

Data Visualization using R

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National Center for the Improvement of Educational Assessment
Dover, NH

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Purpose of today's session

- To learn about R and its capabilities for visualizing data.
- To provide participants with a comprehensive list of resources for producing their own data visualizations.
- To demonstrate the power of programatic drawing over WYSIWYG drawing.
- To inspire participants to develop their own customized visualizations and push the envelope for what is possible

About Me

Dr. Damian Betebenner, PhD

- Senior Associate at the Center for Assessment (NCIEA).
- Developed student growth percentiles and percentile growth trajectories to help states and educational associations employ student growth in decision making [Betebenner, 2008, Betebenner, 2009].
- In the process of refining and sharing these techniques with other states including Colorado, Massachusetts, Arizona, Indiana, and 15 other states in various stages of investigation/adoption.
- Interested in the rise of the data sciences/scientist: Data analysis and data visualization and their use within education. Began using R in 1998.

About the R Software

- R is an GNU open source, free, statistical software environment (package/language) that is available for source compilation or in pre-compiled binary form for numerous operating systems.
- R can be downloaded from CRAN (Comprehensive R Archive Network) <http://cran.r-project.org/>
- The R language has become a *de facto* standard among statisticians for the development of statistical software.
- The philosophy behind R/S (John Chambers): “To Turn Ideas into Software Quickly and Faithfully” [Chambers, 2000, p. v]

About the R Software

Daryl Pregibon, Google

R is really important to the point that it's hard to overvalue it.

- R had a recent New York Times article written about it
<http://www.nytimes.com/2009/01/07/technology/business-computing/07program.html>.
- A particular strength of R is its data visualization capabilities
- The greatest strength of R (in my humble opinion) is the IMMENSE amount of code available online to learn from. Learn from the masters.
- This training session will introduce users to data visualization using R as well as the resources available to continue their explorations.

About Data

Rutherford D. Roger

We are drowning in information [data] and starving for knowledge [information].

- The Economist, February 27th, 2010, devoted a special issue to “The Data Deluge”.
- In 2008, 1,200 exabytes (1.2 ZB) of digital data was created (n.b., giga, tera, peta, exa, zetta, yotta).
- Compound annual increase of data at 60%.
- Petabyte level computing is reaching commodity levels with Amazon EC2/S3 offering specials for petabyte scale projects.

About Data

Hal Varian, Chief Economist, Google

A new kind of professional has emerged, the data scientist, who combines the skills of a software programmer, statistician, and storyteller/artist to extract nuggets of gold hidden under mountains of data. The job of the data scientist will become the sexiest around. Data are widely available; what is scarce is the ability to extract wisdom from them.

- The Data doesn't speak for itself. The data can tell a thousand stories.
- Transforming data into information and ultimately into knowledge requires a broad range of expertise (i.e., the emerging data scientist).
- Goal: The right data to the right people at the right time in the right format!
- To reach this goal subject matter experts **MUST** work more closely with IT specialists, ensuring the right stories are told.

About Data Visualization

- Data visualization leverages the immense capacity of the human eye to extract patterns from visual stimuli.
- Communicating with data is a form of storytelling. Visualization allows the storyteller to communicate more effectively and engage the user in more complicated stories.
- Color, pattern, and symbols can be combined to communicate highly complicated stories that, without pictures, are difficult even for experts to follow.
- As such, data visualization, as communication, is a form of teaching.

