CONTRASTIVE ANALYSIS OF ENGLISH ELECTRONIC ENGINEERING RESEARCH ARTICLES BY CHINESE, THAI AND NATIVE ENGLISH WRITERS: MOVE-STEP STRUCTURE AND VISUAL-TEXTUAL MOVE

SUTONG GAO

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in English Language Studies

Suranaree University of Technology
Academic Year 2021

การวิเคราะห์เปรียบต่างบทความวิจัยทางด้านวิศวกรรมอิเล็กทรอนิกส์ที่เขียนโดยชาวจีน ชาวไทยและเจ้าของภาษาอังกฤษ: โครงสร้างอัตถภาคและอนุวัจน์ และอัตถภาคความสัมพันธ์ระหว่างภาพกับข้อความ

นางสาวซู่ถง เกา

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาศิลปศาสตรดุษฎีบัณฑิต
สาขาวิชาภาษาอังกฤษศึกษา
มหาวิทยาลัยเทคโนโลยีสุรนารี
ปีการศึกษา 2564

CONTRASTIVE ANALYSIS OF ENGLISH ELECTRONIC ENGINEERING RESEARCH ARTICLES BY CHINESE, THAI AND NATIVE ENGLISH WRITERS: MOVE-STEP STRUCTURE AND VISUAL-TEXTUAL MOVE

Suranaree University of Technology has approved this thesis submitted in partial fulfillment of the requirements for a Degree of Doctor of Philosophy.

Thesis Examining Committee

(Assoc. Prof. Dr. Nattama Pongpairoj)
Chairperson

(Asst. Prof. Dr. Issra Pramoolsook)
Member (Thesis Advisor)

(Assoc. Prof. Dr. Supakorn Phoocharoensil)
Member

(Asst. Prof. Dr. Kornwipa Poonpon)
Member

(Dr. Suksan Suppasetseree)
Member

(Assoc. Prof. Dr. Chatchai Jothityangkoon)
Vice Rector for Academic Affairs and Quality Assurance

(Assoc. Prof. Dr. Thara Angskun)
Dean of Institute of Social Technology

เกา ซู่ถง : การวิเคราะห์เปรียบต่างบทความวิจัยทางด้านวิศวกรรมอิเล็กทรอนิกส์ที่เขียนโดยชาวจีน ชาวไทยและเจ้าของภาษาอังกฤษ: โครงสร้างอัตถภาคและอนุวัจน์ และอัตถภาคความสัมพันธ์ระหว่างภาพกับข้อความ (CONTRASTIVE ANALYSIS OF ENGLISH ELECTRONIC ENGINEERING RESEARCH ARTICLES BY CHINESE, THAI AND NATIVE ENGLISH WRITERS: MOVE-STEP STRUCTURE AND VISUAL-TEXTUAL MOVE) อาจารย์ที่ปรึกษา : ผู้ช่วยศาสตราจารย์ ดร.อิศรา ประมูลศุข, 300 หน้า.

คำสำคัญ: บทความวิจัยทางด้านวิศวกรรมอิเล็กทรอนิกส์/โครงสร้างอัตถภาคและอนุวัจน์/อัตถภาคความสัมพันธ์ระหว่างภาพกับข้อความ

งานวิจัยชิ้นนี้มีวัตถุประสงค์ที่จะศึกษาโครงสร้างอัตถภาคและอนุวัจน์และอัตถภาคความสัมพันธ์ระหว่างภาพกับข้อความของบทความวิจัยทางด้านวิศวกรรมอิเล็กทรอนิกส์ที่เขียนโดยชาวจีน ชาวไทยและเจ้าของภาษาอังกฤษ เมื่อเจาะจงลงไป งานวิจัยชิ้นนี้วิเคราะห์และเปรียบเทียบอัตถภาค อนุวัจน์ โครงสร้างอัตถภาคและอนุวัจน์ และอัตถภาคความสัมพันธ์ระหว่างภาพกับข้อความของบทนำ บทระเบียบวิธีวิจัย บทผลการวิจัยและการอภิปรายผล และบทสรุปของบทความวิจัยทางด้านวิศวกรรมอิเล็กทรอนิกส์ที่เขียนโดยสามกลุ่มผู้เขียนข้างต้น

งานวิจัยนี้รวบรวมคลังข้อมูลสามชุด แต่ละชุดประกอบไปด้วยบทความวิจัยทางด้านวิศวกรรมอิเล็กทรอนิกส์ 12 ชิ้นจากแต่ละกลุ่มผู้เขียนโดยใช้เกณฑ์ในการคัดเลือกสี่เกณฑ์ได้แก่ สถานะภาษาที่หนึ่งของผู้แต่งบทความ บทความนั้นเป็นบทความที่เน้นการทดลองมีหลักฐานเชิงประจักษ์ บทความนั้นอยู่ในฐานข้อมูล Scopus และบทความนั้นตีพิมพ์ในช่วงปี 2019 ถึง 2020

จากนั้นงานวิจัยนี้ได้วิเคราะห์บทย่อยทั้งสี่บทของบทความวิชาการทั้งสิ้น 36 ฉบับเพื่อหาอัตถภาค อนุวัจน์ และโครงสร้างอัตถภาคและอนุวัจน์ โดยใช้โครงสร้างอัตถภาคของ Kanoksilapatham (2005, 2015) และ Maswana et al. (2015) เป็นฐานการวิเคราะห์ นอกจากนี้อัตถภาคความสัมพันธ์ระหว่างภาพกับข้อความในบทระเบียบวิธีวิจัยและบทผลการวิจัยและการอภิปรายผลก็ถูกวิเคราะห์โดยใช้กรอบการวิเคราะห์ของ Moghaddasi et al. (2019) เนื่องจากทั้งสองบทนี้มีการใช้ภาพประกอบมากมาย ในขณะที่บทนำและบทสรุปไม่มีการใช้ภาพประกอบ

ผลการวิจัยพบว่าโครงสร้างอัตถภาคและอนุวัจน์ประกอบไปด้วยอัตถภาค 12 อัตถภาค และอนุวัจน์ 34 อนุวัจน์ และมีความแตกต่างกันในด้านโครงสร้างอัตถภาคและอนุวัจน์ระหว่างชุดข้อมูลจากสามกลุ่มผู้เขียน ซึ่งเห็นได้ชัดจากความถี่ของการปรากฏของอัตถภาคและอนุวัจน์ที่จำแนกเป็นประเภทได้แตกต่างกัน นอกจากนี้ผลจากการวิเคราะห์อัตถภาคความสัมพันธ์ระหว่างภาพกับข้อความระบุว่าภาพประกอบต่างๆ ในบทความวิจัยด้านวิศวกรรมอิเล็กทรอนิกส์สามารถจัดกลุ่มได้เป็นสี่กลุ่ม

อัตถภาค ได้แก่ อัตถภาคการสร้างข้อสันนิษฐาน อัตถภาคการประกาศผลการวิจัย อัตถภาคการอภิปรายผล และอัตถภาคการแสดงเครื่องมือการวิจัยหรือสถานที่วิจัย ความแตกต่างระหว่างอัตถภาคความสัมพันธ์ระหว่างภาพกับข้อความในสามชุดข้อมูลนี้พบในความถี่และรูปแบบของอัตถภาคความสัมพันธ์ซึ่งโยงให้เห็นถึงกลยุทธ์ในการใช้อัตถภาคความสัมพันธ์ที่แตกต่างกันระหว่างสามกลุ่มผู้เขียนบทความวิจัยนี้ ในภาพรวมผลของการวิจัยชิ้นนี้ได้ให้ภาพกว้างและความแตกต่างย่อยของแต่ละกลุ่มผู้เขียนบทความวิจัยซึ่งสามารถเป็นข้อมูลช่วยในการเรียนและการสอนการเขียนบทความวิจัยได้

สาขาวิชาภาษาต่างประเทศ ลายมือชื่อนักศึกษา Sutong Gao

ปีการศึกษา 2564 ลายมือชื่ออาจารย์ที่ปรึกษา I. Pramoolsook.

SUTONG GAO: CONTRASTIVE ANALYSIS OF ENGLISH ELECTRONIC ENGINEERING RESEARCH ARTICLES BY CHINESE, THAI AND NATIVE ENGLISH WRITERS: MOVE-STEP STRUCTURE AND VISUAL-TEXTUAL MOVE. THESIS ADVISOR : ASST. PROF. ISSRA PRAMOOLSOOK, Ph.D., 300 PP.

Keyword: Electronic Engineering Research Article/Move-Step Structure/Visual-Textual Move

The present study aimed at investigating the move-step structures and the visual-textual moves of Electronic Engineering research articles (EERAs) written by Chinese, Thai, and native English speaking writers. Specifically, the moves, steps, move-step structures, and visual-textual moves (VTMs) of the four key sections of EERAs; namely, Introduction, Methods, Results and Discussion (R&D), and Conclusion by the three groups of writers were explored as well as compared.

