Building YouTube University Brick by Brick

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http://web.williams.edu/Mathematics/
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**AMS-MAA Special Session on Innovative Ideas in Enhancing Success in Mathematics Classes
Joint Meetings of the AMS-MAA, Seattle, Jan 6, 2015**

Outline

Goal is to engage students.

- Lego courses:
    - ◇ Springboard to good math.
    - ◇ Introduction to Operations Research.
    - ◇ Managing and Being Led.
    - ◇ Giving back to community.

- YouTube:
    - ◇ Advantages of posting lectures.
    - ◇ Technology issues.

Lego Courses

Basics

- This is third consecutive January teaching.

- First two on speed team build (40, 60), this on design (20).

- Mix of strong math majors and humanities students, 3-4 weeks.

- Homepage: http://web.williams.edu/Mathematics/ sjmiller/public_html/legos/

- Slides Day 1: http://web.williams.edu/Mathematics/ sjmiller/public_html/legos/LegoCourse2016.pdf

Springboard: Combinatorics

How many ways are there to stack six 2×4 bricks?

Springboard: Combinatorics
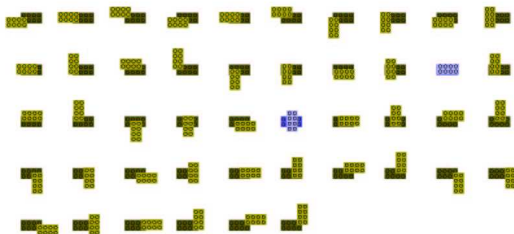
How many ways are there to stack six 2×4 bricks?

Before you count need to decide *what* to count.

http://c-mt.dk/counting/images/
modelsintrosmall.png

Springboard: Combinatorics: II

Require right angles; below is two 2×4:

http://www.math.ku.dk/~eilers/46.jpg

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Leads to chirality, tic-tac-toe....

Springboard: Combinatorics: II

Mathematics Topics

Day 1: January 5, 2015: Telescoping sums, Babylonian Mathematics, Look-up Tables, Fibonacci Numbers, Recurrence and Difference Equations, Method of Divine Inspiration, Binet's Formula, Binomial Theorem, Derivative of x^r, Evaluating sums efficiently.

– Problems to consider:

- Let's say that if you multiply an m digit number and an n digit number that the cost is mn, as this is the number of digit multiplications you need to do (of course, a better approach is to also include a cost of the additions, but that's a little harder as there are possible carries). Try to figure out how to compare the run-time of directly computing a product xy and using the Babylonian formula $xy=((x+y)^2-x^2-y^2)/2$; note that with the Babylonian formula you need to make an assumption about how long it takes to read in a number and then do subtraction and division by 2.

- Read the notes here on solving difference equations, and try some of the problems. If you know eigenvalues and eigenvectors, use those to attack the matrix formulation of the Fibonacci numbers and reach Binet's formula that way.

- Read pages 44 to 49 of this talk of mine on generating functions, another way to solve recurrence relations and reach Binet's formula.

- Notes on analysis review (includes proofs by induction): For us most important part is page 3, where it talks about binomial coefficients and the binomial theorem. Try Exercise 1.1.7 (note it is possible to prove each claim by telling an appropriate story). After proving the binomial theorem find an expansion for $(x+y+z)^n$.

- Show $x^r=\exp(r\log x)$ and use the chain rule to prove its derivative is rx^{r-1}. Note the proof of the derivative is very different than the proof of the derivative of x^n for n an integer. That just uses the binomial theorem. If we have $x^{a/b}$ for a rational number a/b then the proof is by the power rule: if $f(x)=x^{a/b}$ then set $g(x)=f(x)^b=x^a$, and now we can find the derivative of $g(x)$, from which we can get the derivative of $f(x)$. Fill in the details of these arguments.

- Create a look-up table for values of $\sin x$ and $\cos x$. You need to start with inputs where you know the output; good choices are to take $x=mn/2n$ for integers m,n, as we can get these values from the half-angle or double-angle formulas. Continue by using Taylor series (reviewed in the analysis notes, page 6).

- Come up with a good way to evaluate $\sum_{n=0}^\infty (n \text{ choose } k)x_0^{n-k}$ by looking at the modification term by term as you go down. In other words, it's expensive to calculate each summand from scratch. If $a_n=(n \text{ choose } k)x_0^{n-k}$ find a simple formula relating a_{n+1} to a_n and use that to march down the line.

