What impact do high school mathematics curricula have on college-level mathematics placement?

James Wollack
Michael Fish
UW Center for Placement Testing
# Math Background Survey

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4 groups

• Reform
  – Without Calculus (N = 1808)
  – With Calculus (N = 395)

• Traditional
  – Without Calculus (N = 10,564)
  – With Calculus (N = 4,669)
Percentages Correct

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## Average Placement Scores

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<td>498</td>
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<tr>
<td>Trad w/ Calc</td>
<td>672</td>
<td>643</td>
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- All Math Placement Scores have an average of 500 and a standard deviation of 100
  - Traditional w/ Calc group scored 1.4 standard deviations (141 points) higher than Traditional w/o Calc.
- No noticeable difference in standard deviations across groups
  - All approximately equal to 100.
## Percentages Placing at Each Level

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<tr>
<th></th>
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<th>College Alg/Precalc</th>
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Roughly Similar Percentages for Levels 2 - 9
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Nearly double remedial placements under Reform w/o Calculus
Nearly double calculus placements placements under Trad w/o Calculus
## Percentage Placing at Each Level

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Significantly higher percentage of calculus placements under Traditional w/ Calculus
Purpose

• Purpose of this study is to better understand the relative strengths and weaknesses of different curricula with respect to specific math concepts measured by the placement test.
Characterizing Item Performance

\[
c_i + (1 - c_i) \times \frac{1}{1 + \exp(-a_i(\theta_j - b_i))}
\]

- \(a_i\): discrimination for item \(i\)
- \(b_i\): difficulty for item \(i\)
- \(c_i\): lower asymptote for item \(i\)
- \(\theta_j\): is achievement level for person \(j\)

Overall Math Placement Test Achievement

Prob of Correct Response
Differential Item Functioning

• One of the measurement assumptions is that the item characteristic curve (ICC) is identical for different subgroups of examinees.

• When the ICC is different for different subgroups for the same item, the item is said to function differentially.

• ICCs may be plotted for different subgroups and the differences may be studied to form hypotheses about why and where differences exist.

• Here, we examined differences in math placement test characteristics between groups of examinees, based on the type of HS math curriculum they reported.
Example of Typical Item Without DIF

Item 55: Trigonometry Application

Overall Math Placement Test Achievement

Prob of Correct Response

Relatively Easier

Relatively Harder

prop

.35
.55
.40
.66
Differential Item Functioning

Item 53: Evaluating Functions

Overall Math Placement Test Achievement

Prob of Correct Response

Relatively Easier

Relatively Harder

Reform w/o Calc
Reform w/ Calc
Trad w/o Calc
Trad w/ Calc

prop
.35
.76
.44
.88
Item 70: Trigonometry Identities

Prob of Correct Response

Overall Math Placement Test Achievement

Relatively Easier

Relatively Harder

Reform w/o Calc
Reform w/ Calc
Trad w/o Calc
Trad w/ Calc

prop
.33
.54
.38
.63
Item 71: Find inverse of function

Relatively Easier

Relatively Harder

Overall Math Placement Test Achievement

Prob of Correct Response

prop

.25

.65

.28

.72
Design

• Estimated DIF curves for each of the 75 items on the test
• Examined the test content/test objectives for the items showing the most DIF
• Analyzed patterns of items showing DIF to identify sets of thematically similar items.
• Repeated a DIF analysis for each of these subgroups
Simplify Questions

Expected # Correct vs Math Placement Score

- Reform w/o Calc
- Reform w/ Calc
- Trad w/o Calc
- Trad w/ Calc

prop
0.36
0.64
0.44
0.75
Expected # Correct

Math Placement Score

Reform w/o Calc

Reform w/ Calc

prop

.36

.64
Geometry of Triangles Questions

![Graph showing expected # correct vs math placement score for different teaching methods.]

- Reform w/o Calc: .42
- Reform w/ Calc: .66
- Trad w/o Calc: .48
- Trad w/ Calc: .69
Exponentials & Logarithms Questions

Expected # Correct

Math Placement Score

prop

.19

.43

.21

.49
Trigonometry Identities Questions

- Reform w/o Calc
- Reform w/ Calc
- Trad w/o Calc
- Trad w/ Calc

Expected # Correct

Math Placement Score

prop

.29
.52
.35
.61
Math Placement Score

Trigonometry Identities Questions

Expected # Correct

Reform w/o Calc
Reform w/ Calc

prop
.29
.52
**Understanding Trig Questions**

- **Math Placement Score**
- **Reform w/o Calc**
- **Reform w/ Calc**
- **Trad w/o Calc**
- **Trad w/ Calc**

- **prop**
  - .41
  - .66
  - .46
  - .73
Functions Questions

![Graph showing expected number of correct responses as a function of Math Placement Score for different courses: Reform w/o Calc, Reform w/ Calc, Trad w/o Calc, Trad w/ Calc. The graph includes a legend with prop values: Reform w/o Calc = .29, Reform w/ Calc = .68, Trad w/o Calc = .35, Trad w/ Calc = .75.]
Advanced Algebra Questions

Math Placement Score

- Reform w/o Calc
- Reform w/ Calc
- Trad w/o Calc
- Trad w/ Calc

prop
- .35
- .63
- .41
- .71
Summary

• Generally only very small differences between comparable Traditional and Reform groups, after accounting for overall achievement differences
  – Implication is that MPT is fair as a tool for assessing undergraduate math readiness, regardless of HS curriculum.
  – Traditional groups outperformed Reform groups by 7-8% overall and within each of the three subscores.