Three corpora, with each containing 12 EERAs, were compiled based on four criteria: the authors' L1 status; empirical studies; journals indexed by SCOPUS; and publication duration of 2019-2020. All of the four sections of the 36 EERAs in the three corpora were examined with regard to their moves, steps, and move-step structures based on Kanoksilapatham's (2005, 2015) and Maswana et al.'s (2015) frameworks. VTMs in the Methods and the R&D sections were analyzed by adopting Moghaddasi et al.'s (2019) framework since these sections were filled with visuals and VTMs, while the Introduction and the Conclusion were found to lack these features. A pilot study on the move-step structure and VTM of the R&D section was conducted for testing the feasibility of the research design, during which inter-rater reliability check was carried out to enhance the reliability of the study.

The findings revealed a move-step structure of 12 moves and 34 steps as well as the move-step structure variations among the three corpora, which were mainly demonstrated through the frequency of occurrence that designated the moves and steps into different status categories. In addition, the findings from VTM analysis indicated that visuals in the EERAs were assigned to four rhetorical moves: Establishing presumption (EP), Announcing results (AR), Discussion (D), and Displaying apparatus or

site (DAS), representing three rhetorical functions: ontology, argument, and epistemology. The variations of the VTMs among the three corpora mainly lied in the frequency of occurrence of the VTMs and the VTM patterns that suggested distinct VTM employment strategies of the three writer groups. Overall, the findings of the present study, including the move-step structure and VTMs across the three groups, offered both a common holistic picture as well as individual distinctions of each group in terms of the moves, steps, their structures, and the VTMs, which could offer certain assistance in the instruction and learning of RA composition.

School of Foreign Languages   Student's Signature Sutong Gao

Academic Year 2021   Advisor's Signature I. Pramoolsook.

ACKNOWLEDGEMENT

On the path of this academic journey, I have met plenty of wonderful people who never hesitated to support me with their heart and soul.

First and foremost, I would like to express my sincere gratitude to my dearest advisor, Asst. Prof. Dr. Issra Pramoolsook, for his academic excellence and admirably delightful personality. Thanks to his inspiring thoughts and encouraging guidance throughout my academic road, embracing today’s achievement was no longer a dream. Another important quality I have discovered in him, his positive outlook on life, also imposed an active impact on me, for that quality was rare but extraordinarily valued nowadays. I regard him as a lifelong role model to learn from.

I am also deeply grateful to all of the members of my dissertation committee: Assoc. Prof. Dr. Nattama Pongpairoj, Assoc. Prof. Dr. Supakorn Phoocharoensil, Asst. Prof. Dr. Kornwipa Poonpon, and Dr. Suksan Suppasetseree, for their encouraging, insightful, and constructive suggestions. Without them, I could not have made such great improvements of this dissertation.

Then, I would like to offer my special thanks to Suranaree University of Technology for offering me this amazing opportunity to study in Thailand. At the same time, my sincerest thanks go to Xi’an Shiyou University for providing me with great support in the pursuit of this degree overseas.

Last not the least, nobody has been more supportive during this academic journey than the members of my family. Therefore, my sincere thanks extend to my parents, my parents in-law, my husband, my daughter, and my son. It was their unwavering support and belief in me that made me who I am today.

Sutong Gao

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

Page

TABLE OF CONTENTS (Continued)

Page

TABLE OF CONTENTS (Continued)

Page

TABLE OF CONTENTS (Continued)

Page

LIST OF TABLES

Table Page

LIST OF TABLES (Continued)

Table Page

LIST OF TABLES (Continued)

Table Page

LIST OF TABLES (Continued)

Table Page

LIST OF FIGURES

LIST OF ABBREVIATIONS

CH	Chinese Writer/Chinese Corpus
EE	Electronic Engineering
EERA	Electronic Engineering Research Article
NNS	Non-Native English Speaker
NS	Native English Speaking Writer/ Corpus of Native English Speaking Writers
RA	Research Article
TH	Thai Writer/Thai Corpus
VM	Visual Move
VTM	Visual-Textual Move

CHAPTER 1
INTRODUCTION

This chapter provides an overview of the current study on move-step structure and visual-textual move (VTM) in Electronic Engineering research articles (EERAs) by Chinese, Thai and native English writers. The first section presents the importance of English as lingua franca in academy, thus publishing internationally in English proves to be necessary and also difficult. The second section describes the problems the scholars are confronted with in their writing for international publication. The third section offers rationale of the present study based on identified gaps in both theory and practice. Research purposes and research questions are presented in the fourth and fifth sections, respectively. The sixth and seventh sections demonstrate significance of the study and scope of the study. Finally, the chapter ends with definitions of key terms.

1.1 Background

1.1.1 English for International Publication

Recent years have witnessed the fast globalization of the whole world. People from different countries and regions strive to communicate with the outside world to seek for self-development. It is better to understand the languages of the countries to build connection with, which, however, seems absolutely unrealistic and impossible. At the point, English serves as the major communicating medium for enhancing the process of globalization. As Hoffmann (2000) points out, it is undeniable that English has established itself as a language of international prestige, given its status of lingua franca in many important fields of contemporary life. Sherman (2017) depicts that Central and Eastern Europe (former Soviet Bloc countries) are places where English has replaced German and Russian as lingua franca in recent decades. In the eastern part of the world, English as lingua franca (ELF) is also playing a key role in promoting linguistic, cultural and religious diversity in ASEAN (The Association of Southeast Asian Nations), which comprises 10 nations (Kirkpatrick, 2017).

While globalization 'forces sociolinguistics to unthink' languages on the basis of boundaries (Blommaert, 2010, p. 1), the research into English as a lingua franca (ELF) goes beyond territoriality and looks into multilingual and multicultural practices where English plays a crucial role in interaction (e.g., Mauranen, 2012; Seidlhofer, 2013; Jenkins, 2015). This tendency of ELF challenges the traditional connection between language and geographical boundaries and draws scholarly attention (Wang, 2017). The trace of every evidence above shows that English has been firmly established its dominant role in a wide range of fields in exchanging and communicating information for a broad spectrum of purposes.

In the academe, the leading role English is now playing is disseminating academic knowledge all over the world. John Swales more than thirty years ago indicated that the dominant language in higher education and publishing world was undoubtedly English since most academic paper were written in English every year. In fact, the situation remains the same today. The proportion is even more than 90% in some research fields (Hyland, 2006). Scholars from various fields strive to publish their own research findings in international English journals, so that their peers around the world could understand their research and effectively commence academic exchanges with them (Liu & Liu, 2014). To put it another way, the fact that more and more academic exchanges take place at the international level certainly indicates that there are increasingly international scholars with different nationalities attending these exchanges. In the field of Electronic Engineering, English, without exception, is also regarded as the main language when students, scholars and experts intend to exchange academic knowledge among themselves within this international context.

1.1.2 Electronic Engineering

Electronic Engineering (EE) is a discipline that applies modern technologies such as computers for electronic information control and information processing. It mainly studies information acquisition and processing, and the design, development, application and integration of electronic equipment and information systems. To be specific, Vodovozov (2010) defines electronic engineering as:

> *Electronics is a science about the devices and processes that use electromagnetic energy conversion to transfer, process, and store energy, signals and data in energy, control, and computer systems. This science plays an important role in the world progress. Implementation of electronic devices in various spheres of human activity largely contributes to the successful development of complex scientific and technical problems, productivity increase of physical and mental layout, and production improvement in various forms of communications, automation, television, radiolocation, computer engineering, control systems, instrument engineering, as well as lighting equipment, wireless technology, and others. Contemporary electronics is under intense development, which is characterized by emergence of the new areas and creation the new directions in existing field.* (p. 8)

Electronic Engineering has evolved to cover many aspects of society. This discipline is a cutting-edge discipline, and all aspects of modern society and people's daily life are closely related to or dependent on electronic information technology. The products coming out of the technology have brought a great deal of convenience to people's lives, effectively improving our work efficiency and life quality. For instance, PowerPoint slides are widely used in teaching, learning and presentation. Unmanned cars are gradually appearing on the market. Through on-board sensors to sense the surrounding environment and process the perceived information, these cars are able to control the driving direction and speed of the vehicle, making sure the vehicle can safely travel on the road. Face recognition technology is widely used recently. Many people's mobile phones have been installed with face recognition system, which allows people to unlock their mobile phones without any touch of the device. Last but not the least, 5G system is the most advanced wireless communication systems up to now. Compared with 4G, it is faster, more stable and reliable. These technologies and systems are all attributed to the knowledge of the Electronic Engineering discipline. It must be admitted that it does great help to people in all aspects of their lives.

The year 2020 has witnessed the incredible power the Electronic Engineering brought to our real world. Since the very beginning of 2020, we human have undergone a terrible, horrifying pandemic worldwide brought by the novel coronavirus or COVID-19. The virus is highly infectious, making people extremely sick and sometimes even killing them. Due to this reason, people need to control the sources of infection and cut off the channels of transmission. The most effective measure taken to beat the virus is to keep a social distance. Many low, medium, high-risk regions and countries request their people to quarantine, making face-to-face communication impossible. However, during this hard time, people could also communicate, teach, learn and do businesses through the Internet and mobile applications. It was reported that all businesses experienced a heavy attack except for those providing online access for people. Take ZOOM for an example, it is a cloud-based video conferencing service you can use to virtually meet with others - either by video or audio-only or both, all while conducting live chats. It lets you record those sessions to view later. In the first two months of 2020, the growth of Zoom users exceeded that of the whole year of 2019, and the number of meetings increased from 12 million times a day at the end of 2019 to 200 million times a day (Tencent Technology, 2020). Similarly, mobile software and application in China including Tencent Meeting (TM), Ding Talk, etc., welcomed much more users due to suspended classes, ongoing learning and working from home. The services really guarantee that people's life and work progress on the right track. This also is a case showing the huge influence of Electronic Engineering discipline on people's life. The intimate relation between the Electronic Engineering technology and people's lives is too apparent to be ignored.

