STEM Sells: What is higher education really worth?

Summary: A Letter to High School Administrators

Dear High School Administrators:

At the end of the school year, yet another class of graduating seniors will be faced with the life-shaping decision of whether or not to continue their schooling - and if so, which education path to follow. This decision directly impacts the students' ability to attain the jobs of their dreams, and ultimately shapes whether or not their careers will be satisfying and financially stable. Our mutual goal is to ensure the successful careers of our students. For this reason, we have developed a revolutionary model that will assist students in evaluating their education choices logically and objectively; no longer will one of the most critical choices of their lives depend largely on chance. We encourage you to share this model with your upperclassmen students and we recommend thoroughly reviewing it with them on an individual basis to make use of the model's highest potential.

The most useful feature of our model is the fact that it is very malleable, so it can accommodate the needs of a wide variety of students from different families and backgrounds. The first part of our model allows the student to calculate how much he or she should expect to pay for college through an input of his or her individual family income, tuition costs of the college or university he or she is applying to, distance from the student's home to the aforementioned college, and even his or her cumulative GPA. These multifarious variable inputs allow us to provide a model that suits each student's unique requirements. The second part of our model uses a student's GPA and amount of college experience to output the value of their college investment. This value is in the form of how much their labor will be worth in the future, given their qualifications. This part of our model even predicts the expected income of the students based on a given level of success in High School and college and can be compared to the previously calculated cost for college to allow the student to weigh first-hand the costs and benefits of various education choices. The last part of our model has the widest scope, practically automating the comparison of the first two parts (albeit at a lower precision). Given only what an individual values in a career (such as achievement, independence, interpersonal relationships, recognition, and job security), our model returns the most appropriate education path that the student is able to afford, as well as their expected income and financial stability in that position.

There are, without a doubt, certain limitations to our model, so if the result of the model does not resonate with the student, it may be best to avoid conforming to its suggestion. One drawback to our college cost calculator is that it does not have the ability to account for commuters to college or for students who go home via other forms of transportation than cars or airplanes. A drawback to the second and third parts of our model is that they cannot completely unite qualitative workplace values with quantitative values like potential salary, meaning that in some cases students must make their own trade-offs between job satisfaction and financial gain. It is all but impossible to make such personal decisions mathematically.

Nevertheless, we continue to believe that our model can help guide students in the right direction to a large extent. We hope, for all students' sakes, that you will take our recommendations to heart and help improve the career paths of America's future engineers, teachers, and lawyers alike.

Sincerely, Team 4750

Contents

1 Introduction

1.1 Background

Students graduating from high school are forced to make one of the most pivotal decisions of their lives. They are presented with the option to enter the workforce directly, enter college to obtain a two year Associate Degree, or pursue a four year Bachelor's Degree. The latter two options present even further options- students may study a STEM (Science, Technology, Engineering, and Mathematics) major or choose to study a non-STEM major. The nation is currently at a crossroads - the government of President Obama hopes to encourage science education to bolster the economy, while funding for such programs dwindles. As such, graduating high school seniors must decide whether they and their families should make the key investment in STEM education that may result in a brighter future.

This decision will inevitably be influenced by a myriad of factors- the ability of their household to pay for the tuition, the earning potential and financial stability of the degree, and qualitative personal preferences.

1.2 Restatement of the Problem

Given the importance of a college degree on future success but the high price tag of a degree, we have responded to the request to develop a mathematical model to solve the following problems:

- Determine how much college will actually cost a student, beyond just the tuition, by factoring in loan interest, transportation, academic supplies, meal plans, personal benefits, financial aid, and scholarships.
- Calculate the earning potential of non-STEM and STEM degrees, while factoring in the level of degree- High School Diploma, Associate Degree, and Bachelor Degree, and calculate the financial stability of holders of each degree.
- Create a ranking system that factors in qualitative data to help students make an informed, educated, and personalized choice as to what kind of degree to pursue.

1.3 Global Assumptions

- Costs faced by students, as well as income earned by households, all over the country are, on average, only marginally different; there are no significant economic differences across the nation.
- There is perfect competition in the labor market, and the market is not subject to any major shocks.

2 Analysis

2.1 Part I: Paying for an Undergraduate Degree

2.1.1 Rationale

The amount of money an individual pays for an undergraduate degree depends fundamentally on the initial cost of expenses and on the discounts received through various aids and scholarships. To calculate the value of the initial expenses, we summed the costs of all aspects of student life on campus: tuition, fees, room and board, interest on loans taken, transportation, academic supplies, meal plans, and even personal expenses. From this subtotal we subtracted the money the student would receive from financial aid as well as pertinent external grants and scholarships. Once we found the total variable cost of an undergraduate degree for an individual, we could apply President Obama's recent suggestion to make two years of community college free for qualifying students and analyze its effects on our model.

2.1.2 Assumptions

Prior to developing the model, assumptions had to be made for the purpose of simplification.

