An Investigation of the Generic Features of Research Articles Published in *the Bulletin of Iranian Mathematical Society*

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Abstract

In light of the understanding that the analysis of the generic features of different academic genres can enhance the ability of non-native members of academic discourse communities to understand, and where appropriate, to produce them, the present study aimed at investigating the dominant generic structure of research articles in mathematics. To start with a relatively narrow focus, a corpus of thirty mathematics research articles were randomly selected from *The Bulletin of the Iranian Mathematical Society(BIMS)*, and were analyzed in terms of their macro-organizational structure. An eleven-move structure was identified in the analyzed corpus, while it was also found that the research articles in the corpus did not follow the conventional *Introduction-Methods-Results-Discussion* structure found in many other disciplines. *Methods* and *Discussion* sections which are frequently encountered in research articles of many other disciplines were missing in the analyzed articles. It is argued that the findings may have theoretical implications in revealing some discipline specific conventions of organizing macro structure. Since all the authors were Iranian, the emerging model should be treated cautiously because some aspects of the emerging macro structure may also be under the influence of culture specific conventions.

*Keywords***:** Mathematics, Genre, Generic Features, Research Article

Introduction

Developments in the language theory of EAP have been motivated by an oft-repeated desire and suggestion that if academic reading/writing are to be developed that are sensitive to the structural/functional features of certain very specific academic texts, and in particular, to the ways in which such features vary according to disciplines, we need a system of analysis which can "… provide satisfactory models and descriptions of academic and scientific texts and […] enhance the ability of non-native [members of academic discourse communities] to understand, and where appropriate, to produce them" (Holmes 1997, p.32): a delicate system that can enable teachers to convey to prospective members of academic discourse communities the features that make academic discourse standard – in the sense that it performs the functions for which it is intended, and it is acceptable by the community for whom/within which it is produced (also see Hopkins & Dudley-Evans, 1988). That is why in parallel to the developments of EAP programs over the last five decades, a considerable amount of scholarly activity has been conducted and reported in academic journals and books concerning the description of academic discourses in English (see Flowerdew, 2002). This strong motivation has driven EAP into the stream of a theoretical enrichment and development (for a comprehensive historical review of this development, see Dudley-Evans & St John, 1998; Hutchinson & Waters, 1987) which starts with completely descriptive and quantitative *Register Studies* of the 1960s and 1970s, focusing on linguistic properties of different functional varieties or registers (as examples of this movement, see Barber, 1962; White, 1974; Chiu, 1972; Gustafson, 1975). Although the tradition of register analysis never succeeded in achieving its objectives – revealing the functional value of statistically frequent lexico-grammatical features of academic/scientific texts – it paved the way for the development of another theoretically richer movement in both Europe, pioneered by scholars like Allen and Widdowson (see for example Allen&Widdowson 1974) and the United States, pioneered by thinkers like Selinker, Lackstrom and Trimble (see for example Selinker, Lackstrom &Trimble 1973). What then (i.e., the 1970s) became known as *Grammatical-Rhetorical Model* of analysis of

academic/scientific communication provided a deeper understanding of how so called *'lower level'* textual choices are determined by some *'higher level'* discoursal/functional choices. However, the movement was faced with two major theoretical gaps: one related to the theory of text itself, and the other related to lack of appropriate understanding of the nature of social and cultural comp onents of context. The 1980s witnessed a revolutionary attempt by Swales' redefining the classic concept of genre in EAP context. Although scholars working in different schools have contributed to our modern understanding of the concept of genre in different ways (see for example Christie & Martin, 1997; Martin, 1992 who have approached the concept from a *Systemic Functional* perspective; and also see Miller, 1994; Freedman, 1994; Freedman & Adam, 2000 who have approached the concept from a *New Rhetorics* point of view), Swales' work seems to have launched the most massive interest in genre in EAP (seeHyland, 2006).

In his earlier attempts to introduce the concept of genre into EAP research, Swales emphasized the concept of "communicative purpose" as a defining feature (1990, p.58);A genre comprises a class of communicative events, the members of which sharesome set of communicative purposes. The purposes are recognized by the expertmembers of the parent discourse community, and thereby constitute the rationalefor the genre. This rationale shapes the schematic structure of the discourse and influences and constrains the choice of content and style. Communicative purpose isboth a privileged criterion and one that operates to keep the scope of a genre as hereconceived narrowly focused on comparable rhetorical action. In addition topurpose, exemplars of a genre exhibit various patterns of similarity in terms ofstructure, style and intended audience.

Swales' (1999) definition of genre can be decomposed into the following components:

1. Genre is a class of communicative events.
2. The principal criterial feature that turns a collection of communicative events into a genre is some shared set of communicative purposes.
3. Exemplars or instances of genres vary in their prototypicality.
4. The rationale behind a genre establishes constraints on allowable contributions in terms of their content, positioning and form.

   5. A discourse community's nomenclature for genres is an important source of insight.

In Swales' thinking, focusing on the communicative purpose of particular academic groups involves what these groups do with language, starting with the names members themselves give to their practices, such as essays, dissertations and lectures. These are the social, rhetorical actions used by community members to achieve a particular purpose, written for a particular audience, and employed in a particular context.