The above mentioned is the first reason for this research to choose Electronic Engineering for the target discipline. The second reason is that the products and services generated with the great help of Electronic Engineering technology make the discipline popular and widely studied around the globe. A survey in 2019 shows there are 518 universities in China running the Electronic Engineering major (Yao, 2019). That means the population majoring in this discipline is quite large in China, which reflects a large number of people someday may have the opportunities to write their own research articles (RAs) for international publication. They would feel fully prepared if they have been trained or informed of knowledge of move-step structure and visual-textual move (VTM). Scholars and experts in this field are mainly graduate students, teachers, supervisors and professors in universities or engineers in research centers or institutions. To communicate their ideas and thoughts with the outside world, they usually join domestic and international conferences or publish what they have found and achieved in either domestic or international journals. According to the survey conducted by the researcher of the present study, about ninety-four percent of people investigated in this field stated that they must publish in English so that they could meet the requirements for graduation or a promotion. By sharing and disseminating their research findings and achievements internationally, the researchers and experts in Electronic Engineering field could also fulfill contributions to the global economy. The circle of Electronic Engineering thus becomes a smaller world where scholars and researchers shape and develop a common discourse community, in which they share, understand, and also produce discourse. This tendency makes English academic writing a necessary weapon for modern international academic exchanges. In other words, English academic writing ability is therefore a prerequisite for total participation in this international academic discourse community. The researchers and scholars are deemed to have a good command of English, making them able to read, listen, and write to exchange knowledge effectively under that particular circumstance. Apart from good mastery of English, researchers and scholars need to grasp rhetorical structure as well as linguistic conventions of EERAs. The international discourse community established on the basis of English has a set of widely recognized common goals, and members have a communication mechanism that is familiar with and recognized by each other (Swales, 1990). Being fully aware of communicative purposes of the RAs is extremely necessary for researchers and scholars for they provide rationale for a particular genre and in turn shape internal structure of RAs. As members of a discourse community, scholars and researchers should manage to make their discourse expertise reach to a certain level for producing discourses that meet the requirement of the genre. The more they understand the characteristics of academic writing, the better they conform themselves to the discourse community, and the closer to success they become in perfecting their research.

The last and also a practical reason is that the researcher of the present study needs to make sure that data could be collected in three geographically and culturally different regions and countries, i.e., China, Thailand, and English speaking countries. The study will not be feasible if data are inaccessible or insufficient. After conducting some survey, it was found that Electronic Engineering is a discipline popular not only in China but also prevalent in Thailand and English speaking countries.

1.2 Statement of Problems

1.2.1 Difficulties in Writing for International Publication

Authors want to see their papers published in prestigious journals that testify to the importance of their claims, help promote reputations among peers, and provide support for their related proposals for research funding (Myers, 1990). It is true that international research paper publishing is considered crucial and necessary for scholars in getting recognition in their own field. Despite the new knowledge and findings the scholars claim to their academic field, English, the publishing language, or the lingua franca, is regarded as a key mediation. According to Gibbs (1995), most journals included in international databases such as Science Citations Index (SCI) are published in English. Therefore, this indicates that RAs in English play a dominant role in dissimilating academic knowledge, which reflects that the ability to publish RAs internationally is crucial for achieving academic success.

However, it is usually not an easy job for non-native English speakers (NNSs) to complete their writing for international publication. It must be admitted that both Chinese and Thai scholars, groups of NNS scholars under the present study, are faced with the problems of English writing for international publication. The writing quality of academic papers directly determines whether the papers can be accepted and published or whether the writers can obtain the corresponding degree through these papers (Flowerdew, 2000). Therefore, as one key indicator, the quality of academic paper draws the line between success and failure for these scholars. Moreover, with the deepening of international academic exchange and academic information circulation, NNSs' academic writing and communicating ability needs to be promoted. To be specific, taking the situation in China for instance, more and more researchers in

China publish academic papers in international journals in English, and the number of papers published by Chinese researchers in international journals has jumped to the forefront of the world. However, the influence and quoting or citing rate of published papers are far from satisfaction, which is, to a large extent, directly related to the disappointing English academic writing ability of Chinese researchers. These language problems that exist in Chinese researchers' English academic writing include inadequate expression of words, poor coherence of texts, unreasonable structure, to name a few. Other challenges that hinder NNSs under their L1 context to produce or publish their research outcomes internationally includes difficulties in achieving the same effectiveness when writing using their L1 compared with the target language.

Flowerdew (1999a)'s ten types of difficulties researchers encounter when they write for publication clearly illustrate the point. The difficulties listed are grammar, use of citations, making reference to the published literature, structuring of argument, relating text to audience, ways in which to make knowledge claims, ways in which to reveal or conceal the point of view of the author, use of "hedges" to indicate caution expected by the academic community, and "interference" of different cultural views regarding the nature of academic processes. Unsurprisingly, textual organization, the main focus of the current study, indicates researchers indeed have some problems in organizing text structure owing to the shortage of knowledge about RA rhetorical structures. At the same time, Flowerdew (1999a) proposes strategies to use tacit knowledge to solve text organization problems. Flowerdew (1999b) also mentions other writing problems of NNSs' writing for publication in English ranging from a less rich vocabulary, longer time to write, less facility of expression, to less capable of making claims for their research with the appropriate amount of force, etc. The most problematic parts of RAs for NNSs to write are Introduction and Discussion, because they need a persuasive writing style, through which the author's personal voice needs to be expressed. Writers must convince the readers, editors and reviewers of the importance and value of their research and their arguments they put forward. In other words, the way writers write in the Introduction has a huge impact on the way readers think. The difficulty of Discussion/Conclusion section lies in the fact that writers need to make implication of the significance to the study so as to convince the readers, editors and reviewers. The acceptance of the research paper might largely depend on whether writers properly write the Introduction and Discussion sections. If they want to be accepted by this discourse community, they definitely need to acquire a certain degree of generic competence and discoursal knowledge.

Scholars and researchers, therefore, need to be equipped with not only lexical, syntactical, and grammar knowledge, but also rhetorical structure conventionally used in their target disciplines (Swales, 2004). Writing research papers for international publication is a particularly challenging and daunting task for NNSs compared with NSs. They are put at a disadvantage in competing with their NS peers (Marusˇic´ & Marusˇic´, 2001; Cho, 2004; Cho, 2009; Huang, 2010). Apart from putting forward the disciplinary-specific content in their RAs, scholars and researchers also need to meet the strict language requirements of the international journal. They would encounter more difficulties in constructing their language, and more importantly, they find it hard to identify rhetorical boundaries and suit their work in a rhetorical tradition (Swales, 1990; Flowerdew, 1999a; 1999b; Burrough-Boenisch, 2003; Hyland, 2007; Huang, 2010). The critical difficulties of improper rhetorical style may result in failure in getting accepted by the target journal.

Compared with NS scholars, what NNS scholars face is a more challenging task of writing in English, courageously squeezing themselves into the rhetorical and linguistic system so as to meet the requirements of internationally prestigious journals. The might-result-in-rejection language problems are inadequate knowledge of rhetorical organizations and improper linguistic choices. Thai novice authors and graduate students still often face serious problems when they attempt to publish their RAs in international journals (Kanoksilapatham, 2007). Take Thai graduate students in the social science field for an example. The reasons they feel publishing internationally is difficult are two folds. First, they lack knowledge of how to properly use certain expressions, vocabularies, and text structures that are commonly employed in their respective discourse communities and academic disciplines. The knowledge could help them conform to the overall organization that is expected in the target discourse community. Second, the number of international journals in social sciences is relatively small compared to those in the sciences (Flowerdew, 2001), indicating that the models for writing for international publication are in a relative small number. Hence, it is inevitable that enhancing the ability to read and write RAs in English is pivotal, for novice authors in general, for Thai graduate students in particular, for handling academic writing tasks encountered in a higher education setting (Khamkhien, 2015).

Likewise, Chinese engineering researchers and students face the similar writing problems. Yu (2014) identifies three prominent problems of English scientific paper writing: the use of words and sentences, writing methods and skills, and discourse organization. Xiao & Chen (2015) gain a thorough understanding of engineering students' difficulties in English academic writing skill from three perspectives: content, structure and language. They claim that English academic writing has long been Chinese university engineering students' most awkward skill, which is reflected from aspects such as colloquialism of language, inappropriate use of words, monotony of language use, Chinese style of discourse, empty content, etc. Besides, Du (2020) illustrates Chinese engineers' writing difficulties from four perspectives: vocabulary, syntax (complexity and density); coherence and social contexts and communicative purpose. The writing problems of non-native English speaking writers will be discussed in detail in Section 2.6 in Chapter Two.

