Macrostructural Analysis of STEM Students' Research Introductions in the Secondary Education Context: Implications for Pedagogy, Curriculum, and Teacher Professional Development

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Abstract. There is a growing interest in exploring the structure of student academic writing across different disciplinary backgrounds, including the Science, Technology, Engineering, and Mathematics (STEM) field. However, despite the availability of relevant literature on STEM student writing, research on the structure of STEM students' research introductions, particularly within the secondary education context, remains essentially scant. Consequently, STEM student research writers should be redirected towards a genre-based academic writing practice to meet the rhetorical demands of their discourse community. Drawing on this research gap, this qualitative genre analytic study was conducted to explore the structure of STEM students' research introductions, with an

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emphasis on the macrostructures and the move/step occurrences. Ten research introductions submitted as preliminary examination papers by the Grade 11 STEM students in an online research writing course at a private Philippine university were collected and further screened via Turnitin, ensuring their authenticity. Following Biber et al.'s (2007) top-down corpus-based discourse analytic framework, moves and steps in the research introductions were carefully analyzed, with Swales' (1990, 2004) Creating A Research Space (CARS) model as basis for move/step identification. The findings indicated variations in the move structure of students' research introductions, with the majority deviating from Swales' (1990, 2004) model. While the students employed all three moves by Swales (1990, 2004), they hardly established a niche in writing a research introduction. The study highlights important implications for pedagogy, curriculum, and teacher professional development in the context of STEM research writing.

1. Introduction

Academic writing is an essential skill for students. It plays a central role in students' successes in college and in professional world (Leki, 2003; Light, 2001). Writing using appropriate linguistic and rhetorical devices in a specific field enables the students to surmount the academic demands of the curriculum (Tan, 2011). In addition, over 90% of white-collar workers and 80% of blue-collar workers acknowledge writing as an important skill for success on the job (Blackley, 2013). Despite the importance of academic writing, research shows that second language (L2) students continue to struggle to learn how to write appropriately (Javadi-Safa, 2018). The difficulty in academic writing for L2 students could be caused by lack of genre knowledge (Hyland, 2008). Genre knowledge relates to "the idea that members of a community usually have little difficulty in recognizing similarities in the texts they use frequently and are able to draw on their repeated experiences with such texts to read, understand and perhaps write them relatively easily" (Hyland, 2008, p. 543). In addition, genre knowledge allows students to become aware of the fact that academic writing is "staged, goal-oriented, and purposeful" (Martin et al., 1987, p. 25), suggesting that discourse communities share specific writing conventions for their members to conform when writing.

Consequently, there has been a growing body of research on genre-based academic writing (Aranha, 2009; Carstens, 2010; Cheng, 2006; 2008; Flowerdew, 2000; Wingate, 2012). Genre-based academic writing is writing adhering to the linguistic and rhetorical features required by the discourse community where the texts are produced. For example, writing a research article is an example of genre-based academic writing because a research article should be written with appropriate language and structure as dictated by the scientific community. The studies on genre-based academic writing have affirmed that genre-based academic writing enables students to develop genre awareness that is necessary for writing well-structured academic texts. In particular, the study of structures

of research articles, especially research introduction has become an integral aspect of genre-based academic writing. As an essential section of a research article, research introduction entails a "useful purpose of making 'the present story' relevant by placing it appropriately in the context of 'the first story', i.e., previous research in a particular field of study" (Bhatia, 1993, p. 154). A research introduction motivates the present research and justifies its publication (Swales, 1990), insinuating that the relevance of a topic under study is established through the research introduction. A good research introduction, according to Swales (1990), describes the background of the study, reveals the gap that exists in theory and practice, and states the purpose for why the study is pursued. Thus, the readership and utilization of a research article may depend largely on a research introduction. Nonetheless, writing a good research introduction could be difficult for most writers since the process is regarded as slow and troublesome (Swales & Feak, 2012).

A number of studies on research introductions have been conducted across different contexts previously (see Abdullah, 2016; Briones, 2012; Futász, 2006; Geçikli, 2013; Gustilo et al., 2018; Joseph et al., 2014; Ozturk, 2007; Porras & Ingilan, 2017; Samraj, 2008, 2002; Sheldon, 2011). These studies have shown interesting findings, establishing a variety of move patterns of research introductions in various fields. While considerable research has been devoted to the structures of research introductions across different disciplines, rather less attention has been paid to the structures of research introductions written by STEM students, particularly in the secondary education context where the research introductions are not taken from students' completed theses. Past works on STEM student writing have focused on either analyzing the structure of graduate and undergraduate student research introductions (Maswana et al., 2015; Setiawati et al., 2020), exploring the structure of high school student research introductions of completed theses (Buena, 2021), or broadly examining rhetorical organization of students' assignments in a superficial manner (Pilotti & Elmoussa, 2022). Research on exploring the structure of STEM research introduction writing among secondary students remains essentially scarce. It is on this note that the present study was conducted to explore the structure of STEM secondary students' research introductions. In the Philippines, research writing courses are offered as applied subjects to secondary students under the senior high school (SHS) program of the K-12 curriculum, including the STEM students. Considering the distinct nature of STEM as a field, there is a need to ensure that STEM secondary students practice academic writing that is consistent with the disciplinary needs of their discourse community. The findings of the present study are pivotal in the field of L2 writing, particularly in the context of STEM.

The goal of this study is to explore the structure of STEM students' research introductions. Specifically, it aims to provide answers to the following research objectives:
1. Describe the macrostructures of Grade 11 STEM students' research introductions, and
2. Describe the move/step occurrences present in the students' research introductions.

