Math: The gateway to Great Careers

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What I’ll Talk About Today

• Why I think that math is important for everyone in this room
• “Common Denominators” of Great Careers
• An example of how I use math at NASA
Career versus Job

- **Career** is defined by the Oxford English Dictionary as an individual's "course or progress through life (or a distinct portion of life)". It is usually considered to pertain to remunerative work (and sometimes also formal education).

- A **job** is a regular activity performed in exchange for payment, usually as one's occupation. The duration of a job may range from an hour ... to a lifetime ... The series of jobs a person holds in their life is their career.

Career versus Job

• Most of us use the two terms interchangeably
  – But when you think about it, they are different

• Age relates to which you have and which you want to have

• My goal is to get you thinking about what Career you want to develop, and about charting your path
What makes a great career?

• It depends on what matters to you, but there are some common things that many people value…

• What are some things that YOU consider important in a career?
...Things to consider...

- Salary & Benefits
- Hours
- Physical Demands
- Mental Demands
- Skill Sets Required
- Education Required
- Work Environment
- Stress
- Hiring Outlook
- Sense of Worth
- Job Security
- Flexibility
- Predictability
- Travel Requirements
- Family-Friendly
- Prestige
- Opportunities for Advancement
- Interesting!
- Co-workers
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Many, MANY things contribute to Career Satisfaction!!
What are some great careers?

- Again, it depends on what matters to you, but when asked, many people rattle off the same short list…

- What do you think is on that list??
What are some great careers?

• JobsRated.com evaluated 200 jobs in 2010, considering five “Core Criteria”
  – Environment, Income, Outlook, Stress, Physical Demands

• Each of these criteria had several components to them (ex. “income” included salary data plus growth potential)

• 200 Jobs were rated in each Core Criteria, and an overall score was created so that jobs could be ranked.

http://www.careercast.com/jobs/content/jobs-rated-methodology-2010
“Top-10” Careers?

1. **Actuary** Interprets statistics to determine probabilities of accidents, sickness, and death, and loss of property from theft and natural disasters.

2. **Software Engineer** Researches, designs, develops and maintains software systems along with hardware development for medical, scientific, and industrial purposes.

3. **Computer Systems Analyst** Plans and develops computer systems for businesses and scientific institutions.

4. **Biologist** Studies the relationship of plants and animals to their environment.

5. **Historian** Analyzes and records historical information from a specific era or according to a particular area of expertise.

6. **Mathematician** Applies mathematical theories and formulas to teach or solve problems in a business, educational, or industrial climate.

7. **Paralegal Assistant** Assists attorneys in preparation of legal documents; collection of depositions and affidavits; and investigation, research and analysis of legal issues.

8. **Statistician** Tabulates, analyzes, and interprets the numeric results of experiments and surveys.

9. **Accountant** Prepares and analyzes financial reports to assist managers in business, industry and government.

10. **Dental Hygienist** Assists dentists in diagnostic and therapeutic aspects of a group or private dental practice.
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The Common Denominator:

- All of the “top ten” careers identified by JobsRated.com (Careercast.com) involve math
  - Math is part of the job
  - Knowledge of math is necessary to *get* the job
Do you agree with the list?

• This is one example of a “job survey”
• Other methods will shuffle the rankings, depending on how the survey was conducted, and how the data were analyzed (by statisticians!)

• But I would argue that the common denominators in “best” careers, regardless of how you do the math, hold true.
Math as a Gatekeeper

- Good Jobs Require…
- Good *Careers* Require…
- *Great Careers* Require…

- Most experts agree that education is a critical factor
Setting your Sights High!

• College is a no-brainer

• Graduate School is something to consider too

• What does it take to get into an excellent College or University? Graduate Program?
College Entrance Requirements

- Admissions Offices use many criteria, but most emphasize:
  - Your High School Performance
    - Cumulative GPA
    - GPA in specific courses
    - Other factors that separate you from “the pack”
  - Standardized Test Scores
    - ACT
      - Math, English, Reading, Science, Optional Writing Test, Composite
    - SAT
      - Math
      - Writing
      - Critical Reading
Graduate School?

- Admissions Offices & Disciplines for Graduate School mimic Undergrad:
  - Your Performance in College/University
    - Cumulative Undergraduate GPA
    - GPA in specific courses
    - Other factors
  - Standardized Test Scores
    - GRE
      - Quantitative Reasoning
      - Verbal Reasoning
      - Analytical Writing
    - MCAT or OTHER Discipline-Specific Tests
      - …have a math component!
What most applicants want?

• Opportunity
  – to highlight our strengths
  – to address our weaknesses
  – to learn what it takes to succeed

• …We need to get our foot in the door
What are the “gatekeepers?”

- Standardized Test Scores
  - SAT, ACT, GRE, etc.
- Cumulative GPA
Why is Math so Important as an Entrance Requirement?

- People with math skills typically learn *other* academic and career-related disciplines, so they are a good risk for colleges/universities
- People who have solid math skills are thought to be “smart people,” and thus are welcomed into college programs, training opportunities, and great careers
- Math is part of most careers at some level
Recent Example of NASA work

The Challenge?

- Need to be able to accurately predict when an astronaut will run out of “consumables” during Extra Vehicular Activities
- There are several ways to estimate this, but sometimes the estimates don’t match
- How best to combine predictions from multiple methods of estimating??
Recent Example of NASA work

Oh, and one more thing...