Inspired by Swales' definition, Bhatia (1993 & 2004) argues that genre theory, in spite of seemingly different orientations discussed so far, covers a lot of common ground, some of which may be summarized as:
- Genres are *recognizable communicative events* …
- Genres most often are highly *structured and conventionalized constructs* …
- … expert members of discourse communities often exploit generic resources to express both private and organizational intentions within the constructs of *socially recognized communicative purposes*.
- Genres are *reflections of disciplinary and professional cultures* …
- Genres … have *integrity* of their own …

Although the concept of "communicative purpose" has proven useful in characterizing, dividing and defining academic genres, its use as the sole criterion for defining and dividing such genres has received certain criticisms. For instance, Bhatia (2001) believes that if one were looking for clear-cut, definite and objective criteria to define and identify communicative purpose for each genre, one would necessarily be frustrated not simply by the complex realities of the world of discourse but also by the static and formulaic nature of language use that such a view would give to the emergent forms of discourse. The very problem he is talking about refers to the difficulty of relying on "text-internal" factors for the identification of communicative purposes. In his view, these factors can give misleading insights when used on their own: "the only way one can assign the right generic value to any linguistic feature of the genre is by reference to text-external factors" and similarly, " any conclusion based on text-external factors needs to be confirmed by reference to text-internal factors" (p.81).

Following such logic, Bhatia (2001) believes that the most important aspect of applied genre analysis is the notion of *genre integrity* – that is, it is recognizable, sufficiently standardized and is based on a set of mutually accessible conventions, which most members of professional, academic or institutional organizations mutually share.

Swales himself has also admitted that his original emphasis on "communicative purpose" as a defining feature may not include all cases. In his attempt to revisit the concept of communicative purpose, Swales (2004) admits that some variants are detectable in the concept: One such variant acknowledged by Swales has been proposed by Bhatia (1993, p. 13) stressing that the constraints that genre imposes "are often exploited by the expert members of the discourse community to achieve private intentions within the framework of socially recognized purpose(s)". While Swales does not deny the existence of such "private intentions", he finds Bhatia's proposal moot regarding whether these intentions should fall within the scope of investigative endeavors. Another variant acknowledged by Swales (2004) is one proposed by scholars like Orlikowski and Yates (1994) and Bex (1996) which seems to look at the concept of genre form a social point of view – in some contrast to Bhatia's position. Bex argues that a genre is "an aggregation of communicative events that fulfill a common social function" (p.137), which is in line with Martin's (1992) firm position that "genres are social processes, and their purpose is being interpreted here in social, not psychological terms" (p. 503). But Swales rightly argues avoiding the teleological and stressing the social is no simple matter, and as Askehave (1998) has pointed out adoption of a pure social criterion does not solve the problems: since social purposes or functions are complex, multiple, and evasive, it is very difficult to use the criterion of purpose to decide whether a particular discourse belongs in one generic category as opposed to another. We usually do not know at the outset what the *real* communicative purposes of texts are. What we have at the outset is some overt features of form and content. Askehave and Swales (2001) admit that, "If communicative purpose is typically ineffable at the outset or only establishable after considerable research, or can lead to disagreement between inside experts and outside genre analysts, or indeed among the

expert themselves, how can it be retained as a privileged guiding criterion?" (p. 1970).

Arguments and criticisms, like the ones outlined above, lead Swales to suggest that genre may better be seen as a "metaphorical endeavor". " … I now believe that we should see our attempts to characterize genres as being essentially a metaphorical endeavor, so that the various metaphors that can be invoked shed, in varying proportions according to circumstances, their own light on our understanding" (Swales, 2004, p. 61). In so doing, he identifies the following metaphors as helpful in understanding genre (pp.61-8):

- Genre as *frames of action* (guiding principles for achieving purposes using language)

Drawing on Bazerman's (1997) definition of genre, Swales sees genres as frames for social action, not as social actions themselves. In this view, frame becomes a starting point, "an initial orientation, with no consequent guarantee that effective rhetorical action will actually be accomplished" (p.61). Genre, seen metaphorically as frame, can provide only a relatively small part of what might finally be needed for fully communicative action. Hence, genre knowledge becomes a necessary but not sufficient condition for discoursal success.

- Genre as *standards* (expected conventions of layout and language)

Seen metaphorically as standards, the view integrated here is to resist the pressure from some recent writings on genre that see genre as so fluid and dynamic that they primarily offer choices rather than constraints. Swales agrees with Devit (1997) in that too much choice can be debilitating for communicating our meanings and for creating a coherent social life. The metaphor encourages us to see genre as both constraint and choice.

- Genre as *biological species* (development of genres analogous to species change)

This metaphor proves useful in thinking about how genres evolve, spread, and decline. Swales clarifies the concept of this metaphor by describing the birth and growth of the conference poster – a genre that can be ascribed to the increase in the number of those who want or need to make conference presentations, a push to encourage fuller participation of

graduate students, a greater chance for reporting on work-in-progress, and a semiotic shift in recent decades from the verbal to multimodal.