1.1. Literature Review

1.1.1. Theoretical Bases

The most influential theoretical grounding in genre analysis is the Swales' (1990) Creating A Research Space (CARS) model. This framework opines that writers organize a research introduction following the three moves: Move 1 (Establishing a Territory); Move 2 (Establishing a niche); and Move 3 (Occupying the niche). Writers may employ specific steps to accomplish the overall communicative function outlined in each move. This suggests that in establishing a territory within the research introduction, writers may claim centrality, make topic generalizations, or review items from previous research. For instance, in a study of Jackaria et al. (2024), the research introduction begins by highlighting the emergence of generative artificial intelligence (AI) to convince the readers of the importance of AI in education, hence claiming centrality. The CARS framework has been used in genre-based studies.

Due to some of its limitations, however, the framework had received several critiques from other scholars. For example, Anthony (1999) found that, while the model was very successful in describing the overall organization of the research introduction, it could not account for a more detailed description of individual steps. The author argued that some steps were redundant and other essential steps in realizing the goal of a research introduction were lacking. For instance, *Evaluation of research* was not present in the framework, but such a step is important in a research introduction.

Meanwhile, Samraj (2002) who analyzed the structure of research introductions in the fields of Wildlife Behavior and Conservation Biology contended that "a greater degree of embedding is needed" in the framework to account fully for the rhetorical structure of research introductions (p. 16). The author discovered that presenting positive arguments after indicating a gap in the literature was common among the writers of Wildlife Behavior research articles. Hence, *Presenting positive justification* was a necessary integration in the Move 2 of the current framework. In addition, the author claimed that *Reviewing items of previous research*, which was present only as the last step in Move 1 plays a significant role in fulfilling Move 2 as this would help reinforce gaps identified from previous research.

As a result, Swales' (2004) revised CARS model was developed. The 2004 framework, more encompassing, is an improved version of the 1900 model successfully addressing most of the constraints pointed out by the scholars against the old one (Ozturk, 2007). Hence, several works have adopted this framework in analyzing research introduction across different fields (see Farnia & Barati, 2017; Isik Tas, 2008; Jalilifar, 2010; Lintao & Erfe, 2012; Minaei & Sabet, 2017; Sheldon, 2011).

1.1.2. Empirical Studies on the Structure of Research Introductions across Different Fields and in STEM

In recent years, numerous studies on research introductions have been conducted across different contexts. Ozturk (2007), for example, used the CARS model to examine 20 research introductions and the difference between the two sub-disciplines of applied linguistics: L2 writing, and L2 acquisition research. The

study found that the two sub-disciplines employed distinct and almost completely different move patterns. For instance, in L2 writing corpus, two different types of move pattern were almost similarly repeated, whereas in L2 acquisition corpus, one type of move structure was preponderant. Additionally, Samraj (2008) asserted that the CARS model may be applicable to different disciplines; nonetheless, different move patterns could be found across these various disciplines. Similarly, Abdullah's (2016) analysis of the introduction sections of two different disciplines [English Language Teaching (ELT) and Civil Engineering (CE)] corpora revealed variations in structural pattern of ELT and civil engineering research introductions. Furthermore, a variety of move structure in the introduction sections of research articles in psychology, Persian literature, and applied linguistics was found by Adel et. al (2020).

In the field of STEM, Setiawati et al. (2020) analyzed the move structure of research introduction in soft and hard sciences. The study revealed that the move structures of the examined research introductions were consistent with the CARS model regardless of the discipline. As regards the step occurrences, the findings showed that the research introductions from the field of hard science were more constitutive of the *research questions*, *definitional clarifications*, and *presentation of their works* as compared to those from the field of soft science. In a similar vein, Maswana et al. (2015) explored the structures of research articles in five engineering fields. The findings on the research introduction indicated that the three conventional moves were extensively employed in all the disciplines. Nonetheless, variations were found as to the strategies in terms of contextualization of the study, which is the main objective of the introduction. Moreover, a study by Buena (2021) provided insights into the moves structure of the scientific thesis introductions of the Grade 12 STEM students. The study discovered that the students' thesis introductions essentially conformed to the CARS model. However, some difficulty was observed in terms of achieving the Move 2, *Establishing the niche (problem)*. The study concluded that it is important to give primary focus on strategies in reviewing the literature as such can help students review relevant research and establish the research problem. Arévalo et al. (2021) provided a comprehensive error analysis of STEM students' mathematical, linguistic, and rhetorical-organizational assignments. The result showed that the dominant errors were rhetorical-organizational (39%) and linguistic (38%). Furthermore, a more recent study by Pilotti and Elmoussa (2022) examined several factors facilitating STEM students' success in a research writing course. The factors included research writing skills. However, the focus on the research writing skills was superficial as the measurement was self-reported.

As revealed in the literature review, the CARS model of Swales (1990, 2004) has become an influential basis upon which the analyses of research introduction are operated. The model has paved a way for the preponderance of genre-based studies in academic writing, particularly on research introduction. However, despite the existence of these numerous studies, it seems that limited research has been done on the structure of research introduction of secondary students in STEM. While the study on Grade 12 STEM students' research introductions (Buena, 2021), as reviewed in the literature, is insightful, it may have failed to

account for the authenticity of student writing since the data analyzed were completed theses, suggesting that these papers have undergone substantial revisions integrating expert advice, hence making the present work fundamentally relevant. In addition, the studies of Arévalo et al. (2021) and Pilotti and Elmoussa (2022) failed to account for a deeper exploration of the STEM students' structure of research introduction. While rhetorical-organizational element was examined in the research of Arévalo et al. (2021), the analysis was superficial, as it only focused on looking for errors. Thus, an in-depth analysis of the structure of STEM students' research introductions is necessary to understand how STEM students organize their ideas when writing a research introduction.

