Mathematics Department Assessment Liaison, Fernando Miranda-Mendoza

Department Buy-In and Outcome Definition: At the start of the spring 2015 semester, our department formed several committees to decide on student outcomes to be assessed for each class currently offered. After several discussions at later department meetings, my colleagues decided to focus on assessing student learning outcomes from Math 99 (Intermediate Algebra with Geometry), Math 140 (College Algebra), and Math 207 (Calculus & Analytic Geometry I). Those outcomes that are essential for success in Math 207 are of particular interest for my colleagues.

Math 207 is the first class of a three-semester calculus sequence (at our institution this sequence consists of Math 207, 208, and 209). It is an Illinois Articulation Initiative (IAI) transferable course. Students that wish to pursue a career in a STEM field must master the material from Math 207 to successfully complete the rest of the sequence. The concepts and techniques learned in calculus are widely used in other quantitative fields, especially in engineering, but also in other fields such as finance.

A thorough understanding of algebra is one of the most important prerequisites for success in Math 207. Anecdotal evidence and observations from my colleagues give weight to the idea that, despite fulfilling the necessary prerequisites, students may still not know important algebraic techniques. Moreover, students may still be able to understand calculus concepts yet struggle with the algebraic aspects. This is an issue that affects student learning and that should be addressed early on before it propagates to other higher-level classes.

We decided this semester to only concentrate on student learning outcomes from Math 207 that rely on algebraic skills from previous prerequisite classes. The main goal was to create a small pilot assessment and the necessary framework to conduct a bigger assessment during the fall 2015 semester.

Assessment Research and Design: Faculty decided to design a small pilot assessment based on outcomes from Math 207. The design of this pilot assessment should be such that we can isolate those skills that are exclusively from Math 207 from those that belong to Math 140 and Math 99.

The Math 207 faculty committee selected the following two student learning outcomes to be assessed:

A. “Apply derivatives to problems involving optimization and related rates.”
B. “Analyze the behavior of functions and their graphs using first and second derivatives (e.g., determine local and absolute extrema, concavity, and inflection points).”

Both of these outcomes incorporate techniques and skills from the three classes of interest (Math 99, 140, and 207) and are ideal for an assessment of students’ skills from each class.

The first outcome above on “optimization” (outcome A) usually involves an applied setting that students are expected to translate into mathematical terms. Some faculty suggested that we design the pilot assessment tool in such a way that students can work through this optimization problem regardless of whether they can translate the applied setting into the right mathematical terms.

Pilot Tools and Processes: The Mathematics Department unit-level liaison (Fernando Miranda-Mendoza) was given the task to create the pilot assessment tool in consultation with faculty currently teaching Math 207. Together with faculty input and also with the help of Applied Sciences unit-level liaison Jennifer Asimow, a small pilot assessment tool was designed and refined. This small assessment (see Appendix A) consists of two questions, each one divided into three parts. Each part was written in such a way as to isolate those techniques from calculus (Math 207) from those that belong to algebra (Math 99 or 140). The first question assesses outcome B (on the “behavior of functions”) while the second is written to assess outcome A (on “optimization”).
As mentioned before, outcome A is typically tied to applied situations that demand more than just mathematical ability. If a student cannot comprehend the situation described in writing, then the necessary mathematical expressions cannot be obtained and no further progress can be made. Therefore, to concentrate on the mathematical skills, the second question of this pilot tool provides the student with the mathematical expression necessary to get started. We believe that, in this way, we can genuinely assess outcome A without interference from issues related to reading comprehension.

Finally, both questions in this pilot tool were also written in such a way that students are required to use concepts from calculus and do not resort to other approaches that may avoid Math 207 techniques (such as numerical simulation).

See Appendix B for the scoring rubric that will be adapted and used with student results. This rubric will allow us to rate student performance on each part of the pilot assessment depending on whether they succeeded/failed at the basic algebra level or at the higher conceptual calculus level.

Administer Specific Assessment: The pilot assessment will be administered in a few sections of Math 207 before the end of the Spring 2015 semester (during weeks 15 and 16).