- Genre as *families* (instances of a genre are more or less similar to 'core' exemplars)

This metaphor, which can be clearly linked to the previous one, reminds us of Swales' (1990) definition in which exemplars of a genre are expected to exhibit various patterns of similarity in terms of structure, style and intended audience. Drawing on the concept of 'prototype', the metaphor gathers together the exemplar members which share a common "genealogical history" (Swales, 2004, p.65). Hence, while communicative purpose has, in Swales' tradition, been nominated as the privileged property of genre, "other properties such as form, structure and audience expectations operate to identify the extent to which an exemplar is prototypical of a particular genre" (Swales, 1990, p.52).

- Genre as *institutions* (typified and interrelated processes and values of an institution)

To Swales (2004), considering genres as institutions can be helpful in at least two ways: (a) it allows us to see them as being more than their material manifestations. In other words, we are encouraged to avoid looking at genres as just visible and/or audible products, but as complex institutions which involve more or less "typified processes of production and reception and forming part of larger networks and values they support" (p.66); and (b) it allows us to see that we are partly co-constructed as we shift from one "frame of social action" to another; hence, we do not need to characterize ourselves as distinctive identities.

- Genre as *speech acts* (the conventional actions a genre is intended to perform)

Although speech act theory, in its original context, has proved inefficient in being applied to longer stretches of discourse (Schifrin, 1994), Swales believes that the key principle of speech act theory – that any utterance may have a multiplicity of functions and meanings and that the local context can strongly influence our interpretation and realization of any speech act – brings a useful "directedness" to our perception of generic exemplars.

Swale argues that these metaphors offer a rich and multifaceted view of genre which captures its complex and varied nature. The following figure represents the metaphors-based characterization of the concept of genre:
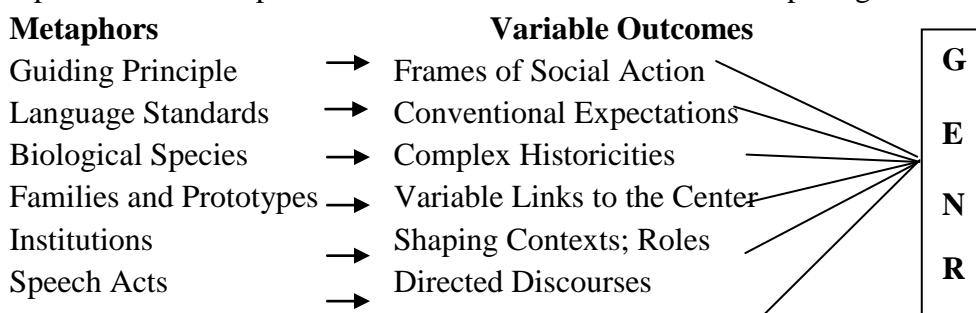
Metaphors		**Variable Outcomes**
Guiding Principle	→	Frames of Social Action
Language Standards	→	Conventional Expectations
Biological Species	→	Complex Historicities
Families and Prototypes	→	Variable Links to the Center
Institutions	→	Shaping Contexts; Roles
Speech Acts	→	Directed Discourses

G E N R

Figure 1. Metaphors-based characterization of genre (Swales, 2004, p. 68)

As the metaphor-based conception explicitly demonstrates genres are understood to evolve and change in response to changes in the needs of the discourse community (Dudley-Evans, 1994). This view does not see genres as fixed and static; rather, genres are seen as changing and emerging over time (Miller, 1994). This conception of genre is also supported by Berkenkotter and Huckin (1993, p.4) who present a set of principles for genre based on a synthesis of a number diverse theoretical orientations (including Gidden's Structuration Theory). The principles are:

Dynamism: Genres are dynamic rhetorical forms that are developed in response to current recurring situations in a community. They serve to give the community coherence and meaning. Genres change over time in response to needs.

Situatedness: our knowledge of genres is derived from and embedded in our participation in the communicative activities of daily professional life.

Form and content: genre knowledge embraces both form and content ….

Duality of structure: as we draw on genre rules to engage in professional activities, we constitute social structures […] and simultaneously reproduce these structures.

Community ownership: genre conventions are signals of a discourse community's norms, epistemology, ideology and social ontology.

The concept of genre as developed above can have significant contributions to our understanding of how the features of a specific genre can be influenced by the shared communicative purposes of a specific discourse community: The notion of discourse community – which found its due significance in the work of Swales (1990) (see section 2.3.4.3.) – helps to specify culture by" reducing huge national or ethnic conglomerates to a human scale" (Hyland, 2005, p.138) and provides a descriptive and explanatory framework of how meanings are socially constructed, taking into account the forces outside the individual which contribute to guiding purposes, establishing relationships and ultimately shaping text. When Becher (1989) described disciplinary communities as 'tribes', he meant to identify them as separate cultures, each with its own norms, bodies of knowledge, categorizations, sets of conventions, and modes of inquiry. Within each culture, individuals acquire a competence in specialized discourses to create a convincing reader-writer environment; each community has its own unique ways of how something can be said and we are more likely to persuade our readers if we can frame our ideas in ways which appeal to appropriate community recognized relationships. Recognition of this assumption has triggered a number of studies on the discipline specific features of academic genres (particularly research article) and their subgenres as summarized below:

Table 1
Move-based Studies on Different Rhetorical Sections of RA in Different Disciplines

