very unfortunate; the 4-year degree is

somewhat of a misnomer. In fact, the average is closer to 5 years, which results in a further increase in expected cost.

2.5.2 Cost of 4.68 Year College

2.5.2.1 Average Costs of College Today

The average cost of college was \$19,339 for the 2011-2012 year. (25, "Tuition Costs") Costs for public college rose 40% over the 10 year period from 2001-2011. Costs for private nonprofit college rose 28% over the same period.

College Cost Growth 2001-2011

College Type	Total Growth	Annualized Growth
Public	40%	3.4%
Private Nonprofit	28%	2.5%

The weighted rate of growth using the composition figures given in **Section 2.5.4** is

$$R_W = 73\% \times 3.4\% + 25\% \times 2.5\% = 3.07\%$$

Extrapolating for four years with the weighted growth, college costs approximately \$21,825 today.

2.5.2.2 Yearly Cost of College

The per annum cost of college, assuming \$21,825 college cost today (\$19339.00 extrapolated to today using the weighted college price growth rate), can be determined with

$$C(t) = 21,825(1 + R_W)^t,$$

where C is the annual cost, and R_W is the weighted rate of college price.

2.5.2.3 Total Cost of College

Applying the yearly cost formula over 4.68 years and assuming that college costs vary continuously, instead of discretely, the total cost of college can be modeled with

$$C_{Total} = \int_0^{4.68} C(t) dt$$

Evaluating the integral with $R_W = 3.07\%$, $C_{Total} = \$109,721$.

2.5.3 Financial Aid

Need-based financial aid is calculated by subtracting the EFC from the total cost of college. A table of need-based financial aid is given. Using statistics from Figure 4 of (9, "Grants and Loan Aid"), student loans made up 27% of need-based financial aid.

Need-Based Financial Aid

Type of Family	Income	Total Cost	EFC (4.68 years)	Financial Aid
1 Parent / 1 Child	\$35,000	\$109,721	\$42,017	\$67,704
1 Parent / 1 Child	\$75,000	\$109,721	\$119,761	(\$10,040) ¹
1 Parent / 1 Child	\$125,000	\$109,721	\$192,414	(\$82,693) ¹
2 Parents / 3 Children	\$35,000	\$109,721	\$17,288	\$92,433
2 Parents / 3 Children	\$75,000	\$109,721	\$52,243	\$57,478
2 Parents / 3 Children	\$125,000	\$109,721	\$77,033	\$32,688

1. Because the EFC is greater than the Total Cost, Financial Aid is zero, and the payments made by the family will be equal to Total Cost. The figures displayed are the difference between the cost and the required EFCs.

Loan Amounts - Financial Aid

Type of Family	Income	Financial Aid	Loan Amount
1 Parent / 1 Child	\$35,000	\$67,704	\$18,280
1 Parent / 1 Child	\$75,000	\$0	\$0
1 Parent / 1 Child	\$125,000	\$0	\$0
2 Parents / 3 Children	\$35,000	\$92,433	\$24,957
2 Parents / 3 Children	\$75,000	\$57,478	\$15,519
2 Parents / 3 Children	\$125,000	\$32,688	\$8,826

2.5.4 Loan Payments

As stated before, the loan amounts are 27% of Total Cost - EFC. These are given in the preceding table. The monthly payment formula for c , the monthly payment, is given by

$$c = \frac{rP}{1 - (1 + r)^{-N}} = \frac{Pr(1 + r)^N}{(1 + r)^N - 1},$$

Where N is the number of payments and r is the monthly interest rate, equal to $r_{annual}/12 = 4.66\%/12$.

The total interest paid is equal to

$$I_{Total} = Nc - P$$

A table of loan amounts, monthly payments, and total interest paid is given below.

Loan Amounts, Monthly Payments, and Interest Paid

Type of Family	Income	Loan Amount	Monthly Payment	Interest Paid
1 Parent / 1 Child	\$35,000	\$18,280	\$190	\$4,623
1 Parent / 1 Child	\$75,000	\$0	\$0	\$0
1 Parent / 1 Child	\$125,000	\$0	\$0	\$0
2 Parents / 3 Children	\$35,000	\$24,957	\$260	\$6,312
2 Parents / 3 Children	\$75,000	\$15,519	\$162	\$3,925
2 Parents / 3 Children	\$125,000	\$8,826	\$92	\$2,232

The cost of the loan is the present value of all of the loan payments.

The present value of one payment can be calculated as

$$PV = \frac{X}{(1+r)^n},$$

where X is the nominal value of the payment, r is the discount rate, and n is the number of years. We can set n to the rate at which one can earn on a comparable investment: 9.6% in the stock market. As such, the modified loan values are given below. Important to note is that these are *less* than the principal of the loans. This is because the

historical return in the stock market is greater than the interest charged on the loans. These modified loan values can be added to the discounted total of the EFCs to obtain the total cost to the family right after college. The total costs are given below:

Type of Family	Income	Total Cost
1 Parent / 1 Child	\$35,000	\$64,844
1 Parent / 1 Child	\$75,000	\$119,761
1 Parent / 1 Child	\$125,000	\$192,413
2 Parents / 3 Children	\$35,000	\$37,340
2 Parents / 3 Children	\$75,000	\$64,712
2 Parents / 3 Children	\$125,000	\$84,124

Note that the median household income in the USA in 2013 was \$51,900. The average of \$35,000 and \$75,000 is \$55,000, close to the median income. Therefore, it makes sense to say that the median college cost will be approximately the average of all 4 of the costs of those two incomes (1 and 3 children), or \$71,665.

