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The use of linguistic resources by mathematics teachers to create analogies

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ABSTRACT

Researchers have documented the use of analogies by teachers when introducing mathematical concepts. This article asks the question *what linguistic resources do teachers use to create analogies?* The article applies systemic functional linguistics to examine examples in which a geometry teacher used analogies to connect daily life instances and mathematical ideas. Specifically, the method applies cohesion analysis to examine the teacher's use of lexical cohesion, conjunctions, and reported speech in the creation of analogies. The teacher created a parallel structure between the target and base of the analogies. The study demonstrates how linguistic analysis can be useful for researchers studying how teachers construct the mathematical classroom register through analogies, particularly when connecting colloquial and mathematics discourses.

Introduction

Prior research has recommended that teachers draw on students' prior knowledge to develop their mathematical understanding (Kilpatrick, Swafford, & Findell, 2001; National Research Council [NRC], 2000). Analogies can be useful for teachers to build on students' prior knowledge by establishing connections between their experiences and mathematical ideas. However, cross-national studies of mathematics teachers report variations in the use of analogies according to specific cognitive principles that can support analogical reasoning (Richland, Zur, & Holyak, 2007). The main question guiding this article is *what linguistic resources do teachers use to create analogies?* To answer this question, I examine how one geometry teacher constructed analogies in an attempt to connect students' life experiences with the concepts and procedures of the geometry curriculum. I examine the linguistic resources that the teacher used to create analogies intended to clarify the proof of a theorem. I apply analytical tools from systemic functional linguistics (SFL) to investigate how the teacher established connections between the base and target of the analogies. Providing a better understanding of how teachers construct analogies can improve support for students who learn mathematics using analogical reasoning.

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Theoretical perspectives

Social semiotic perspectives on language in mathematics classrooms

This work is situated within a social semiotic perspective (Lemke, 1990; Morgan, 2006), which posits that language is a fundamental tool for making meaning. In the context of mathematics classrooms, examining the uses of mathematical language could lead to a better understanding of how mathematical meanings are constructed within the classroom environment (Schleppegrell, 2010). The notion of a mathematical register (Halliday, 1974; Pimm, 1987) and, more specifically, the construct of a "mathematics classroom register" (Herbel-Eisenmann, Wagner, & Cortés, 2010) are useful for understanding that the meaning-making processes include using specialized terms that differ from common sense (Martin, 1993) and creating arguments that can be accepted in mathematics classrooms. Examining the linguistic choices that teachers make by using a mathematics classroom register can indicate how teachers help students make sense of mathematical ideas. I use SFL, a theory of language that proposes that meanings are constructed in a text by identifying the choices that speakers make (Halliday & Matthiessen, 2004). In the examples, I focus on the teacher's linguistic choices when establishing connections between terms that belong to the mathematics classroom register and terms that describe experiences from daily life.

Using analogies in mathematics teaching

Researchers have argued that using representations of mathematical concepts requires students to apply reason by analogy (English, 1997; English & Halford, 1995). The evidence suggests that mathematics teachers use analogies in their classrooms. For example, Richland, Holyoak, and Stigler (2004) observed that eighth-grade mathematics teachers used analogies when introducing mathematical concepts and procedures and that the teachers generally assumed the responsibility of identifying the components of the analogy. Bayazit and Ubuz (2008) also documented teachers' use of analogies in relation to the concept of function. In addition, the evidence shows that curricular materials, such as linear algebra textbooks (Harel, 1987), include examples that support analogical reasoning. Therefore, students can be exposed to analogical reasoning through both teachers' examples and curricular materials.

Researchers have proposed various definitions of analogies in instruction. Pimm (1981, p. 100) has offered a useful image of an analogy as a mathematical proportion (e.g., A:B::C:D) in which more information is available for one set of relationships (e.g., A:B) than another (e.g., C:D). Lemke (1990, p. 87) has described analogies in science teaching relative to thematic patterns, which are patterns of semantic relations. Lemke (1990, p. 117) states, "Students learn to transfer semantic relationships from the familiar thematic items and their pattern to the unfamiliar items and their pattern." The cognition literature describes analogies as mappings from a base, B, to a target, T (Gentner, 1983). The base includes specific prior knowledge that constitutes the foundation of the analogy, and the target includes the new knowledge that the analogy specifies.

The problem of how individuals establish mappings from the base to the target of the analogy has been discussed in the cognition literature. Gick and Holyoak (1980) observed that it is possible for people to rely on analogical reasoning to solve a new problem even if the mapping from the original problem to the new problem is incomplete. However, the authors discussed the key problem of addressing contextual information and stated that the "successful transfer of learning generally involves overcoming contextual barriers" (p. 349). The authors suggested that the mapping process is essential for individuals to establish comparisons between situations that have commonalities despite their apparent difficulties. Reed (2012) has stated that instructional support for establishing mappings can result in differences in learning through analogies. Therefore, a linguistic analysis of how a teacher introduces analogies by establishing mappings between the base and target of the analogies could clarify instructional supports.

Using linguistics to study analogies in mathematics classrooms

I focus on the linguistic resources for achieving cohesion (Halliday & Hasan, 1976). Cohesion includes the resources for establishing connections regarding the meanings in a text.

Lexical cohesion

Lexical cohesion involves establishing semantic connections between chains of linguistic terms in a text. A lexical cohesion chain can show whether the types of word choices used in an analogy specify the established relationship between the base and target. For this purpose, I locate the terms that have lexical cohesion and have been used in reference to both the base and target of the analogy. Halliday and Hasan (1976) identify two main types of lexical cohesion: *reiteration* and *collocation*. Through reiteration, speakers may use different words to echo what has been previously stated. Halliday and Matthiessen (2004) identify four types of reiteration: (a) *repetition*, (b) *synonymy*, (c) *hyponymy*, and (d) *meronymy*. Repetition denotes using the identical word. Synonymy denotes using a word that has the identical meaning as a preceding word, particularly within the context of the discussion (e.g., "proof" and "argument"). Hyponymy refers to a relationship between classes, either because some lexical items belong to the identical class (known as co-hyponyms) or because one term is a superclass or a subclass of another term. For example, "triangle" and "square" are co-hyponyms because they are classes of "polygons," and "polygon" is the general class that includes items such as "triangle" and "square." Meronymy denotes a relationship in which