Author(s)	Year	Section	Field	Findings
Samraj	2002	Introductio n	Wildlife Behavior/ Conservation Biology	Step *Review of Literature* Can be identified in 3 moves
Lim	2006	Methods	Business/Management	3 moves and 12 steps
Brett	1994	Results	Sociology	3 moves
Holmes	1997	Discussion	History/ Political/ Science/ Sociology	8 moves
Williams	1999	Results	Medicine	Identification of a linear (not cyclical) pattern of presenting findings

Posteguillo	1999	Results	Computer Science	3 moves
Yang & Allison	2003	Results and Discussion	Applied Linguistics	3 obligatory moves and 3 optional moves
Kanoksila patham	2005	Results	Biochemistry	4 moves
Nwogu	1997	IMRD	Medicine	11 moves
Bruce	2009	Results	Sociology vs. Organic Chemistry	Report vs. Explanation

Following the assumption underlying the above mentioned studies, the present research sought to identify the generic structure of research articles in mathematics. The assumption leading this objective was that the philosophy dominating a specific discipline will shape unique communicative purposes for that discipline and that these unique communicative purposes can influence the conception of research in that discipline and can in turn influence the way the generic structure of research articles is shaped by the researchers.

Method

Corpus

A corpus of 30 research articles (RAs) written by Iranian mathematics researchers was constructed from *The Bulletin of Iranian Mathematical Society* (BIMS).BIMS is a quarterly publication of the Iranian Mathematical Society in English and an international open access journal. It publishes original research papers in all areas of mathematical sciences, accessible to a broad audience. All the RAs studied in this research were selected randomly from among the RAs published in the period of 2011- 2013. This journal was recommended by some Iranian informants in the discipline. The informants claimed that the journal was a well-known and prestigious journal for Iranian mathematics researchers.

Table 2
Information about the Corpus

Number of RAs	Number of pages	Number of authors	Publication date
30	323	69	2011- 2013

Procedure of Analysis

The analysis began with identifying the macro rhetorical sections of the RAs. In analyzing this structure, the commonly accepted Introduction-Methods-Results-Discussion (IMRD) framework (e.g., Brett, 1994; Holmes, 1997; Swales, 1990) was adopted.The analysis continued with the move analysis of each rhetorical section. Some samples of these analyses appear in Appendix 2. In analyzing the move structure, textual clues and surface signals were usually fairly reliable indicators; however, since we defined them as functional units, our ultimate criterion for assigning value to them was functional/discoursal rather than formal. In other words, we did not trust the linguistic signals per se in the identification of moves. In most cases, the unit of analysis was the sentence. The frequency of each move was calculated by its consideration in a text just once. When a move occurred twice or more in a text (it was recycled); this additional occurrence was not considered in frequency analysis.

In the present study, the criteria for considering a move as obligatory or optional are defined according to Kanoksilapatham (2005): if the frequency of occurrence of a move is 100%, it is an obligatory move. If the frequency of occurrence of a move is below 60%, it is an optional one. The move should be considered conventional if the frequency of occurrence ranges from 60% to 99%.

Reliability Matters

In many discourse studies of this type, it has become almost a standard procedure to involve a specialist informant or to seek his/her reactions on various aspects of the investigation. In the present study, the informant received a short introduction to the IMRD framework and move structure before checking samples of the analysis. After identifying the moves and assigning functional values and labels to them, the researchers and the

informant dealt with cases where there were disagreements and developed a common stance towards the emerging model.

Results

Findings of the First Phase of the Analysis (IMRD Rhetorical Structure)

The frequencies of the rhetorical sections in the corpus are provided in Table 3.

Table 3
Frequency of Rhetorical Sections in the Corpus

Introduction and/or Introduction and … (GSH)	Complementary Introduction (CSH)	Method	Results (GSH)	Results (CSH)	Discussion	Conclusion
30	7	0	10	41	0	3

GSH= Generic Section Heading; CSH= Content Section Heading

As illustrated in Table 3, the findings of the first phase of the analysis (macro rhetorical structure) showed that the RAs in the corpus do not follow the conventional IMRD (Introduction, Method, Results, Discussion) structure. In the analyzed RAs, the Method and Discussion sections were missing (See Figure 1).
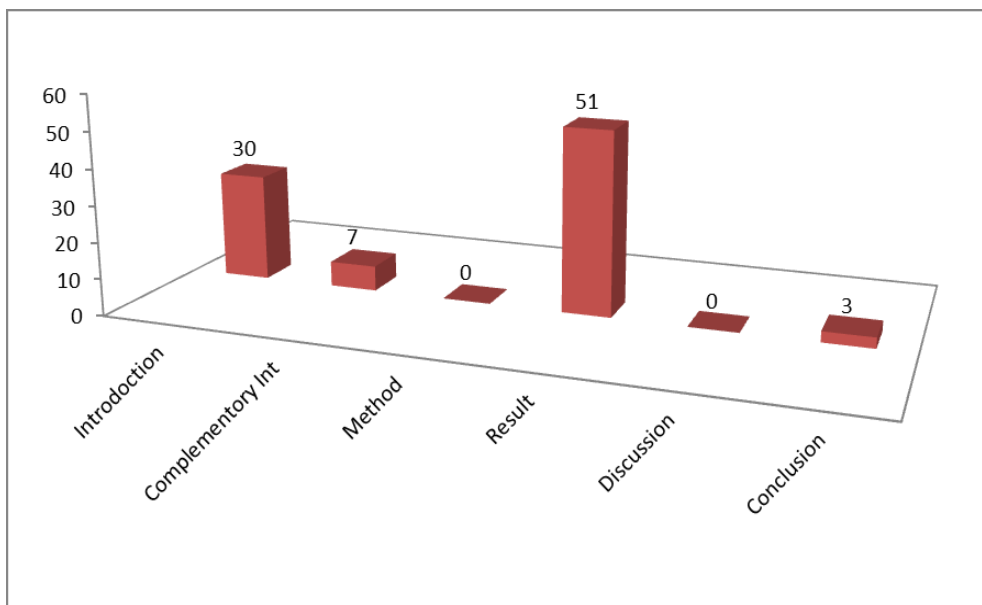
Figure 1. Rhetorical Structure of RAs in the Corpus

