A Systemic Functional Linguistics Analysis of Mathematical Symbolism and Language in Beginning Algebra Textbooks

Preliminary Research Report

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Abstract: I propose the use of systemic functional linguistics (SFL) as a tool to better understand how mathematical ideas are conveyed through multiple semiotic resources. To demonstrate the tools that SFL offers, mathematical symbols and written language in college beginning algebra textbooks will be examined. I argue that using SFL to research how mathematical content is communicated to undergraduate students can expose important nuances that may otherwise go unnoticed.

Key Words: Beginning Algebra, Language and Mathematics, Mathematical Symbolism, Systemic Functional Linguistics, Textbooks

How well do college beginning algebra textbooks integrate mathematical symbolism and language? To answer this question I will use systemic functional linguistics (SFL) to link the mathematical symbolism to language. To make this connection, two topics will be focused on: the use of the hyphen, as both an operator for subtraction and modifier for the opposite; and the simplification of algebraic expressions. These topics were chosen not only because many students in these courses struggle with them, but because their simplicity can reveal how SFL can be used as an aid for researcher to tease out subtle distinctions in a subject matter that is so clear in their minds that they might otherwise be overlooked.

This research is extended from the work of Kay O'Halloran (i.e. 2000; 2005) which looks at the multisemiotic nature of mathematics through the systemic functional linguistic perspective. My research differs from much of the linguistic research in mathematics education (i.e. Herbel-Eisenmann, 2007; Mesa & Change, 2010; Wagner & Herbal-Eisenmann, 2008) in that it looks at the linguistic nature of the mathematical symbols alongside the use of language with a focus on content.

The choice to examine college beginning algebra textbooks comes from of the lack of research in teaching and learning in college development mathematics (Stigler, Givvin, Thompson, 2010) despite the need, and the potential role of the textbook.

Developmental mathematics

The number of college students needing developmental mathematics is larger than many realize. More than one out of five students entering college are required to take a developmental mathematics course and in two-year public institutions more than one out of every three students needs to take at least one developmental mathematics course (NCES, 2003). Developmental college mathematics courses include arithmetic, beginning algebra, and intermediate algebra, and are labeled developmental or remedial because it is expected that students would have acquired this knowledge in high school or earlier. Compounding this issue, the a majority of students (70%) taking developmental mathematics courses need more than one attempt to pass these courses (Attewell, et al., 2006).

While community colleges are open-access[1] institutions which offer individuals a means of upward social mobility (Cohen & Brawer, 2008), developmental education plays an important role within the colleges by increasing access and equity for underprepared students (Perin & Charron, 2006). Developmental mathematics courses (or the equivalent knowledge) are required for future college courses in science, technology, and engineering, and for those students who intent to transfer—over 90% of four-year colleges have a quantitative component to their general education requirements to obtain bachelor's degree (Lutzer, Rodi, Kirkman & Maxwell, 2007, pg. 64).

Textbooks

I have chosen to examine textbooks because they are a resource for both the student and teacher. The textbook represents part of the intended curriculum that is a source of potential learning for the student (Mesa, 2004) and support for the teacher (Newton & Newton, 2006). While the resources a part-time faculty member or even a full-time faculty member has available varies by individual and college, the textbook is one resource that is always available. As a result the textbook may even guide the content and methods of a course.

There are over 60 textbooks available for beginning algebra at the college level published in a number of different formats[2]. The textbooks I have chosen are based on their use (by number of students and number of colleges) in Michigan community colleges. Within each textbook the sections on subtraction of numbers, negative numbers, order of operations, combining like terms, and simplification of expressions will be identified for analysis.

SFL Tools

So far, I have obtained 5 textbooks and am exploring which SFL tools will be most useful. To date I have identified several SFL tool to use.

To explore the use of the hyphen as subtraction and the opposite of, analyzing cohesion of the text through reference chains, conjunctions, and lexical chains will show how the text uses and develops the hyphen as a symbol and what language accompanies its use. This analysis will make explicit and highlight the two uses of the hyphen, particularly if they are interchanged and how they are related. An important aspect of how I want to explore the cohesion of the text is to analyze not only the mathematical symbolism and the written language, but also how they interact. In my initial examination of the texts, there is often a crossing of the two meanings of the hyphen with out explanation and there are occasions when the mathematical symbols have one meaning but the words express or imply the other.

To explore the order of operations, combining like terms and simplifying expressions looking at rank-shift, in addition to the cohesion of the text is of interest. The notion of rank-shift is of particular interest for these topics because of how lexically dense and highly embedded mathematical symbolism can be and using written or spoken language to describe this can be very difficult.

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[1] Jackson Community College, Jackson, MI has recently moved away from this trend. Any student scoring below a certain grade level in reading, writing, or mathematics will not be admitted to the college.

[2] Only textbooks with different author/title combinations were counted. Textbooks of different editions, packaging (i.e. with solutions manual, online access), bindings or combined course (i.e. beginning and intermediate algebra) were not counted. This was brief survey was done using Amazon and four publisher websites. The publishers were chosen based on those books found in the Amazon search and were Pearson Higher Education, McGraw Hill Higher Education, Cengage Higher Education, and Kendal/Hunt Publishing.

Further Research

The textbook is simply one form of mathematical discourse to be examined. Further research could explore using SFL to parallel the spoken and written language and mathematical symbolism in lectures. It could also be used to compare how these semiotic resources are used by teachers and students.

In presenting my preliminary findings, I will give examples of the different SFL tools I have used and show findings of interest. I seek general input and interpretations of my work so far, what others see as the potential for using these tools, and suggestions for further steps

Questions

How could the SFL tools presented be useful in exploring higher level undergraduate mathematics?

Are there other SFL tools that could be used to further explore the connections in mathematical content between the different semiotic resources?

Does SFL seem like an appropriate tool to explore the similarities and differences between how instructors and undergraduate students use the different semiotic resources? How could research of this sort contribute to our understanding of the differences in how mathematicians and novices (undergraduate students) think about mathematics?

How can these SFL tools be used to better understand how undergraduate students make sense of and make connections between the different semiotic resources?

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