Livin’ Large: Lessons Learned from the Large-Lecture Lifestyle

David Quarfoot
Associate Teaching Professor
Department of Mathematics
dquarfoot@ucsd.edu

UCSD’s Jeannie Auditorium: 600 seats
Up and Running

socrative.com ➔ Login ➔ Student Login ➔ Room Name = QUARFOOT

OR

App store ➔ Socrative Student

Choate Rosemary Hall
2001-2008, private boarding
Class sizes: 5-15 students

University of Utah
2008-2010, public
30-60 students

Roxbury Latin School
2010-2012, private day
5-15 students

UCSD
2016-present, public
80-400 students
Up and Up (and Up!)

My recent class sizes: 450, 240, 90, 250, 80, 130, 320, etc.

Winter 2023 Class Sizes (after drop deadline)

- Precalc (100, 100, 120)
- Calc 1 non-STEM (240, 240, 200, 200)
- Calc 1 STEM (260, 200, 160)
- Calc 2 non-STEM (140, 330, 200, 130, 100)
- Calc 2 STEM (160, 400, 150)
- Intro Stats (200, 130, 200)
- Linear Algebra (500, 160, 130)
Lesson 1: Use Flexible Class Policies

Let $p$ be the probability that a random student will miss a deadline, skip a class/discussion, not take an exam, etc. for any reason.

Let $X \sim \text{Binom}(n, p)$ be the number of students in a class of $n$ who fail to meet a deadline, skip class, etc.

\[
E(X) = np
\]

\[
\begin{align*}
25 \cdot 0.05 &= 1.25 \quad \text{exceptions} \\
200 \cdot 0.05 &= 10 \\
450 \cdot 0.07 &= 31.5
\end{align*}
\]

$\times \frac{\text{number of events}}{\text{course}}$
Flexible Class Policies I Use

- Drop $x$ of $y$ homework assignments/attendance checks
- Classes always podcast
- Head off tech excuses (HW due at 9 PM with 2 hour tech issue window)
- Drop $x$ of $y$ exams with final exam replacement

**Formula 1:**
- 30% Homework (out of 95% of max points)
- 20% Exam 1
- 20% Exam 2
- 30% Final Exam

**Formula 2:**
- 30% Homework (out of 95% of max points)
- 20% Better Exam score
- 50% Final Exam

(This formula basically replaces the lower Exam score with the Final Exam Score.)

Grades using Two Formulas $n = 207, r = 0.947$

$y = x$ line
Lesson 2: Rare and Ultra-rare Events Occur Many Times

Let \( \lambda = \frac{1 \text{ rare event}}{100 \text{ student-day}} \cdot \frac{300 \text{ students} \cdot 70 \text{ days}}{1 \text{ class-quarter}} = 210 \frac{\text{rare events}}{\text{class-quarter}} \)

\[ X \sim Pois(\lambda = 210) \]

- Forget calculator at exam
- Car breakdown
- Submitted wrong homework

Let \( \lambda = \frac{1 \text{ ultra-rare event}}{1000 \text{ student-day}} \cdot \frac{300 \text{ students} \cdot 70 \text{ days}}{1 \text{ class-quarter}} = 21 \frac{\text{ultra-rare events}}{\text{class-quarter}} \)

Athlete concussion, car drove into apartment, suicide email, death in family, car accident, scooter accident, drug abuse, housing loss, 3x class repeat, etc.
Lesson 3: Little Hope of a Shared Knowledge Base

Let $p$ be the probability a random student is familiar with a problem’s context.

Your Turn: Given a class of size $n$, what is the probability all students will be familiar with the context?

Let $S_i$ be the event that student $i$ knows the context.