2. Methods

The study followed the qualitative research approach, particularly applying genre analysis with the use of textual data. The employment of genre analysis in the present study was consistent with the study's goal, that is, to explore the structure of research introductions with emphasis on the macrostructure and move/step occurrences. As a framework of analysis, genre analysis is useful for scrutinizing the cognitive structuring of texts in certain aspects of language use (Bhatia, 1991). Cognitive structuring is marked by the rhetorical moves the members of specialist community employ as organizational patterns of their writings (Bhatia, 1993).

The study was conducted at a private university in Metro Manila, the Philippines. The university is an autonomous institution offering six educational programs: Elementary School, Junior High School, Senior High School, College Division, Law School, and Graduate School. The selection of a private university as a research context was by convenience since it was at the height of the pandemic when this study was conducted, and the lead researcher was teaching at this university during that time. The present study was limited to the context of the SHS program. The choice for the SHS program was due to the fact that it was the only secondary education program offering research writing courses, which is relevant to the study's research problem. During the conduct of the study, the SHS program at the university was offered in four tracks: Academic, Technical-Vocational, Arts and Design, and Sports. The participants of the study were from the Academic track, specifically under the STEM strand. The students were composed of ten (10) groups who were enrolled in a research writing course, *Practical Research 2: Quantitative Research*, under the class supervision of the lead researcher. Each group was composed of five to seven students as members. The lead researcher was the course instructor of the student participants when this study was conducted. He is an English language educator whose research interests include academic writing and genre analysis and has extensive experience in research writing and publication. During the conduct of the study, all classes in the university were implemented online, both synchronously and asynchronously, due to the restrictions brought about by the COVID-19 pandemic. Hence, the use of convenience sampling in selecting the participants enabled the researchers to consider some practical criteria, such as accessibility and the willingness to participate (Dornyei, 2007).

The instrument used was a writing task, *Writing the Research Introduction*, which was designed as a preliminary examination in the said research writing course. As a common practice in the university, the I-M-R-D structure of writing a research paper instead of the traditional chapter-by-chapter format was used; hence, Research Introduction constituted the first part of the students' I-M-R-D papers. The task contained seven parts: *Background/Introduction*, *Statement of the Problem*, *Conceptual Framework*, *Significance of the Study*, *Scope and Delimitation*, *Operational Definition of Terms*, and *References*. A sample research introduction from the lead researcher's former students was provided to serve as a supplementary support in developing the task. A rubric for assessing the students' papers as well as guidelines in terms of mechanics and formatting was also attached for students' reference. The rubric and the guidelines were researcher-made, designed by the lead researcher for the class, based on existing literature on research writing. The details about the task were uploaded in Canvas, a Learning Management System (LMS), and students were expected to turn in their works therein.

The data collection involved the following processes. Each group of students was asked to propose a research topic and submitted a research concept explaining their choice of the topic and its relevance to their chosen SHS strand. With the lead researcher's approval, the groups were then tasked to read literature and studies related to their research topic and submitted a matrix of literature review. Early in the semester, the students were informed regarding the study; an informed consent was sought from their parents/guardians. Subsequently, the students were asked to write a research introduction as their preliminary examination paper in the research writing course where they were instructed to incorporate the literature and studies they submitted in the literature review matrix. Prior to the task, the students received genre-based writing instructions from the lead researcher, showing them how to write an effective research introduction following Swales' (1990, 2004) CARS model. The students worked collaboratively online in developing their research introduction for two weeks. After two weeks, the students submitted their research introductions in Canvas. Each research introduction was retrieved and subjected to plagiarism check via Turnitin. The selection criterion was that the submitted research introductions should not exceed 10% similarity index of Turnitin report. Ten research introductions passed the set criterion, hence subjected to further analysis, with each assigned a codename to protect the identity of the student participants. To ensure authenticity of student writing, the data analyzed in this study were the students' first drafts, which means that teacher feedback was not yet incorporated.

The revised CARS model of Swales (2004) was employed in analyzing the data. However, *Centrality claims*, a step in Move 2 from the old model, was integrated. The reason for the step integration was to account for specific rhetorical strategies built within Move 1 so that a more comprehensive structure of each move in the framework could be accounted to describe the macrostructures of the research introductions. Such step integration has also been done in previous research (e.g. Joseph et al., 2014; Farnia & Barati, 2017). A cognitive judgement (Kwan, 2006) was employed rather than linguistic features in identifying the function of a text

and text boundaries (see also Bhatia, 1993; Paltridge, 1994, as cited in, Biber et al., 2007). Cognitive judgement means that the analysis operates at the macrostructural level, looking at how segments of texts are linked together based on their communicative functions to provide a coherent thought. Thus, regardless of linguistic devices, move/steps were designated to segments of text depending on their communicative functions. It is noteworthy that, since move/step identification based on communicative functions could result in varying move/step lengths, a segment of text, consisting of a sentence or a group of sentences (a paragraph or so), that fulfilled a distinct communicative function based on the study's framework constituted a move/step in this study (Zhang & Wannaruk, 2016). However, should a segment of texts convey more than one communicative function, the researchers would do the common practice, which is assigning it to a move that appears to be the most salient (Del Saz-Rubio, 2011; Holmes, 1997; Ozturk, 2007). Sub-headings other than Introduction/Background (e.g. Statement of the Problem, Conceptual Framework, etc.) were excluded since the focus of the present study was on move/step identification in the research introduction sub-section only.

As for the detailed procedure for data analysis, a top-down corpus-based discourse analytic framework by Biber et al. (2007) was followed. Specifically, following the ideas of Biber et al. (2007), the subsequent steps were undertaken in analyzing the research introductions in this study:
> (1) reading the research introduction thoroughly to gain a big picture of the overall rhetorical purpose of the text;
> (2) reading and re-reading the research introduction more closely to gain an in-depth understanding of its communicative functions;
> (3) segmenting each research introduction into discourse units;
> (4) identifying the functional type of each discourse unit in each research introduction;
> (5) analyzing complete texts as sequences of discourse units shifting among the different functional types; and
> (6) describing the general patterns of discourse organization across all texts in the corpus.