2.6 Community College

2.6.1 Community College Costs Compared to Four-Year Colleges

The average community college costs \$2,713 per year in tuition. The average four-year institution costs \$7,605 per year. That amounts to a \$4,892 savings per year. The total savings for a 2-year community college can be calculated as

$$S_T = 4,892(1 + R_W) + 4,892 = 9,934$$

Subtracting this from the total price of college and recomputing the costs results in a cost schedule similar to this:

Type of Family	Income	Adjusted Costs
1 Parent / 1 Child	\$35,000	\$62,689
1 Parent / 1 Child	\$75,000	\$119,761
1 Parent / 1 Child	\$125,000	\$192,413
2 Parents / 3 Children	\$35,000	\$35,185
2 Parents / 3 Children	\$75,000	\$62,557

2 Parents / 3 Children	\$125,000	\$81,969
------------------------	-----------	----------

As in the previous table, the median income is approximated by the \$35,000 and the \$75,000 figures. The average for those college costs is \$70,048. Remember that this is for getting a four-year degree by transferring from a community college. For getting a two-year degree (associate's) the cost is approximated by

$$C = C_{bachelors} - \Delta Tuition,$$

where C is the annual cost.

Calculating the total cost is a matter of adding:

$$C_{Total} = C(1 + R_W) + C = C(2 + R_W)$$

This produces

$C = C_{bachelors} - 4,892 = 16,933$ and $C_{Total} = 16,933(2 + 3.07\%) = 34,386$. We can conclude that the cost for a two-year degree is \$34,386.

2.6.2 Obama's Community College Plan

Using the previous formula for S_T ,

$$S_T = 7,605 + 7,605(1 + R_W) = 15,443$$

The modified cost schedule is shown below.

Type of Family	Income	Adjusted Costs
1 Parent / 1 Child	\$35,000	\$61,494
1 Parent / 1 Child	\$75,000	\$119,761
1 Parent / 1 Child	\$125,000	\$192,413
2 Parents / 3 Children	\$35,000	\$33,990
2 Parents / 3 Children	\$75,000	\$61,362
2 Parents / 3 Children	\$125,000	\$80,774

The average cost for the median earner is \$69,152. It is \$28,877 for a two-year degree.

2.7. Testing and Justification

According to the National Center for Education Statistics (NCES), the average cost of a 4-year education was \$76,000, (25, "Tuition Costs") which is close to the model's prediction of \$69,152. The reason for this discrepancy is the high-wage bias present in

college attendees. This model can be tested through a survey of college debt, costs, and family income of recent college graduates. We can conduct surveys of a sample with a median income similar to the national median income and then measure the average college costs for different-sized families. All values are discounted to present value. Since these values are very similar, the model is valid.

Average Cost Estimates	Current Model	Government Estimates (25, "Tuition Costs")
4-year education	\$71,665	\$73,753
2-year education	\$33,361	\$29,762

2.8 Sensitivity

The costs of college are sensitive to interest rates, as with the rest of the calculations. The present values of these loans are highly dependent on the return on capital and the interest rates on the student loans. They also change rapidly with increases in living cost. Expected financial contributions change with initial assets, for which we assumed reasonable amounts. However, since each student's financial situation is different, these assets are only estimates, and the actual costs of college may differ greatly from the expected costs.

3. Part 2: The Financial Benefits/Costs of a STEM Education

3.1. Analysis of the Problem

Today, there is no model for the costs and earning potentials of various degrees. Unlike other models, which value all income streams at face value, regardless of how far in the future they occur, we discount future income to the present. To accurately account for the net benefit of attending college, the time value of money must be accounted for; wealth earned later in life is worth less than wealth early on. Therefore, interest rates on student loans and returns on investments must be considered. In addition, the varying initial financial situations and aptitudes of students may result in different values for the overall benefit of a college education. Thus, the stated value will only reflect the

average benefit or cost for each degree. Degrees will be grouped into STEM, non-STEM 4-year degrees, 2-year degrees, and no degree. We are interested in finding the present value of the total career earnings of STEM, non-STEM, and non-bachelor's students and then subtracting the present value of the cost of a college education. This will deliver the net value of each degree. The values can then be compared to determine which is best financially.