About Programmatic Drawing

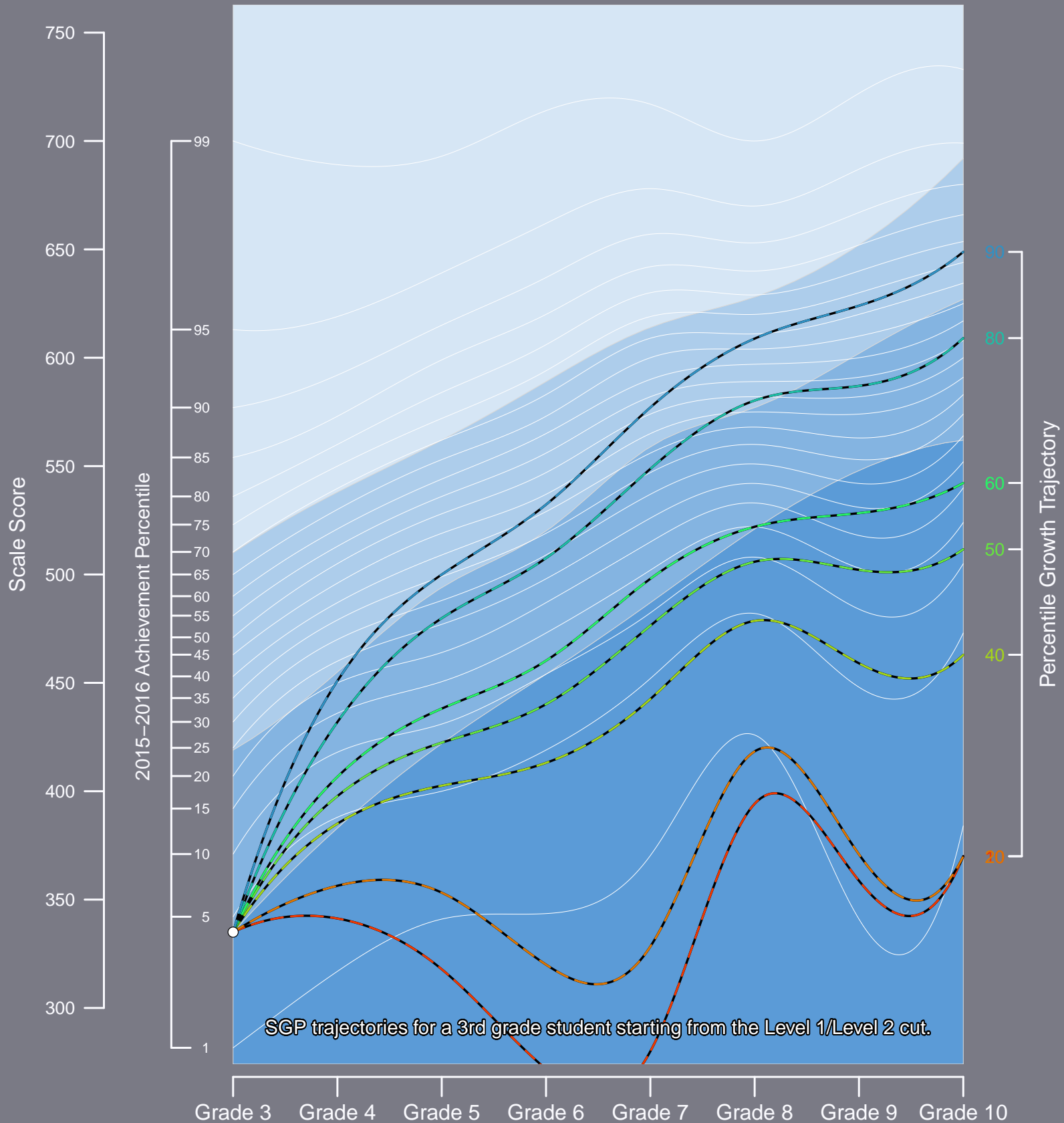
Byron Ellis via Twitter

[R] is for making new things. Point and click is for redoing old things.

- Almost all graphical programs (especially those incorporated in statistical analysis packages) rely upon WYSIWYG interface.
- WYSIWYG pros: Easy to learn. WYSIWYG cons: Limited ability to customize.
- Because of constrained options, WYSIWYG interfaces both dictate and limit the stories you can tell with your data.
- Programming your drawings (i.e., programatic drawing) allows for unlimited possibilities, constrained only by the creator's imagination.