In the past decade, the number of international academic journal papers published by Chinese scholars has grown rapidly. Data from China Institute of Science and Technology Information show that from 2009 to 2019 (as of October 2019), Chinese scientific and technological researchers have published a total of 2.606 million international papers, continuing to rank second in the world, with an increase of 14.7% over the time of statistics in 2018. However, *NATURE*'s report shows that although the number of Chinese scientific and technological papers is large, the overall quality is not high. If measured by the citation impact, which represents academic influence, the quality of China's scientific and technological papers still lags behind the world average. The academic influence of China's scientific research does not match the amazing growth of output. Stuart Govan, publishing director of IET (the Institution of Engineering and Technology) China, when explaining the high rejection rate of Chinese researchers' articles, indicates that in addition to the fact that the research topic is not new and the promotion of the existing topic seems not significant, language problems also matter most. Specifically, they are: (1) The English writing of some Chinese academic articles is not clear enough in terms of linguistic expression; (2) The form and structure of the articles are not clear and they are not written under standard paradigm required by academic journals; (3) the reference of the articles is not the latest and newest resources, and it is difficult to find the source of some citations (Wang, 2012). These problems are closely related to the fact that Chinese scholars have not been systematically trained in writing and publishing papers in English journals during their study in universities. The homogenization of English teaching in China has always been serious. General English or Basic English dominates from primary school to university to graduate school and there is a lack of courses for professional study and research in university. Even though a few universities offer thesis writing courses (mostly dissertation writing) at the graduate stage, the majority of universities still take general English as the mainstream course from undergraduate to graduate level. The course on journal article writing is basically absent in both undergraduate and graduate stage of colleges and universities in China.

However, it is not sufficient to only examine move-step structure of RAs. Indeed, most genre studies concentrate upon written texts due to at least two reasons described by Johns (1998): First, is that applied linguists and composition researchers are more interested in, and comfortable with, written language. Most are trained in the humanities, where words are central to disciplinary values and argumentation. Second, in some academic classrooms and disciplines such as literature, graphs, charts and other visual representations are not central to disciplinary values. Thus, these components in RAs are ignored by most genre researchers since they mainly focus on only textual components (Hyland, 2006; Johns, 2013; Tardy & Swales, 2014). Genre research pioneers believe that those components are also worthy of attention because they contribute to the RA's rhetoric. For example, when proposing research in multimodalities as a future ESP topic, Johns (2013, p. 20) claims that "it is surprising that so little research has been completed either on the visual/verbal interaction in texts or on academic or nonacademic visual rhetoric". Tardy and Swales (2014), when emphasizing the importance of multimodal elements in some genres, depict them as "so essential that it would be impossible to overlook them in an analysis".

Multimodal/visual genre analysis is also regarded as a new direction (Tardy & Swales, 2014).

Johns (1998), Miller (1998), Rowley-Jolivet (2004), O'Halloran (2010), Gross and Harmon (2014), Morell (2015) and Moghaddasi et al. (2019) have devoted themselves to the study of visuals in ESP and EAP fields. These previous studies are limited in number and disciplines in focus. They mainly involve the fields of science such as Biology and Mathematics. The present research, however, is designed to fill this gap through exploring VTM (after move-step analysis) in EERAs.

1.2.2 Difficulties in Electronic Engineering RA (EERA) Composition

RA is not only one communication form in academic community, but also one of the necessary and crucial venues for researchers to establish their academic identity in the discourse community. RAs in each discipline or field have different move-step features, and this is the reason for many genre scholars to focus on examining RA structures in and across various disciplines. They attempt to find out the features of move-step structures or establish the most appropriate move-step framework for the target disciplines. EERAs also have their own characteristics in terms of moves, steps, move-step structures and VTMs.

There are many researches on move-step structures of RAs in a variety of disciplines. RA structures of different discipline own distinctive features, and that's the reason for genre scholars to study RAs from a wide range of disciplines and even identify the disciplinary features in terms of move-step structure. However, RA move-step structure in the field of Electronic Engineering remains scarcely explored or even non-existent. When composing RAs for international publication, EE researchers might find it difficult to identify a move-step framework for reference. In addition, ESP teachers might find that there is no specific writing framework to teach their students. On the other hand, international journals, different from local Chinese and Thai journals, have their own writing and structural requirements, which could cause problems for Chinese and Thai researchers writing English RAs. Needless to say, it is of critical necessity for these two groups of writers to adopt the international writing convention for their RAs. According to Connor (1996), unawareness of cross-cultural differences in text structures is believed to be the main cause of NNS writers' lack of success in the international community. It is another challenge imposed on NNS writers.

The other obvious feature of EERAs is that they have a large number of visuals or visual representations integrated especially in their body part. According to the preliminary examination the researcher initiated on the general move-step structure and visual, it was found that one EERA could contain up to more than 20 visuals (including tables and figures). The least number of visuals that an EERA contains is 4-6. These visuals or visual representations help present data in limited spaces and enhance argumentation. However, how to effectively integrate visuals and the associated textual moves into an argument is a crucial skill for researchers in the discipline to communicate, to learn from each other and even to enhance their authorial credibility. Honestly to say, adequately integrating VTM into RA arguments appears to be another challenging task for EE researchers.

To sum up, when composing a RA, researchers need to pay close attention not only to the move-step structure, but also to the VTMs since these two key structural factors cooperate together in achieving EERA's communicative purposes.

1.2.3 Preliminary Needs Analysis: Questionnaire and Interview

In order to make sure the research problems reviewed from the literature indeed exist, preliminary questionnaire and interview were conducted with groups of Chinese Electronic Engineering university teachers and graduate students. The questionnaire containing 21 questions mainly aimed to investigate the general international publishing situations so as to firstly confirm the problems and secondly understand the problems better. The questionnaire and interview were conducted in Chinese. Appendices A and B contain the English translation versions. The reason for adding questionnaire and semi-structured interview before conducting the whole research was that they could help the researcher of the current study understand the broader social contexts of the genre in focus, i.e. RA. The invited academic specialists, despite not being the writers of the articles going to be examined, gave responses as members of the particular discourse community through voicing their understanding and commenting on the understudied issues. Their opinions mattered very much as they were actual representatives of this discourse community.

Before sending out the questionnaires and conducting the interview, the researcher of the present study should guarantee the reliability and validity of these two self-designed instruments for the needs analysis. Therefore, all of the items of the questionnaire and interview were examined and evaluated by one disciplinary insider. Specifically, the researcher informed the disciplinary insider of the purpose of the study and the preliminary needs analysis. Then, the disciplinary insider were asked to evaluate and grade each item according to a 21-grade percentage scale (0%, 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, and 100%) on the relevance and validness of the items to the purpose of the present study. The results, obtained from calculating the mean percentage, showed that the mean of items in the questionnaire and the interview was 90% and 95%, indicating sufficient reliability and validity.

Thirty-six participants, all from School of Electronic Engineering in a Chinese University, answered the questionnaire designed by the researcher herself. Twenty-one questions related to international publication, English RA writing issues, visuals and their functions were included in the questionnaire. This questionnaire functioned as a preliminary investigation on the knowledge of RA international publication the students and teachers hold. The data gathered were analyzed quantitatively mainly through percentage counting. The results showed that 61.1% of participants confirmed that international RA publication was very important for them; 36.1% considered it important. 94.4% of them considered that publishing internationally was necessary because there were graduation requirements for them to meet. 58.3% of the participants considered writing for international publication difficult; 11.1 % considered it very difficult. 75% of them regarded language and text structure as the main difficulties. The other main difficulty lied in the content of the RAs. The reasons for difficulties in language and text structure were mainly originated from unsolid English foundation and lack of publishing and English writing training experiences. The majority of the participants (92%) confirmed they had never taken professional English writing training courses, and they would like to take such courses for enhancing their English writing knowledge. As for visuals and VTMs in RAs, 97% of the participants confirmed that they were necessary in RAs. However, they had limited knowledge about how to organize them and how they functioned as rhetorical moves in RAs. 75% of the participants would like to receive more information and support in terms of visuals and VTMs.