- All loans are payed through fixed, low-end payment.
- The student buys textbooks for all courses rather than rents them.
- The only big trips the student takes are traveling home four times a year during break.
- The student owns a car, abides by the laws of the road, and uses his/her private car over public transportation whenever he/she can.
- The student seeks to maintain reasonable levels of hygiene.
- The student applies for and accepts the maximum amount of financial aid offered.
- The student's parents maintain a stable income.
- The cost of car travel depends only on gas usage (i.e. there are no leaks, flat tires, etc).
- The student lives on campus for 32 weeks per year.

2.1.3 Model Development

Costs

Tuition and loan interest: Not only do the prices for tuition, fees, board, and room (which are usually sold together as a package) vary between colleges, but the amount of loan money that a student borrows - and thus the additional interest fee that the student pays - varies on an individual basis. Therefore, though we use averages to simulate certain scenarios for the results of our report, it is critical to introduce tuition and loan repayment as variables. The image below is a projection for the cost of loan interest to be paid *in addition to the original tuition/fee/room/board price* by a student working toward a Bachelor's Degree. Such a student could expect to borrow a total of $26,800 in loans [15] and pay an additional $25,063 for interest (with a standard deviation of $5,876) [14].

However, if a student were to work toward an Associate Degree rather than a Bachelor's Degree, the student could expect to pay around $18,700 in loans [15] and an additional $14,975 for interest (with a standard deviation of $3,882) [14]. The image below is a projection for the cost of loan interest to be paid *in addition to the original tuition/fee/room/board price* by a student working toward a Associate Degree.

Transportation: Depending on how far away from home the student lives, we assumed that he visits home on four breaks per year via either a car or an airplane. Since the Road Safety Authority limits the daily number of hours spent behind the wheel to nine [18], and most roads in the United States have a speed limit of 55 miles per hour [19], the most miles a student can travel home by car in a day is 495, and any distances larger than 495 miles must be covered by plane.

The cost of a round trip to a home m miles away, four times a year, for one year, and at a fuel cost of $2.33 per gallon [20] and efficiency of 36 miles per gallon [21] is represented by

$$Cost_{transport} = \frac{\$2.33}{gal} \cdot \frac{1gal}{36mi} \cdot \frac{m\ mi}{trip} \cdot 8\ trips = \$0.5275m; m \leq 500mi.$$

In general, the cost of a one-way airplane ticket from any city in the United States to any other city within the country 500 or more miles away is approximately $300 [22]. This constitutes the second part of our piecewise function:

$$Cost_{transport} = \frac{\$300}{trip} \cdot 8\ trips = \$2400; m > 500mi.$$

Academic supplies: According to The College Board's estimates, which assume that the student buys textbooks for all courses, one year's worth of textbooks will cost approximately $1,200 [17]. The costs of paper, binders, notebooks, and writing utensils is negligible compared to this amount.

Meal plans: The College Board estimates that the annual price for a meal plan is approximately $9,804 at a 4-year public college [17].

Personal expenses: Whether at college or at home, people have basic needs for survival, and college rooming and meal plans can't cover everything.r Assuming the student does their laundry once per week, a $3.00 wash and dry cycle would result in a total cost of $96 per year of college [23].

College students often purchase many items to survive living on their own, some items out of necessity and others out for increased comfort. Expecting an average college student to spend $20 per week on food, drinks, and medicine, as well as $10 per week on purchasing new apparel and replacing missing socks, the total cost over four years of college for these expenses would be $960. Additionally, the student will probably purchase items to help maintain basic hygiene (such as soap, shampoo, and toothpaste) that might cost up to $15 per month at college, bringing the annual total for these types of purchases up to $1,072 [23].

Finally, college wouldn't be the same without friends and entertainment, and meal plans aren't always perfectly aligned with students' schedules, so we allotted $40 per week to the student for entertainment and eating out. This yields a total of $1,280 over the course of a year [23].

All together, we expected the student to spend approximately $2,448 on personal expenses annually, a similar result to The College Board's prediction of $2,000 annually [16].

Benefits

Financial Aid:

Students are awarded financial aid to help offset the cost of tuition of college. The financial aid that is awarded is computed by the U.S. Department of Education through [24]

$$\textit{Financial Aid} = \textit{Tuition - Expected Family Contribution}$$

The Expected Family Contribution can be estimated as a function of four variables: *Income*, *Number of Parents*, *Number of Working Parents*, and *Number of Children*.

In addition to the total household income, the parents' total assets (essentially net worth) need to be considered as well. In order to make the *Expected Family Contribution* easy to calculate based only on *Income*, the parents' assets need to be estimated from the total household income. We did this through an exponential regression analysis using data supplied by CNN Money [16], giving the function

$$Assets = 8801 * (1.0000343)^{Income}.$$

To get at a more accurate measure of available income, though, the parents' total allowances need to be considered and subtracted. The total allowances is the sum of the income tax, state tax, social security tax, income protection allowance, and employment expense allowance [24]. *Income Tax* is calculated based on both *Income* and *Number of Working Parents* [25]. If *Number of Working Parents* = 1 or 2, then the following tables are used to calculate *Income Tax*:

TABLE 1: Income Tax: One Working Parent

Income Range	Income Tax
0 – 9,225	$0.1 * Income$
9,226 – 37,450	$0.15 * Income$
37,451 – 90,750	$0.25 * Income$
90,751 – 189,300	$0.28 * Income$
189,301 – 411,500	$0.33 * Income$
411,501 – 413,200	$0.35 * Income$
413,201 or more	$0.396 * Income$

TABLE 2: Income Tax: Two Working Parents

Income Range	Income Tax
0 – 18,450	$0.1 * Income$
18,451 – 74,900	$0.15 * Income$
74,901 – 151,200	$0.25 * Income$
151,201 – 230,450	$0.28 * Income$
230,451 – 411,500	$0.33 * Income$
411,501 – 464,850	$0.35 * Income$
464,851 or more	$0.396 * Income$

State Tax and *Social Security Tax* are calculated solely from *Income* [24]:

TABLE 3: State Tax

Income Range	State Tax
$0 - 14{,}999$	$0.043 * Income$
15,000 or more	$0.033 * Income$

TABLE 4: Social Security Tax

Income Range	Social Security Tax
$0 - 113{,}700$	$0.0765 * Income$
113,701 or more	$8{,}698 + 0.0145*$ (Income-113,700)

Income Protection Allowance is a modest allowance for basic living expenses, and it addresses well-body care. It is a piecewise function of *Number of Children* and *Number of Parents*: [24]

TABLE 5: Income Protection Allowance

Number of Parents + Number of Children	Income Protection Allowance
2	17,400
3	21,720
4	26,830
5	31,650
6	37,020

Employment Expense Allowance is a non-discretionary expense that enables the continued production of income (such as uniforms, tools, and malpractice insurance). It is a piecewise function of *Income*, *Number of Parents*, and *Number of Working Parents*.

If *Number of Parents* = 2 and *Number of Working Parents* = 1, then *Employment Expense Allowance* = 0. Otherwise, *Employment Expense Allowance* is a piecewise function of *Income*: [24]

TABLE 6: Income Protection Allowance

Income Range	Employment Expense Allowance
$0 - 11{,}428$	$0.35 * Income$
11,429 or more	4000

Once we have values for the *Income Tax*, *State Tax*, *Social Security Tax*, *Income Protection Allowance*, and *Employment Expense Allowance*, we sum them to obtain the total allowances. Using a formula provided by the Information for Financial Aid Professionals, we can find an estimate for the Adjusted Available Income (AAI): [24]

$$AAI = Income - Allowance + 0.12 * Assets$$

To convert the Adjusted Available Income into the Expected Family Contribution, we use the following chart provided by the Information for Financial Aid Professionals: [24]

TABLE 7: Family Contribution

Adjusted Available Income (AAI)	Expected Family Contribution
$0 - 15{,}600$	$0.22 * AAI$
$15{,}601 - 19{,}600$	$3{,}432 + 0.25 * (AAI - 15{,}600)$
$19{,}6001 - 23{,}500$	$4{,}432 + 0.29 * (AAI - 19{,}600)$
$23{,}501 - 27{,}500$	$5{,}563 + 0.34 * (AAI - 23{,}500)$
$27{,}501 - 31{,}500$	$6{,}923 + 0.40 * (AAI - 27{,}500)$
31,501 or more	$8{,}523 + 0.47 * (AAI - 31{,}500)$

Finally, we return to the equation

$$\textit{Financial Aid} = \textit{Tuition - Expected Family Contribution.}$$

Thus, with knowledge of a school's tuition, the total household income, the number of children, the number of parents, and the number of working parents, we can calculate the amount of financial aid a student would expect to receive.

Scholarships:

The consideration of scholarships here includes every type of scholarship that is not awarded through financial aid. From data obtained from the Guaranteed Scholarships website [26], we find a linear correlation between scholarship amount and high school GPA (on a 4.0 scale):

$$Scholarship = 2242 * GPA - 4092$$

with, of course, a lower limit of 0.

2.1.4 Results

We have a final equation based on adding up the costs per year, subtracting the benefits per year, and multiplying by the number of years (4 for a Bachelor's Degree and 2 for an Associate Degree). So the net cost for obtaining a college degree is:

$$Net\ Cost = (Number\ of\ Years) * (Tuition\ +\ Loan\ Interest\ +\ Transportation\ + \\ Academic\ Supplies\ +\ Meal\ Plans\ +\ Personal\ Expenses\ -\ Financial\ Aid \\ -\ Scholarships)$$

where Academic Supplies, Meal Plans, and Personal Expenses are constants, Tuition and Loan Interest are functions of Number of Years, Transportation is a function of Distance To College, Financial Aid is a function of Household Income, Number of Children, Number of Parents, and Number of Working Parents, and Scholarships is a function of GPA. These functions within the Net Cost function were all previously described.