3.2. Assumptions

1. All careers are equivalent in happiness. Therefore, job stress, enjoyability, and vacation time are not taken into account. This assumption is a key component of the question asked.
2. Investments have fixed interest rates. While this is not true in the short-term fluctuations of the stock market, over the long run, these fluctuations stabilize into long-term growth.
3. All liabilities will be paid off legitimately; no loans are defaulted on, no taxes are evaded, and no income is derived from criminal activities. Loan defaults change the costs of college and of living, and are typically not considered an option by most families.
4. The sole sources of income are a job and a tax-deferred investment portfolio. The portfolio is used to allow for the time value of money. Any other sources of income would skew the calculations of wealth.
5. All income is before-tax, and wealth is saved in tax-privileged accounts, such as a house and retirement accounts. This entails an estate lower than \$5 million, and all money saved is deposited into tax-advantaged retirement accounts, following the rules for minimum withdrawals and maximum contributions. College is paid for with before-tax money from 529 plans, and any other expenses are assumed to be tax-deductible. Therefore, we can ignore taxes, as all expenditures considered are before-tax or tax-exempt.
6. Students begin with zero wealth; the benefits of a STEM versus non-STEM degree are being considered. While the students who acquire STEM degrees often come from more affluent families than those who do not complete college, to ensure a fair comparison, all students are assumed to begin from the same level of affluence.
7. The earnings function throughout the career is assumed to be linearly increasing from the entry-level to the exit-level wage. Thus, we can use the average wage in the field to approximate the total earnings throughout the career. Wages typically increase more slowly percentage-wise as they grow higher, so this

assumption dampens the exponential function of percentage growth to a more conservative model.

8. The cost of college for non-STEM and STEM 4-year degrees is the same. Typically, tuition is similar for all courses at universities, and living expenses do not vary. Few 4-year universities ask for different amounts for different majors.
9. Employees are never unemployed for significant lengths of time. Earnings accrue in every year from graduation to retirement. Typical unemployment periods are less than 6 months and do not contribute significantly to the time worked. In addition, typically people find part-time jobs during periods of long unemployment.
10. Students do not work in college; they begin their careers after graduation. They also decide to have children 4 years after high school graduation. These assumptions are valid, as expenses increase after graduation and most people find jobs immediately to begin earning money.
11. President Obama's plan to make community college free will not take effect. Our planning cannot take into consideration proposals which have not yet been passed, as expectations are often disproved, and the deadlock in Washington has yet to be resolved.

3.3 The Model

3.3.1 General Equations

Two quantities, wealth and income, will determine the overall financial stability of a person. The yearly income is equal to job earnings. Over the average employment period, 38.3 years (5, BrownEcon), the total wealth derived from the job is

$$W(T) = \int_0^Y [E(T) - C(T)] dT,$$

where Y is 38.3 years, E is a function of time determining the job earnings for year T after graduation from high school, and C is a function of time determining the consumption (living expenses) T years after graduation. Discounting the wealth to the present,

$$W(T) = \int_0^Y \frac{E(T) - C(T)}{(1+R)^T} dT,$$

where R is the discount rate (9.6%).

The earnings per year are about

$$E(T) = E_{avg},$$

where E_{avg} is the average wage. The total benefit of a college education is calculated by subtracting the cost of education from the benefit conferred on future earnings, and

then discounting the total to the present, to determine the present value of each possible degree. This benefit is

$$NPV = [W(T) - L(T)] / (1 + R)^T,$$

where L is a function of time determining the cost of an education, expressed by

$$L(T) = (1 + R)^T \times L(0)$$

where $L(0)$ is the initial loan amount. This expresses the cost of interest and time value in the loan. R is about 4.66% for student loans, and 9.6% for savings/investment, which approximates the return of an aggressive portfolio. Costs of college must be discounted depending on the length of the education.

$$P_{Present} = \frac{P_{After\ college}}{(1 + R)^{Length\ of\ College}},$$

where P is the total cost of the college education after graduation.

3.3.2 Costs of College

The cost of college for both STEM and non-STEM 4-year degrees is \$71,665, the cost of an associate's degree is \$33,362, and the cost of a high school diploma is assumed to be standard living expenses, which amount to about \$28,089 for one adult and one child (14, "Living Wage Calculator"). Accounting for investment returns before college loans are due after graduation, the cost of a 4-year degree is \$49,666, the cost of an associate's degree is \$27,772, and the cost of a high school diploma is \$0. The table below summarizes the costs of a post-secondary education.

Type of Degree	Time	Cost at High School Graduation	Cost after College
STEM degree	4 years	\$49,666	\$71,665
non-STEM degree	4 years	\$49,666	\$71,665
Associate's degree	2 years	\$27,772	\$33,361
High School Diploma	0 years	\$0	\$0