The semi-structured interview was conducted in August, 2020. The two specialist informants, coming from the Schools of Electronic Engineering from two different universities in China, were a lecturer and a Ph.D candidate, respectively. After clearly stating the purposes of the current study, the researcher received their permission to be interviewed. However, face-to-face interview was not feasible due to the severe outbreak of COVID-19 worldwide. Therefore, online interviews with each of the informants were conducted and recorded under their total permission. To gain further information as a supplement for the questionnaire, they were consulted to share their general knowledge about the discipline of Electronic Engineering, their understanding and experience of international publication, and also their problems encountered when composing their RAs. The interview revealed that both of the informants had national and international publishing experience, and their problems in writing for publication were mainly lack of vocabulary, improper use of grammatical and syntactical knowledge, and less knowledge about RA format and structure. Neither of them had any experience of attending academic English writing course owing to the fact that the compulsory English courses they took were all general English. All English proficiency tests such as College English Test Band 4 (CET4) and Band 6 (CET6) were mainly about general English. The situation remained the same when they were enrolled in graduate school. Both of the informants emphasized, other than innovativeness of the topic and reasonableness and logic of contents, language and structure were the most important, since they mattered most in expressing clear ideas and logic. All of these key factors contributed to the road to successful publication. When asked how they solved the problems concerning English RA writing, the Ph.D candidate claimed that he would firstly go to the RA writing resources available online and quickly check the requirements of the target journal as a preparation for writing. The teacher, with more publishing experiences, would firstly outline the structure of the RA. When dealing with the problems in English writing, both of the informants highlighted that they would adopt solutions or strategies such as memorizing phrases and vocabulary specific to their field, consulting grammar books, and reading published RAs as reference models. As for visual knowledge, they mentioned they just put the graphs and figures in the place that they thought reasonable, barely noticing the rhetorical function they display. They would love to learn more of such knowledge for composing their RAs more efficiently.

To sum up, the two informants provided valuable information about they themselves writing in English for international publication. The problems they met seem to be in line with the writing problems identified in Flowerdew's studies (1999a, 1999b), which in turn proved a great necessity for the current study to investigate the move-step structures and VTMs of English EERAs. Findings of the in-depth investigation would hopefully make massive contribution to the practice in assisting researchers especially the novice ones to take their next steps into the international publication world. In addition, findings of the present study would enrich pedagogy in rhetorical and linguistic knowledge thus benefit genre linguists, scholars and students, and thus make a supplementary contribution to the existing genre-based research field.

1.3 Rationale of the Study

As mentioned above, genre approach is the main way that could help researchers improve their rhetorical awareness. Being an important approach to textual analysis, it plays a key role in teaching academic writing in non-English speaking countries. Through genre analysis, researchers can dig deeper not only on the textual level, but also on promoting communication by reflecting the cultural norms and value system of a certain discourse community, constituting the social context, supporting the author's argumentative expression and constructing the relationship with audiences.

The present study examines the move-step structures and the VTMs of EERAs and then compare them among three different writer groups. Examining the move-step structures of the EERAs from three groups separately is the first aim of the study. As mentioned in the previous *Statement of Problems*, there is a need to inform the researchers in EE field of both the move-step structures and the VTMs so that they could better perform in academe in learning of writing for publication by conforming to the disciplinary conventions. The researchers, except for NSs, seldom have the chance to learn how to write RAs in English for international publication. Chinese Electronic Engineering students and scholars have confirmed their English RA writing problems in grammar, move-step structure and VTM in the preliminary needs analysis. While Thai scholars, being NNSs as Chinese scholars, would have the same or similar problems of English RA writing. As a Ph.D candidate studying in Thailand, the researcher regards it as a great opportunity as well as an obligation to make academic contributions by means of investigating Thai experts' RAs in terms of move-step structure and VTM. For the group of NSs, they have language advantages over Chinese and Thai scholars, however, some of them may not or be fully aware of the rhetorical structures and the VTMs that play the key role in their writing. Thus, these three writer groups are determined to be the target group for analysis.

Second, the researcher plans to compare the results and findings among the three groups. Previous genre studies have done plenty of explorations on disciplinary, and subdisciplinary variations for the purpose of pedagogical implications, e.g., how to guide students in writing class. In addition, the results from the present study would benefit Electronic Engineering researchers from the three groups in learning from each other in terms of writing for international publication. The present study conducts a contrastive analysis to compare their move-step structures and VTMs. Firstly, RAs in the same discipline of Electronic Engineering may present different move-step structures and VTMs due to different cultural factors. The three groups of writers all succeed in publishing. Through the investigation, we may have chance to know more about the cultural factors that have impact on their English writing. Secondly, the variations obtained from this study could provide scholars in EE field with more writing conventions for international publication. The move-step structure is not fixed in one discipline. It may have different forms of representation under different contexts, and they even change with the time going by. The variations found in the three groups would show us three different ways of writing and organizing RAs. Scholars from the three different backgrounds might know about the other two groups' features of RA structure. If they think one of the moves is plausible and beneficial, they could adopt the move for perfecting their RAs. Conversely, they could avoid the move if they consider it unnecessary. Three different groups of writers could learn from each other's technique in move application. Thirdly, compared with move-step analysis of two groups of discourse, three groups represent a larger proportion and covers a wider range of EE writers, which means the findings could benefit more students and scholars. Fourthly, ESP and EAP instructors from China, Thailand, and English speaking countries could use the findings for relative course development since move-step structure is considered as the core of RA writing. The two types of knowledge and their variations found among the three groups might be applicable for activities in writing class. For example, instructors could lead students to think about and discuss the move-step structures belonging to the two or even three groups, and let them figure out the most appropriate ones and eventually present their ideas in front of the class. Such instruction process could strengthen students' rhetorical awareness in English RA writing.

Last but not the least, gaps identified through briefly reviewing the related literature also contribute to the study's rationale. Many move-step studies have been conducted and they generally fall into three categories. The first category is the studies focusing on individual section of RAs. The second category covers move-step analysis across disciplines or subdisciplines. The third category consists of contrastive move-step analyses across different languages, i.e., Chinese and English RAs, and studies of English RAs written by different L1 writers. The last category is relatively rare in number. From the related literature, RAs in their entirety in the field of Electronic Engineering written by three different groups remains unexplored. There is a blank for contrastive analysis on the full-length RA move-step structures among three groups of writers. The present study, therefore, aims to fill this gap.

The above mentioned is just one of the two layers of analyses. The first layer is move-step analysis of the EERAs by Chinese, Thai and NS writers, while the second layer of the present research is the VTMs in the EERAs of the three groups. Previous studies mostly focused on only rhetorical structures or only linguistic features such as hedging, stances, and lexical bundles, etc. However, the researcher thinks besides those linguistic features, there is an equally important component in the EERAs that deserves attention and investigation since VTM contributes to EERAs' overall communicative purposes. It would be better that the two layers of analyses are combined because move-step structure and VTM serve as a complimentary role to each other. By conducting this integrated analysis will, from a more complete angle, contribute to the genre theory as well as writing teaching practices.

1.4 Research Purposes

The purposes of this study is to analyze both the move-step structures and the VTMs as well as to make comparison of them in EERAs among Chinese, Thai, and NS writers. To achieve this, two layers of analysis are going to be conducted. More specifically, the present study aims to:

1) investigate the moves, steps, and move-step structures of the Introduction, Methods, Results and Discussion, and Conclusion sections of Electronic Engineering RAs (EERAs) written by Chinese (CH), Thai (TH), and native English speakers (NS).

2) find out the variations of the moves, steps and move-step structures of the Introduction, Methods, Results and Discussion, and Conclusion sections of EERAs among the CH, TH, and NS corpora.

3) examine the visual-textual moves (VTMs) in EERAs written by Chinese (CH), Thai (TH), and native English speakers (NS).

4) find out the variations in terms of the VTMs in EERAs among the CH, TH, and NS corpora.

1.5 Research Questions

Four research questions are formulated in accordance with research purposes:

1) What are the moves, steps and move-step structures of the Introduction, Methods, Results and Discussion, and Conclusion of Electronic Engineering RAs (EERAs) written by Chinese (CH), Thai (TH), and native English speakers (NS), respectively?

2) What are the variations of the moves, steps, and move-step structures of the Introduction, Methods, Results and Discussion, and Conclusion of EERAs among these three groups?

3) What are the visual-textual moves (VTMs) in EERAs written by Chinese (CH), Thai (TH) and native English speakers (NS), respectively?

4) What are the variations in terms of the VTMs among these three groups?

1.6 Significance of the Study

As a major way to achieve recognition for scholars in their research field, RA publication is a crucial, necessary, and hard process in the journey of personal academic development. To target the problems faced by these scholars, this current study makes a detailed and in-depth analysis of both move-step structure and VTMs of RAs by three different cultural writer groups. There is both theoretical and practical significance for the current study.

1.6.1 Theoretical Significance

First, this research contributes to the enrichment of ESP genre research field. Findings of the first and the third Research Questions generate the types of moves, steps, move-step structures and VTMs in RAs by Chinese, Thai and NS groups, respectively. The knowledge offers new insights into move-step structures of RAs in general, and in EERAs in particular. Especially, they shed light on EERAs compared in three different contexts. Second, the similarities and variations identified from the second and the fourth Research Questions mainly manifest the characteristics in terms of moves, steps and move-step structures and VTMs that the three groups share and do not share. These findings, on one hand, contribute to the diversity of move-step structure and visual-textual knowledge of RA genre; on the other hand, provide us with an opportunity to know more acceptable and feasible move structures and VTMs within the same discipline. Last but not the least, providing interpretation for the differences through careful and in-depth analyses could shed light on the underlying possible reasons, being it cultural background or language transfer, that contribute to the differences in move-step structures and VTMs. Last but not the least, the present study enriches the contrastive rhetoric theory in genre analysis by contrasting and comparing the structural patterns and visual-textual moves generated from three groups of writers. The findings of comparison and contrast would reveal their rhetorical structural awareness and the impact of their L1 developed under their own social and academic context on their L2.