As indicated in Figure 1, all the RAs in the corpus (100%) used the generic heading of *Introduction*; only three of them used compound section headings (e.g., *Introduction and Preliminaries*, and *Introduction and Motivation*). Nearly one-fourth of the RAs in the corpus (23.33%) included additional complementary introduction sections (for example, *Definitions* or *Preliminaries)*. Our informant stated that most often it is usual (in this journal and other journals) that the researchers compound these two sections and name it as, for example, *Introduction and Preliminaries* and *Introduction and Definitions* or just *Introduction*.

It was also found that all the RAs of the corpus included results section. 16 out of 30 RAs in our corpus (53.33%) used two or three results sections. It indicates that presenting results in two or three sections is typical in RAs of mathematics. However, not all RAs used the generic section heading. Only 10 out of 51 results sections were generically labeled as *Main Results* (9 instances) and *The Results* (1 instance); the rest used content headings. Hence, as Graves et al. (2013) also mentioned, two characteristics were remarkable in math RAs: 1) multiple results sections were presented at each

RA and 2) content section headings dominated the presentation of generic headings.

Only 3 RAs in the corpus comprised a Conclusion section and all used generic heading *Conclusion(s)*. Of course, RAs in mathematics conventionally use content section headings rather than generic section headings especially in the Results sections, which can be considered a remarkable difference with other disciplines. This tendency was also observed in the corpus of this study (See Table 4).

Findings of the Second Phase of the Analysis

A functional criterion was adopted for the identification of the moves and the titles were chosen according to their common functional orientation. Eleven moves were identified in the mathematics RAs. Table 5 summarizes the rhetorical moves in these RAs.

Table 5
Rhetorical Moves of Mathematics RAs

Move/ Step	Introduction Section
Move 1	Introducing the Field by:
Step 1	Summarizing the previous researches (Literature review)
Step 2	Definition of the concepts and notations
Step 3	Indicating topic importance
Move 2	Preparing for the Present Research by:
Step 1	Indicating a possible extension of the previous research
Step 2	Indicating a gap in the previous research
Move 3	Introducing the Present Research by:
Step 1	Stating the aim of the research
Step 2	Describing briefly the work carried out
Step 3	Announcing the findings
Step 4	Indicating the research article structure
Move 4	Recalling and Introducing the Basic Definitions and Notations
Move 6	Introducing and Defining the Particular Topic (defining research's main parameters)
	Preliminaries Section
Move 4	Recalling and Introducing the Basic Definitions and Notations
	Results Section
Move 5	Introducing the present section by:
Step 1	Definition of the concepts and notations

Step 2	Stating the aim of the section
Step 3	Stating the procedure
Step 4	Announcing the findings of the section
Move 4	Recalling and Introducing the Basic Definitions and Notations
Move 6	Introducing and Defining the Particular Topic (defining research's main parameters)
Move 7	Stating Proofs and Results
Move 8	Giving some examples
Conclusion Section	
Move 9	Restating the Procedure
Move 10	Restating the Findings
Move 11	Justifying the Findings

Introduction Section

The function of Introductions is to contextualize a research study being presented in the relevant literature, claim its novelty, and present main features of the study (Swales, 1990). The structure of the Introduction section is presented in Table 6 in terms of functions and move frequency.

Table 6
Rhetorical Moves of the Introduction Section of Mathematics RAs

Move/Step		N	n	%
Move 1	Introducing the Field by:	30	30	100
Step 1	Summarizing previous researches	30	30	100
Step 2	Definition of the concepts and notations	30	22	73.33
Step 3	Indicating topic importance	30	9	30
Move 2	Preparing for the Present Research by:	30	19	63.33
Step 1	Indicating a possible extension of the previous research	30	15	50
Step 2	Indicating a gap in the previous research	30	5	16.66
Move 3	Introducing the Present Research by:	30	27	90
Step 1	Stating the aim of the research	30	12	40
Step 2	Describing briefly the work carried out	30	12	40
Step 3	Announcing the findings	30	12	40
Step 4	Indicating research article structure	30	9	30
Move 4	Recalling and Introducing the Basic Definitions and Notations	30	13	43.33
Move 6	Introducing and Defining the Particular Topic (defining the research's main parameters)	30	4	13.33

Note: **N** refers to the total number of RAs analyzed in this study, **n** refers to the number of RAs containing the move specifically identified, and **%** refers to the frequency of occurrence of a move.