3.3.3 Earnings After College

3.3.3.1 Annual Incomes After College

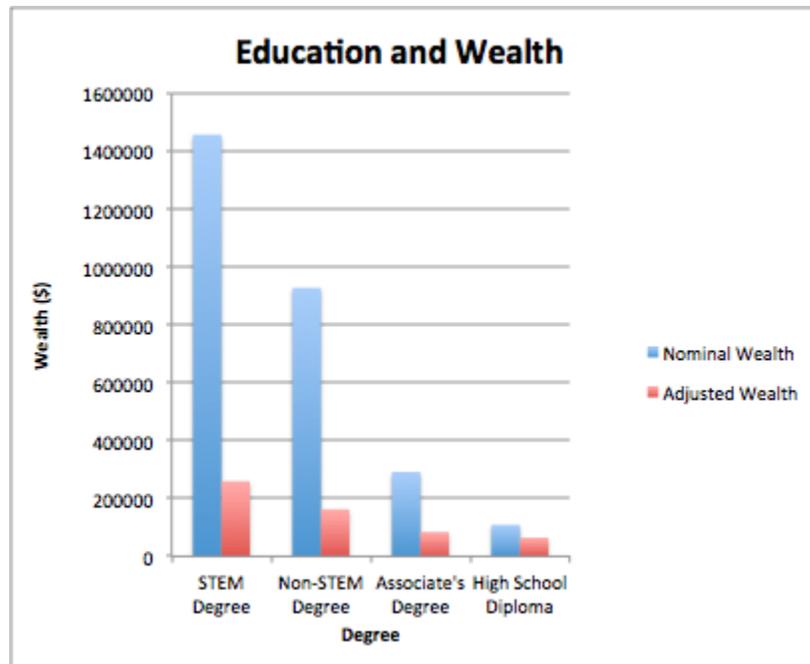
The average income from a STEM degree is about \$66,123, while graduates with non-STEM degrees earn \$52,299 on average, graduates with an associates degree earn \$35,700, and those without any degree at all earn approximately \$30,000 per year. Graduates with STEM degrees earn more than double those without any degree and significantly more than those with other 4-year degrees and 2-year degrees.

3.3.3.2 Total Career Earnings

Taking into account stock market returns and living expenses, STEM graduates earn \$259,368 over the course of their careers, graduates with non-STEM bachelor's degrees earn \$162,551, graduates with an associate's degree earn \$83,992, and non-graduates earn \$64,402. All of the above figures are expressed in terms of present value at the time of graduation from high school. The table below summarizes the earnings for various degrees. Nominal earnings are the sum of earnings accrued over the entire career, while adjusted earnings account for the time value of money. STEM graduates nominally have more than 10 times the wealth of those who only pursue a high school diploma, and significantly more than those with other degrees, and over 4 times the adjusted wealth of a high school graduate.

	Wealth (nominal)	Wealth (adjusted)
STEM Degree	\$1,456,702	\$259,368
Non-STEM Degree	\$927,243	\$162,551
Associate's Degree	\$291,501	\$83,992
High School Diploma	\$108,998	\$64,402

Below, there is a graphical representation of this table.



3.3.4 Value of College

Using the equations above in **Section 3.3.1**, the NPV of a STEM degree is \$209,701. The NPV of a non-STEM degree is \$112,884. For non-4-year degrees, an associates degree has a value of \$48,532. The value of only pursuing a high school diploma is \$64,402. Clearly, as students gain more education, they earn enough in the future to more than offset the cost of college. In addition, STEM degrees are extremely attractive due to the graduates' high incomes. The table below summarizes the value of each type of degree. Note that the associate's degree and the high school diploma graduates do not choose to have children until 4 years after high school graduation, and so their savings rate increases by \$14,045 (since their living expenses are approximately halved) for the years that they work while the 4-year students are in school. This chart exposes a surprising conclusion; it is better to forgo any post-secondary education than to pursue an associate's degree. However, with higher education levels, earnings increase drastically. Note that the present values of the education are relatively small because of the high return on capital offered by the stock market (9.60%).

Type of Degree	Time	Wealth	Cost (at graduation from high school)	Value
STEM 4-year Degree	4 years	\$259,368	\$49,666	\$209,701

Non-STEM 4-year Degree	4 years	\$162,551	\$49,666	\$112,884
Associate's 2-year Degree	2 years	\$83,992	\$35,461	\$48,532
High School Diploma	0 years	\$19,494+\$4 4907 = \$64,402	\$0	\$64,402

3.3.5 Testing

The model can be tested by taking a simple random sample of the states in the U.S. and then taking a cluster sample of the cities in the state. With this city, a random phone dialing system can be implemented to dial 1000 homes within that city. This method of sampling provides plausible amounts of information to analyze which will be more likely to follow the patterns in the population, which is what the model was applied to. The system will then be programmed to ask questions about their income and wealth. These values can then be tested against the predicted values. The income values relative to age should increase relatively linearly, and their net worth should be slightly lower than in this table because expenses are not actually tax-deductible, and the expected expenses were a bare minimum. Allowances must be made for luxury and unnecessary spending.

3.3.6 Justification

This model accurately takes into account the time value of money in the costs and benefits of different degrees. Instead of taking future earnings at face value, they are discounted to present a clearer picture of the value of higher education. College costs paid after graduation are also discounted to the end of the senior year in high school, to provide an accurate picture of costs while soon-to-be college freshmen pick their universities and allow families to understand the true costs and earning potentials of each major and degree. An entire lifetime's worth of earnings is studied to make sure that the decision to go to college takes into account future earnings and eventual retirement. Figures for college costs are taken from the previous section.

3.3.7 Sensitivity

This model for the value of a college education is extremely sensitive to changes in prevailing interest rates. Small changes in interest rates lead to great changes in the ranking and values of each education option. Changes in the living expense amount also would greatly affect the estimated wealth, possibly even resulting in negative wealth being accrued at some incomes.