Reading the research introductions was an essential step in analyzing the data because the researchers had to develop an initial understanding of the research introductions. It is important to note that the researchers come from diverse educational backgrounds. Hence, this procedure provided the researchers with an initial, common understanding of the research introductions analyzed. After an initial understanding was developed, further reading and re-reading of the research introductions were performed. This step allowed the researchers to develop a deep and thorough comprehension of the research introductions, especially focusing on the communicative purposes of each research introduction. Segmenting the research introductions into discourse units came as the next step where the researchers chunked the research introductions into parts based on the common communicative functions they serve in the whole text. Then, these segments of research introductions were assigned moves and steps, following Swales' (1990, 2004) CARS model. A further review of the analysis was then

performed, ensuring that the assigned moves and steps were faithfully constitutive of the communicative functions found in the research introductions. Finally, the general move patterns or the macrostructures of the research introductions were described, for example, M1-M2-M3, where M stands for move and the numerical value attached stands for the move number as outlined in Swales' (1990, 2004) CARS model. Move/step occurrences were further examined through their frequency of occurrences and were then described in percentage.

The process of data analysis was long and recurring. There were times when the researchers had to re-analyze the research introductions several times, trying to look at the framework, review previous literature, and analyze and re-analyze the data. The researchers opine that such recursive and iterative nature of data analysis and literature triangulations helped establish the validity and reliability of the findings of the present study.

3. Findings and Discussion
The goal of this study was to explore the structure of STEM students' research introductions. The specific objectives were to describe the macrostructures of the STEM SHS students' research introductions and to account for their move/step occurrences. Hence, the findings are presented and discussed in reference to these research objectives.

3.1. Macrostructures of STEM SHS Students' Research Introductions
The analysis revealed variations in the move structure of students' research introductions. As can be seen from Table 1, each research introduction was found to have a rather different move structure. For example, while RI6 tends to conform to the framework of Swales' (1990, 2004) with the typical M1-M2-M3 move structure, RI5 would start with M3 (Presenting the present work) without establishing a niche. This finding suggests that the students may have unique styles of structuring their arguments when writing. This is consistent with what is explained by Kanoksilapatham (2011) as "the expected idiosyncrasy of individual writers or groups of writers" in research writing (p. 66).

Table 1. Macrostructures of STEM SHS Students' Research Introductions

Research Introduction	Move Structure
1	M1-M3-M1-M3
2	M1-M3-M1-M3-M1-M3-M1-M3-M1-M3-M1
3	M1-M3-M2-M3-M2-M1
4	M1-M3-M1-M3-M1-M2-M3
5	M3-M1-M3-M1
6	M1-M2-M3
7	M3-M1-M3-M1-M3-M1-M3
8	M1-M3
9	M1-M2-M1-M2-M3
10	M1-M3-M1-M3-M1-M3-M1-M3

Note: RI - Research Introduction

While differences in the move structure were evident in the students' research introductions, there appears to be one move structure that is more significant than others. For instance, the occurrence of M1-M3 structure was typical in about 80% of the research introductions analyzed. An example illustrating this move pattern can be seen in the text segment of RI2 below. The employment of such move structure advises that the students consider it highly important to establish a territory and then present the current work. Further, this suggests that while the students might seldom establish a niche, they would attempt to provide the readers with background information as well as the relevant details about their present research. The possible reason for the preponderance of this move structure could be the students' lack of previous knowledge of relevant research literature, hence prompting them to proceed in announcing their present research after providing a short background. Such a writing structure fails to establish a niche somewhere in between the M1 and M3.

> **[M1]** *Mckean et al. (2000) recognized that stressors alone do not produce anxiety, depression or tensions. Rather, the interaction between stressors and the person's perception and the reaction to these stressors cause stress. Everybody has experienced it or has it within their high school life. The resources available to a person in order to deal with specific stressful events and situations affect the level of stress they experience (Zeidner, 1992). This can imply as a consequence in all the human circumstances within every academic practice.*
>
> **[M3]** *This study will give significant pieces of information concerning the effects of academic stress on the mental health of SHS students. Within this study, it will recognize the negative effects of academic stress that might be alarming to every student.*
>
> *-RI2*

Remarkably, three important observations can be surmised based on the analysis: the move recurrence, the use of M3 as an opening move, and the lack of M2. The recurrence of moves was found in most of the research introductions analyzed. For example, M1 recurred in almost all the research introductions, except for RI6 and RI8 whereas M3 recurred in 7 research introductions except for RI6, RI8, and RI9. Specifically, it can be gleaned from the text segment of RI10 below how M1 and M3 recurred within the research introduction. The findings of previous works (Oztürk, 2007; Rahman et al., 2017; Paltridge & Starfield, 2007) showing that move recurrence may be explained by the length of a text seems to be less applicable in the present study because the shortest research introduction analyzed still recurred moves, as evident in RI5.

> **[M3]** *Cyberchondria is a health condition wherein exceedingly and chronically worrying about being seriously ill (Starcevic & Berle, 2015). We looked at how regular, relatively harmless symptoms can lead to severe, unusual conditions related to the common symptoms.* **[M1]** *According to some research, it indicates that online search engines can worsen medical issues.* **[M3]** *The term cyber from cyberchondria is*

> *combined with Hypochondriasis to reflect the cause of this mental state emanating from the cyberworld, more specifically, the Internet (Starcevic & Berle, 2013). Reasons may deviate to the behavior person who is continuously engaged with the cyberworld.* **[M1]** *Recent studies showed that cyberchondria is deeply associated with anxiety. As we investigate, many aspects direct a role in developing cyberchondria.*
>
> *-RI10*

Another important finding is that some research introductions started with M3 instead of M1 as manifest in RI5 and RI7. A specific example from the text segment of RI5 is shown below to illustrate this finding. The unusual use of M3 as a move opening in a research introduction is not surprising. A study by Gustillo et al. (2018), for instance, indicates that M3 was remarkable as an opening move in Filipino undergraduate thesis' introduction through purpose statement. Similarly, an earlier study by Oztürk (2007) shows that M3 was observed as an opening move via methods summarization in applied linguistics research introduction. However, in the present study, M3 was found as an opening move through definitional clarification. This suggests that the students may have considered their readers as general audience who might need to develop an initial understanding of the key terms before further exploring the relevance of the research topic.