To calculate the Net Cost for the six given test cases, we'll assume the Number of Years is 4 because 4-year colleges are far more popular than 2-year colleges, although the calculation can be easily redone for 2-year colleges. We'll also assume average Tuition, Loan Interest, Distance to College (for Transportation), and GPA (for Scholarships). The final assumption is that the Number of Parents is equal to the Number of Working Parents. This gives the following table, with the six given scenarios:

TABLE 8: Net 4-Year College Cost

Household Income	Number of Parents	Number of Children	Net 4-Year College Cost
\$35,000	1	1	\$9,581
\$35,000	2	3	\$5,464
\$75,000	1	1	\$102,504
\$75,000	2	3	\$88,254
\$125,000	1	1	\$162,921
\$125,000	2	3	\$162,921

2.1.5 Projected effects of President Obama's suggestion

President Obama recently proposed to make two years of community college free for anyone with a high school GPA of 2.5 or higher [27]. The average high school GPA is 2.8 with a standard deviation of 0.4, so 77 percent of high school students would qualify for free community college [5].

The high school students who would have gone to community college anyway would save half of the net cost calculated above (since they only get two years for free) for whichever situation applies to them.

There are also high school students who would otherwise have gone on to get a Bachelor's Degree, but, given President Obama's suggestion, would spend their first two years of undergraduate education at community college. These students would similarly save two years' worth of net college cost calculated in section 2.1.4.

The average four-year college tuition is \$23,066 per year, and the average interest on loans for two years is \$12,532. This amounts to \$58,664 that 77% of high school students would have the opportunity to save.

2.2 Part II: STEM Jobs : Earnings and Security

2.2.1 Rationale

In this section, we consider how much a STEM student's earning potential will be after receiving a degree, and compare this to the earning potential of individuals who pursued non-STEM degrees or who entered the labour force directly. We do so by making use of the Mincer Earnings Function, and making improvements to account for the differing values of STEM and non-STEM educations and for varying student accomplishment. We then evaluate the security of STEM jobs in order to determine if a graduate can indeed make as much money as his or her earning potential would suggest.

2.2.2 Assumptions

For the purposes of modeling, the following local assumptions were made:

- Earning potential is modelled such that each unit of labour is worth the same amount.
- We assume earnings potential is directly related to "skill" , where skill is a function of education and work experience which represents the value of an individual's labor per unit time.
- We make the assumption that the classes taught as part of two-year degrees are a subset of those taught in a four-year program, and thus extrapolate between data from four-year and two-year colleges. This is based on the similar nature of the information taught for the two types of degree.

- We further assume that the education one receives at any college is approximately equivalent, and that GPA scores are given out by different colleges in a uniform manner.
- We assume that all STEM and non-STEM companies have similar levels of training and education for their employees. Therefore, individuals who receive substantially more training or learning than average from their companies may not be accurately modelled by our equations for earning potential.
- We assume that the growth for jobs in both STEM and non-STEM fields and the number of new graduates in all fields to not fluctuate from their current values over the next decade. This assumption therefore means that the model does not account for any rapid growth or shrinkage in any sector, as such a phenomenon is inherently unpredictable.
- When considering employment, we do not account for people moving from STEM to non-STEM fields once they have already taken up a job in STEM. We also did not make any special allowances for people moving between jobs in STEM fields, as we assume that a smooth transition probably will not have much of an effect on financial security.
- We assumed that the short-term probability to get a job is only dependent on the level of degree obtained by the worker. This was assumed because the U.S. Census Bureau revealed that the majority of college graduates, particularly in the STEM field, did not work in their respective fields after graduation [8].

2.2.3 Model Development: Earning Potential

In order to develop the Mincer earnings equation, we first model the skill of an individual. Let S_t represent the individual's skill during year t. The individual starts with a base skill level S_0. After a year of education, the skill level will have increased by a factor of p_e, which represents the efficacy of the education. Hence, the new skill will be $S_{t+1} = S_0(1+p_e)$. After n years of education, $S_n = S_0(1+p_e)^n$ will be the skill level. One further improves his or her skills through gaining work experience - therefore, each year after education is completed, $S_{t+1} = S_t(1+k_t * p_w)$, where k_t accounts for how the amount of training is not constant each year. Overall,

$$S_t = S_0(1+p_e)^n \prod_{i=n+1}^{t} (1+k_i * p_w)$$

To make the model linear, we take the natural logarithm of both sides of the equation and estimate $(1+k_i * p_w) \approx e^{k_i * p_w}$:

$$ln(S_t) = ln(S_0) + n\ ln(1+p_e) + p_w \sum_{i=n+1}^{t} k_i$$

Data has shown that $\sum_{i=n+1}^{t} k_i$ is proportional to both the number of years of experience, and to the the square of the number of years of experience [1]. This quadratic dependence is among other factors a result of more senior workers not learning as much from work experience. Hence:

$$ln(S_t) = ln(S_0) + +n\ ln(1 + p_e) + p_w(\alpha_1(t - n - 1) + \alpha_2(t - n - 1)^2)$$

As per our assumptions, one's skill is directly proportional to earning potential. As this is a logarithmic model, all that we need to change to account for the constant of proportionality is the constant term S_0. Hence, the equation for earning capacity is

$$ln(Earnings) = ln(Earnings_0) + C_{edu} * (years\ of\ college\ education) +$$
$$C_{linear} * (years\ of\ work\ experience) + C_{quadratic} * (years\ of\ work\ experience)^2,$$

where the coefficients and variables have been consolidated to better reflect their roles in the model. The following parameters were then found by fitting data to the model :