4. Part 3: The Real Value of a Job

4.1. Analysis of the problem

What does it mean for an occupation to be “likable” or “happy”? In short, it reduces to two things: income and happiness. Unfortunately, these two quantities are vastly different. One can easily be quantified in currency terms. The other varies greatly depending on different personalities. However, using the World Happiness Report (12, Helliwell), we managed to approximately equate the two values. By calculating the percentile of the happiness coefficient we derived and indexing it with the vacation times of the happiest countries in the world, we converted happiness coefficients to vacation times. Vacation times could then be converted to monetary values with the wage.

4.2 Assumptions

We assumed that happiness in the world was somewhat correlated with vacation times. Using the World Happiness Report’s ranking and their respective minimum vacation times, we could convert happiness coefficients to vacation times using percentiles.

4.3 Designing a Model

The happiness coefficient formula takes into account:

- Stress
- Job security (measured as growth of job/average growth)
- Risk (measured as number of deaths per worker / average number of deaths per worker)

The wage formula takes into account:

- Income
- Vacation time
- Benefits

By adding the results of these two formulas using the happiness conversion to monetary values, we can obtain a total score for an occupation, which can then be converted through percentiles to a composite score from 0-99. Then it can be ranked.

4.4 Algorithm

$$H_c = \frac{s}{RD},$$

where H_c is the happiness coefficient.

s , which stands for job security, is measured by growth of the profession divided by the average growth in employment. The average growth in employment is 1.05% (1, "Aerospace Engineers").

R , the risk, is measured by the number of deaths in the profession per worker divided by the number of deaths in the workforce per worker. The average number of deaths per worker is 0.000032 (25, "Occupational Health and Safety Administration").

D , the measure of dissatisfaction, is the percentage of workers in the profession who are dissatisfied with their job.

Caveat:

Note that the average growth rate must be positive (and it is) in order for this metric to work. Also note that a negative growth rate for the profession ensures a low percentile for the profession, since it makes the H_c less than zero.

$$F_c = vW + hW = (v + h)W,$$

where F_c is the financial coefficient, v is the number of vacation hours, and h is the number of hours worked.

The conversion from H_c to dollar units is done as follows:

Let P be the profession that H_c is assigned to.

Let list L be the ascendingly sorted list of happiness coefficients for the professions in the set of professions to be considered.

Python Code:

```
L = [happiness_coefficient(prof) for prof in professions].sort()
```

Let I be the index of last element that is less than the happiness coefficient for P , $H_c(P)$.

Python Code:

```
I = 0
```

```
for i in L:
```

```
    if i > Hc:
```

```
        break
```

```
    else:
```

```
        I += 1
```

Compute the percentile, X , of H_c by computing $100.0 \times I / \text{len}(L)$, where $\text{len}(L)$ is the length of L , or the number of professions sampled.

Calculate the index, Y , from X by dividing X by 10 and flooring it to the greatest integer that is less than it.

Index the list: [25,21,20,20,25,10,25,25,24,20] with index Y . List indices start from 0. This is the number of vacation days. To determine the monetary value of the H_c , multiply the number of vacation days by 8 hours / day, and then multiply that quantity by the hourly wage.

The total score is the sum of the converted H_c and the value of F_c . Its units are in dollars. The composite score is the percentile of the total score set that a certain score falls within. Ranking is done in descending order; the best jobs are those with the highest composite scores. According to the OSHA, there are approximately 3.2 deaths per 100,000 equivalent full-time workers in the whole workforce. According to the BLS, the average occupation grows by 1.05% a year.

4.5 Justification

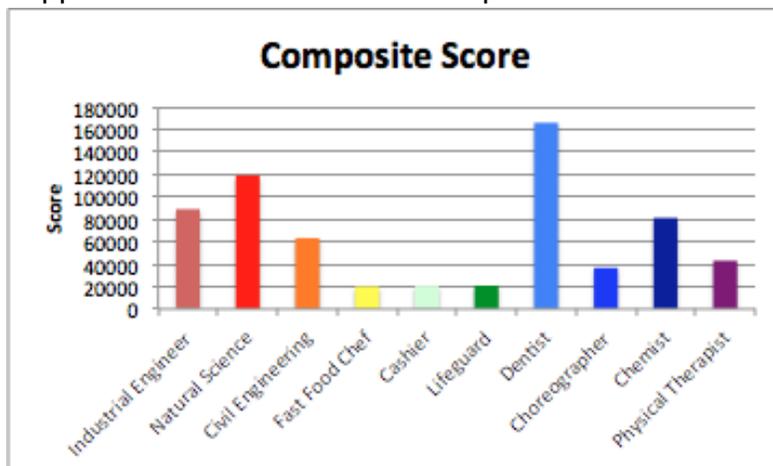
The list [25,21,20,20,25,10,25,25,24,20] is the list of minimum employee leave per annum values, in order, for the top 10 ranked countries on the 2013 World Happiness Report, namely, Denmark, Norway, Switzerland, The Netherlands, Sweden, Canada, Finland, Austria, Iceland, and Australia (12, Helliwell). Reasoning that vacation time has a correlation with happiness, we derived the conversion list from the World Happiness Report. Recognizing that happiness, a very qualitative aspect of a job, and finance, a very quantitative aspect of a job, are mutually incompatible in their raw forms, we realized that conversion was necessary. As such, we used the conversion to vacation time as an intermediate step to convert the happiness coefficient into monetary terms to make both mutually compatible for arithmetic. The sum provides a nice ranking, but to make it better, we change it into percentiles to produce a composite score, which can also be ranked and is more intuitive. A caveat of this method is that it is prone to creating division by zero errors; these are considered “infinite”. Additionally, happiness is perceived differently by many, and the happiness coefficient cannot capture it. Wages have a large impact on the scores because they are important; most go to work to make a living.