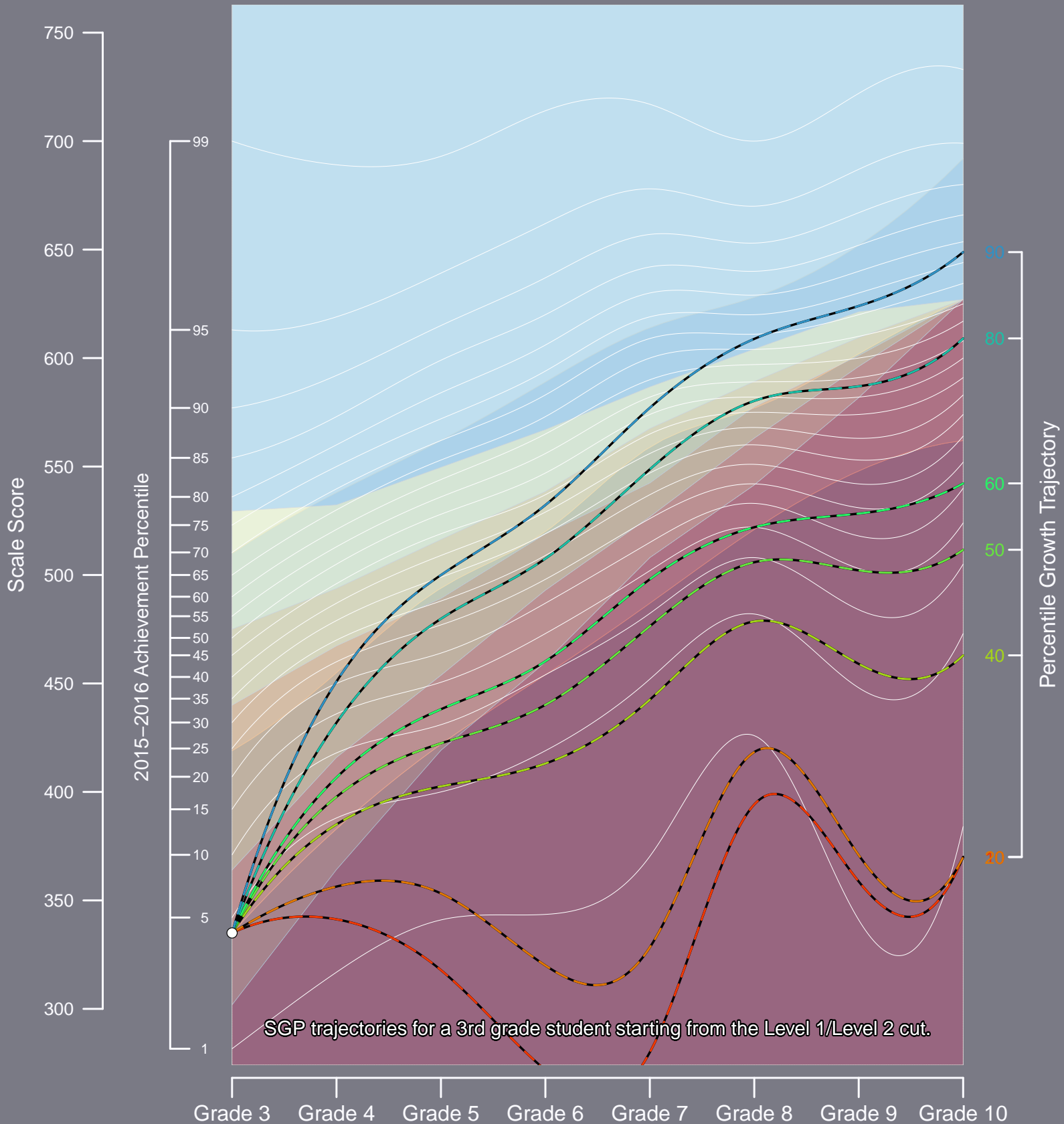
DEMONSTRATION: 2015–2016 Mathematics

