Quantitative Reasoning Learning Progression: Rasch Analysis

Robert Mayes (Georgia Southern University)

QR Research Team: Jennifer Harris Forrester (University of Wyoming), Jennifer Schulttfield Christus (University of Wisconsin Oshkosh), & Franziska Peterson (University of Wyoming)

NARST 2015

Abstract

NSF funded Culturally Relevant Ecology, Learning Progressions, and Environmental Literacy Project (DUE-0832173) which we called Pathways established learning progressions for environmental science in grades 6 to 12:

- Quantitative Reasoning (QR) research team studied impact of QR on environmental science
- QR essential for environmentally literate citizen to make data informed decisions.
- More needs to be known about the progression of students’ QR development in STEM

The development of learning progressions requires an iterative research design that explicates the progression of learning over long periods of time. The purpose of this study is to develop and verify a hypothesized learning progression for QR with environmental science as a context.

Research Method

Creating learning progressions (LP) involves grounding the lower anchor in domains accessible to sixth graders. In addition, intermediate levels of understanding need to be identified through which they pass on their way to attainment of the upper anchor. The upper anchor is based on expert views of what QR a scientifically literate citizen should know and be able to do by the 12th grade. This is done through an iterative research process where LP is informed by student interviews and closed-form assessments.

Semi-structured Interview: hypothesized LP was first tested empirically via semi-structured interviews

Closed form assessments: based on interview analysis, 3 closed-form assessment versions for Quantitative Interpretation (QI) were developed, one for each science strand in Pathways (Biodiversity, Carbon, and Water) across three different scales of environmental science (Macro scale - personal experience of the world, Landscape scale - global generalizations, Micro/Atomic scale - hidden mechanisms). These assessments focus on four components of QI that we have identified: trends, predictions, translation, and revision.

Over 500 students from 3 states completed a version of the closed form assessments online using Qualtrics. Rasch Analysis was used to analyze the assessment data, both to improve the assessments and determine QI trends from grade 6 to 12.

The following is an example of a QI assessment item for trends.

Research Questions and Goals

The purpose is to establish a learning progression for QR within the context of environmental science for middle and high school students (8th to 12th grade).

Central research question:

How do students develop QR in the context of environmental science across 6th–12th grade?

Procedural question:

What are the QR progress variables (dimensions of understanding, application, and practice) that support the development of an environmentally literate citizen?

What level of QR within the context of environmental science do students bring to the discourse at the sixth grade level?

What are the key QR conceptual stepping stones to moving from a novice to environmentally literate citizen? How do these inform a QR learning progression?

What are the QR tasks students at a given learning progression level should be capable of performing?

QR Learning Progressions Framework

<table>
<thead>
<tr>
<th>Level</th>
<th>Anchor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4th</td>
<td>Lower</td>
<td>Trends: determine multiple types of trends including linear, power, and exponential trends; recognize and provide quantitative explanations of trends in model representation within context of problem.</td>
</tr>
<tr>
<td>5th</td>
<td>Intermediate</td>
<td>Predictions: makes predictions using covariation and provides a quantitative account which is applied within context of problem.</td>
</tr>
<tr>
<td>6th</td>
<td>Upper</td>
<td>Translation: translates between models; challenges quantitative variation between models as estimations or due to measurement error; identifies best model representing a context.</td>
</tr>
<tr>
<td>7th</td>
<td></td>
<td>Revisions: revise model theoretically without data, evaluate competing models for possible combination (Schwarz).</td>
</tr>
</tbody>
</table>

References


Rasch approach is a modern latent trait model that allows examination of both item statistics and person statistics using the same linear scale. Removed persons were not simply those representing extreme measures, but those representing improbable response patterns relative to item measures and other participants.

Results

• An infit standardized score greater than 2 indicates a suspicious score, either where the odds were too perfectly met (too predictable) or there is too much noise (unpredictable). Mean OK, S.D., Max. Min concerns.
• All three assessments have alpha levels above 0.72 indicating relatively high reliability.
• Item fit statistics, when combined with difficulty and ability measures suggest closer examination of items for revision, as well as breaking up the 96 item administration into shorter sets of items to help increase participant focus.
• Rasch ruler indicates for the biodiversity assessment 14 person measures exceeded all items, indicating they had better than a 50% chance to get all items correct. Person measures are higher than the item measures, a number of item measures do not overlap with person measures on the lower end of the scale, which tends to increase error for both item and person measures.