4.6 Examples and Analysis

Occupation	Raw Score (not normalized to percentiles)
Industrial Engineer (3)	89,636
Natural Science Manager (2)	119,114
Civil Engineering Technician (5)	63,256

Fast Food Chef (10)	20,175
Cashier (9)	20,720
Lifeguard (8)	20,812
Dentist (1)	165,978
Choreographer (7)	36,691
Chemist (4)	81,220
Physical Therapist Assistant (6)	43,077

As you can see, the scoring mechanism assigns high scores to more intuitively “desirable” jobs. Jobs such as “Fast Food Chef” have much lower scores than jobs such as “Dentist.” However, these measurements are extremely sensitive to wages because both H_c conversion and F_c involve multiplication with wages. Changes in wages will directly impact the score. Coincidentally, the ten jobs listed are sorted in ascending order in both pay and composite score. However, this makes sense. Many people take a job because they need money. Otherwise, they wouldn’t spend eight hours a day away from their loved ones. Below is a bar chart showing the relative happiness scores for the ten occupations.



Part 5: Conclusion

5.1 General:

5.1.1 Is College Worth It?

After going through this report, the reader may wonder: “So, is college worth it?” We’ve presented many caveats, nooks, and crannies for the reader to consider. In short, the answer is yes. College, especially a STEM degree, yields far more than working at a

minimum wage job with a high school diploma. However, we realized that 2-year degrees are not worth the time, effort, and opportunity costs for the meager increase in salary. We recommend getting a 4-year degree in college, particularly in the Science, Technology, Engineering, and Mathematics departments. However, even four-year degree holders of other majors have significantly better outlooks than individuals who elect not to go to college. It may be true that college is not for everyone. Nevertheless, 4-year college seems like the most viable solution for most, and it rightfully holds a major place in society's education system. There is some truth to the old aphorism, "Follow the tide."

5.1.2 Weaknesses:

Generally, the calculations made used estimates and so are not very precise. We made several simplifying assumptions, such as constant living expenses and a lack of taxes. The latter was not such a major problem because there exist a number of tax-deferred vehicles such as 401(k) and IRA accounts, as well as 1033 deferred exchanges for strong compounding. Also, the values calculated are extremely sensitive to the loans' interest rates and the returns on capital available in the stock market. Furthermore, the categories evaluated are very general; "STEM degree" can refer to many degrees in science, technology, engineering, and mathematics. We did not evaluate each specific type of degree or go into detail on other kinds of degrees.

5.1.3 Strengths:

Most importantly, this model takes into account the far future and predicts reasonably accurate estimates of college costs. It is relatively simple and can be applied in a basic computer program or Excel spreadsheet, making it a valuable tool for families to decide whether to pursue a STEM, 4-year, or 2-year degree. Unlike many similar models, it also accounts for the decreasing value of money in the future.

5.2 Summary: Part 1

In Part 1 of this report, we investigated college costs and the amount that transferred through to the families. We took into account financial aid (although we did not get specific figures for merit-based financial aid), including student loans. We assumed that the families could pay their EFCs without taking extra loans. We also used average statistics to determine that 27% of financial aid is given in the form of a loan. We assumed that the Stafford loan interest rate is a good representation of the average student loan. After making these various assumptions, we used the tools of finance to calculate the present values of both the EFCs and the loan payments, given an interest rate, which we got from Vanguard data. We then summed the present values to obtain the cost of college for the families from the various scenarios presented and for an average family.

5.3 Summary: Part 2

In Part 2 of this report, we determined the value of 4-year STEM, 4-year non-STEM, 2-year, and high school degrees. We discounted the student loan payments and the earnings from the job. We assumed that taxes were irrelevant in our calculations and determined the value of the future stream of earnings by subtracting basic living expenses from the incomes. The cost of college discounted to the present was then subtracted from the value of the earnings. We determined that a STEM education provided the most financial security, with more than four times the present value and ten times the nominal value of a high school diploma.

5.4 Summary: Part 3

We managed to combine two very unlike values to create a composite “goodness” or “value” score for an occupation. We took two scores: one for the financial aspect of satisfaction, which was measured in dollars, and one for the happiness derived from the job, which was measured with a happiness coefficient. We converted the latter into the former and then added them, pushing the values onto a scale to determine composite scores. After completing an analysis of the raw scores of ten careers, we determined that the model is relatively accurate; less “desirable” jobs were assigned appropriately lower scores. STEM jobs completely took the top, with the exception of the dentist occupation, which took the first place. The minimum wage jobs that could be earned with a high school diploma took the lowest slots in the ranking. Therefore, for income security and happiness, STEM is the way to go.