- $Earnings_0$, a measure of the base earning potential of an individual with no college education or work experience, estimated as the average salary of a high school graduate with no prior jobs.
- C_{edu}, a measure of the value of one year of education on the earning potential
- C_{linear}, a measure of the value of one year of work experience on the earning potential
- $C_{quadratic}$, a measure of how opportunities for work experience are lost as one becomes more senior

Using MATLAB, data from the Bureau of Labor Statistics was fitted to the model using a regression, giving the following values and standard errors for the various parameters [3]:

TABLE 9: Results of Regression for Earning Potential

Parameter	Value	Standard Error
$Earnings_0$	\$ 33532	\$ 862
C_{edu}	0.1022	0.00844
C_{linear}	0.04728	0.0055733
$C_{quadratic}$	-0.0008234	0.0001361

To refine this model, we first accounted for how STEM education changes the value of C_{edu}, as a year of STEM education may be worth a different amount in terms of skills gained from a year of non-STEM education. Averaging the entry level salaries of various STEM and non-STEM jobs that require 4 year degrees, it was found that there is a 26.0% difference in salaries [6]. To account for this change, $C_{edu\_stem} = \frac{ln(1.26)}{4} + C_{edu} = 0.1600$. We also analysed the differences in C_{linear} between STEM and non-STEM jobs, but using data for salaries for middle-aged employees in STEM and non-STEM jobs we found that the ratio $C_{linear\_stem}/C_{linear}$ was around 1.00079, which was insignificant compared to the actual value of C_{linear}. Therefore, we ignored this variation. Similar analysis established that variation in $C_{quadratic}$ was also irrelevant compared to the value of $C_{quadratic}$.
We further improved the model by adding a factor to account for the differing abilities of

students to learn information and develop skills. In order to do so, we analysed the variation of earning potential with high school GPA and found an almost linear relation [4]. Using an exponential regression, we were able to estimate $Earnings = Earnings_0 * e^{0.0991*GPA}$, where in this equation $Earnings_0$ is the earning potential of someone with a GPA of 2.8, the national average. [5].
In order to add the effects of GPA into our model, we adjusted C_{edu} with an additive GPA factor of $0.02494(GPA - 2.8)$, where the coefficient of the difference of the GPA from the mean GPA is 0.0991/4 to account for the four years of high school. Therefore, $C_{edu\_gpa} = C_{edu} + 0.02494\ (GPA - 2.8)$, Furthermore, by analysing the GPAs and earnings of students only in STEM majors, we found that there was an average GPA of 2.9 and a slightly stronger relation between GPA and earning potential in STEM [2]. This data was used to calculate the equation $C_{edu\_stem\_gpa} = C_{edu\_stem} + 0.02495\ (GPA - 2.9)$.

Adding these corrections to the model gives the following formulae to model the earning potential of STEM and non-STEM students:

$$ln(Earnings\_STEM) =$$
$$ln(32776) + (0.1600 + 0.02495\ (GPA - 2.9)) * (years\ of\ college\ education) +$$
$$04728 * (years\ of\ work\ experience) - 0.0008234 * (years\ of\ work\ experience)^2,$$

$$ln(Earnings\_non - STEM) =$$
$$ln(32776) + (0.1022 + 0.02494\ (GPA - 2.8)) * (years\ of\ college\ education) +$$
$$04728 * (years\ of\ work\ experience) - 0.0008234 * (years\ of\ work\ experience)^2$$

2.2.4 Model Development: Financial Stability

We modeled the financial stability of a worker separately for both short-term and long-term factors.

In the short-term, the worker must be able to find a job that will support the person financially. As cited in the assumptions, we modeled the short-term percentage that a worker will get a job to be only dependent on the level of degree obtained- high school diploma, Associate Degree, and Bachelor's Degree. Let P_{st} represent the short-term probability of getting a job. Then,

$$P_{st} = 1 - u_d$$

where u_d is the mean unemployment rate of the level of degree obtained. When the data for the mean unemployment of a high school diploma, Associate degree, and Bachelor's degree were compared between the years 1997 and 2007, the following results were obtained [9]:

TABLE 10: Unemployment by Educational Level

	High school diploma	Associate degree	Bachelor's degree
Average	4.4182 %	3.6091 %	2.2364 %
Standard Deviation	0.6705 %	0.6848 %	0.4739 %

In the long-term, the worker must be able to keep the job in order to be considered to be financially stable. This long-term probability does not depend on the level of degree, as the job has already been obtained. Instead, the probability of being able to retain a job is dependent on the factors influencing the field of profession. Let $P_{lt}(t)$ represent the long-term probability of being able to keep a job for t years. Then, P_{lt} can be modeled as

$$P_{lt} = (1 - u_f(\frac{graduates}{growth})^t e^{-k*t})$$

where u_f is the unemployment rate of the field at present, and $(\frac{graduates}{growth})^t$ models the change in unemployment rate as more graduates (measured in % new workers in the workforce) begin to seek jobs and as growth (measured as % change in number of jobs) creates new job opportunities. t is the years of experience of the worker, and k is a factor which reflects the ability of a worker to retain a job more effectively as he or she gains more experience.