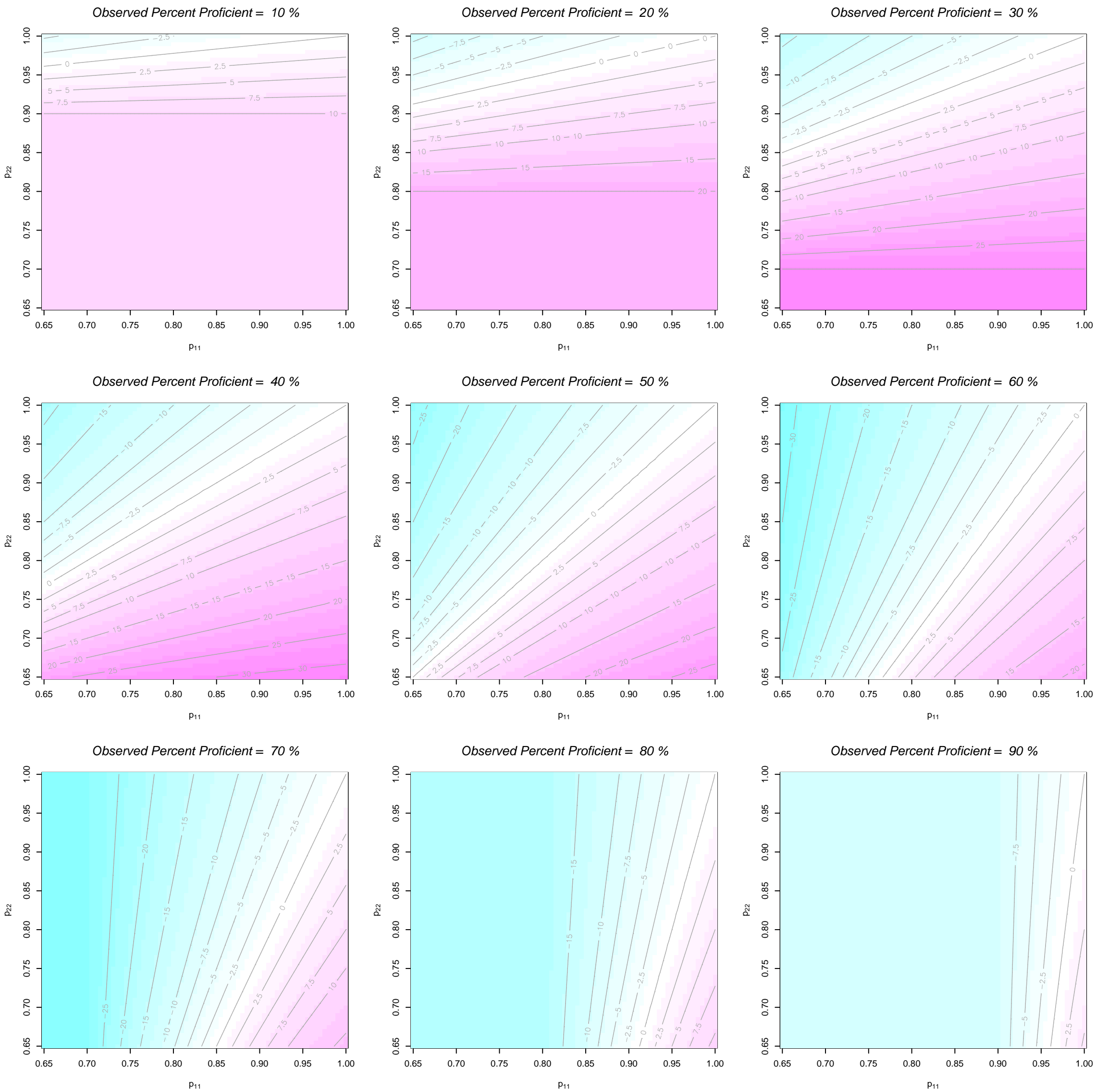
Norm & Criterion Referenced Growth & Achievement