5.5 Closing Remarks

The waters of college finance are strange and untested. Thousands of college students wade into the surf, not seeing the hazards and treasures that lurk beneath. Navigating the real world is a true challenge and a departure from the insulated world that is high school. Choosing the path or route through the ocean requires good guidance; dead reckoning isn't going to work here. Through financial models and reasonable assumptions, we can produce a guiding star for the average college freshman to align their sextants. Our model develops a thorough method for guidance of a student. Waves and storms may sway and swing the ships into new worlds and new places, but the stars will guide the ships away from the rocks of despair (depression), the whirlpools of bankruptcy (financial trouble), and the tempting sirens of spendthrift behavior (financial immodesty). It would be irresponsible not to use a model to predict future college costs and act accordingly; this would be like a captain not bringing a map on his long journey across the seven seas. Education is valuable, just like the explorers before us. It allows us to open new frontiers, from the Wild West to the wild vacuum of

the Moon. Truly, regardless of the method one chooses, as long as one plans ahead, he shall eventually make it. We wish all rising college freshmen good luck on their treacherous end of their high school careers. However, this end is a new beginning: one to an era that will define their lives. Perhaps more domestic problems, such as cost reduction, might be the new frontier.

6. References:

1. "Aerospace Engineers." *Bureau of Labor Statistics*. U.S. Bureau of Labor Statistics, n.d. Web. 1 Mar. 2015. <<http://www.bls.gov/oooh/architecture-and-engineering/aerospace-engineers.htm>>.
2. "Averaged Freshman Graduation Rates for Public Secondary Schools, by State or Jurisdiction: Selected Years, 1990-91 through 2009-10." *National Center for Education Statistics*. U.S. Department of Education Institute of Education Sciences National Center for Education Statistics, n.d. Web. 1 Mar. 2015. <http://nces.ed.gov/programs/digest/d12/tables/dt12_124.asp>.
3. "Average Entry Level Salaries." *SimplyHired*. Simply Hired, n.d. Web. 1 Mar. 2015. <<http://www.simplyhired.com/salaries-k-entry-level-jobs.html>>.
4. Baum, Sandy, Kathie Little, and Kathleen Payea. "Trends in Community College Education: Enrollment, Prices, Student Aid, and Debt Levels." *CollegeBoard*. College Board, 2011. Web. 1 Mar. 2015. <<https://trends.collegeboard.org/sites/default/files/trends-2011-community-colleges-ed-enrollment-debt-brief.pdf>>.
5. *BrownEcon*. Brown Economic Consulting, n.d. Web. 1 Mar. 2015. <http://www.brownecon.com/bea_calculators/worklifeexp/default.asp>.
6. *Bureau of Labor Statistics*. U.S. Bureau of Labor Statistics, n.d. Web. 1 Mar. 2015. <<http://www.bls.gov/news.release/pdf/ebs2.pdf>>.
7. *Bureau of Labor Statistics*. U.S. Bureau of Labor Statistics, n.d. Web. 1 Mar. 2015. <<http://www.bls.gov/tus/charts/work.htm>>.
8. "College Student Spending Average." *NationWide*. Nationwide Mutual Insurance Company, n.d. Web. 1 Mar. 2015. <<http://www.nationwide.com/college-student-spending-habits-infographic.jsp>>.
9. DeVaney, Sharon A., and Zhan Chen. "Job Satisfaction of Recent Graduates in Financial Services." *Bureau of Labor Statistics*. U.S. Bureau of Labor Statistics, n.d. Web. 1 Mar. 2015. <<http://www.bls.gov/opub/mlr/cwc/job-satisfaction-of-recent-graduates-in-financial-services.pdf>>.