1.6.2 Pedagogical Significance

From genre practitioners’ perspective, the study could not only shed light on the understanding of genre theory, but also provide insights for their teaching. The findings of the study will be of great help for ESP or EAP instructors to design academic writing courses as well as to develop academic writing teaching materials. From the perspective of EE scholars and students, the present study could help raise their rhetorical awareness and deepen their understanding of RA move structures. The identified moves, steps, move-step structures, and VTMs in turn provide valuable models for those who attempt to publish their RAs internationally. Publishing RAs internationally, as mentioned before, is becoming fierce since the expectation and requirement for the discourse community are becoming increasingly demanding in the process of international academic exchanges. Apart from innovative ideas, new methodology, pioneering research findings, the most important perspective is concerned with structure of the texts and language characteristics. Therefore, it is necessary and essential to become to know how moves, steps, their structures and VTMs function to achieve RA's communicative purposes. Specifically, the pedagogical significance can be illustrated from the following aspects:

The findings of Research Questions 1 and 3 are pedagogically beneficial for ESP and EAP instructors and students in Electronic Engineering field. The moves, steps, move-step structures, and VTMs of EERAs written by Chinese, Thai, and NS writers are examined respectively so that their features and move-step structure models are presented. ESP or EAP instructors could employ those knowledge when designing an English writing curriculum. At the beginning of the writing course, instructors could help raise students' awareness of move-step structure and VTM, and gradually build their genre knowledge by introducing different kinds of move-step structure models. Instructors could also let students search for information and commence an investigation on the models suitable for their discipline. The investigations of all move-step structures including the ones having been introduced and presented in class could be used for discussion. The three groups of move-step structures and VTMs could serve as an introduction to genre as well as models for analyzing RA move-step structures in relevant fields. For students especially in the Electronic Engineering field, most of them lack particular training for writing RAs. The findings of the study could serve as a guideline for them to produce and present clear and effective information in RAs. Moreover, they could choose among the move structures that are appropriate for them whenever they need to write and publish a RA. The results of move-step and VTM analyses would help ESP and EAP practitioners and scholars in EE discipline better understand the function of move-step structure and VTM. Specifically, some VTMs present argument function, some present ontological function, some may present two or more than two functions at the same time, some visuals could stand isolated presenting function without help of textual language, etc. This kind of information would help instructors and students pay more attention to the VTMs, and understand better the rhetorical function as well as the rhetorical moves related to each visual. Having a clear and logical presentation of the moves, which contributes to the whole RA's rhetoric, is necessary and crucial for producing a satisfactory RA. In addition, this study is beneficial in the way that the findings may be applied to academic discourse or RA reading instruction. Students could get to know the function of each part of the discourse through examining the move-step structure, and understand how the author constructs the text, what rhetorical function that a VTM expresses, and how the authors maintain the relationship with the readers in the process of writing for achieving their communicative goals. This reading instruction and learning process deepens students' understanding of RA writing and enhances their positive and critical thinking ability.

The findings of Research Questions 2 and 4 are significant in that knowing the variations could help understand more about the differences in move-step and VTM that might have been caused by different cultural factors and the writers' L1. However, those differences do not make this RA better or the other worse because all RAs are successfully published. The variations are seen as a factor contributing to the diversity of move-step structure and VTM in the genre study field. These variations would let genre practitioners see how the writers in each group present their EERAs using different move-step structures and VTMs to reach such same goals as informing the readers, arguing for their key and main claims, and creating new knowledge, etc. ESP and EAP instructors could add the knowledge about the variations developed under different contexts, which could expand students' horizon and raise their awareness of move-step structure and VTM differences. Just as disciplinary or interdisciplinary variations, variations generated under different cultures and language contexts could assist genre practitioners to understand better the understudied genre from different perspectives, providing them with more and diversified genre knowledge for their future research. Students might be inspired when the knowledge of variations is presented. In front of them, there are three choices of move-step structures and VTMs. It is through knowing the variations that they could infer which move-step structure is more favored and appropriate under their academic and social contexts. They could make use of each move that they consider more proper and avoid those less proper ones within the norms of their discipline and social context. Of course, they could also merge and adapt the move-step structures to form a new one that they consider feasible for their RA writing.

1.7 Scope of the Study

The present study aims to explore the moves, steps, move-step structures and the VTMs as well as their variations in EERAs written by Chinese, Thai and NSs. The scope, determined by the research purposes, is therefore confined to the following areas.

1) The understudied field is Electronic Engineering (EE), therefore the data going to be collected are RAs within the Electronic Engineering field.

2) The understudied scope of RAs covers the Introduction, Methods, Results, Discussion, and Conclusion sections in each EERA in the three corpora.

3) RA included are not confined to the IMRD structure since some papers may not have exact headings of "Introduction", "Methods", "Results", "Discussion", and "Conclusion". They are selected from international peer-reviewed journals in SCOPUS from 2019 to 2020.

4) Thirty-six RAs, with 12 written by Chinese, Thai and NS writers each, are under investigation for two layers of analysis: move-step structure and VTM.

5) The move-step analysis covers the moves, steps and move-step structures in EERAs in the three corpora; VTM analysis covers the VTMs associated with the visuals in the EERAs in the three corpora.

6) Move-step identification for developing a coding protocol is based on the Kanoksilapatham's (2005, 2015) frameworks and Maswana et al. (2015) developed from

Nwogu (1997), who in turn uses Swales (1981, 1990) as the basis for drawing up move categories. The reasons for selecting these models will be provided in Chapter 3.

7) VTM identification and analysis are taking Gross & Harmon (2014) and Moghaddasi et al. (2019) as references.

1.8 Definition of Key Terms

1) Move

A move refers to a section of a text that performs a specific communicative function. Each move not only has its own purpose but also contributes to the overall communicative purposes of the genre (Biber et al., 2007). In Swales' words, these purposes together constitute the rationale for the genre, which in turn shapes the schematic structure of the discourse and influences and constraints choice of content and style, with texts in a genre exhibiting "various patterns of similarity in terms of structure, style, content and intended audience" (1990, p. 58). In short, move represents semantic and functional unity of texts that has specific purposes. In addition, move generally has distinct linguistic boundaries that can be objectively analyzed (Biber et al., 2007). In the present study, a move is interpreted as a section of text that contains only one single communicative purpose regardless of its length.

2) Step

Move may contain multiple elements that together, or in some combination, realize the move (Biber et al., 2007). These elements are referred to as 'steps' by Swales (1990). The steps of a move primarily function to achieve the purpose of the move to which it belongs (Swales 1981, 1990; Dudley-Evans & John, 1998). In the present study, step is interpreted as a section of text under a certain move category that contains only one communicative purpose, which also contributes to the communicative purpose of the move it belongs to.

3) Visuals/visual elements/visual representation/visual information

Visuals/visual elements/visual representation/visual information in the present study covers figures (including all kinds of graphical visuals such as graphs, photos, pictures, etc.) and tables in the Electronic Engineering RAs in the three corpora.

4) Visual-Textual Move (VTM)

Moghaddasi et al. (2019) claim that visuals, when pointed to by verbal language, are frequently associated with specific moves including 'Establishing presumptions', 'Proof', 'Announcing results' and 'Discussion'. These moves are defined as Visual-verbal move in their study. However, the researcher of the current research provides another term for these moves which is Visual-textual move (VTM) since the word "verbal", referring to the verbal language, is mainly the spoken form a language; while "textual" is used instead to refer to the textual language, the written form of a language. Thus, VTM in the present study refers to textual language pointing to/associated with a specific visual/visual element. VTM performs rhetorical functions of a visual. It is through VTM that a visual's rhetorical functions are demonstrated.

5) Visual Move (VM)

Apart from VTM, visual move (VM) is another concept in Moghaddasi et al. (2019), referring to the visuals not pointed to/associated with textual language that performs rhetorical functions. They replace textual moves and are independent. They perform rhetorical functions on their own (Moghaddasi et al., 2019). The difference between VTM and VM is that the former is textual language associated with a visual in texts, while the latter is visual itself which stands alone performing rhetorical functions.

6) VTM Sequence

One visual has its' own VTM sequence, which includes all the VTMs that are associated with the visual in a sequential order. For example, if one visual is identified with 3 VTMs: *AR*, *D*, and *AR*, the VTM Sequence of the visual is *AR+D+AR*. From a VTM sequence, the number of VTMs, their sequential order and the VTM types could be informed. For example: the VTM sequence *AR+D+AR* indicates that a visual is first associated with 3 VTMs (*AR*, *D* and *AR*). Second, their order of appearance is *AR*, *D*, and *AR*. Third, there are only two types of VTMs in this VTM sequence (*AR* and *D)*. Identification of VTM sequence is a preparatory step to categorize the VTM patterns of all the visuals in the whole corpus.

7) VTM Pattern

The VTM pattern of one visual is deducted from the visual's VTM sequence. It only takes the VTM type into consideration. Take the visual with the VTM sequence

AR+D+AR as an example. Although there are three VTMs in this VTM sequence, there are only two types of VTMs: *AR* and *D*. Thus, the VTM pattern of the visual is *AR+D*. VTM pattern demonstrates a visual's function or multifunction.