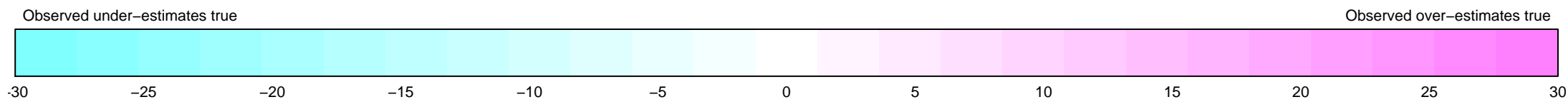
DEMONSTRATION: 2015–2016 Mathematics

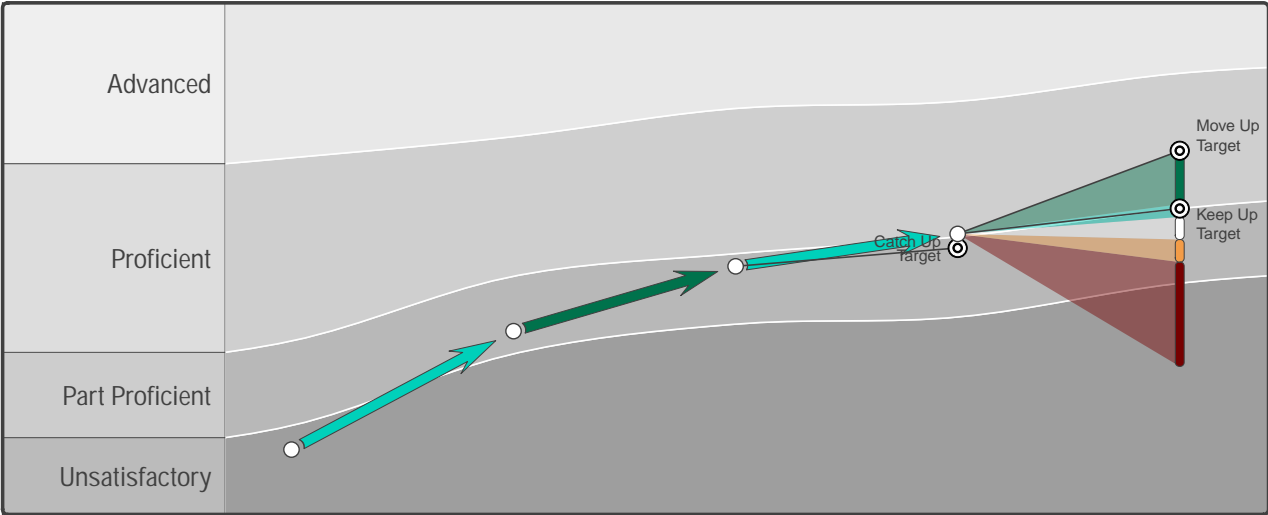
Norm & Criterion Referenced Growth & Achievement





Bias in Observed Percent Proficient (Observed – True)





Reading

Achievement

DEMO Reading Scale Score

Growth


Level	Percentiles
Very High	81st – 99th
High	61st – 80th
Typical	40th – 60th
Low	20th – 39th
Very Low	1st – 19th


Scale Score	449	533	579	602	
Achievement Level	Unsatisfactory	Part Proficient	Part Proficient	Proficient	Proficient (620)/Advanced (661)
Achievement Target					
Growth Percentile	69	85	74		
Growth Level	High	Very High	High		
Growth Target				Catch Up (60)	Keep Up (76)/Move Up (99)