> **[M3]** *Online learning is an education supported electronically that takes place over the Internet.* **[M1]** *As online learning continues to grow, it is important to know students' overall challenges in the online learning world.*
>
> *-RI5*

Moreover, the absence of M2 in most of the research introductions was notable with only four research introductions (RI3, RI4, RI6, and RI9), making use of M2. An example of text segment from RI8 can be seen below where M2 is clearly missing within the research introduction. The reason for the lack of M2 in the students' research introduction could be attributed to their inability to synthesize related literature and studies. It is important to note that initially the students had submitted literature review matrix containing at least 10 articles related to their chosen topic, and they were tasked to integrate these in writing their research introduction so that they could establish a niche. From the analysis, however, it appears that the students hardly cited sources to justify their arguments. Hence, this lack of literature citations may be the reason why they might have failed to identify a gap which is an essential part of niche establishment in a research introduction. This aligns with the finding of Buena (2021), emphasizing the need for teachers to focus on teaching students the strategies in reviewing the literature to help them review relevant research and establish a research gap.

> **[M1]** *A lot of studies already existed about the factors that affect students' career choices. For example, Kazi & Akhlaq's study 2017 found out that parents and peers influence students' career choice.*

[M3] *This study will be very helpful to Senior High students. This will help not only to fulfill their desires but also to be one of the elements of fulfilling their aspirations in life. Because we believe as researchers of this study that the importance of choosing the course according to the preference of the students will greatly help them to be more determined and they will have the motivation to finish the chosen course without compulsion.* -RI8

3.2. Move/Step Occurrences in STEM SHS Students' Research Introductions
To describe move occurrence and its realizations across the entire corpus, moves and steps were summarized. Table 2 shows that all the three moves in Swales' (1990, 2004) were employed. Specifically, M1 (Establishing a territory) was obligatory as it was observed in all the research introductions analyzed. The finding indicates that the students seem to give high regards on territorial establishment in writing a research introduction. This is consistent with Swales' (1990, 2004) statement that re-establishing the significance of the research field itself is central to gaining acceptance of one's work in the eyes of the discourse community members. On the contrary, M2 (Establishing a niche) was found to be optional with only 40% occurrence. This result implies that, as opposed to territorial establishment, niche establishment may be less valued by the students in writing a research introduction. Meanwhile, M3 (Presenting the present work) was regarded obligatory with 100% occurrence. This finding substantiates Swales' (1990, 2004) assertion that the need to ascertain how the niche in the broader field will be occupied and defended within a research introduction is of paramount importance in writing a research introduction.

Table 2. Move/Step Occurrence in STEM SHS Students' Research Introductions
Move/Step

Move/Step	Research Introduction (N=10)	Move Occurrence
Move 1 = Establishing a territory	10(100%)	Obligatory
Step 1 = Claiming centrality	7(70%)	Quasi-obligatory
Step 2 = Topic generalization of increasing specificity	10(100%)	Obligatory
Move 2 = Establishing a niche	4(40%)	Optional
Step 1A = Indicating a gap	4(40%)	Optional
Step 1B = Adding to what is known	-	-
Step 2 = Presenting positive justification	-	-
Move 3 = Presenting the present research	10(100%)	Obligatory
Step 1 = Announcing the present research descriptively and/or purposively	8(80%)	Quasi-obligatory
Step 2 = Presenting RQs or hypotheses	-	-
Step 3 = Definitional clarifications	7(70%)	Quasi-obligatory
Step 4 = Summarizing methods	-	-
Step 5 = Announcing principal findings	1(10%)	Optional
Step 6 = Stating the value of the present research	4(40%)	Optional
Step 7 = Outlining the structure of the paper	-	-

Note: 100% = obligatory, 99%-51% = quasi-obligatory, and 50%-0% = optional (Adapted from Yang & Allison, 2003)

With respect to move realization, it could be seen that M1 was achieved by *claiming centrality* (70%) and *topic generalization of increasing specificity* (100%). Clearly, *topic generalization of increasing specificity* was an essential step for the students in establishing a territory. The finding suggests that the students may have felt the need to establish a territory by describing current practices or phenomena which may be closely relevant to their personal experiences or observations. Unlike when making centrality claims, a research writer may not need to relate to the field to show the novelty of the research when generalizing a topic, hence reliance on personal experiences or observations (Samraj, 2002). Meanwhile, M2 was achieved only by *indicating a gap* (40%). The reason for such minimal use of gap indication in niche establishment may again be due to the students' failure to integrate the literature and studies they initially reviewed to realize their research introduction. Lastly, M3 was achieved by four steps: *Announcing the present research descriptively and/or purposively* (80%); *Definitional clarifications* (70%); *Announcing principal findings* (10%) and *Stating the value of the present research* (40% %). Interestingly, of the four steps, *Announcing the present research descriptively and/or purposively* and *Definitional clarifications* were the only quasi-obligatory in accomplishing M3. The result negates the assertion of Swales (2004) which states that statement of the research aims or purpose towards the end of the introduction section is an obligatory step in achieving M3.