$P(S_1 \text{ and } S_2 \text{ and } \ldots \text{ and } S_n)^{\text{ind.}} = P(S_1) \cdot P(S_2) \cdots P(S_n) = p^n$

Example: $(0.9)^{15} \approx 0.206 \quad (0.9)^{50} \approx 0.005 \quad (0.9)^{200} \approx 7 \cdot 10^{-10} \approx 0$

My failed settings: (American) deck of cards, baseball, prime numbers, term “divisible”, north/south/etc.
Probability of a Shared Knowledge Base (Class Sizes: 15, 50, 200)

Probability **all** students will be familiar with a given context (assuming independence)

Probability a **single** student is familiar with a given context
Lesson 4: You Must Consider the Larger Physical Space

More apparent

- Voice amplification, restating
- Write larger
- Use thicker chalk, thicker graphics
- Laser pointers/bluetooth distances
- Color distinctions wash with distance
- Energy/lesson sparkle must scale

Less apparent

Powerpoint weights: 0.5, 0.75, 1, 1.5, 2.25

Vibrato in larger spaces study
Videos [here](#), Manim code [here](#) (videos not viewable in PDF file)
Lesson 5: Students Have Space and Interaction-Ratio Expectations

“... there is more to space besides navigation and assessment: people have different emotional experiences at different places, which create emotionally tinged representations of space.”  

Paper

Contrast: Haunted house vs. house you grew up in vs. White House

Interaction Ratios

<table>
<thead>
<tr>
<th>Ratio</th>
<th>tutor</th>
<th>teacher</th>
<th>teacher</th>
<th>teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 : 1</td>
<td>tutee</td>
<td>small class</td>
<td>large class</td>
<td></td>
</tr>
<tr>
<td>partner</td>
<td>spouse</td>
<td>sports team</td>
<td>theater-goers</td>
<td></td>
</tr>
<tr>
<td>owner</td>
<td>pet</td>
<td>department</td>
<td>passengers</td>
<td></td>
</tr>
<tr>
<td>therapist</td>
<td>patient</td>
<td>Bachelorette</td>
<td>suitors</td>
<td></td>
</tr>
</tbody>
</table>

To Socrative! IR Example Brainstorm

- deeply known, partnership, active
- anonymous, transactional, passive
Large-Lecture Affordances

1. Quality student-generated data sets!
   - Real-time analysis  To Socrative! Data Generation!
   - Distributions are better realized
   - Narrow confidence intervals, high-powered hypothesis tests
   - Less common misconceptions appear
2. The class size \((m)\) can imitate ideas \(\rightarrow \infty\)

\[
\begin{align*}
X & \rightarrow \overline{x}_1 \\
\{x_{11}, x_{12}, \ldots, x_{1n}\} & \rightarrow \overline{x}_1 \\
\{x_{21}, x_{22}, \ldots, x_{2n}\} & \rightarrow \overline{x}_2 \\
\cdots & \cdots \\
\{x_{m1}, x_{m2}, \ldots, x_{mn}\} & \rightarrow \overline{x}_m \\
\text{Histogram of } \overline{x} \text{ values} & \text{ (i.e., sampling distribution)} \\
\text{limits, Riemann sum approximations, } & \text{improper integrals, Central Limit Thm.}
\end{align*}
\]

3. Greater reach (breadth vs. depth trade-off)

Small school: 50 students/year \(\cdot\) 30 years = 1500 students/career
Large school: 1000 students/year \(\cdot\) 30 years = 30000 students/career
4. High probability at least 1 person knows a specialty area

Let $p$ be the probability a random student knows about a topic.

$P(\text{at least 1 knows}) = 1 - P(\text{no one knows})$

$\qquad = 1 - P(S_1 \text{ doesn’t know and } \cdots \text{ and } S_n \text{ doesn’t know})$

$\qquad \overset{\text{ind.}}{=} 1 - (1 - p) \cdots (1 - p) = 1 - (1 - p)^n.$

For $p = \frac{1}{50}$, $P(\text{at least 1 knows}) \approx \begin{cases} 0.26, & n = 15 \\ 0.64, & n = 50 \\ 0.98, & n = 200 \end{cases}$

Exotic settings where at least one student knew: Xenoblade Chronicles 2 item farming, age cutoffs in the Canadian ed system, pronoun avoidance for transgender students, two-sport pro athletes, engine size (liters) and MPG ratings for cars
Thanks and Questions

Lessons:

1. Use flexible class policies
2. Rare and ultra-rare events occur many times
3. Little hope of a shared knowledge base
4. You must consider the larger physical space
5. Students have space and interaction-ratio expectations

Affordances:

1. Quality student-generated data sets
2. The class size can imitate ideas $\rightarrow \infty$
3. Greater reach
4. High probability at least 1 person knows a specialty area