8) Contrastive Rhetoric

Contrastive rhetoric is defined as:

> *"An area of research in second language acquisition that identifies problems in composition encountered by second language writers and, by referring to the rhetorical strategies of the first language, attempts to explain them."* (Connor, 1996, p. 5)

9) Variation

Variation in the present study refers to the differences in terms of move-step structure and VTM among EERAs written by Chinese, Thai, and NS writers. The findings of differences might attribute to the way different groups of writers dealing with their EERA writing with the diversity of their cultural backgrounds and conventions.

1.9 Summary

This chapter presented an overview of background and necessity of the present study, which sought to describe as well as compare the move-step structures and the VTMs in RAs in the field of Electronic Engineering (EE) by Chinese, Thai and native English writers. Through a quick review of literature and a preliminary needs analysis, the researcher of the study identified the research problems and gaps that needed to be filled. Thus, the study would focus on both the move-step structures and the VTMs of the EERAs of the three groups of writers. Four research questions were formulated in accordance with research purposes. Significance, scope, and definition of key terms of the study were provided afterwards. Hopefully, the findings of the study would truly bring benefits to those EE scholars in composing and publishing international English RAs.

CHAPTER 2
LITERATURE REVIEW

This chapter intends to present the review of related literature for the proposed study. It begins with the introduction of genre and genre studies for the aim of establishing the theoretical background. The second part reviews previous studies on move-step analysis in academic genre, particularly research articles (RAs), to get an overview of the scope, methodology, and results or findings discovered. This part covers move-step analysis on RA individual sections and RA as an entirety. The third and fourth parts are concerned with visual studies under academic context and in the ESP field. The fifth and sixth parts introduce contrastive rhetoric theory and identified research gaps, respectively. Finally, this chapter ends with non-native researchers' writing RA for international publication.

2.1 Genre and Genre Studies

2.1.1 Definition of Genre

The concept of genre has been widely used in applied linguistics for assisting language teaching and learning. It also provides researchers in the genre analysis field with valuable theories as well as frameworks while they are conducting their studies, thus lending a hand for achieving their academic success. The definitions of genre proposed by scholars from different approaches and perspectives indicate distinctions of academic focuses. For linguists who work under the context of the Systemic Functional approach, genre is concerned with the cultural context under which a text occurs. Martin et al. (1987) define genre as "staged, goal-oriented social process", as well as the schematic structure of language use in specific contexts for the purpose of communication. They believe that genre is the context level above register and under ideology, and it is the specific realization form of register in a specific culture. Members of a particular culture cooperate with each other purposefully to complete this social process, which reflects the purpose of a genre. A genre reflects its goal orientation when it tends to accomplish a task. It is a staged process since the realization of a specific goal requires multiple steps. In other words, genre is a language strategy to achieve the overall rhetorical goal in a specific culture. It emphasizes the purposefulness, interactivity, sequentiality of genre, and the way in which language and context are related.

Swales (1990) assigns five characteristics to a genre. First, a genre is a class of communicative event, in which language (and or paralanguage) plays both significant and an indispensable role. The frequency of communication events varies; Secondly, the principle critical feature that turns a collection of communicative events into a genre is some shared set of communicative purposes. Thirdly, Exemplars or instances of genre vary in their prototypicality. Fourthly, the rationale behind a genre establishes constraints on allowable contributions in terms of their content, positioning and form. Last, a discourse community's nomenclature for genres is an important source of insight. The most influential and widely cited and classic definition of genre in the field of Applied Linguistics is proposed by Swales (1990, p. 58).

> *"A genre compromises a class of communicative events, the members of which share some set of communicative purposes. These purposes are recognized by the expert members of the parent discourse, and thereby constitute the rationale for the genre. This rationale shapes the schematic structure of the discourse and influences and constrains choice of content and style. Communicative purpose is both a privileged criterion and one that operates to keep the scope of a genre as here conceived narrowly focused on comparable rhetorical action. In addition to purpose, exemplars of a genre exhibit various patterns of similarity in terms of structure, style, content and intended audience."*

Through this definition, a genre contains a series of events with the same communicative purpose (in which language plays a crucial role in communicative events). Members of the genre (especially experts) unanimously agree on a set of language expression system that can be distinguished from other genres in terms of text organization, word choices, sentence construction, and rhetoric style, so as to achieve common communication purposes. Therefore, according to their own knowledge system, social context and the purpose of communication with the interlocutors, a discourse community regulates the external language form and structure of the discourse they communicate, and the formed genre can be identified by its members and thus interactions among these members are generated. In other words, academic genres include different discourse forms due to different contexts and purposes, such as lectures, surveys, book reviews, etc. In addition to the communicative purpose, another important concept in this definition is the arrangement of discourse types according to the prototype degree, that is, to what extent a discourse can become a typical representative of a specific genre. It needs to be taken into account the expectations of the discourse community for form and content. Therefore, although these forms and characteristics could not set boundaries for the identity of the members, they can help establish the centrality of membership. According to Swales (1990), research articles, reports, financial support applications, etc., have different schema structures because of their different communicative purposes. He describes that genre is different from *register* in linguistics. The former focuses on the structure based on different sections of the text, while the latter is based on the unity of formal and informal style, which links linguistic features with appropriate context and situational features. Swales' (1990) definition can be used as a reliable rhetorical functional teaching framework, which is helpful for students to understand the discourse features shared by members of the discourse community.

Genre analysis provides a useful framework for the study of language use from the perspective of Applied Linguistics (Bhatia, 2006). In fact, the purpose of this kind of analysis is to extract explicit and implicit norms within a genre, so as to help new members develop their generic competence.

2.1.2 Three Approaches to Genre Studies

A genre is a recognized type of communicative behavior. The complexity of a genre is one agreement reached by researchers from different disciplines (Johns et al., 2006). Different disciplines study genre from different angles and perspectives. According to Hyon (1996), three approaches to genre are considered as the most influential and representative in terms of theorization, research and pedagogical implication. They are (a) Australian Systematic Functional Linguistics (Martin, 1989; Christie, 1991; Joyce, 1992), (b) North American New Rhetorical Studies (Miller, 1984; 1994; Bazerman, 1988), (c) English for Specific Purposes (ESP) (Hopkins & Dudley Evans, 1988; Swales, 1990; Bhatia, 1993; Thompson, 1994).

2.1.2.1 The Systemic Functional Linguistics (SFL)

The School of Systemic Functional Linguistics is also called the Sydney School. Originally proposed by linguists and teachers, its intention is to promote language education, helping linguistics become a tool that can assist teaching and learning in classroom. Built on the basis of Halliday's (1985, 1994) theory of systemic functional linguistics, SFL does not describe language grammatically, however, it stresses meaning construction as the main purpose of language. It is based on four assumptions of language: language use is functional; the function of language lies in the construction of meaning; social contexts have an impact on meaning; language users construct meaning by making specific language choices in a specific context.

From Systemic Functional Linguistics view, genre is regarded as 'a staged, goal oriented social process' (Martin, 1992, p. 505), emphasizing the purpose and order of different genres, which reflects Halliday's concern about the systemic connection between language and context. Genres are social processes as they are achieved due to interaction among members of a culture; it is goal-oriented because they are evolved in order to achieve things; it is staged because meaning is generated step by step, making writers to take more than one step to achieve their goals. When sharing the same purpose, the group of texts often own the same structure and thus they belong to the same genre.

Systemic Functional Linguistics uses functional concept of a language in analyzing both oral and written texts so as to describe purposeful and structural elements of these texts. Genre is regarded as a kind of schematic structure, a structure that is shared by texts in a specific culture to achieve specific communicative purposes, and is realized by lexical and grammatical elements. The main contribution of this School lies in the analysis of various *pre genres* (Swales, 1990), such as reports, descriptions, narratives, and anecdotes, which can be combined to form more complex and mature macro genres such as news stories and research reports. Researchers work to describe the social function and lexico-grammatical features of these *pre genres*. Understanding these *pre-genres* is very important for acquiring basic literacy, and is crucial for primary and immigration education. However, SFL does not attach significance to the establishment of a specific professional or academic genre. The aim of SFL is to construct a theoretical and analytical tool that regards language as a social process, which in turn provides a comprehensive, concrete and systematic description of linguistic patterns.

2.1.2.2 The New Rhetoric Tradition

The New Rhetoric School, initiated by a group of North American postmodern scholars from different disciplines, was formed on the basis of the rhetoric tradition, postmodern social and literary theories, as well as the research on rhetoric and writing in North America (e.g., Freedman & Medway, 1994). New Rhetoric focuses less on genre forms than the actions these forms are used to accomplish, and it tends to use qualitative research tools which explore connections between texts and their contexts rather than those which describe their rhetorical conventions (Miller, 1984). Genres are a motivated, functional relationship between text type and rhetorical situation. That is to say, a genre is neither a text type nor a situation, but rather the functional relationship between a type of text and a type of situation. Text types survive because they work and because they respond effectively to recurring situations (Coe et al., 2002).