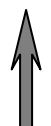
Achievement



Growth

How to interpret this student growth & achievement report

 DEMO Scale Score

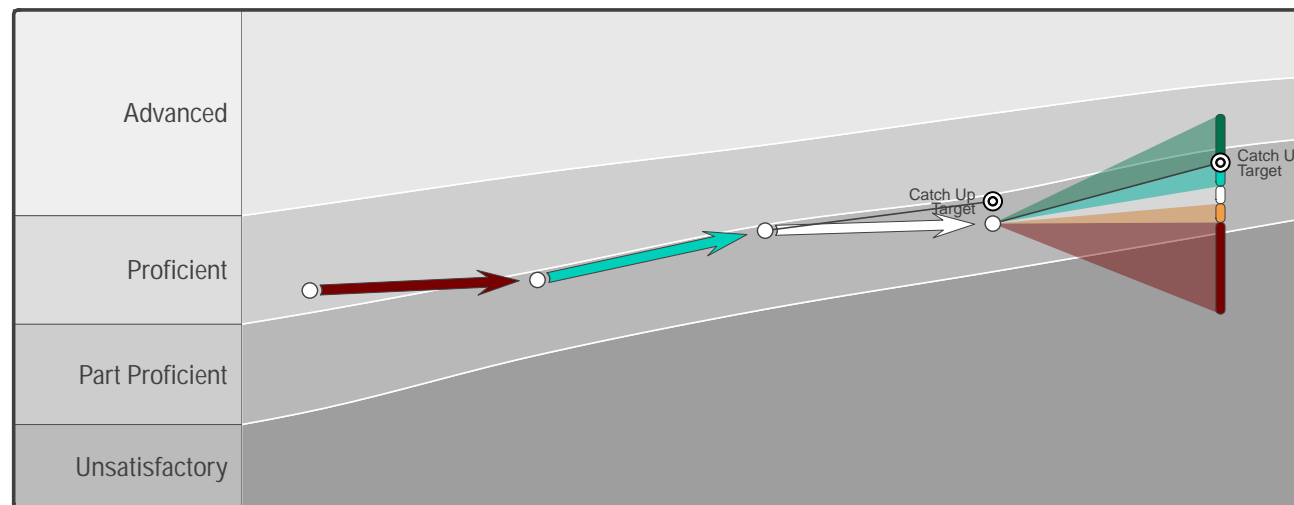
 DEMO Achievement Levels

 Student Growth Percentile

 Catch Up/Keep Up
 Move Up/Stay Up Targets

Suggested Uses

- Review past growth to assess student academic progress toward DEMO achievement goals.
- Develop remediation or enrichment plans based on rate of growth needed to reach higher DEMO achievement levels.
- Identify the rate of progress needed in order to reach or maintain proficient status on the DEMO next year.



