Psychometric Challenges and Opportunities in the Evolution of STAR

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Denny Way, Educational Testing Service

Presentation at the California Educational Research Association
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Overview of Presentation

• Two Presenters (and perspectives):
  – A technical presenter: Denny Way, ETS Director of Psychometrics for STAR and CAHSEE programs
  – Discussant from a content and policy perspective: Bob Anderson, California Department of Education
Overview of Presentation

• Three Presentation Topics
  – Standards-based Test Development: What is the best way to measure rigorous content standards given students at a variety of proficiency levels?
  – Vertical Scaling the CSTs: What are the pros and cons of vertical scales for the CSTs?
  – Linking the Stanford/9 and CAT/6 norm-referenced tests: What are the technical plans for the 2003 STAR?
Overview of the Presentation

• Structure of the presentation
  – Technical information and analyses first
  – Content and policy perspectives next
  – Questions, comments, discussion from the audience
Topic 1: Balancing Content Rigor and Psychometrics in Standards-Based Assessment

• The CSTs are aligned with state-adopted standards that describe what California students should know and be able to do in each grade and content area tested.

• The CSTs report student performance with respect to five performance levels:
  – Advanced, Proficient, Basic, Below Basic, and Far Below Basic.
Topic 1: Balancing Content Rigor and Psychometrics in Standards-Based Assessment (Continued)

- Review of the standards suggests that questions must be sufficiently challenging to appropriately measure the standards.
- Question difficulty can be modified, and questions of varying difficulty can each provide valid measurement of the same content standard.
Analyzing Test Difficulty and Psychometric Characteristics: An Illustrative Study

• “What if” analysis of differences in item difficulty

• Hypothesized a normally distributed student population with “simulated” students at five levels of proficiency

• Used Item Response Theory (IRT) to simulate different test characteristics
  – Level of average item difficulty
  – Variability in item difficulty

• Evaluated the results in terms of errors of measurement and reliability
Characteristics of Three Possible Tests (All Tests with 75 Items)

- A difficult test with few extremely easy or difficult items
- An easier test with a normal range of item difficulties
- An easier test with a wide range of item difficulties
### Characteristics of Three Possible Tests

<table>
<thead>
<tr>
<th></th>
<th>Difficult</th>
<th>Normal</th>
<th>Uniform</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean P-Value</td>
<td>0.46</td>
<td>0.60</td>
<td>0.60</td>
</tr>
<tr>
<td>Std P-Value</td>
<td>0.16</td>
<td>0.18</td>
<td>0.26</td>
</tr>
<tr>
<td>Min P-Value</td>
<td>0.22</td>
<td>0.25</td>
<td>0.22</td>
</tr>
<tr>
<td>Max P-Value</td>
<td>0.80</td>
<td>0.95</td>
<td>0.98</td>
</tr>
</tbody>
</table>
Some Technical Details

• Used 1PL Model with constant guessing parameter of 0.20
• Calculated “score information function” at 31 ability levels from –3.0 to 3.0 by 0.2
• Conditional standard errors equal to the square root of the reciprocal of the score information function
• Simulated 1000 cases and estimated test characteristics (mean, SD, reliability)
Conditional Standard Errors of Three Possible Tests

- **Far Below Basic**
- **Below Basic**
- **Basic**
- **Proficient**
- **Advanced**

**SE of Ability** vs. **Ability**:

- **P=0.46**
- **P=0.60**
- **Uniform**
## Technical Characteristics of three Possible Tests

<table>
<thead>
<tr>
<th></th>
<th>Difficult</th>
<th>Normal</th>
<th>Uniform</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number Items</td>
<td>75</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>Test Mean:</td>
<td>33.56</td>
<td>44.64</td>
<td>44.69</td>
</tr>
<tr>
<td>Test SD</td>
<td>13.47</td>
<td>14.38</td>
<td>10.83</td>
</tr>
<tr>
<td>Reliability:</td>
<td>0.92</td>
<td>0.94</td>
<td>0.90</td>
</tr>
</tbody>
</table>
Topic 1 Conclusions

• Different psychometric characteristics of tests result in errors of measurement at different points of the score scale
• Standards-based tests are challenging to create because it is difficult to measure well at every proficiency level
• Technical test specifications should be set with knowledge of the psychometric implications
Topic 2: Developing Vertical Scales for the CSTs

- Current CSTs have unique scales for each grade and content area
- This means that scores may only be compared for the same grade and content area
- Norm-referenced tests provide vertical scales for comparing student growth, but NRTs do not measure the state content standards
What is a Vertical Scale?