4. Conclusion

This study was conducted to provide insights into the macrostructures and move/step occurrences of secondary students' research introductions in the field of STEM. Applying qualitative genre analysis, ten research introductions written by the Grade 11 STEM students in an online research writing course were collected, screened, and further analyzed to explore their macrostructures and move/step occurrences. The procedure for data analysis conformed to Biber et al.'s (2007) top-down corpus-based discourse analytic framework, with Swales' (1990, 2004) CARS model as basis for move/step identification. As can be surmised from the findings, the macrostructures of STEM SHS students' research introductions vary considerably. The students use various rhetorical moves and steps in writing a research introduction, with a variety of move patterns deviating from Swales' (1990, 2004) CARS model. There is evidence that the students may overuse specific rhetorical strategies within the text by means of move/step recurrence. They also hardly establish a niche when writing a research introduction because they mostly rely on their personal experiences or observations rather than on previous research in the field. Further, they tend to define terms at the beginning or in the early part of their research introductions without first establishing the relevance of the topic. Therefore, it can be concluded that, generally, STEM SHS students' ability in structuring academic texts such as a research introduction may be dictated by their idiosyncratic writing styles as well as their lack of knowledge of the field. The study enhances our current understanding of the application of Swales' (1990, 2004) CARS model, implying that novice research writers such as STEM secondary students may need enough exposure in reading published research articles within their discipline to develop genre knowledge.

Notwithstanding this conclusion, caution should be taken considering the limited size of the corpus analyzed. A more comprehensive exploration of STEM student writing with the use of a larger corpus size or involving multiple data sources is recommended for future research. It is also important to note that the present study was conducted during the COVID-19 pandemic where the teaching and learning was held fully online; hence, future research may consider conducting a study that is based on face-to-face situations to compare the findings of this study.

5. Implications

Based on the findings and conclusions, several important implications on pedagogy, curriculum, and teacher professional development can be drawn from the study. In terms of pedagogy, teachers may adopt a genre-based approach when teaching research writing to STEM students. For instance, before teaching the students how to write a research introduction, teachers may assign reading tasks that make use of actual published research papers in different sub-fields of STEM. These reading tasks should enable the students to critically pay attention to the linguistic and rhetorical structure of the texts. Then, subsequent meetings may focus on facilitating a discussion that integrates the students' outputs from prior reading tasks. The use of genre-based approach could develop students' genre knowledge, which is essential in improving organizational skills in research writing. As research writing is "staged, goal-oriented, and purposeful" (Martin et al., 1987, p. 25), genre knowledge helps students to become acquainted with the various linguistic and rhetorical features expected of the genre they are assumed to produce given their field. With genre-based approach, students see real-world examples to understand how academic texts such as a research article are constructed within their field, which in this case, is STEM. In addition, teachers should recognize the diverse needs of the students. As some students start their research introductions with M3 (Presenting the present work), it may be beneficial for the teachers to provide guidance on effectively integrating definitional clarification as an opening move, ensuring that the audience gains a preliminary understanding of key terms before delving into the main content. Moreover, teachers should provide constructive feedback on the incorporation of literature and encourage students to revise their introductions, ensuring proper citation practices and a more robust establishment of the research context.

As with the study's implications for the curriculum, a separate academic writing course that is tailored to the disciplinary needs of STEM students may be offered as a prerequisite in the current senior high school STEM curriculum. To date, the SHS curriculum for STEM has not integrated an academic writing course tailored to the needs of students in this academic track. A relevant example of curricular enhancement needed is the design of a STEM-based academic writing course, where learning competencies are drawn from genre-based academic writing in STEM aligned to students' learning needs. This means that the learning competencies should be aligned to the expected disciplinary knowledge and skills for academic writing practice in the different sub-fields of STEM. The goal of such an academic writing course is to develop the STEM students' academic writing skills, especially in terms of rhetorical organization in the context of STEM research writing. Through this course, the students specifically get to

"deconstruct" and "construct" STEM-oriented texts until they become so immersed in the linguistic and rhetorical structures that they can independently produce on their own. By offering a prerequisite STEM-based academic writing course, the students will gain a practical understanding of the typical disciplinary discourses that are salient for research writing in the field of STEM.

Finally, on teacher professional development, there is a need to design, implement and evaluate a competency-based training for teachers on teaching research writing in STEM. The training may be initiated at an institutional level in the case of private schools. For public schools, the training may be instigated by the national, regional, or divisional professional development bureaus. Research teachers need to recalibrate their content and pedagogical knowledge in research writing because most of them are STEM teachers, not academic writers nor writing teachers. With teachers' enhanced skills in both content and pedagogy in relation to STEM research writing, their ability to transform students in becoming successful STEM research writers is limitless.

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7. References

Abdullah, S. (2016). An analysis of cross-discipline research article introduction structures through a modified create-a-research-space (CARS) model. *EFL Journal, 1*(1), 1-16. https://efljournal.org/index.php/efljournal/article/view/1/pdf

Adel, S. M. R., Moghadam, R. G., & Amiri, A. (2020). Moves in introduction sections of research articles in psychology, Persian literature, and applied linguistics: A genre-based study. *Language Studies.* https://www.researchgate.net/publication/338402717_Moves_in_Introduction_Sections_of_Research_Articles_in_Psychology_Persian_Literature_and_Applied_Linguistics_A_Genre-based_Study

Anthony, L. (1999). Writing research article introductions in software engineering: How accurate is a standard model? *IEEE Transactions on Professional Communication*, 42, 38–46. https://doi.org/10.1109/47.749366

Aranha, S. (2009). The development of a genre-based writing course for graduate students in two fields. *Perspectives on Writing*, 23, 465. https://doi.org/10.37514/PER-B.2009.2324.2.23

Arévalo, M. J., Cantera, M.A., García-Marina, V., & Alves-Castro, M. (2021). Analysis of university STEM students' mathematical, linguistic, rhetorical–organizational assignment errors. *Education Sciences,11*(4), 1-17. https://doi.org/10.3390/educsci11040173

Bhatia, V. K. (1991). A genre-based approach to ESP materials. *World Englishes, 10*(2), 153-166. https://doi.org/10.1111/j.1467-971X.1991.tb00148.x

Bhatia, V. K. (1993). *Analyzing genre: Language use in professional settings*. Longman. https://www.routledge.com/Analysing-Genre-Language-Use-in-Professional-Settings/Bhatia/p/book/9780582085244

Biber, D., Connor, U., & Upton T. (2007). *Discourse on the move; Using corpus analysis to describe discourse structure*. John Benjamins Publishing Company. https://benjamins.com/catalog/scl.28

Blackley, S. B. (2013). Writing competence: A necessity for the 21st century workplace (Web log post). https://www.lexercise.com/blog/writing-competence-a-necessity-for-the-21st-century-workplace.