Mathematics

Achievement

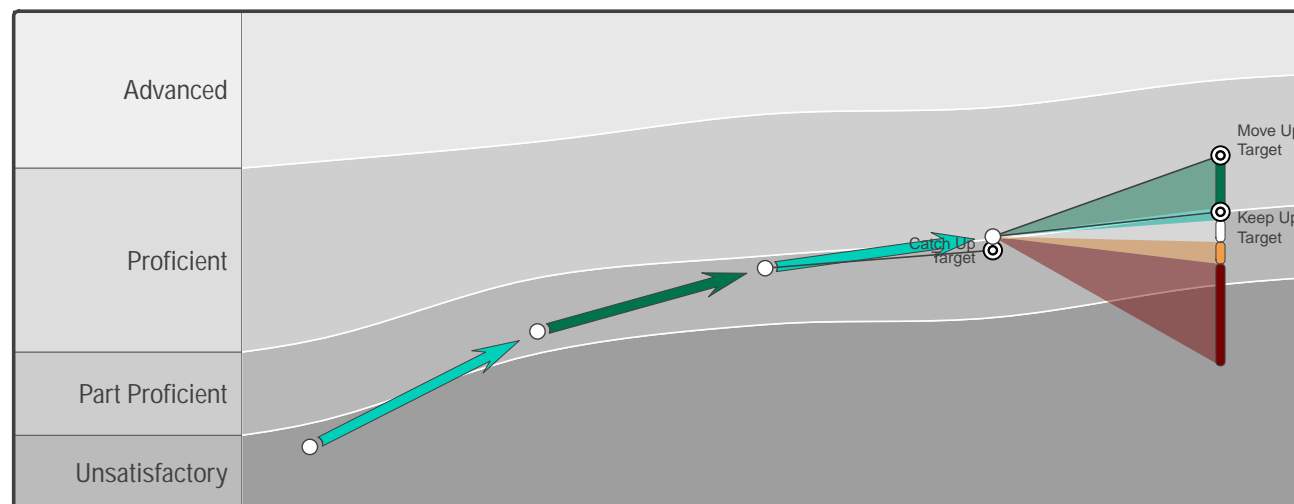
 DEMO Mathematics Scale Score

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Achievement

Growth



Reading

Achievement

 DEMO Reading Scale Score

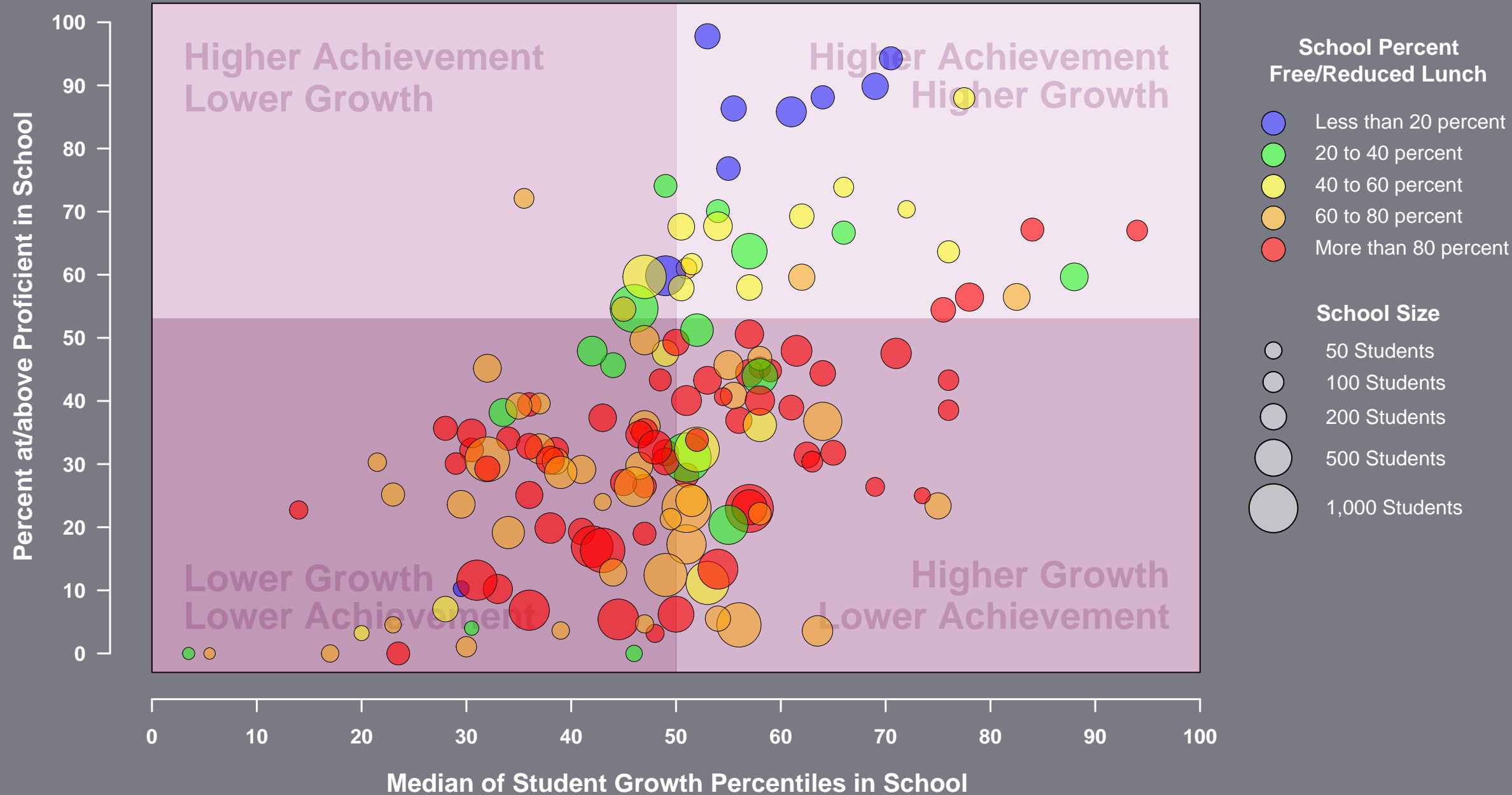
Growth

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Achievement

Growth

District C: 2008 CSAP Math School Results
Student Growth versus Student Achievement by Percent Free/Reduced Lunch



So Many Amazing Resources: Free

- Numerous help manuals installed when R is installed (Under the Help dropdown menu in Windows)
- One can download R and numerous resources at the CRAN (Comprehensive R Archive Network)
<http://cran.r-project.org/>.
- Click on the “Contributed” hyperlink at CRAN to access dozens of free resources in many languages.
- Most resources provide many nuggets of wisdom that proves to be useful. Good places to start include:
 - John Maindonald's *Using R for Data Analysis and Graphics—Introduction, Examples and Commentary*
 - John Verzani's *Simple R*
- R has a very active listserve for R (R-help) that is easy to search using Google and keywords.

So Many Amazing Resources: Free

- The R Graph Gallery. Great examples with source code:
<http://addictedtor.free.fr/graphiques/>.
- Spatial Data and R. Great examples with source code
<http://r-spatial.sourceforge.net/>.
- A four part online video tutorial for using ggplot