Operations Research

Goal: Build in under 10 minutes from unopened box.

http://web.williams.edu/Mathematics/

Organization

- 1 second in command (4 in 2nd year)
- 7 Bag Captains
- 7 Assistant Bag Captains
- 7 Sorters
- 3 Strategists / General
- 1 Publicist
- *N* Builders
- Motivation for jobs:
  https://www.youtube.com/watch?v=O1E6To440TA
  https://www.youtube.com/watch?v=s9t0AHNofgk
- Instructions:http://web.williams.edu/Mathematics/
  sjmiller/public_html/legos/6005794.pdf

The Big Event

This is the Flyer you were Looking For

If you're free on the 24th of January (a Friday), around 3:30 pm come help us try to set what will hopefully be a Guinness World Record: building a Lego Super Star Destroyer in as short a time as possible!

If you're interested, email Professor Miller at Steven.J.Miller@williams.edu!

Hope to see you there!

"Sir, the probability of successfully building a Super Star Destroyer in less than ten minutes is approximately 3,720 to 1...."
"Never tell me the odds!" – Han Solo, replying to C-3PO

YouTube

Using technology to help with challenges

Many ways to use technology, concentrating on recordings.

Two very different options: straight recording, OIT-production.

- Calc III: Taylor Series in a Day: Sony Flip Cam: https://www.youtube.com/watch?v=yr01SLw9t4c.
- Calc III: Green's Theorem in a Day: OIT Camera Crew: https://www.youtube.com/watch?v=Iq-Og1GAtOQ.
- Probability: Differentiating Identities (3/16/15: Swivl): http://youtu.be/4EWY0U7LhX8.

- Double plus ungood: https://www.youtube.

Integrating recorded lectures

What is the purpose of recorded lectures?

- More material (both at home and in class).

- Aids absent students / students who want to review.

- Use material as review / supplement in other classes.

- Easier to travel.

- Remote students.

Unexpected bonus: I was fine during a gas evacuation!

Implementation issues

- Will students watch it?

- What will they get from it?

- How effective is it?

- Difference b/w upper level and lower level courses.

- Strength liberal arts colleges knowing each other, lose greatly online.

Remote Student: Post-core Complex Analysis

My overall experience taking a class online was very positive. This was an opportunity to take a class that I would have otherwise not have been able to take (except as an independent study). Without the structure, a fixed syllabus, and helpful lectures, I wouldn't have covered as much material in an independent study. Once we overcame the technical hurdles and were able to have videos for all lectures, I benefitted tremendously from the lectures. Despite watching with headphones in a quiet section of a library, I found it more challenging to focus on watching the videos than focus on a professor in a physical classroom. I got distracted more often than I would in a physical classroom and would have to watch some videos more than once. Further, I didn't have the option of clarifying things in the moment (with another student or the professor) and felt more compelled to figure things out myself before emailing a fellow student or the professor. While this meant that I had to work harder on watching videos multiple times or re-reading sections of the textbook, I would say that the overall experience was more challenging, but not less meaningful, than a course in a physical classroom.

YouTube and the World: Broader Impact

- Often don't know who watches, though some contact.

- Broader impact: posting general lectures, research talks, conferences.

- Standard tutorials: saves time.

- Continue and build relationships with former students.

Technology issues

- OIT recording: high quality, time intense:
    - ◇ Processing time.
    - ◇ Student workers.

- SONY flip cam: low quality, easy, not as good but good enough?
    - ◇ Big issue: blackboard real estate.
    - ◇ Simple: just upload to YouTube!

- iPad Swivl: high quality, decent upload.

Going forward....

- Hollywood level videos great, lot of time and effort but better understanding?

- How much to flip, and how to integrate?

- Split work among several institutions?

Video References

- OIT videos:
  ◇ Double plus ungood: Discusses applications of Fibonacci numbers to roulette, 6:43 minutes: https://www.youtube.com/watch?v=Esa2TYwDmwA.
  ◇ Duality: Introduction to duality and linear programming, 3:30 minutes: https://www.youtube.com/watch?v=aMorr1h4Egs.
  ◇ Tangent lines: Review of tangent lines, 3:33 minutes: https://www.youtube.com/watch?v=lEJ06epMLEQ.

- Course videos: Calculus III, Probability, Complex Analysis:
  http://web.williams.edu/Mathematics/sjmiller/public_html/150/articlesvideos.htm
  http://web.williams.edu/Mathematics/sjmiller/public_html/341Fa15/articlesvideos.htm
  http://web.williams.edu/Mathematics/sjmiller/public_html/372Fa15/articlesvideos.htm.

- Tutorial videos:
  ◇ LaTeX: http://www.youtube.com/watch?v=dKUtJpG4Rt0.
  ◇ Mathematica: http://www.youtube.com/watch?v=g1oj7CIqGM8.

- Conferences / Talks:
  http://web.williams.edu/Mathematics/sjmiller/public_html/math/talks/talks.html.