Move 1: Introducing the Field

In all of the RAs, Move 1 appears initially. In some introductions, Move 1 is used cyclically (two or three times in the texts). The realization of Move 1, Steps1-3 is illustrated in the following examples (the main characteristics of each move and step are bold):

Move 1, Step 1: Summarizing the *previous research*

This step functions to review what people have previously done in the relevant field.

Example: Under some suitable conditions on the coefficients, **many scholars have studied** the limiting behavior of moving-average process $\{Xk; k \geq 1\}$. [RA 15]

Move 1, Step 2: Definition of the concepts and notations

This is a new step that is found in mathematics RAs. The function of this step is to define mathematical concepts and introduce symbols.

Example: **Let k be** an algebraically closed field of characteristic p > 0. A curve of genus 1 **is said to be** super singular if, as an elliptic curve defined over k, its group of p-torsion k-points is trivial. [25]

Move 1, Step 3: Indicating topic importance

This is an optional step which allows the author to elaborate the importance of the topic of the study.

Example: **Recently**, localization operators **have been a subject of study** in quantum mechanics, in PDE and signal analysis. [26]

Move 2: Preparing for the present research by

Move 2 draws scientists' attention to weakness in the existing literature (Kanoksilapatham, 2005). In few cases Move 2 was embedded in Move 3. Move 2 covers 2 steps.

Move 2, Step 1: Indicating a possible extension of the previous research

In this step, authors mention previous studies and indicate that it is possible to extend a particular study and its findings.The key words for identifying this step were using verbs and nouns, such as, *to extend* and *improvement.*

Example: Note that **this result is an improvement of the results of** Jones, Ellis and Moravec … [9]

Move 2, Step 2: Indicating a gap in the previous research

This step elaborates a gap between the existing research and previous research. The usual characterization of this step is using negative verbs.

Example: Montes in his DisPGB algorithm **has not explicitly used** Buchberger's criteria. [13]

Move 3: Introducing the present research by:

In this move, the author is expected to offer a way to cross the gap mentioned in the previous move (lakic, 2010), or present the way that s/he wants to extend the previous study. Move 3 is used cyclically in some introductions. Except the initial position which is specific for Move 1, Move 2 and Move 3 may appear in different positions in Introduction. Move 3 appeared before or after Moves 2 and 4 in this study. But, it (Move 3) is mostly encountered after Move2. This move consists of 4 steps in this study.

Move 3, Step 1: Stating the aim of the research

The function of this step is to allow the author to state the purpose or the objectives of doing that research. The main characteristics of this step are the words, such as, *aim, purpose* and *goal.*

Example: **The main purpose of the present work is** to study the duals of g-frames for Hilbert C*-modules. [12]

Move 3, Step 2: Describing briefly the work carried out

This step focuses on the main features and processes of doing the study.

Example: **In this paper, we study the complete** convergence of sequence … **We also,** extend Theorem 2 in Sadeghi and Bozorgnia [17] to the case of …. [15]

Move 3, Step 3: Announcing the findings

In this step, the author reveals the principal findings of the study. The main characteristics of this step are: *we prove that*, *we (will) show that*, *our main results are*.

Example: Here, **we prove** some nonlinear ergodic theorems for action of semi groups on Hadamard spaces. **Our main results** are … [1]

Move 3, Step 4: Indicating the research article structure

This step allows the author to mention the whole structure of his or her research article.

Example: **This paper is organized as follows. Section 2** is devoted to the study of … .**In Section 3** we study … **In the last section,** we apply some … [3]

Move 4: Recalling and introducing the basic definitions and notations

This is a new move which is found in mathematics RAs. This is an important move that is seen in different positions. It appears in Introductions, Preliminaries and Results sections. As thedefinitions of the concepts, notations and symbols are very important in mathematics, so the researcher or the writer uses any situation to reach this end. We can say that Move 4 is a mixture of Move 1, Step 1 and Step 2, that is, in this move authors define specialist terminology and introduce notations of the previous researches. The main characteristic of this move is the word *recall.*

Example: **We recall here some basic notions** of hyper group theory. [27]

Move 6: Introducing and defining the particular topic (defining the research's main   parameters)

Like Move 4, Move 6 is a new move which is introduced in this paper. The function of this move is to describe the main problem and introduce the main topic of the study. In fact, in this move, the author introduces a problem or the topic of the study in the form of a lemma, proposition or a theorem and prepares himself to prove it. So, the main characterizations of this move are the words *lemmas, Proposition* and *Theorem.* The main position of move 6 is the Results sections. But, it is found in 4 out of 30 Introductions and it is deemed optional in this section.

Example: The **following lemmas** and corollary are important in the proof of our main results.[15]

Preliminaries Section

This section is presented in mathematics RAs to complete the Introduction section (Table 7).

Table 7
Rhetorical Moves of the Preliminaries Section of Mathematics RAs

Move/Step		N	n	%
Move 4	Recalling and Introducing the Basic Definitions and Notations	30	7	23.33

Note: **N** refers to the total number of RAs analyzed in this study, **n** refers to the number of RAs containing the specific move identified, and **%** refers to the frequency of occurrence of a move.