By subsuming constants into each other, we can simplify the expression to

$$P_{lt} = (1 - u_f e^{-\kappa*t})$$

Using historical data from the Georgetown Center on Education and the Workforce, we determined the value of κ, which was found to be 0.0050 for the average STEM career and 0.0046 for the average non-stem career [12].

2.2.5 Results

Applying the model for earning potential to an average student in STEM and non-STEM majors just after graduation, we found the amount that students can make if they take different educational paths:

TABLE 11: Earning Potential at Entry Level

Education	Earning Potential
High school Diploma	\$ 33 532
Two-Year Degree (non-stem)	\$ 41 203
Two-Year STEM Degree	\$ 46 206
Four-Year Degree (non-stem)	\$ 60 002
Four-Year STEM Degree	\$ 63 630

As the calculations show, the STEM degrees seem to create more earning potential than non-STEM degrees. According to this model, this trend appears to hold true for any amount of college education from 0 to 4 years.

The model further showed that individual accomplishment is a key variable in determining earning potential. In both STEM and non-STEM 4 year degree models, the effect of GPA on earning potential is clearly evident from the following graphs.

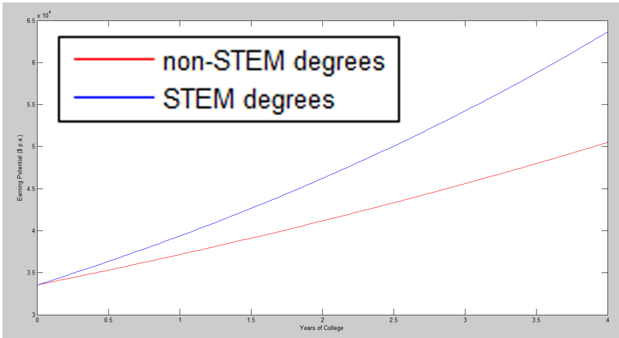

FIGURE 1: Years of Education vs. Earning Potential

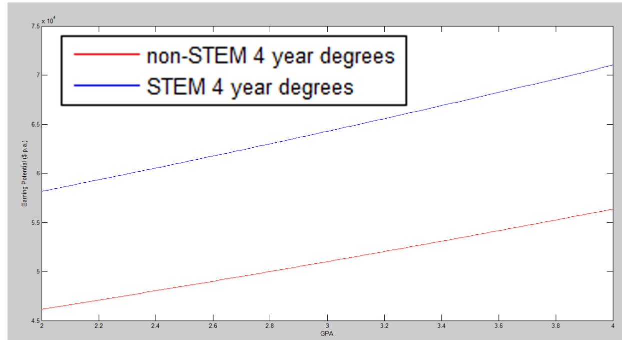

FIGURE 2: GPA vs. Earning Potential for 4-year Degrees

From a long-term perspective, STEM majors continue to have a higher earning potential. After 10 years, the model predicted the following earning potentials:

TABLE 12: Earning Potential after 10 Years

Education	Earning Potential
High school Diploma	$ 38 432
Two-Year Degree (non-stem)	$ 41 538
Two-Year STEM Degree	$ 45 603
Four-Year Degree (non-stem)	$ 64 301
Four-Year STEM Degree	$ 72 130

Using the average annual expenditures and required income to achieve the average annual expenditures from the Bureau of Labor Statistics website, the following data was calculated [11].

TABLE 13: Average American Expenditure [11]

	Per Household	Per Earner
Required Income before Taxes	$ 63 784	$ 49 065
Average Household Expenditure	$ 51 100	$ 39 308

Note: Each household has an average of 1.3 earners [11].

We defined total financial stability as being able to spend an average amount of money in a fiscally sound manner, which necessitates an individual income of $49065 before taxes. After applying the model for financial stability, the following results were obtained for the short-term employment:

TABLE 14: Unemployment & Salary by Educational Level - Entry Level

	High school Diploma	Associate degree	Bachelor's degree
Probability of Employment [9]	0.9558	0.9639	0.9776
Adjusted Salary (non-STEM)	$ 32 049	$ 39 715	$ 58 657
Adjusted Salary (STEM)	-	$ 44 829	$ 62 204

The adjusted salary reflects the expected value of the salary, found by taking the product of the Earning Potential and the probability of being employed. From this data, we see that at least initially, only a person with a Bachelor's degree (in STEM or other fields) will make enough money to have an average level of expenditure. However, a STEM Associate degree will almost provide enough to have average expenditure levels as soon as one enters the workforce. Applying a normal model to unemployment and to earnings, we can predict that 43.99% of STEM majors with Associate degrees and 37.02% of non-STEM majors with Associate degrees will have enough money to be financially stable. Negligible percentages of High School Diploma holders will make enough to be financially stable, and negligible percentages of Bachelor's Degree holders (STEM and non-STEM) will not make enough to be financially stable.
For long-term economic security, we calculated the probability that one keeps their job over a period of time.

