What is the Power Law Formula for standards-based grading?

An internet search for “Power Law Formula” results in hundreds of listings in a wide variety of fields including astronomy, meteorology, and engineering. In his highly regarded book TRANSFORMING CLASSROOM GRADING, Robert J. Marzano describes the use of this formula for standards-based grading. The math behind the power law formula is quite complex (see below), but all that’s necessary for its use is that you know what it does, how to interpret its scores, and when best to use it.

In essence, the power law formula predicts what the student’s next score will be based on scores already present. It can be thought of as a mathematical calculation that answers the question: “If the student were assessed right now on a skill, at what level would the student likely perform?” Since a student’s grade on a standard is meant to be an indication of skill at a certain moment in time, the power law formula can be used to calculate standard grades.

To gain an understanding of how the power law works, let’s look at sets of student scores and the power law calculation of each set. To keep things simple, let’s say there are four assessments and four students and each student has earned the same scores 1.00, 2.00, 3.00 and 4.00, but in a different order. If we were to simply average the four scores, all students would receive a 2.50. However, with the power law, we’ll get different values because the power law puts more weight on recent assessments. Let’s take a look:

<table>
<thead>
<tr>
<th>Student</th>
<th>Assessment #1 (least weight)</th>
<th>Assessment #2</th>
<th>Assessment #3</th>
<th>Assessment #4 (greatest weight)</th>
<th>Power Law Score</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>1.00</td>
<td>2.00</td>
<td>3.00</td>
<td>4.00</td>
<td>4.00</td>
<td>The scores show continuous improvement. The student will likely demonstrate mastery on the next assessment.</td>
</tr>
<tr>
<td>#2</td>
<td>1.00</td>
<td>3.00</td>
<td>2.00</td>
<td>4.00</td>
<td>3.66</td>
<td>The scores show irregular improvement. The student will likely demonstrate high but not complete mastery on the next assessment.</td>
</tr>
<tr>
<td>#3</td>
<td>2.00</td>
<td>4.00</td>
<td>1.00</td>
<td>3.00</td>
<td>2.16</td>
<td>The scores show very uneven performance. The student will likely demonstrate a mid-level of achievement on the next assessment.</td>
</tr>
<tr>
<td>#4</td>
<td>4.00</td>
<td>3.00</td>
<td>2.00</td>
<td>1.00</td>
<td>1.28</td>
<td>The scores show continuous decline. The student will likely demonstrate a low level of achievement on the next assessment.</td>
</tr>
</tbody>
</table>

As you can see, the power law formula can result in more meaningful values than averaging. Should it then always be used? No! The power law formula is best used on narrowly defined standards (i.e. Subtraction of mixed numbers with borrowing). Avoid its use with broadly written standards that consist of multiple skills – the results will be less meaningful.

For those with the inclination, here’s the power law formula used by Impact where x is the ordinal number of the score, s is the score and N is the number of scores with all scores in date order:
Options for Calculating Mastery in JumpRope

JumpRope has several options to mathematically calculate mastery for each student and standard / learning target. We believe that there is merit to each strategy, and we choose not to legislate in our software. Rather, we give each teacher the ability to pick the calculation type for every standard, and we give schools the ability to pick a default calculation type.

1. **Weighted Average**: This calculation type takes an average of all assessments for each student on each learning target. If teachers assign a weight to an assessment, this will incorporate the appropriate weight when calculating the average. This method is the easiest to understand, since it is close to traditional grading systems.

2. **Max Value**: This calculation type simply takes the highest score ever achieved by each student on each learning target. In this way, the highest level of mastery ever demonstrated is what is considered the final level of mastery on a standard. It works well if teachers are only using robust summative assessments of learning within the JumpRope system, but breaks down if scores are entered for e.g. formative assessments.

3. **Power Law**: This calculation type is based on research on cognitive development. It is a time-based average, and automatically adjusts assessment weights to give higher weight to the more recent assessments. In this way, it more closely represents true student learning progress. However, it is more difficult for students to understand or teachers to predict because the formula is very complex. If you're interested and mathematically-inclined, we'd love for your input on the power law's exact algorithm, check out the details on the reverse side of this page.

4. **Most Recent**: This calculation type carries the most recent assessment score achieved, based on the date assigned to the assessment (rather than the date the score was entered). As with Max Value, this works best when all assessments are robust or when a final assessment is guaranteed to be robust.

5. **Decaying Average**: This calculation type assigns progressively-decreasing weights to older assessments. Working backwards, each assessment is worth 66.667% of the teacher-assigned weight, compounded exponentially. In effect, newer assessments automatically "count more" in the overall score. Teacher weights still apply.

More information on how JumpRope calculated mastery can be found here:

http://goo.gl/aNx3kl