Move 4: Recalling and Introducing the Basic Definitions and Notations

As it is mentioned in the previous section (Introduction, Move 4), the function of this move is defining specialist terminology, recalling and introducing notations which the researcher rely on throughout the article; it embedded reviewing previous results in itself.

Example: In the section, **we recall the basic definitions and notations** needed in the paper. [13]

Results Section

The Results section is generally perceived to describe the findings in an ostensibly objective manner (Kanoksilapatham, 2005, p. 279). The structure of the Results section of Mathematics RAs is summarized in Table 8.

Table 8
Rhetorical Moves of the Results Sections of Mathematics RAs

Move/Step		N	n	%
Move 5	Introducing the Present Section by:	51	37	72.55
Step 1	Definition of the concepts and notations	51	20	39.21
Step 2	Stating the aim of the section	51	16	31.37
Step 3	Stating the procedure	51	10	19.6
Step 4	Announcing the findings of the section	51	10	19.6
Move 4	Recalling and Introducing the Basic Definitions and Notations	51	8	15.68
Move 6	Introducing and Defining the Particular Topic (defining research's main parameters)	51	51	100
Move 7	Stating Proofs and Results	51	51	100
Move 8	Giving Some Examples	51	10	19.6

Note: **N** refers to the total number of Results sections analyzed in this study, **n** refers to the number of Results sections containing the specific move identified, and **%** refers to the frequency of occurrence of a move.

Note that the number of Results sections in mathematics RAs is more than the other sections. Some RAs had two or three Results sections. So, the number of results sections was more than the total number of RAs. Thus, in this section, in order to obtain the frequencies of the moves, we allocated the total number of the Results section as N.

Move 5: Introducing the Present Section by

Move 5 is presented in 37 Results sections and it is deemed conventional in this study. In all of the RAs, Move 5 appears at the initial part of the section. Move 5 covers 4 steps.

Move 5, Step 1: Definition of the concepts and notations

This step is the same as Move 1, Step 2. As it was mentioned earlier, the function of this step is to define mathematical concepts and introduce symbols.

Example: **In this section, we study this notion**, especially in the category of unital amenable Banach algebras. **We begin with a precise definition of this concept**.

Definition. An element a 2 A is called principally left [resp. right] *von Neumann regular* if …...[3]

Move 5, Step 2: Stating the aim of the section

This step functions to describe the objectives of the presented section.

Example: **Our goal in this section** is to define and characterize L-dual frames for L-frames in $L^2(G)$. [2]

Move 5, Step 3: Stating the procedure

This step explains how and with which processes the data of the study have been collected. The main characteristics of this step are the words *first, second* and *then*.

Example: **In this section, we first discuss** the structure and properties of the (R, S)-symmetric and (R, S)-skew symmetric matrices and … [4]

Move 5, Step 4: Announcing the findings of the section

The function of this step is to announce the principal findings of the section.

Example: **In this section, we state the final result** of this paper. **We will show** that the second … [8]

The steps of move 5 did not follow a fixed order of occurrence;all the steps are deemed optional in this section.

Move 4: Recalling and Introducing the Basic Definitions and Notations

The function of Move 4 is illustrated before (in Introduction Move 4). The realization of Move 4, in the Results section, is illustrated in the following example:

Example: Throughout the paper *A* and *M***denote** a Banach algebra and a Banach A-bimodule, respectively…. **Recall that** if *E* is a subset of an algebra *B*, the right annihilator ran … is defined to be … [7]

Move 6: Introducing and defining the particular topic (defining the research's main   parameters)

As it is stated before (Introduction, Move 6), the function of this move is to describe the main problem and introduce the main topic of the study. The main position of move 6 is the Results sections, before stating the results.

Example: In order to prove the main result we need the following lemma.

Lemma 3.1*Let G be a p-group of class k and exponent pe with a free presentation F/R. Then, for any c ≥ 1, every outer commutator of weight w > c in F/[R, cF] has an order dividing pe+m(c+k−w), where m = [logp k].* [9]

Move 7: Stating proofs and results:

Authors in this movehighlight the results obtained from the study.

Example: Using the above notation,**we now establish the following result** ... [21]

Move 7 is another significant move in this study. Conventionally, this move is obligatory in any study. The nature of the results in mathematics RAs is most often modifying the definitions and extending the findings of previous research.

Note that Move 6 and Move 7 were occurred more frequently in each Results section. But, we have count them just once.

Move 8: Giving some examples:

The author in this move gives some examples to show the results; it is an optional move in this study.

Example: The following example shows that a biatBanach algebra is not in general ….   **Example2.17.** Let D ….. [28]

Conclusion Section

This is an optional section which is so rarely used in this discipline. As Graves et al. (2013) mentioned,Conclusion sections are more common in applied math papers and rare in pure math RAs.

Table 9.

Rhetorical Moves of the Conclusion Section of Mathematics RAs

Move/Step		N	n	%
Move 9	Restating the Procedure	30	1	3.33
Move 10	Restating the Findings	30	2	6.66
Move 11	Justifying the Findings	30	1	3.33

Note: **N** refers to the total number of RAs analyzed in this study, **n** refers to the number of RAs containing the specific move identified, and **%** refers to the frequency of occurrence of a move.