<http://blog.revolution-computing.com/2010/03/video-hadley-wickham-gives-a-short-course-on-graphics-with-html>
- Revolution Computing (a company that produces a version of R that cost \$\$\$) has a blog that is REALLY cool:
<http://blog.revolution-computing.com>
- Data Mashups using R. An amazing tutorial (\$4.99 from O'Reilly).

So Many Amazing Resources: Published Books








- The Grid Graphics Package (and traditional graphics overview) [Murrell, 2006]
- Lattice Graphics Package: Depyan Sarkar [Sarkar, 2008].
- ggplot Graphics Package: Hadley Wickham [Wickham, 2009].
- Spatial Data Analysis and Visualization [Bivand et al., 2008].

Inspiration

“A Thing of Beauty is a Joy Forever”

John Keats

References

-  Betebenner, D. W. (2008).
Toward a normative understanding of student growth.
In Ryan, K. E. and Shepard, L. A., editors, *The Future of Test-Based Educational Accountability*, pages 155–170. Taylor & Francis, New York.
-  Betebenner, D. W. (2009).
Norm- and criterion-referenced student growth.
Educational Measurement: Issues and Practice, 28(4):42–51.
-  Bivand, R. S., Pebesma, E. J., and Gómez-Rubio, V. (2008).
Applied Spatial Data Analysis with R.
Springer, New York.
-  Chambers, J. M. (2000).
Programming with Data.
Springer, New York.
-  Murrell, P. (2006).
R Graphics.
Springer, New York.
-  Sarkar, D. (2008).
Lattice: Multivariate Data Visualization with R.
Springer, New York.
-  Wickham, H. (2009).
ggplot2: Elegant Graphics for Data Analysis.
Springer, New York.