

From Calculus Reform to Equity: An Evolution of Course Structure, Assessment, and Goals

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Outline

Goal: Give an overview of “Michigan Math,” from then to now.

- **The History of Michigan Math**
 - Calculus Reform and before
 - Math Introductory Program, 2000–2020
- **Equity, Assessment, and (more) Reform**
 - Equity, Assessment, and Exams
 - A new model
- **Issues and Implications:** things that remain and which should be considered



UM: Angell Hall

Michigan Math (Pre)Calculus Reform

- **Pre-1990s: Pre-Calculus Reform**
 - Intro **courses taught by faculty and grad students**
 - Max **class sizes 35–45** (lower for grad students)
... with one large class experiment
 - **Minimal uniformity** between sections
 - **Substantial complaints** from students about calculus
- **Calculus Reform: 1987–95**, over 350 NSF projects



TI-81

At Michigan: “*New Wave Calculus*”

- **Class size to 24 students(?)**
- **Calculators** required
- **Strong conceptual focus**
 - Assessment of skills moved to **gateway tests**
- Increased **uniformity in class**: team homework, exams
- **Courses taught by post-docs, graduate students, some faculty**



Calc class, 1990s

Sidebar: Gateway Tests

- The original mastery assessment
 - At Michigan: **skills assessment**: prerequisite skills (course before calc: functions/algebra); derivatives (calc); prerequisite skills (calc II: derivatives); integrals (calc II)...
- Original implementation: **Pencil and paper!**
 - But **grading and returning** didn't work well
 - And the **Math Lab was swamped** with test takers (not students getting help)
- Early 2000s: **Online Implementation**
 - **Practice anytime, anywhere**
 - **Credit in proctored lab**
 - **Lab of about 30 seats** supported: course before calculus; calculus I, II, & III; linear algebra (two courses)



Gateway testing lab

Michigan Math: 2000–2020

- Classes of 32 (since 2015, 18)
- Very strong conceptual focus
- Very strong focus on active learning
- Very structured and uniform
 - Uniform exams, gateway, homework (team, web)
 - Uniform schedule
- Instructors: Graduate students and post-docs (*in fall, ≈30% new*)
- Assessment
 - Uniform Scale on:
 - 95%: 2 midterms & final; 5%: web homework
 - Adjustments to grade from:
 - In-class quizzes; Team homework; Gateway test(s)



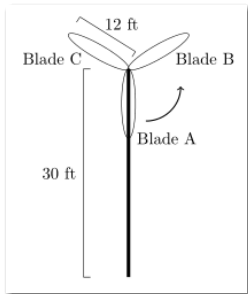
Intro program course, 2000s

Course Structure, Assessment & Equity

- Equity, Plus
 - Active learning in class, formal team roles on homework, small class sizes
 - Highly conceptual focus, application and intuition
- Equity, Minus
 - 95% of assessment by high-stakes exams
 - Highly challenging exams
- Sample exam problem:

A wind turbine, spinning counterclockwise at a constant rate, stands 30 ft tall to its spinning axis. It has three blades, 12 ft long. At exactly 1pm, blade A is pointing straight toward the ground. Blade A takes exactly 1.5 sec to return to this position. Let $A(t)$ be the height from the ground, in feet, of the tip of blade A.

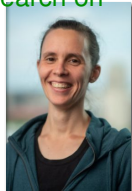
- (i) Write a formula for the trig function $A(t)$
(ii) The height $C(t)$ of the tip of blade C is a transformation of $A(t)$
circle all correct transformations. $C(t) = A(t - 0.5)$;
 $C(t) = A(t - 2\pi/3)$;...



Wind Turbine

Assessment of Assessment

- **Summers 2017, 2018:** Are exams getting harder over time?
 - Credit: **Elaine Lande** (lecturer, CSP), our **Center for Research on Learning and Teaching (CRLT)**
 - **Grant to investigate**
 - **Evolution** of exams (1994–present)
 - **Equity and how to improve**
- **Conclusions:** Well, maybe.
 - **Underlying factors** include
 - **Conceptual** demands non-routine (“**novel**”)... which evolves
 - **Recommendations** to coordinators
 - Monitor **Number of words** matters (on exam); **Number of concepts** per problem part. **Monitor exam composition**



Elaine Lande

Equity and Course Design

- **CRLT: Foundational Course Initiative**
 - **Math 105** (Course before calculus: “Data, Functions, and Graphs”) starts summer 2019
 - **3 year program**
 - **Goals:** address equity concerns, in instruction and assessment
- **FCI Components**
 - **Course Design Institute:** summer workshop
 - **Support:** financial, consultants (Susan Cheng, Anthony King)
- **Plus additional support:** College grant, University facilities



FCI CDI, 2019

Assessment Changes

- Add Mastery Assessment
- Add guaranteed course scale
 - ... with ceiling scale based on mastery points
- Pilot test: **Winter 2020**
- New Assessment Model:



New testing lab

2020–22	2022–
2 exams (30%)	3 exams (40%)
webhw (5%)	webhw (5%)
teamhw (5%)	teamhw (5%)
quizzes (5%)	quizzes (5%)
10 masteries (55%)	6 masteries (45%)

- “Learning Component” is 15% of grade
- No grade adjustments at the end of term

Assessment Sample: 105 Mastery

- **Mastery 3 (2020–2022):** **Previews of transformations, concavity, and quadratic functions**