Move 9: Restating the procedure

In this move, the author provides a summary of the study carried out. The main characteristic of this move is stating the procedure using the past tense.

Example: **We have considered** the (R; S)-symmetric and (R; S)-skew symmetric solutions … . By making use of the decompositions (2.6), **we presented** general analytic formulae, and gave necessary and sufficient conditions for guaranteeing the existence of these solutions. [4]

Move 10: Restating the findings

This move occurred to summarize the results and findings of the study; it is an optional move. The main characteristic of this move is stating the findings in past tense.

Example: Also, **we derived** necessary and sufficient conditions for the existence and the expressions for the general (R; S)-symmetric and (R; S)-skew symmetric solutions to the pair of matrix equations in some special cases. [4]

Move 11: Justifying the findings

Authors make this move to judge their study. This is an optional move in this study.

Example: Let ….. be a doubly infinite sequence of independent sub-Gaussian random variables with …., **then all of the above theorems and lemmas are true in this case**. Moreover if …. , **then our results are true.** In particular, the results of Sadeghi and Bozorgnia [17] are valid in this case. [15]

Sequence of the Moves

The choice of move order was determined based upon the frequency of the moves in each position. For instance, Recalling and Introducing the Basic Definitions and Notations was coded as Move 4 because it was the most frequent move in the fourth position of the mathematics RAs. Table 10 represents the move order of Mathematics RAs.

Table 10
Move Order of the Mathematics RAs (considering move recycling)

RAs	Move Order	RAs	Move Order
1	12134567567	16	1357579
2	1234567567567	17	1567
3	1234567567567	18	12345675687
4	135676789	19	1234567
5	1231567567	20	143678
6	1234567	21	14131667
7	143467467	22	13467467
8	1234567567	23	13613467
9	13213467	24	13567
10	12134567	25	132467567
11	1213567567567	26	123435675678
12	1213446785678	27	1456785678
13	1234567	28	135678
14	1234567	29	13254678567
15	1324656710	30	1236467678

The occupation of the first position by the Introducing the Field and its obligatory nature implies the importance of this move in Mathematics RAs. Move cycles are also clear in this table. Repetition of Moves 5, 6 and 7 is

because of repetition of Results sections.Therefore, the general sequence of moves in the Mathematics RAs could be recognized as 1234567891011.

Move Cycles

Move structure analysis of the corpus revealed that move cycles occurred in Move 1 (Introducing the Field) and Move 3 (Introducing Present Research). High number of move cycles was found in Move 1 which was recycled in eight RAs of our corpus. Move 3 was recycled only in three RAs.

Examples: **Move 1** (step 1) We denote by *H* (*D)* the space of holomorphic function on the open unit … (step2) We refer to [15] for the theory of this space... **Move 4** Now we recall some particular cases…**Move 1** (step2) Li and Stevic [4] studied the…**Move 3** Our aim here is to study the…**Move 1** (step 1) The notation $a\_\sim b$ means that… [21]

Discussion

The analysis of the research articles in mathematics in terms of the macro IMRD structure and the moves that constitute theses macro rhetorical sections highlights the significance of the concept of "communicative purpose" in defining the concept of genre. The original concept of genre as suggested by Swales is based on the assumption that the communicative purposes which distinguish one discourse community form others determine both the macro structure and the micro (e.g., lexical, grammatical) features of the texts which play a role in the life of a specific discourse community. Hence, the very fact that the conventional IMRD pattern is structured differently in mathematics should be understood in light of the philosophy of science dominating this discipline and the philosophy of knowledge construction leading the production of research in this community. In fact, as we have highlighted in the introduction section of the present article, understanding the true nature and structure of a specific genre cannot be independent of the processes that lead to the construction of that genre. This would certainly require a true ethnography and cannot be achieved by a mainly text-oriented analysis of the type we have reported here. As Becher

(1989) argues, a detailed [ethnographic] analysis of disciplinary discourses can help not only to bring out characteristic cultural features of disciplines but also to highlight various dimensions of the domains of knowledge they relate to. Becher also suggests that through such an analytic perspective, we will be able to understand why disciplines differ in terms of generating, developing, expressing and reporting arguments [emphasis ours]. Hence, one gap which should be acknowledged in the present study is related to the absence of this ethnographic dimension. The authors of this article attempted to compensate this by communicating with the authors of the texts in the corpora and eliciting their own judgment about the structure of research article in mathematics, but due to lack of cooperation on the authors' part this attempt failed. Of course, it was possible to have some general intuitions about why the structure of a research report does not follow the conventional rhetorical patterns; however, we preferred to avoid this and just hope for further complementary research in the future.

Even without the deeper insights we expected form the analytic procedure of this research, the findings of the present investigation can have valuable implications for the novice researchers of the filed. Emphasizing the very assumption underlying this and similar genre-based investigations, we believe that the emerging move-based pattern is able to provide a satisfactory model of research article in the investigated discipline and enhance the ability of Iranian novice mathematicians to understand, and where appropriate, to produce this academic genre; the emerging model can also act as a delicate system that can enable expert researchers of the filed to convey to prospective members the features that make a research article standard – in the sense that it performs the functions for which it is intended in the discipline, and it is acceptable by the community for whom/within which it is produced.

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