Briones, R. R. Y. (2012). Move analysis of philosophy research article introductions published in the University of Santo Tomas. *Philippine ESL Journal*, 9, 56-75. https://www.academia.edu/11168910/Move_Analysis_of_Philosophy_Research_Article_Introductions_Published_in_the_University_of_Santo_Tomas

Buena, M. D. B. (2021). Moves analysis of the scientific thesis introductions of the Grade 12 STEM students of the University of the East-Caloocan Campus. *Psychology and Education Journal, 58*(4), 1690-1701. http://psychologyandeducation.net/pae/index.php/pae/article/view/4918/4297

Carstens, A. (2010). *The effectiveness of genre-based approaches in teaching academic writing: Subject-specific versus cross-disciplinary emphases* (Doctoral dissertation, University of Pretoria). https://repository.up.ac.za/bitstream/handle/2263/24689/Complete.pdf?sequence=7

Cheng, A. (2006). Understanding learners and learning in ESP genre-based writing instruction. *English for Specific Purposes, 25*(1), 76-89. https://doi.org/10.1016/j.esp.2005.07.002

Cheng, A. (2008). Analyzing genre exemplars in preparation for writing: The case of an L2 graduate student in the ESP genre-based instructional framework of academic literacy. *Applied Linguistics, 29*(1), 50-71. https://doi.org/10.1093/applin/amm021

Del Saz-Rubio, M. M. (2011). A pragmatic approach to the macro-structure and metadiscoursal features of research article introductions in the field of Agricultural Sciences. *English for Specific Purposes, 30*(4), 258-271. https://doi.org/10.1016/j.esp.2011.03.002

Dornyei, Z. (2007). *Research methods in applied linguistics*. Oxford: Oxford University Press. https://elt.oup.com/catalogue/items/global/linguistics/oxford_applied_linguistics/9780194422581?cc=global&selLanguage=en&mode=hub

Farnia, M. & Barati, S. (2017). Writing introduction sections of research articles in applied linguistics: Cross-linguistic study of native and non-native writers. *Indonesian Journal of Applied Linguistics, 7*(2), 248-256. https://doi.org/10.17509/ijal.v7i2.8357

Flowerdew, L. (2000). Using a genre-based framework to teach organizational structure in academic writing. *ELT Journal, 54*(4), 369-378. https://doi.org/10.1093/elt/54.4.369

Futász, R. (2006). Analysis of theoretical research article introductions written by undergraduate students: a genre-based approach. *Acta Linguistica Hungarica, 53*(2-3), 97-116. http://real.mtak.hu/54937/

Geçikli, M. (2013). A genre-analysis study on the rhetorical organization of English and Turkish PhD theses in the field of English language. *International Journal of*

Business, Humanities and Technology, 3(6), 50-58. https://www.ijbhtnet.com/journals/Vol_3_No_6_June_2013/7.pdf

Gustilo, L., Capacete, M. P., Alonzo, A., Camba, A., & Navarete, J. E. (2018). An analysis of move-strategy structure and functions of informality in Philippine English undergraduate theses: Implications for teaching academic writing. *The Asian EFL Journal, 20*(12.4), 193-217. https://www.researchgate.net/publication/330263378_An_Analysis_of_Move-strategy_Structure_and_Functions_of_Informality_in_Philippine_English_Undergraduate_Theses_Implications_for_Teaching_Academic_Writing

Holmes, R. (1997). Genre analysis, and the social sciences: an investigation of the structure of research article discussion sections in three disciplines. *English for Specific Purposes, 16*(4), 321-337. http://dx.doi.org/10.1016/S0889-4906(96)00038-5

Hyland, K. (2008). *Metadiscourse: exploring interaction in writing. Reprinted. Continuum Discourse Series*. Continuum. https://www.amazon.com/Metadiscourse-Exploring-Interaction-Continuum-Discourse/dp/0826476112

Isik Tas, E. (2008). *A corpus-based analysis of genre-specific discourse of research: The PhD thesis and the research article in ELT* (Doctoral Dissertation). Middle East Technical University. http://etd.lib.metu.edu.tr/upload/3/12609375/index.pdf

Jackaria, P. M., Hajan, B. H., & Mastul, A. H. (2024). A comparative analysis of the rating of college students' essays by ChatGPT versus human raters. *International Journal of Learning, Teaching and Educational Research, 23*(2), 478-492. https://doi.org/10.26803/ijlter.23.2.23

Jalilifar, A. (2010). Research article introductions: Sub-disciplinary variations in Applied Linguistics. *The Journal of Teaching Language Skills, 2*(2), 29-55. https://dx.doi.org/10.22099/jtls.2012.407

Javadi-Safa, A. (2018). A brief overview of key issues in second language writing teaching and research. *International Journal of Education and Literacy Studies, 6*(2), 15-25. https://files.eric.ed.gov/fulltext/EJ1182214.pdf