• Find a method that works even when things go wrong!
  – Crazy readings from a sensor
  – Flaky sensor that goes in/out
  – Completely broken sensor
  – Combinations of the above
  – Other stuff that we’ll think of too!
Our “Best Estimate”

W4 Coefficients
- O2: 0.52
- CO2: 0.11
- LCG: 0.11
- HR: 0.26

Estimated MetRate vs Hours
Our “Best Estimate”

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Estimated MetRate vs Hours

- O2
- CO2
- LCG
- HR

Hours: 0 to 3.5
What if a sensor fails?
Summary of Met Rate ($\mu$) Estimation Process

Step 1. Preliminary estimation of $\mu$. Apply principal-axis analysis to $x_1$, $x_2$, and $x_3$ with one retained factor assumed to be proportional to $\mu$. Use (2)-(4) to get preliminary estimate $\hat{\mu}^{(0)}$.

Step 2. Preliminary calibration of heart rate (HR). Assume for some $c_0$ and $c_1$ that $c_0 + c_1 \cdot (HR)$ is also an unbiased estimate of $\mu$. Regress $\mu^{(0)}$ on $HR$ to get preliminary calibration $x_3^{(0)} = c_0 + c_1 \cdot (HR)$.

Step 3. Intermediate estimation of $\mu$. Repeat factor analysis with 4 variables $x_1$, $x_2$, $x_3$, and $x_3^{(0)}$. Again use (2)-(4) to get new estimate $\hat{\mu}^{(1)}$ of $\mu$.

Step 4. Final calibration of heart rate. Regress $\hat{\mu}^{(1)}$ on $HR$ to get final calibration $x_3$ of $HR$.

Step 5. Final estimation of $\mu$. Repeat factor analysis with 4 variables $x_1$, $x_2$, $x_3$, and $x_3$ and use (2)-(4) to obtain final estimate $\hat{\mu}$.

**Met Rate Factor Model**

Principal factor ($f$)

$$f = \alpha \cdot \mu + \epsilon$$

$$\mu = (f_j)$$

$$\alpha = (1/n) \cdot \bar{f}_j$$

Observing estimators of met rate (assumed unbiased)

$$x_i = \mu + \epsilon_i \quad (i = 1, \ldots, k)$$

$$x = (x_1, \ldots, x_k) = \mu + \epsilon$$

Factor estimation

$$f = \alpha \cdot \mu$$

$$x = (X - J \cdot \mu)^{-1}$$

where

$$A = k \times 1$$

$$M = (M_1, \ldots, M_k)$$

Sample means

$$D = \text{diag}(d_{11}, \ldots, d_{kk})$$

Simple $SD$s

$$R = k \times k$$

correlation matrix of $X$

(Note: $J = \frac{1}{d} \cdot A^{-1} \cdot A = 1$)

**Estimate of BTU’s used ($\hat{B}$)**

$$\hat{B} = \hat{\mu} \cdot \hat{\epsilon}$$

$$= \hat{\epsilon} \cdot X \cdot \hat{\mu}$$

$$= \hat{\mu} \cdot \hat{\epsilon} \cdot X$$

$$= \hat{\mu} \cdot \hat{\epsilon} \cdot (\hat{\mu}^{-1} \cdot X)$$

$$= \hat{\mu} \cdot \hat{\epsilon} \cdot (\hat{\mu}^{-1} \cdot X)$$

Let $V(e_i) = \hat{\epsilon}_i$ and assume $e_i$ independent.

Then $V(\hat{B}) = (\hat{\mu})^2 \cdot V(\hat{\epsilon}_i)$, estimated by $$(\hat{\mu})^2 \cdot V(\hat{\epsilon}_i)$$

**Estimation of $\Sigma$**

Step 1. Assume the components of each $e_i$ follow a second-order autoregressive model:

$$e_i = \rho_e e_{i-2} + \rho_e e_{i-1} + \epsilon_i$$

Step 2. Perform AR(2) regression of $e_i$ on $\epsilon_i$ to obtain estimates of $\sigma^2$, $\rho_1$, and $\rho_2$.

Step 3. Calculate $\Sigma = V(e_i) = \frac{\sigma^2}{1 - \rho_1 - \rho_2}$.

**Estimation of Allowable Time Remaining in EVA**

Write $\hat{B}(T) = \hat{B}$ after $T$ hours of EVA.

Assume spacesuit life support system can accommodate a maximum total energy expenditure of $R_{\text{max}}$ (BTU).

Then the time remaining $T_r$ is estimated by $T_r = R_{\text{max}}^{-1} / B(T) - T$.

Use $\Delta (B/T)^{1/2}$ as SE of $B(T)$ to get confidence limits for $T_r$. With a little math!!
Problem Solved??
Final Remarks...
Take-Home Lesson #1?

- Math Matters
- Math can be a career in and of itself
- Applied math leads to many careers
- These careers tend to be highly praised, with attributes that most people value
For the Math Lovers…

• Good news for us!

• Jobs requiring what we like to think about and do are “out there!”

• All that “math stuff” that we learn in school really has a purpose in life and work!

• We can get paid to do stuff that we love to do anyway!!

• And we can make a difference in the world too.
Take-Home Lesson #2?

- Math Matters
- Math is a “gatekeeper” to great careers not typically thought of as “in the math field” because it is a key component to the entrance exams required for College, University, and Post-Graduate education.
For everyone else??

• There are many great careers that don’t involve (as much) math as part of daily “work-life”

  Historian
  Dental Hygienist
  Paralegal Assistant
  Philosopher
  Technical Writer
  Web Developers
  Pharmacist
  ...many others

• With equal benefits to self and society

• Nevertheless, many of the jobs that people rate highly require knowledge of math
  – If for no other purpose, math serves as a “gate keeper” to great careers
Where will your career take you?

Go down deep enough into anything and you will find mathematics.

~Dean Schlicter