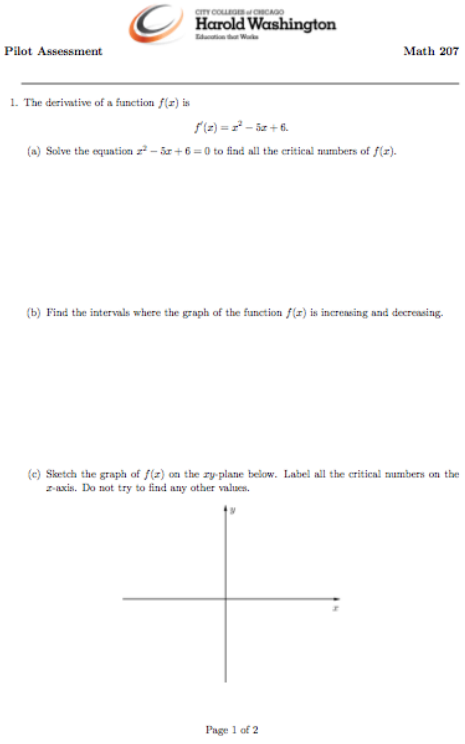
Data Analysis: We hope to obtain a good number of student results in order to use the analytics tool OpenBook to perform some analysis over the summer of 2015. The analysis will hopefully provide us with some useful insights to perform a bigger assessment next fall 2015.

Supporting Evidence-Based Change (Use of Findings): At the first departmental meeting in fall 2015, the results from the small pilot will be presented to faculty in order to receive their input and guide our next steps.

Success Factors: One of the biggest success factors thus far is the increased awareness of assessment among our faculty. There have been several discussions to narrow down the scope of our assessment and to find a good question to answer. These discussions are expected to continue into the fall of 2015. This was the first semester in our department with unit-level assessment activities, and there was not a previous assessment framework. Alongside the assessment tool, necessary forms such as student and faculty volunteer instructions as well as informed consent statements were also developed. This will be refined and used in future departmental assessments.

Recommendations: Recommendations for our next steps will be given based on the analysis of the results from the small pilot assessment and upcoming faculty discussions. This analysis will be presented to faculty at the first department meeting in fall 2015.

Mathematics Appendix A: Pilot Assessment Tool



Pilot Assessment Math 207

1. The derivative of a function $f(x)$ is

$$f'(x) = x^2 - 5x + 6.$$

(a) Solve the equation $x^2 - 5x + 6 = 0$ to find all the critical numbers of $f(x)$.

(b) Find the intervals where the graph of the function $f(x)$ is increasing and decreasing.

(c) Sketch the graph of $f(x)$ on the xy-plane below. Label all the critical numbers on the x-axis. Do not try to find any other values.

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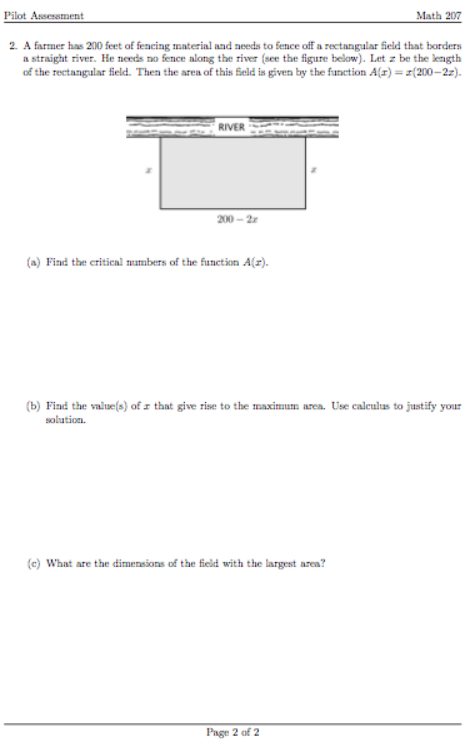

Pilot Assessment Math 207

2. A farmer has 200 feet of fencing material and needs to fence off a rectangular field that borders a straight river. He needs no fence along the river (see the figure below). Let x be the length of the rectangular field. Then the area of this field is given by the function $A(x) = x(200-2x)$.

RIVER

x x

$200 - 2x$

(a) Find the critical numbers of the function $A(x)$.

(b) Find the value(s) of x that give rise to the maximum area. Use calculus to justify your solution.

(c) What are the dimensions of the field with the largest area?

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Mathematics Appendix B: Scoring Rubric

Score	Criteria
3	Conceptual understanding apparent; consistent notation, with only an occasional error; logical formulation; complete or near-complete solution/response.
2	Conceptual understanding only adequate; careless mathematical errors present (algebra, arithmetic, for example); some logical steps lacking; incomplete solution/response.
1	Conceptual understanding not adequate; procedural errors; logical or relational steps missing; poor response or no response to the question posed.
0	Does not attempt problem or conceptual understanding totally lacking.

Source: Emert, John W., and Charles R. Parish. "Undergraduate Core Assessment in the Mathematical Sciences." *MAA Notes* 49 (1999): 46-48. Print.