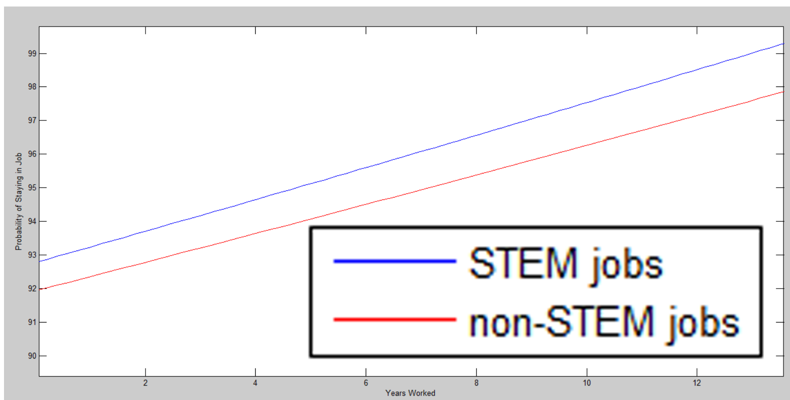

FIGURE 3: Job Retention in STEM (blue) and non-STEM fields (red)

We then tabulated the probability of staying in a job after 10 years in various categories.

TABLE 15: Job Retention after 10 years (%)

	High School Diploma	Associate degree	Bachelor's degree
non-STEM	93.1	95.8	96.6
STEM	-	97.05	97.45

The model showed that long-term financial security may be more attainable with STEM jobs, as these jobs have a higher percentage of retention. We then found the adjusted salary, which is the expected value of the salary, in order to evaluate financial stability.

TABLE 16: Unemployment & Salary by Educational Level - 10 Years' Experience

	High school Diploma	Associate degree	Bachelor's degree
Adjusted Salary (non-STEM)	\$ 35 780	\$ 39 793	\$64 202
Adjusted Salary (STEM)	-	\$ 44 257	\$ 70 291

The data shows that there is only minor variation in the adjusted salary of the Associate degree holder, while that of the Bachelor degree holder goes up. Having an above-average ability to spend responsibly still is only possible for holders of a Bachelor's degree.

2.3 Part III: Evaluating Quality of Life through Work Values

2.3.1 Rationale

Once a student has obtained a degree, the next step is to pursue a career. While the most obvious factor people entering the work force consider when choosing a job is compensation/salary, there are numerous qualitative factors which should be taken into consideration in order to decide upon the optimal career path for a specific person that will result in the most job satisfaction.

For students who know what type of qualities they'd like in their dream career, but do not know the best way to pursue them, this model can be used to determine the optimal degree to obtain in order to qualify for such a type of occupation.

2.3.2 Assumptions

- Statistics of work values for various occupations provided by O*Net Online apply to all workers of those occupations.
- The user does not have previous preferences in terms of occupational field, and will choose the optimal occupation based solely on similar work values and no other parameter.

2.3.3 Work Values of Occupations

All occupations, due to their varied tasks, responsibilities, and required skills, have different aspects which contribute to a worker's overall satisfaction. Also known as work values, these values, which exist for most to all jobs and are provided by O*Net Online [7], allow users to check their compatibility for different jobs based on their personalities or priorities. Each work value is provided as an index out of 100; a higher index indicates that the specific work value is considered to be more important for members of that occupation.

As defined by O*Net Online, the five main work values analyzed by our model are:

- **Achievement**: Occupations are oriented towards results and allow employees to use their strongest abilities, giving them a feeling of accomplishment.
- **Independence**: Occupations allow employees to work on their own and make decisions.
- **Recognition**: Occupations offer advancement, potential for leadership, and are often considered prestigious.
- **Relationships**: Occupations allow employees to provide service to others and work with co-workers in a friendly non-competitive environment.
- **Working Conditions**: Occupations offer job security and good working conditions.

2.3.4 Model Development: Work Values

The five work values for one job a are normalized by dividing each value by the sum of all work values in order to obtain the percentage of relative importance for each:

$$V_a = W_a/(W_a + W_b + \ldots + W_n)$$

where V is the normalized work value, W the raw work value, and n the number of work values in total.

Let V_{a1} be the percentage for the first work value, V_{a2} the percentage for the second, and so on for the remaining work values for job a. Users of the model then rank themselves based on how important they hold the five criteria to be on a scale from 1 to 5, with 1 considered to be not at all important and 5 to be extremely important. The same method used above is now applied again to the user supplied values in order to obtain 5 more normalized percentages, V_1, V_2, and so on. These percentages are then the work values that the user considers to be the most important.

The similarity between the the user and the occupations can then be quantified as the distance between the two sets of work values plotted on a 5-dimensional space, with each axis corresponding to a work value. This distance is given by the Euclidean norm:

$$\mathbf{d} = \sqrt{(V_1 - V_{a1})^2 + (V_2 - V_{a2})^2 + (V_2 - V_{a2})^2 + (V_3 - V_{a3})^2 + (V_4 - V_{a4})^2 + (V_5 - V_{a5})^2}$$

The distance $\mathbf{d}$ can then be computed for the remaining jobs, each with their own work values, to obtain the set of distances for all jobs, S. Because the model aims to determine the one job whose values most closely matches the user's, the optimal job is therefore the one whose distance from the user's point is the least, or the one which differs the least from the user's values. The similarity, O, between the user's and the optimal job's set of work value is then given by:

$$O = \min(S)$$

where min() returns the minimum of a set of values.