10. "FinAid." *FinAid*. Ed. Mark Kantrowitz. FinAid, n.d. Web. 1 Mar. 2015.
<<http://www.finaid.org/calculators/quickefc.phtml>>.
11. "Grants and Loan Aid to Undergraduate Students." *National Center for Education Statistics*. U.S. Department of Education Institute of Education Sciences National Center for Education Statistics, Apr. 2014. Web. 1 Mar. 2015.
<http://nces.ed.gov/programs/coe/indicator_cuc.asp>.
12. Helliwell, John, Richard Layard, and Sachs, Jeffery, eds. "World Happiness Report 2013." *UNSDSN*. Sustainable Development Solutions Network, n.d. Web. 1 Mar. 2015.
<http://www.studentsreview.com/satisfaction_by_major.php3>.
13. Hill, Catey. "Parents: You're Saving for College All Wrong." *MarketWatch*. MarketWatch, 12 Apr. 2014. Web. 1 Mar. 2015.
<<http://www.marketwatch.com/story/parents-youre-saving-for-college-all-wrong-2014-04-10>>.
14. "Income of Young Adults." *National Center for Education Statistics*. U.S. Department of Education Institute of Education Sciences National Center for Education Statistics, n.d. Web. 1 Mar. 2015.
<<http://nces.ed.gov/fastfacts/display.asp?id=77>>.
15. "Interest Rates and Fees on Federal Stafford Loans." *StaffordLoan*. Edvisors, n.d. Web. 1 Mar. 2015. <<http://www.staffordloan.com/stafford-loan-info/interest-rates.php>>.
16. "In U.S., Average Retirement Age Up to 61." *Gallup*. Gallup, n.d. Web. 1 Mar. 2015.
<<http://www.gallup.com/poll/162560/average-retirement-age.aspx>>.
17. "Job Satisfaction by Major." *StudentsReview*. StudentsReview, n.d. Web. 1 Mar. 2015.
<http://www.studentsreview.com/satisfaction_by_major.php3>.
18. "Living Wage Calculator." *LivingWage*. Ed. Amy Glasmeier. Massachusetts Institute of Technology, n.d. Web. 1 Mar. 2015.
<<http://livingwage.mit.edu/>>.
19. Luckerson, Victor. "The Myth of the Four-Year College Degree." *Time*. Time, 10 Jan. 2013. Web. 1 Mar. 2015. <<http://business.time.com/2013/01/10/the-myth-of-the-4-year-college-degree/>>.
20. Luhby, Tami. "America's Middle Class: Poorer than You Think." *CNN*. Morningstar, n.d. Web. 1 Mar. 2015.
<<http://money.cnn.com/2014/06/11/news/economy/middle-class-wealth/>>.
21. "Maternal Age." *Child Health USA 2012*. U.S. Department of Health and Human Services, Health Resources and Services Administration, Maternal and Child Health Bureau, n.d. Web. 1 Mar. 2015.
<<http://mchb.hrsa.gov/chusa12/pc/pages/ma.html>>.

22. *National Center for Education Statistics*. U.S. Department of Education Institute of Education Sciences National Center for Education Statistics, n.d. Web. 1 Mar. 2015. <<http://nces.ed.gov/ccd/tables/AFGR0812.asp>>.
23. "Number, Percentage Distribution, Unemployment Rates, and Median Salaries of 25- to 29-year-old Bachelor's Degree Holders and Percentage of Degree Holders among All 25- to 29-year-olds, by Field of Study: 2009 and 2011." *National Center for Education Statistics*. U.S. Department of Education Institute of Education Sciences National Center for Education Statistics, n.d. Web. 1 Mar. 2015. <http://nces.ed.gov/programs/digest/d12/tables/dt12_447.asp>.
24. "Number, Percentage Distribution, Unemployment Rates, and Median Salaries of 25- to 29-year-old Bachelor's Degree Holders and Percentage of Degree Holders among All 25- to 29-year-olds, by Field of Study: 2009 and 2011." *National Center for Education Statistics*. U.S. Department of Education Institute of Education Sciences National Center for Education Statistics, n.d. Web. 1 Mar. 2015. <<https://studentaid.ed.gov/types/loans/interest-rates#what-is-the-interest-rate-factor>>.
25. "Occupational Safety & Health Administration." *Occupational Safety & Health Administration*. U.S. Department of Labor, n.d. Web. 1 Mar. 2015. <<https://www.osha.gov/oshstats/commonstats.html>>
26. O'Shaughnessy, Lynn. "20 Surprising Higher Education Facts." *USNews*. U.S. News & World Report LP, 6 Sept. 2011. Web. 1 Mar. 2015. <<http://www.usnews.com/education/blogs/the-college-solution/2011/09/06/20-surprising-higher-education-facts>>.
27. "Percentage Distribution of Recipients of Bachelor's Degrees in Various Fields of Study 1 Year after Graduation, by Time to Completion, Enrollment and Employment Status, and Occupation: 2001 and 2009." *National Center for Education Statistics*. U.S. Department of Education Institute of Education Sciences National Center for Education Statistics, n.d. Web. 1 Mar. 2015. <http://nces.ed.gov/programs/digest/d12/tables/dt12_448.asp>.
28. "Real-Time Insight into the Market for Entry-Level STEM Jobs." *burning glass*. Burning Glass Technologies, n.d. Web. 1 Mar. 2015. <<http://www.burning-glass.com/research/stem/>>.
29. "Repayment Plans." *FinAid*. Ed. Mark Kantrowitz. FinAid, n.d. Web. 1 Mar. 2015. <<http://www.finaid.org/loans/repayment.phtml>>.
30. "State by State Data." *Project on Student Debt*. Institute for College Access and Success, n.d. Web. 1 Mar. 2015. <http://projectonstudentdebt.org/state_by_state-data.php>.

31. "Tuition Costs of Colleges and Universities." *National Center for Education Statistics*. U.S. Department of Education Institute of Education Sciences National Center for Education Statistics, n.d. Web. 1 Mar. 2015. <<http://nces.ed.gov/fastfacts/display.asp?id=76>>.
32. "Vanguard portfolio allocation models." *Vanguard*. Vanguard Group, n.d. Web. 1 Mar. 2015. <<https://personal.vanguard.com/us/insights/saving-investing/model-portfolio-allocations>>.