Joseph, R., Lim, J.M.H., & Moh. Nor, N. A. (2014). Communicative moves in Forestry research introductions: Implications for the design of learning materials. *Procedia – Social and Behavioral Sciences*, 134, 53-69. Https://doi.org/10.1016/j.sbspro.2014.04.224

Kanoksilapatham, B. (2011). Civil engineering research article introductions: Textual structure and linguistic characterisation. *The Asian ESP Journal, 7*(2), 55-84. http://asian-esp-journal.com/wp-content/uploads/2016/01/AESP-Volume7-Issue2-April-2011.pdf

Kwan, B. S.C. (2006). The schematic structure of literature reviews in doctoral theses of applied linguistics. *English for Specific Purposes*, 25, 30–55. https://doi.org/10.1016/j.esp.2005.06.001

Leki, I. (2003). Research insight on second language writing instruction. *ERIC Digest*. https://www.cal.org/wp-content/uploads/2022/05/ResearchInsightsonSecondLanguageWritingInstruction.pdf

Light, R. J. (2001). *Making the most of college: Students speak their minds*. Harvard University Press. https://www.amazon.com/Making-Most-College-Students-Speak/dp/067401359X

Lintao, R. B. & Erfe, J. P. (2012). A move-analytic contrastive study on the introductions of American and Philippine master's theses in Architecture. *Journal on English Language Teaching 2*(1), 15-26. https://files.eric.ed.gov/fulltext/EJ1070213.pdf

Martin, J. R., Christie, F., & Rothery, J. (1987). Social processes in education: A reply to Sawyer and Watson (and others). In I. Reid (Ed.), *The place of genre in learning: Current debates* (pp. 46-57). Geelong, Australia: Deakin University Press

Maswana, S., Kanamaru, T. & Tajino, A. (2015). Move analysis of research articles across five engineering fields: What they share and what they do not. *Ampersand*, 2, 11. https://doi.org/10.1016/j.amper.2014.12.002

Minaei, R., & Sabet, M.K. (2017). A comparative corpus-based analysis of genre specific discourse: the quantitative and qualitative academic papers in the field of the TEFL. *Theory and Practice in Language Studies, 7*(4), 294-304. https://www.academypublication.com/ojs/index.php/tpls/article/view/tpls0704294304/1093

Ozturk (2007). The textual organisation of research article introductions in applied linguistics: Variability within a single discipline. *English for Specific Purposes, 26*(1), 25-38. https://doi.org/10.1016/j.esp.2005.12.003

Paltridge, B., & Starfield, S. (2007). *Thesis and dissertation writing in a second language: A handbook for supervisors.* Routledge. https://www.routledge.com/Thesis-and-Dissertation-Writing-in-a-Second-Language-A-Handbook-for-Students/Paltridge-Starfield/p/book/9781138048706

Pilotti, M. A. E., & Elmoussa, O. (2022) Initial approach to a research writing course: a case study of STEM and non-STEM female students under pressure to succeed, *Cogent Education,9*(1), 1-12. https://doi.org.10.1080/2331186X.2022.2127471

Porras, A. & Ingilan, S. S. (2017). Genre analysis of linguistic research introductions. *Multidisciplinary Research Journal, 2*(1). https://www.academia.edu/35614964/Genre_analysis_of_linguistics_research_introductions

Rahman, M., Darus, S., & Amir, Z. (2017). Rhetorical Structure of Introduction in Applied Linguistics Research Articles. *International Journal of Interdisciplinary Educational Studies, 9*(2), 69-84. http://journals.mindamas.com/index.php/educare/article/view/800/763

Samraj, B. (2002). Introductions in research articles: variations across disciplines. *English for Specific Purposes,* 21, 1-17. http://dx.doi.org/10.1016/S0889-4906(00)00023-5

Samraj, B. (2008). A discourse analysis of master's theses across disciplines with a focus on introductions. *Journal of English for Academic Purposes, 7*(1), 55-67. https://doi.org/10.1016/j.jeap.2008.02.005

Setiawati, D., Nabilla, S. N., Suherdi, D. Kurniawan, E., Gunawan, W. & Lubis, A. H. (2020). A move analysis of research article introduction written by Indonesian authors: The case of soft and hard sciences. *Advances in Social Science, Education and Humanities Research,* 546, 127-132. https://doi.org/10.2991/assehr.k.210427.020

Sheldon, E. (2011). Rhetorical differences in RA introductions written by English L1 and L2 and Castilian Spanish L1 writers. *Journal of English for Academic Purposes,* 10, 238-251. https://doi.org/10.1016/j.jeap.2011.08.004

Swales, J. M. (1990). *Genre analysis: English in academic and research settings.* Cambridge University Press. https://search.worldcat.org/title/23079178

Swales, J. M. (2004). *Research genres: Explorations and applications*. Cambridge University Press. https://doi.org/10.1017/CBO9781139524827

Swales, J. M., & Feak, C. B. (2012). *Academic writing for graduate students: Essential tasks and skills*. The University of Michigan Press. https://doi.org/10.3998/mpub.2173936

Tan, B. H. (2011). Innovative writing centers and online writing labs outside North America. *Asian EFL Journal, 13*(2), 391-418. http://asian-efl-journal.com/PDF/Volume-13-Issue-2-Tan.pdf

Wingate, U. (2012). Using academic literacies and genre-based models for academic writing instruction: A 'literacy' journey. *Journal of English for Academic Purposes, 11*(1), 26-37. https://doi.org/10.1016/j.jeap.2011.11.006

Yang, R., & Desmond, A. (2003). Research articles in applied linguistics: moving from results to conclusions. *English for Specific Purposes*, *22*(4), 365-385. https://doi.org/10.1016/S0889-4906(02)00026-1

Zhang, B. & Wannaruk, A. (2016). Rhetorical structure of education research article methods sections. *PASAA*, 51. 155-184. https://files.eric.ed.gov/fulltext/EJ1112248.pdf