

Math Placement at Pacific Lutheran University

The Art of Matching Students to Math Courses

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- But only somewhat – $R_{adj}^2 \approx 0.25$.

Why have a placement process?

- Appropriately placed students have a better understanding of how our math courses sequence.
- Appropriately placed students have an improved academic experience.
- Appropriately placed students are less likely to waste time and tuition.
- Appropriately placing students leads to more uniform abilities in classes which improves both the learning experience and the teaching experience.

PLU – Who we are:

- Private, suburban, regional, Lutheran affiliated
- Selective liberal arts college plus three professional schools
 - Business (BA, MBA)
 - Nursing (BSN,MSN)
 - Education (BA, MA, Certification)
- 3000 undergraduates
- 750 - 800 freshmen and transfers per year
- All undergrads except those placing at or above multivariable calculus participate in math placement.
- Placement window is enforced by flags in the computer registration system.

The Possible First Courses

- Math 105 & 107 – Math enrichment for the *math challenged*
 - Meet general university math requirement only
- Math 115 – College Algebra & Trigonometry
 - Precursor for all higher numbered math courses
- Math 123 – Mathematics for Elementary Ed Majors
 - Math required to teach grades K-8 from a pedagogical point of view
- Math 128 – Math for Business
 - The default required math course for School of Business
 - lines, linear systems, basic interest theory, a *little bit* of calculus
- Math 140 – Precalculus
 - The default required math course for the Natural Sciences
- Math 151 – Calculus I (limits, derivatives) = AP AB
- Math 152 – Calculus II (integration, infinite series) = AP BC
- Math 253 – Multivariable Calculus (repeat I & II in 3D)

Something is missing!

PLU does NOT offer Algebra 1.

Students *who do not qualify for Math 115 or higher but who need to take Math 123 or a higher numbered course* must go to a community college for Algebra 1 (also known as Math 99).

The Placement Inputs

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- Student answers to math background questions
- Divine inspiration (We are Lutherans!)

The Placement Exam

- Traditional algebra and trigonometry
- Multiple choice questions with distractors
- Static (no randomization)
- Calculators are not supposed to be used
- On-line, not proctored

The Math Background Questions

All question responses from pull-down menus

- Last math course taken (or taking)
- Grade earned/anticipated in last math course
- How recently last course was taken
- How much trig (none, less than a semester, a semester, more)
- How much calculus (none, a semester or less, a year, more)
- Type of calculus (AP/lower IB, BC/higher IB, neither)
- AP exam taken (AB, BC, none)
- Anticipated major (STEM, business, various other categories)
- Self-placement in a first course
- Gender, age, comfort level with math

The Placement Outputs

The output from the model is a predicted grade (4 point grade scale) for each possible first course.

What the Placement Director sees:

- HS GPA, SAT Math and SAT Verbal (but NOT AP exam scores)
- Student answers to survey questions
- Weighted placement exam score for each possible first course (Math 115 through Math 152)
- Predicted Grade for each possible first course (Math 115 through Math 152)

What the student sees

- A list of courses for which they are eligible
- A personalized placement statement
- Contact information for Math Placement Director
- In the future: A statement that if a student believes his or her performance on the exam was not representative, then that student should review algebra and/or trigonometry, and retake the math placement exam after waiting at least 48 hours.

What the student sees (sample statements)

- "Eligible for Math 105 and Math 107 (Gen. Univ. Req. ONLY). If your goal is a higher numbered math course, please take an appropriate algebra course at a community college, and then retake the math placement exam."
- "Eligible for Math 105 and Math 107 (Gen. Univ. Req. ONLY). If your goal is a higher numbered math course, please start with Math 115."
- "Eligible for Math 123 (for elementary ed majors only), Math 128 and Math 140; choice depends on interests and major."
- "Eligible for Math 123 (for elementary ed majors only) and Math 128. Eligible for Math 151 (calculus I); for stronger preparation, start with Math 140 (Precalculus)."

- (For a student who indicates Business as their intended major)
"Eligible for Math 128 and Math 151. Note that the School of Business recommends that students take Math 151 rather than Math 128 if they are eligible to do so."
- "With a year of AP AB calculus, you should be ready for Math 152 (Calculus II). If believe that you need to repeat Calculus I (Math 151) due to a low AP exam score or for some other reason, please contact the math placement director with an explanation of why."
- "With a year of AP AB school calculus and strong placement exam scores, you should be ready for Math 152 (Calculus II). If you have studied techniques and applications of integration (integration by parts, trig substitutions, arc length, volumes of rotation, improper integrals) and infinite series (convergence and divergence, geometric series, power series, Taylor polynomials), then you should be ready for Math 253 (multivariable calculus)."

- (For a student who inappropriately self-places into Math 105 or 107)
"You are NOT eligible for Math 105 and Math 107. Eligible for ... "
- (For a student who reports a year of calculus but no trigonometry):
"Eligible for Math 152 (Calculus II); if you have had no trigonometry (triangle relationships, sines, tangents, trigonometric identities), please start with Math 140 (Precalculus)."
- "Your math placement exam score is inconsistent with a reported grade of X in *Course Y*. We recommend that you briefly review algebra and then retake the math placement exam. Your current placement is ... (usually Math 115 or Math 140)."

Model Fitting – The Placement Exam Score

- Five years worth of course grades and placement exam question response data are used to calibrate the models.
- One model for Math 115/123/128, one model for Math 140, one model for Math 151/152
- Multiple regression on student answers for each question versus earned grade in course
- Colinearity means raw results have numerous negative correlations between correct question answers and high grades in course
- Bayesian adjustment so that all question weights in model are nonnegative and in range 0 - 3
- Maximum placement exam score is an integer about 70
- Minimum desirable placement exam score should be at least 20

Model Fitting – The Predicted Course Grade

- Five years worth of course grades and placement data are used to calibrate the models.
- Separate models for Math 115/123, Math 128, Math 140, Math 151, Math 152
- Soft cutoff scores (Placement is an art, not a science.)
- Multiple regression on predictors versus grade earned in course
- Primary models use *all* of HS GPA, Math SAT, placement exam score plus more
- Secondary models for missing data (no HS GPA, no Math SAT, neither HS GPA nor Math SAT)
- Primary models have R_{adj}^2 values of roughly 0.20 to 0.25
- Some gender and age effects but gender and age not used in primary models.

- Not all students understand that they can study and retake the placement exam.
- Placement exam typically taken late April through and mid June by incoming freshmen.
- Student advising and registration for incoming students occurs in June and is contemporaneous with AP calculus reading period.
- Not all students take their first math course in the fall or even within the first year.
- Cost reduction

Future Refinements

- Messages clarifying that students can review and retake the math placement exam
- Some way of incorporating AP exam scores (especially negatively for low AP exam scores)
- Expiration date – results expire 18 months after student takes exam if student has not already started a math course.
- Survey of student satisfaction with placement system and placement results
- Coordination with gateway exams being developed for the calculus courses and possibly in precalculus
- Consideration of an external placement exam - Aleks, MAA/Maple, other - to replace internal exam

Costs and who pays them

- The math placement director receives one course of release time annually.
- Director duties include:
 - 750 - 800 individual placements
 - Handling all questions and challenges from students and parents
 - Working with academic advising staff and helping to train faculty advisors
- PLU computing services maintains the databases and online exam system.
- Recalibrations (roughly every five years) cost approximately two summer course equivalents.
- Cost of adoption of an external exam currently exceeds quintennial recalibration costs.

Thank you!

The paper will be available on the author's website:

<http://www.plu.edu/~stuartjl/>

Just Google: "Stuart" AND "Placement Talk" AND "PLU"