• Reform w/ Calc versus Reform w/o Calc showed biggest differences
  – Exp. & Log
  – Trig Identities
  – Functions
  – Advanced Algebra
Case Study: Nekoosa High School Study

• Study examined the change over time in
  – ACT-Math scores
  – UW Math Placement Test scores
    • Math Basics, Algebra, Trigonometry
  – Actual math placements (using UW-SP math algorithm)
    • Remedial Math
    • Intermediate Algebra
    • College Algebra / Trigonometry
    • Calculus
Participants

• Nekoosa High School students who
  – graduated between 1998 and 2007
  – graduated in the top 50 of their HS class
  – subsequently took the UW Math Placement Test
• 283 of the 500 students (56.6%) met the eligibility criteria
  – Annual sample sizes: 25 – 32
Curricula Studied

• Graduating years
  1998 – 2001
    • Purely traditional math
      – Introductory algebra through pre-calculus
  2002 – 2003
    • Dual track, including both traditional math and Core Plus math
  2004 – 2007
    • Purely Core Plus math
    • CORE I through CORE IV

  – AP-Calculus was adopted by school for 2000-01 school year
    • Available to a few traditional kids, but mostly CORE Plus students
Percentage Placing at Each Math Level

Nekoosa Math Level

UW–System Math Level

Percentage Placing into each Level

- Remedial
- Int Alg
- Col Alg / Trig
- Calculus
Nekoosa Longitudinal Trends in Calculus vs. Remedial Placement

[Graph showing trends in placement percentages for Remedial Math, Calculus, Statewide Remedial, Statewide Calculus, and Nekoosa Transition Years from 1998 to 2007.]
Nekoosa Longitudinal Trends in ACT-M Scores

Nekoosa ACT-M
Nekoosa ACT-M Trends
Wisconsin ACT-M
National ACT-M
Nekoosa Transition Years

Year
Placement Percentage
### Percentages of Students Placing at Each Level and Average ACT-M Scores by Math Curriculum

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Percentages of Students Placing at Each Level and Average ACT-M Scores by Math Curriculum

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Major Findings

- CORE-Plus students performed significantly less well on math placement test and ACT-M than did traditional students.
- Change in performance was observed immediately after switch.
- Score trends throughout CORE-Plus years actually decreased slightly:
  - Inconsistent with a teacher learning-curve hypothesis.
- CORE-AP students fared much better, but not as well as the traditional-AP students:
  - Both sample sizes were low.
Limitations / Alternative Explanations

• Placement Test Scores and Placement Algorithms changed in 2002.
  – To the extent that old and new scores/algorithms behave differently, interpretations are clouded
  – We conducted a study to estimate the new scores from the old scores (for students who tested before 2002).
    • Allowed a single placement algorithm to be used for all students

– Reasons for Confidence in Findings
  • Old and new scores were highly correlated
  • Re-analysis provided results that mirrored exactly those from original study
  • ACT-M scores revealed same pattern as placement test scores
Limitations / Alternative Explanations

• Teacher Variables
  – Staffing changes
  – Teacher experience/quality
  – Familiarity with CORE-Plus

• Student Variables
  – How much and when was math taken
    • 4-years of math: 79% CORE-Plus, 77% Traditional
  – Can’t control for quality of student who attended a UW campus

• School Variables
  – Declining enrollment
    • Slightly easier to rank in top 50 during CORE Plus years
  – Incoming quality and the effect of middle-school curricula
  – Changing demographics
Data Availability for Other Districts

• The Center for Placement Testing has begun to provide placement data to schools/districts (for most recent year) on a request basis
  – Resources for collaborations on a larger study are limited, but will be offered as possible
    • Please ask
Information Exchange

- Schools / Districts will need to provide the Center with an electronic file (ASCII or Excel) containing
  - Merge information
    - Students’ (legal) names
    - Birthdates
  - Any other information to analyze
    - Highest math course
    - Years of language study
    - Class rank
- Center will provide
  - Summary statistics
    - Number of students testing, average score, and standard deviation
  - Histogram of placement scores (or subscores for math)
  - Table of placement decisions
  - Placement score breakdowns for extra information
Data Availability for Other Districts

• Contact information

General info or to request a report
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About a possible collaboration
Jim Wollack
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608-262-0675

UW Center for Placement Testing
1025 W. Johnson St., #373
Madison, WI 53706
• Powerpoint slides for this presentation are available at
  http://www.testing.wisc.edu/conference_papers.html

• For more information, please contact
  – Jim Wollack, Director
    UW Center for Placement Testing
    (608) 262-0675
    jwollack@wisc.edu