- Suppose the function $f(x)$ has the domain $[-7, -2]$ and range $[-12, 14]$. Let $g(x) = f(x + 4) + 5$.
 - (a) What is the domain of $g(x)$?
 - (b) What is the range of $g(x)$?
 - (c) If the point $(0, 6)$ is on the graph of $f(x)$, what point must be on the graph of $g(x)$?
- Suppose a quadratic function $f(x)$ has its vertex at $x = 0.5$. Values of $f(x)$ are:

x	-2	1	2
$f(x)$	-4	2	0

- (a) What are the zeros of $f(x)$?
- (b) What is $f(-5)$?
- (c) Find the y -coordinate of the vertex of $f(x)$
- Suppose harvesting m pounds of wheat produces $h(m)$ pounds of white flour, and a pounds of white flour produces $r(a)$ slices of white bread. For each of the following give a mathematical expression for the quantity (possibly involving h and/or r):
 - (a) The number of slices of bread that can be produced from 4 pounds of flour is [____] slices.
 - (b) The number of slices of bread that can be produced from 35 pounds of wheat (made into white flour) is [____] slices.
 - (c) The weight of wheat, in pounds, needed to produce 95 pounds of white flour is [____] lbs.
- (Plus two more.)

Instructional Changes

- Math 105: 2000–2020
 - Math 105 provided greatest support to instructors (lesson plans, coordinator support)
 - New, least experienced instructors were placed into course
- Math 105: 2020–
 - Only experienced instructors in math 105
 - With Equity buy-in
 - Increased focus on equity in course materials
- Instructor Training: 2020–
 - CRLT Inclusive Teaching session at start of our new instructor training week
 - Increased focus on equity in training



New instructor training session

From Here... to Calculus

- A note about scale
 - Math 105, fall: 525 students, 30 sections, 25 instructors
Math 105, winter: 130 students, 8 sections, 5 instructors
 - Math 115, fall: 1800 students, 105 sections, 80 instructors
Math 115, winter: 750 students, 50 sections, 40 instructors
- Calculus (math 115) entered FCI in summer 2021
 - Original plan: Pilot winter 2023
 - Pandemic plan: Pilot fall 2021

2021–22	2022–
2 exams (50%)	3 exams (55–65%)
webhw (4%)	webhw (4%)
teamhw (3%)	teamhw (3%)
quizzes (3%)	quizzes (3%)
prepwork (2%)	prepwork (2%)
4 masteries (38%)	3–4 masteries (23–33%)

A Note About Change and Instruction

- Our Masteries may assess several Standards: Masteries are “chapter level”
- Why have exams?
 - Assess problem solving, math communication: which are not well assessed by online masteries
 - Assess ability to do novel or new problems: exams aren't repeated
- Equity-focused instruction
 - Is hard to build
 - Requires buy-in
 - Requires successful implementation
 - but: Mindset may be cultural
 - Ongoing work
 - Course meetings converted to focus on instructor development
 - Pairs project: pair experienced/less experienced instructors

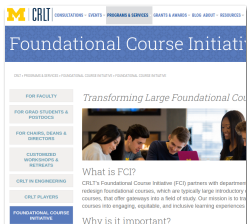


Hanna Bennet in class

Assessment and Outcomes

Never believe a study of one case... or done in a pandemic

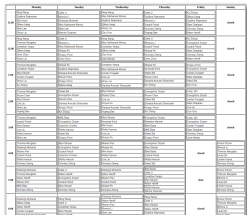
- All students in math 105 in winter 2020 who fully participated to the end of the semester earned a passing grade
- Students' mastery attempts remained high throughout the semester
 - *Growth mindset?*
- Instructor observation:
 - *[These] students were particularly likely to be hard hit by the challenges associated with COVID, and the new grading system made it extremely easy to be flexible... The fact that assessments were repeatable and the grading scale was published in advance also helped to reduce student concerns about cheating, because they knew that a classmate cheating wasn't going to negatively impact their grade.*



CRLT's FCI webpage

Issues and Thoughts Going Forward

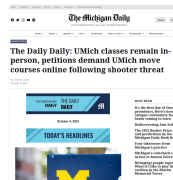
- **Workload** is not decreased by these efforts
 - fall 2022: **11,816 logged proctored lab visits** (9/6–10/19/22)
 - **Peak so far: 1,300/day**
*current lab hours: Mon–Thu, 11am–10pm;
Fri 11am–4pm; Sun 4–10pm*
 - **Staffing proctored labs** is a challenge
 - **Managing volume** is a challenge
 - **Equity**
 - And instructors: **instructors get sick**
 - And students: **accommodations** are an increasing challenge
 - **Logistical work** is increased
 - e.g., **managing retake requests** (but: reopen tokens)



Lab proctoring schedule (partial)

Implications

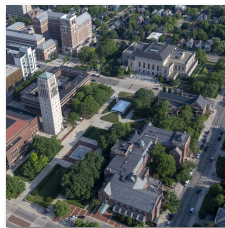
- Change requires investment
 - **Person-hours:** 105 CCD team: Hanna, Paul, Elaine, Susan, Anthony, Christina, Nawaz, me; 115 CCD team: Beth, Angela, Michael, Anthony, Claudia/Anna, Lizbee, me
 - **Finances:** FCI, LSA, UM Facilities
- and Support
 - *“After a few complaints. . . any unsympathetic department chair or dean might have quickly squelched the new program without a fair trial. Fortunately, we had full support from both.”* –Mort Brown
- and More
 - this work occurs through: a new accommodation system, pandemic, online instruction, graduate student strike, Title IX incident, and shooter threat (so far)
 - It’s not clear how sustainable that is



Michigan Daily article

Looking Forward

- Where we are
 - **Masteries, Equity**: feel like they are moving in the right direction
 - **Preliminary evidence is reassuring**
- Where are we going
 - **Forward!**
 - *... with work to make things sustainable*
 - **with continued updates**
 - **Calc II: Foundational Curriculum Initiative?**
- **Ongoing Assessment**
 - **FCI support**
- **Equity**



UM: Burton Tower and Rackam