2.3.5 Results

All jobs have a minimum degree requirement which must be at least fulfilled in order to qualify for the specific occupation. Once O has been determined, the minimum degree required for job O can then be determined. Jobs that are not STEM-related can also be differentiated from STEM-related jobs. This degree is then returned to the previous model in order to obtain the cost of the degree and the potential benefits. The same method can also be used for the remaining jobs in set S to obtain the next-best possibilities for the user.

The Society for Human Resource Management has data on the average influence which common contributors have on job satisfaction. This sample data can be used to determine the best occupation based on the qualitative work values.

The influence of each contributor was derived by surveying 600 employees and asking for their opinions on the importance each contributor has in determining job satisfaction. Each contributor was ranked qualitatively, with the four choices being: "Very Unimportant", "Unimportant", "Important", and "Very Important" [23]. In order to translate this into quantitative data, the choices was weighted on a scale from 1-4, with "Very Unimportant" having 1 point and "Very Important" having 4 points. The raw work value for each answer choice was determined using:

$$V = \%answer * weight$$

where $\%answer$ was the percentage of people who chose the answer choice and $weight$ was the corresponding weight for that answer. The final (raw) work value for each contributor was then simply the sum of all individual answer choice values of V.

Based on the five aspects explicated before from O*Net, applicable contributors were then aggregated together to obtain the raw work values for all five aspects (e.g. the contributors "Communication between employees and senior management" and "Relationship with coworkers" were combined into the aspect "Relationship"). These raw values were then converted, using the method of normalization explained in 2.3.4, into the final normalized values.

Five jobs were chosen from the vast pool of available occupations to make the sample calculation faster. Each job, however, had a unique minimum degree and was chosen to represent all 5 types in this sample calculation. The jobs were: **Registered Nurses, Electromechanical Technician, Mechatronics Engineers, Construction Carpenters, and Sales Managers**. After calculating the normalized values and conducting the distance measurement in the 5-dimensional plot for each job compared to the sample data, the results were:

TABLE 17: Sample Jobs

Sample Jobs	5-Dimensional Distance
Registered Nurses	0.141807
Electromech. Technician	0.147773
Mechatronics Eng.	0.18959
Const. Carpenter	0.250861
Sales Manager	0.215353

Based on this data, the nurse was deemed the most suitable job, and a 2-year, non-STEM degree the most suitable degree based on job satisfaction alone.

3 Discussion

Our model found that the costs of a college education can vary from \$5,464 to \$162,291, depending on familial circumstances. As the average American yearly household expenditure is \$51,100, this can represent a significant investment. Our model found that the cost of college is not as simple as paying tuition, and costs such as paying to travel home during vacations, paying for food, books, and personal supplies, and interest on loans can all add up to create a great burden on a student.

For certain higher-achieving students attending community colleges, a plan proposed by President Obama was estimated to save an average of \$58,664. To improve this aspect of the model one can add variables to account for geographic variation, which will affect the cost of both college and travel. Furthermore, correlations between other variables and academic performance will better reveal which students will be likely to receive scholarships.

The investment in STEM education gives returns. By using an adjusted Mincer earnings equation model, we found that a two year degree in STEM on average leads to a 12% higher initial earning potential compared to non-STEM two year degrees, while a STEM Bachelor's degree provides about 5% more earning potential than its non-stem counterpart. Our models also showed that While there is a 44% chance to be financially stable with an Associate STEM degree, a Bachelor's degree in any field almost guarantees financial security even at the entry level. However, this model could have been improved by analyzing the different aspects of the various fields and careers within STEM, as STEM cannot accurately be modelled as a monolithic field of study, in order to better determine how the attainment different degrees affect eventual economic performance. The regression performed showed that the model was very stable with regards the amount of schooling and amount of work experience, but needs further testing with regards to stability of the GPA variable.

Finally, we developed a model to quantify qualitative elements of job selection. By evaluating an individual student's desire for five key values in the workplace and matching them to a database of jobs using a Euclidean distance algorithm, we were able to find the ideal job for each individual. The results of running this model for the average student found that jobs requiring a 2-year degree in an non-STEM field were the most satisfying. This tool could be further developed by including more categories for values in the workplace, to better reflect the different needs and wishes of each individual. By conducting surveys of worker satisfaction specifically geared to testing these work values, more accurate data can be collected which will further improve the model and for allow sensitivity testing.

Using the three tools developed, a student can be better equipped to choose what path they will follow in college. By evaluating their qualitative desires, an ideal area of study can be identified. With the Mincer earnings equation model, a quantitative analysis of the degree needed for this target career can be performed to estimate earnings, and further analysis will reveal the likelihood of financial stability. Finally, an evaluation of family and personal data by our tuition model will find the cost of the education, allowing for the performance of an accurate and unbiased cost-benefit analysis to better decide a student's best path.

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