The Quantitative Reasoning for College Science (QuaRCS) Assessment

Quantitative Reasoning for Higher Education: What Does the Research Say? (Session CS 22)
AAC&U Crossing Boundaries: Transforming STEM Education
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In collaboration with: Don McCarthy, Erin Dokter, Sanlyn Buxner and Ed Prather
With support from the NSF Transforming Undergraduate Education in STEM Program
Which quantitative skills are important in STEM?

• Algebra
• Area and Volume
• Calculus
• Dimensional Analysis and Unit Conversions
• Error, Precision, Accuracy
• Estimation
• Exponents and Logarithms
• Geometry and Spatial Reasoning
• Interpret Graphs
• Interpret Tables
• Linear and Exponential Growth
• Measurement

• Percent and Percent Change
• Plotting/Making Graphs
• Probability, Odds, Risk
• Proportional Reasoning
• Scientific Notation
• Significant Figures
• Simple Operations (+/-/x/÷)
• Statistics
• Using Numbers in Written Work

In Life??
STEM Educator Survey

Perceived Importance of Various Quantitative Skills by Astronomy/Math Educators

Astronomy Educators (N=19)
Math/Numeracy Educators (N=29)

- Science Literacy
- Savvy Consumer/Citizen
- Average (Included in Assessment)
- Average (Not included)
Your cable bill is $36 per month from January 1 through September 30 and then doubles to $72 per month starting October 1. What is your average monthly bill over the course of the entire calendar year (January-December)?

### Number of Injuries by Ability Level for Skiers at Resort Y in the Years 2000-2010

<table>
<thead>
<tr>
<th>Level of Expertise</th>
<th>Total Visitors</th>
<th>Number of Minor Injuries</th>
<th>Number of Severe Injuries</th>
<th>Number of Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novice</td>
<td>12,152</td>
<td>384</td>
<td>122</td>
<td>1</td>
</tr>
<tr>
<td>Intermediate</td>
<td>9,498</td>
<td>96</td>
<td>65</td>
<td>0</td>
</tr>
<tr>
<td>Expert</td>
<td>802</td>
<td>11</td>
<td>16</td>
<td>5</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>22,452</strong></td>
<td><strong>491</strong></td>
<td><strong>203</strong></td>
<td><strong>6</strong></td>
</tr>
</tbody>
</table>
Score Distribution

QuaRCS Score Distribution for General Education Science Students

N=1480
Mean=13.8
Median=13.0
Std Dev=5.3
**Correct Answer Confidence**

- Very Confident
- Confident
- Not Very Confident
- I guessed

**Incorrect Answer Confidence**

- Very Confident
- Confident
- Not Very Confident
- I guessed

**Graphs**

- The left graph shows the percentage of correct answers with confidence levels.
- The right graph shows the percentage of incorrect answers with confidence levels.

**Legend**

- NOVICE
- EXPERT
Attitude Questions

• Basic demographics: race, gender, age, disability status
• Academic demographics: class, major, most recent math course, intended math/science coursework, reason for choosing course/major
• Attitudes/perceptions about numbers, graphs and mathematics
Basic Demographics

Assessment Score By Race

- African American (N=150)
- Asian (N=912)
- Caucasian Hispanic (N=369)
- Native American (N=37)
- Other (N=53)

Assessment Score By Gender

- Men (N=693)
- Women (N=777)

Assessment Score By Disability Status

- Physical Disability (N=39)
- Cognitive Disability (N=35)
- Learning Disability (N=109)
- Prefer Not to Specify (N=161)

Assessment Score By Age

- 18-25 (N=142)
- 26-35 (N=42)
- 36+ (N=16)
Academic Demographics

Assessment Score By Major

Assessment Score By Class

<table>
<thead>
<tr>
<th>Major</th>
<th>QuaRC Score</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humanities (N=91)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Sciences (N=123)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education (N=93)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EMC (N=94)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health Fields (N=92)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Journalism (N=32)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undecided (N=106)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Class</th>
<th>QuaRC Score</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshmen (N=600)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sophomores (N=431)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Juniors (N=237)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seniors (N=190)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (N=20)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Attitudinal Correlations

Assessment Score By Level of Agreement with Statements

- I feel confident using numbers in my non-math courses: $R=0.98$
- I feel confident using numbers in my daily life: $R=0.99$
- Numerical skills are important to the understanding of science: $R=0.96$
- Numerical skills are important in my daily life: $R=0.99$

Assessment Score By Opinions About Doing Mathematics

- Interesting to Boring: $R=0.98$
- Useful to Useless: $R=0.99$
- Easy to Hard: $R=0.98$
- Fun to Scary: $R=0.94$
Self-Reported Effort

Knowing that this survey is being used for research to try to improve courses like yours and that your answer to this question will not be shared with your instructor, please honestly describe the amount of effort that you put into this survey.

a) I just clicked through and chose randomly to get the participation credit
b) I didn’t try very hard
c) I tried for a while and then got bored
d) I tried pretty hard
e) I tried my best on most of the questions
Assessment Score By Effort

Explains 29% of variation in QuaRCS score
Scores by Effort

QuaRCS Score Distribution for General Education Science Students

N=1480
Mean=13.8
Median=13.0
Std Dev=5.3

N=697
Mean=16.6
Median=17.0
Std Dev=4.8
<table>
<thead>
<tr>
<th>Class 1 (N=145,122)</th>
<th>Classes 2&amp;3 (N=42,28)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Adjective</strong></td>
<td><strong>Pre to Post</strong></td>
</tr>
<tr>
<td>Interesting</td>
<td>5.66%</td>
</tr>
<tr>
<td>Useful</td>
<td>2.72%</td>
</tr>
<tr>
<td>Useless</td>
<td>-1.09%</td>
</tr>
<tr>
<td>Boring</td>
<td>-4.19%</td>
</tr>
<tr>
<td>Hard</td>
<td>-3.11%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Classes 4,5 &amp; 6 (N=72,30)</th>
<th>Class 7 (N=416,336)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Adjective</strong></td>
<td><strong>Pre to Post</strong></td>
</tr>
<tr>
<td>Interesting</td>
<td>-9.94%</td>
</tr>
<tr>
<td>Useful</td>
<td>-2.43%</td>
</tr>
<tr>
<td>Useless</td>
<td>1.07%</td>
</tr>
<tr>
<td>Boring</td>
<td>10.38%</td>
</tr>
<tr>
<td>Hard</td>
<td>0.93%</td>
</tr>
</tbody>
</table>
Conclusions
Thank You!

For More Information:

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www.katefollette.com/QL

Funding

Collaborators
Don McCarthy
Erin Dokter
Ed Prather
Sanlyn Buxner

“Re-Numerate” Newsletter

QuaRCS
Development
ant Validation
Article in
Numeracy