- Also referred to as a “developmental scale”
- Content defines a “developmental continuum” for a particular area
- With developmental scales, tests used in different grades are calibrated against one another
- Developmental scales facilitate the estimation of individual growth and the use of individualized test administration
Example of a Vertical Scale

Grade 2

Grade 3

Grade 4

Grade 5

Grade 6

Grade 7

Grade 8

200 275 350 425 500 575 650 725

<---- Increasing Scores by Grade Level ----->
Issues with Vertical Scales

• Vertical scales are only sensible when the content supports interpretations across levels.
• Scales suggest interpretations that may not be appropriate.
• Vertical scaling differs from test equating in that the linking does not assume parallel forms:
  – Scaling methodology an important consideration.
  – Content dimensionality may have a greater impact.
Vertical Scales and Content Considerations

- Standards more closely aligned across grades:
  - English Language Arts
  - Mathematics from Grade 2 to 7

- Standards less closely aligned across grades:
  - End of Course Mathematics Tests
  - End of Course Science Tests
  - End of Course History and Social Science Tests
What Has to Happen to Produce Vertical Scales for the CSTs?

- Policy decision must be made
- CSTs must include common items across adjacent grades
- New score scales must be defined and technical work to accomplish vertical scaling must be done
- Issues related to within-grade proficiency levels must be addressed
- Could be done as part of 2004 STAR
Topic 3: Linking the Stanford / 9 and CAT / 6 Scales

- Background
- ETS Technical Plans
  - Analyses prior to 2003 STAR administration
  - Analyses as part of the 2003 STAR administration
SAT/9 – CAT/6 Linking Study: Background

- The Academic Performance Index (API) includes contributions from NRT results.
- NRT contributions have decreased over the past three years.
- The API has had increasing contributions from the CSTs and now includes CAHSEE results as well.
Evolution of the API

- **Base 1999 (Growth 2000)**
  - 100% Stanford 9

- **Base 2000 (Growth 2001)**
  - 100% Stanford 9

- **Base 2001 (Growth 2002)**
  - 64% Stanford 9
  - 36% CSTs

- **Base 2002 (Growth 2003)**
  - 29-40% Stanford 9
  - 56-60% CSTs
  - 0-15% CAHSEE

- **Beyond 2003**
  - CST Science and History/Social Science
  - CAPA
  - Attendance Rates
  - Graduation Rates
Any new NRT chosen for 2003 would have required a linking study.

ETS proposal included use of the California Achievement Test, Version 6 (CAT/6).

Linking study is needed to provide concordance between CAT/6 scores and Stanford 9 equivalents in order to calculate the NRT contribution to API growth.
Linking Study Designs

- Two linking study options
  - Direct study where SAT/9 and CAT/6 are administered “together”
  - Indirect study where SAT/9 and CAT/6 scores are linked using CST test scores as an external anchor

- Indirect study chosen because of cost, feasibility, and technical considerations
ETS Technical Linking Plans

- Linking will be done using equipercetile methodology
- CSTs will be used as a common anchor between SAT/9 scores obtained in 2002 and CAT/6 scores obtained in 2003
- Study will have two parts
  - Initial investigations of SAT/9 and CSTs
  - Complete linkings once CAT/6 scores are available
Some Technical Details

• Use of the CSTs in the linking
  – Clearly defined for ELA and grades 2-7 mathematics
  – More complicated for high school math and science tests

• Analyses of subpopulations
  – Provides detail about invariance of the overall linkings
  – Comparisons can include specified subgroups, school districts, and even individual schools
Some Correlation Data for High School Mathematics

<table>
<thead>
<tr>
<th>CST Content Area</th>
<th>Correlation with SAT/9</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Year Integrated Math</td>
<td>0.63</td>
</tr>
<tr>
<td>Algebra I</td>
<td>0.64</td>
</tr>
<tr>
<td>Second Year Integrated Math</td>
<td>0.76</td>
</tr>
<tr>
<td>Geometry</td>
<td>0.77</td>
</tr>
<tr>
<td>Third Year Integrated Math</td>
<td>0.72</td>
</tr>
<tr>
<td>Algebra II</td>
<td>0.75</td>
</tr>
<tr>
<td>High School Summative Math</td>
<td>0.85</td>
</tr>
</tbody>
</table>
Closing Notes on the Linking Study

- ETS technical gurus will provide consultation on linking study analyses
- Initial analyses will be reviewed by CDE and their API advisors
- Final analyses will be completed over the summer after sufficient data from STAR 2003 are available
Further Technical Information

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