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Understanding students’ ability to communicate mathematics in developmental mathematics courses

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Introduction

The Developmental Mathematics Program (DMP) consists of three mathematics courses: Pre-Algebra, Algebra I, and Algebra II. The overarching goals of these courses are to provide students with the skills and concepts needed to complete a college-level mathematics class. To help students develop these skills, students are often required to provide written descriptions or explanations of their work. This project focuses on Algebra I students’ abilities to express themselves in writing and how students’ writing progresses over a semester.

Questions

Given the emphasis on writing in Algebra I, both in the class activities and the weekly writing assignments:
- How do students’ writing skills change over the semester?
- How does writing on a homework assignment, in which students have at least a week to polish, compare to responses to exam questions that require writing?
- Is there any correlation between writing ability and success in Algebra I?

Data Collection

Two random samples of Fall 2013 Algebra I student were created. Each sample contained 80 students (about 12% of the population). All writing assignments and exams produced by the students in these two samples were scanned for later analysis.

What to Measure

There are many aspects of mathematical writing that one could try to measure including but not limited to:
- Clarity
- Correctness
- Completeness
- Coherence
- Organization or flow of thought
- Did the response address the question asked

Tackling all of these in one study would be far too overwhelming not only because of the amount of coding but also in terms of the overlap of these measures. In determining what to measure, I thought about tracking individual students and groups of students throughout a semester to look for growth. In terms of growth, I am most interested in clarity and completeness.

What is Clarity?

Clarity is being coded on a scale from 0 to 3 with 0 representing a response that is clear and 3 representing an unclear response or a nonsensical response.

Examples: Student Responses from Writing Assignment 2

WA 2 #6b: Give three other examples of input-output relationships in real life that cannot have negative replacement values for the output variable. Explain why they cannot have negative output values.

S1 More examples of variable that cannot have negative replacement values are dosage of medicine, age, and weight.

S2 time, age, and height

Your height, because you can grow and you can’t have negative height. How many cars you have, because you can have multiple cars, but you can’t have negative cars. How many video games you own, you can’t own a negative amount but you can have multiple.

Weather, gas prices, food choices. Weather is always changing therefore cannot be negative. If gas prices went negative people would be happy, no one wants to eat the same food every day.

S4 PEMDAS

S5 PEAMDAS

Coding Process for Clarity

The above student responses are arrange in decreasing order of clarity:
- Both S1 and S2 would be coded 0 since there is no ambiguity in what the students communicated.
- S3 would be coded 1 since it is unclear if the student meant actual height or the change in height as the variable.
- S4 would be coded 2 since it is unclear what aspects of the weather or food choices are being addressed.
- S5 would be coded as 3 since this is a nonsensical response; the acronym given for the order of operations is clearly unrelated to the question asked.

Originality

Originally both categories (clarity & completeness) were to be coded on a scale from 0 to 3, but then my team brought forward the idea of looking at the types of incompleteness. The thought being that knowing types of incompleteness would be more beneficial for instructors and in terms of redesigning some course material. We are still working on the types of incompleteness of interest, but some possibilities being considered are:
- Response failed to address any aspect of the question
- Response did not completely answer the question
- Response uses the question to answer the question
- Response contains gaps in reasoning
- Missing background
- Missing connections between statements
- Missing connections between symbolic notation and context
- Proof by example

Quantitative Aspects

All of the student responses have been typed into a spread sheet for ease of quantitative analysis of items like
- Sophistication of vocabulary using EDL grade-level list
- Use of key expressions (correct mathematical terminology)
- Ratio of verbal to symbolic in a response
- Length of response as compared to average response length
- Level of readability using Flesch-Kincaid grade level test

Follow-up Questions: possible next projects

- How does a pre-algebra student’s writing compare to an Algebra I student’s writing?
- How does an Algebra I student’s writing compare to an Algebra II student’s writing?
- Is there any correlation between one’s writing ability and one’s mathematical maturity? If so, could/should we incorporate writing as part of placement?