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"Let $G = (V, E)$ be a graph": Turning the abstract into the tangible in introductions in mathematics research articles

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ABSTRACT

While academic writing, especially the research article (RA), has been widely studied for its generic structure, organizational patterns, and linguistic features in a broad cross-section of disciplines, relatively little attention has been devoted to this genre in mathematics. This paper explores the rhetorical structure of introductory sections of RAs in mathematics. Using Swales' (1990) and 2004 CARS (Create a Research Space) models as points of departure, the study investigates the move structure used in the introductory material in 30 RAs in mathematics. The results suggest that the move structure of RAs in mathematics departs somewhat from patterns identified in other disciplines; notably, that 'establishing presumptions' about abstract mathematical objects is an essential building block for setting arguments about knowledge claims in mathematics. Authors in mathematics establish their presumptions as well as employ variations on the Swalesian moves to successfully Create a Research Space. We propose that these variations arise out of the hypothetical nature of the mathematical concepts, and the social grounds of mathematics as a logic-driven, argumentation-mediated discipline. These results have implications for using a genre-based approach in EAP classes of mathematics.

1. Introduction

Scholars in various fields have extensively studied the generic structure of research articles (RAs) in numerous academic disciplines, analyzing their typical lexico-grammatical features and organizational patterns. One aim has been to work out the writing conventions in disciplines as social practices of discourse communities. Scholars have examined article abstracts (in biology, Samraj, 2005; in sciences, Hyland, 2000; in applied linguistics and educational technology, Pho, 2008), results sections (in sociology, Brett, 1994; in chemistry, Bruce, 2009), methods sections (in management, Lim, 2006), and discussion sections (in social sciences, Holmes, 1997; in physics, Parkinson, 2011; in dentistry, Basturkman, 2009, 2012). The introduction sections have received the most attention following Swales' CARS model (for example, in social sciences, Crookes, 1986; in software engineering, Anthony, 1999; in biology, Samraj, 2002; in applied linguistics, Yang & Allison, 2003; Ozturk, 2007; in sport science and medicine, Zeng, 2009; in agriculture, Del Saz-Rubio, 2011; in civil engineering, Kanoksilapatham, 2011; and

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in management, Lim, 2012). These studies observed no striking differences in the structure of RA introductions, although they did catalog variations: (1) the absence of a move or step in extended background sections in social sciences; (2) a cycling pattern in biology literature reviews; (3) variations in move patterns in applied linguistics sub-disciplines; and (4) the use of definitions to illustrate difficult concepts in software engineering.

Despite the study of RAs in many disciplines, little attention has focused on mathematics. Existing research includes analyses using functional grammar and discourse analysis (Barton, 2008; Halliday, 2004; Huang & Normanda, 2007; Morgan, 1998, 2005; O'Halloran, 2005; Pimm, 1984, 2004; Rowland, 1992, 1995, 1999, 2000; and others), focusing largely on textbooks and classroom discourse in school settings. Researchers have examined the use of imperatives, nominalizations, and passive constructions, and algebraic symbolism and discourse markers to express deductive reasoning. Ernest in his preface to Morgan (1998) offers one reason as to why analyses of move structure in mathematics have been neglected, noting that language is sometimes seen as playing a descriptive rather than a constitutive role in mathematics. He argues that an 'absolutist epistemology' (Morgan, 1998, p. *ix*) in mathematics grants it a 'superhuman real' and privileges mathematical thought and cognition over mathematical talk and text. Another very likely reason is the intimidating nature of mathematics RAs for nonspecialists, that is applied linguists doing discourse analysis, as opposed to the compelling nature that math RAs have for the math community. Though it is an established strategy in genre analysis to solicit advice from disciplinary informants on the disciplinary conventions as well as RA content, some discourse analysts believe that, ideally, they should understand everything and at a deep level. For researchers who hold this view, the symbolic language that dominates mathematical discourse may add to its intimidating nature. The result is that applied linguists with a background in mathematics might show interest in the topic.

However, interest in the topic is slowly emerging. Lin and Evans (2012), for example, have considered applied mathematics in a cross-disciplinary study of the overall macro-organization of RA structure. A further recent study of math RAs focused on stance and engagement (McGrath & Kuteeva, 2012). Although these studies offer new insights into aspects of mathematics RAs, they do not take into account the rhetorical structure of RAs in the discipline. To address this gap, we undertook a study of RAs in mathematics. In Graves, Moghaddasi, and Hashim (2013) we reported on the macro-organizational structure of RAs in mathematics. This article reports the variations uncovered by our analysis in move structure and order in introductory sections in mathematics RAs as compared with Swales' 1990 and 2004 CARS models. We speculate that these variations arise out of the hypothetical nature of mathematics as a field, the argumentative requirements of mathematical discourse, and the ideological belief that mathematical findings are assumed to be valid. These variations in structure and move order have implications for EAP, ESP, and graduate writing instruction that uses a genre-based approach and includes mathematics students.

2. Methods of data collection and analysis

The sample from which our conclusions are drawn was a corpus of 30 research articles from five journals targeting a readership of research mathematicians and practitioners (see Appendix A for a list of articles and journal titles). The criteria for journal selection were representativeness (defined as publishing outstanding research topics in the discipline), reputation, and accessibility. The research mathematicians consulted in this study recommended seven journals in discrete math; two were excluded because they appear in print only. We selected discrete mathematics for our subject area because this was the area of expertise of several of our informants. The chosen journals are indexed by ISI Web of Knowledge, have high impact factors, and are easily accessible online.

Using a stratified random sampling method, we chose six articles from each journal. The period of publication covered from 2007 to 2009. Author, paper type, issue, and year of publication were the strata used to sample the data. To avoid introducing elements of subjectivity based on a given author's style or on the idiosyncrasies of a single journal issue, we selected only one article from an author and only one article per issue. Only original research articles were included. One article in our sample turned out to be a review article. When close examination of the rhetorical structure of the article showed marked structural variation from that of the original RA, we replaced it with an original RA.

We selected mathematics as the focus for this project because of the relative lack of attention it has received in genre analysis in applied linguistics. One of the authors has some background in mathematics, having taken university courses; another author has extensive experience analyzing rhetorical structures in science discourse (including mathematical biology and biostatistics) in dissertations and RAs.

Article topics were selected to span the branches of discrete mathematics with pure or applied orientations. We decided not to distinguish between applied and pure mathematics as a major stratum in our sampling in this study based on the rationale that this distinction is often difficult to make and lacks a clearly argued epistemological basis. According to our informants, although many mathematicians are academically affiliated with pure, applied, or even client engineering departments, there is still no consensus as to the borderline between pure and applied math research. Indeed, the term 'applied' in research mathematics is a fuzzy modifier. At one extreme, it seems different from pure mathematics where it refers to actual immediate applications already present at the forefront in subjects like image processing and computer modeling. At the other extreme, it differs very little from pure mathematics when it answers questions posed by particular practical problems, those problems that have been so fascinating to mathematicians and so broadly studied by them that the problems ultimately extend beyond the original application context. Examples of this second extreme are the theory of differential equations and graph theory.