This School mainly focuses on university teaching within the L1 environment, including rhetoric, writing research and professional writing. Hyon (1996) describes that it advocates attention to the social functions of genre under specific context rather than its formal or prescriptive features. Bazerman (1988) and Freedman and Medway (1994) hold similar opinions that it is not sufficient paying attention only to the external and formal characteristics of texts. Social and situational contexts matter, too.

New Rhetorical scholars investigate the social, cultural and institutional contexts of a genre. Through these contexts, we can understand the conditions of creativity and the context of meaning negotiation. New Rhetoric School regards the genre as a flexible instrument for members of expert communities. Novice writers are not its main concerns. They mainly focus on how expert members use genres for social purposes and how they are created and evolved. Because of this focus, research has investigated issues such as the historical evolution of genres (Atkinson, 1996); the processes of revising and responding to reviewers in writing scientific articles (Berkenkotter & Huckin, 2016); the social impact of transferring genres into new contexts with different purposes (Freedman & Adam, 2000); and the study of genres in the workplace (Pare, 2000; Dias et al., 1999).

Genre pedagogies from the New Rhetoric criticize ESP and SFL approaches for isolating genres from their complex and authentic contexts. Students should be provided with opportunities to observe genres under their real situation of use. Therefore, observation and interviews should be combined with analyses of genres in writing classes for students' access to the authentic contexts. Raising students' awareness of contextual characteristics of genres and of the communities who use them is the main emphasis of the New Rhetoric (Bazerman, 1988). Therefore, students should actively learn at least one genre in each course by using "mini ethnographies" to investigate it, or by focusing on specific events in the community (e.g., Devitt, 2004). Therefore, the writing class, which combines observation and interview with genre analysis, can let students get real context to use language.

Both the New Rhetoric School and the Systemic Functional Linguistics School pay attention to situational contexts. However, the former focuses more on the production and use of the genres, whereas the latter leans more towards the linguistic features of genres. Bakhtin (2000) argues that genres refer more to the typical form of discourse. Genres are the repeated social behaviors formed in response to the continuous evolution of the situational context (Miller, 1984). Despite the continuous evolution of genre, people increasingly emphasize the dynamic nature of genre, that is, the way they develop and display diversity, but at present it is a stable social behavior. It is this stability that enables individuals to understand, recognize and produce genres to achieve specific social purposes.

2.1.2.3 English for Specific Purposes (ESP)

The ESP approach of genre studies focuses on genre in a narrower sense. It does not regard genres as resources in a broader culture, but as properties of a specific discourse community. Genre here comprises a class of communicative events employed by specific discourse communities whose members share broad communicative purposes (Swales, 1990). These purposes are the rationale of a genre and help to shape its structural construction as well as the choices of content and style. Genre analysis in ESP is mainly used to carry out research-based language teaching. It investigates the structure and meaning of discourse, the requirements of communicative actions under academic and professional contexts, and the teaching practices developed on these behaviors so as to reveal the constraints of social context on language use. ESP is influenced by the other two Schools in many aspects. For example, ESP and SFL focus on language teaching but with different contextual focus. ESP, instead of concentrating on L1 or immigration teaching context, is confined with contexts of ESP itself. This research tradition mainly focuses on the rhetorical organization pattern and the linguistic characteristics of a particular genre. Discourse structure is analyzed as a series of moves, which are comprised of one or more steps. It could help non-native speakers to cope with the writing task in the academic or professional context. It can also help native speakers adapt to the academic style of new disciplines.

John Swales and Vijay Bhatia are two famous representatives of the ESP approach. Swales (1990) proposes the CARS (Create a Research Space) model, which divides the Introduction section of research articles into three basic moves. Rhetorical moves are communicative actions used to achieve specific communicative goals (Swales, 2000). Later, Swales (2004) reminds that an overly rigid and mechanical framework should not be adopted in move analysis. Thus, he adds other possible steps to the CARS model. Bhatia (1993) develops the genre concept of Swales (1990) and extends the scope of genre research to the genres, sub-genres and fusion of genres in professional context. He argues that many ESP scholars pay more attention to the formal features of genres than to their specific functions and social contexts. In his ESP genre research, Bhatia (2002) emphasizes the importance of intertextuality, the relationship between texts under study and other relevant texts in the social and cultural context.

However, instead of intuitive understanding and informed classroom practice, the study of genre features provides valuable information on how language functions. ESP teaching methods are more diverse than those of SFL, and are often targeted at specific communicative groups. It puts great emphasis on providing students with a variety of genres and requires them to reflect on their own genre practice. Therefore, the methods emphasize the enhancement of rhetorical awareness through classroom analysis of the genres students need to write, usually through the comparison of texts and the production of mixed genre portfolios (e.g., Johns, 1997; Swales & Feak, 2003).

ESP research emphasizes the way discourse achieves its communicative purposes and the role the genre plays within the discourse community, rather than genre classification.

2.1.2.4 Comparison among the Three Schools

Genre studies of the three different Schools share some common points. One of the purposes of these three Schools is to describe and explain the relationship between social functions and language use in a specific cultural context, however, they all have their own unique methods in defining and analyzing genres. These different theoretical perspectives are reflected in the genre-based teaching practice. Specifically, the differences among the three are as follows:

(1) In the aspect of research focus, the ESP School regards genre analysis as a way to meet non-native speakers' needs in academic and professional settings, and focuses on the communicative purpose and move structure of the texts. The New Rhetoric School in North America pays more attention to the social context of the genres, and emphasizes their social functions and behaviors, as well as the beliefs and values of that discourse community has for those genres. The Systemic Functional Linguistics research tradition is generated almost simultaneously with the ESP and New Rhetoric tradition. Built on Halliday's Systemic Functional Linguistics framework, it mainly focuses on primary and secondary school writing and non-

professional discourses, and explores the relationship between lexico-grammatical structure and social function of discourses.

(2) In terms of the scope of teaching application, the New Rhetorical School focuses on writing research and professional writing under L1 context, while the ESP School is mainly concerned with college students of L1 or L2 contexts. The analysis frameworks provided by SFL tradition are believed to explain the use of genres at all levels of education, not only for post-secondary education. In fact, genre teaching in Australia started from the writing of students in primary school, and then later expanded to secondary schools, adult immigration programs and academic courses (Feez, 2001).

(3) As far as research methods are concerned, the ESP School tends to adopt top-down methods and a comprehensive use of different discourse models. Those models are suitable for specific groups with more specific needs, usually adults. Emphasis is given to cultivating students' rhetorical awareness through genre analysis. The SFL School regards genres as language strategies to achieve rhetorical goals in a specific culture.

It is necessary to emphasize the common goal of the three Schools is to analyze the relationship between genres in different contexts and to teach students to give meaningful feedback in specific contexts. They all pay attention to deepening the understanding of the expected and the prescriptive level of knowledge in professional discourse. They all take education and teaching as the background. In addition, they all have reached the following consensus: genre is the result of people's repeated actions in a specific way in a discourse community; relative stability of the community leads to stability of generated genres, which would offer social experience coherence and meaning; the specific linguistic characteristics of a genre are neither completely determined by the context or genre, nor absolutely determined by the genre, and it is not controlled by individual writer; discourse is not simply produced by the individual who expresses meaning, but is influenced by community or culture, and would change if needed; the understanding of genre includes the form and content under the specific purpose and context; and the language of discourse should be combined with the function implemented under the specific context.

The three genre traditions view language as the central feature of human behavior. Language, with the help of genre, contributes to the construction of meaning and social context, making it not just a tool to convey ideas. These three traditions also share the same goal, that is, to analyze the relationship between writing and specific context. However, their intellectual structure, educational background, focus and the use of genre in the classroom are different. Table 2.1 demonstrates the comparison of the three perspectives on genre.

Table 2.1 Perspectives on Genre (Hyland, 2004, p. 50)

Orientation	Primary Focus	Intellectual Roots	Pedagogy	Education Context	Sample Genres
SFL	Discourse structure and features	Systemic linguistics	Vygotsky (ZPD) teaching- learning cycle	L1 schools, adult migrants	Narrative, report, recount
NR	Social purposes, context	Post-structuralism	Heuristics general formats	L1 university composition	Political briefs, patents, medical records
ESP	Discourse structure and features	SFL, CLT, Pragmatics	Consciousness raising, needs analysis	Occupational and academic training	Article, memo, sales letter

Choosing among the three Schools for teaching requires consideration of the combination of teachers' interests, students' needs and teaching environment. At the same time, it should be pointed out that although genre study is divided into three different traditions, the boundaries among them are becoming increasingly overlapped, and there is a trend of continuous integration in recent years (Swales, 2009).

The present study falls into the category of the ESP approach based on the following evidences. Firstly, it focuses on both non-native and native writers in professional or academic setting. Secondly, it adopts a top-down approach for exploring the overall move-step structure and visual-textual move (VTM) of EERA within EE discipline and variations among non-native and native English writers. Thirdly, the pedagogical purposes are to raise EE scholars' awareness and to provide them with writing conventions for international publication, thus contributing to their career development. Since research article is the main venue that researchers get their research findings transmitted and known by their peers, research article, this genre, is introduced in the next section.

2.2 Research Article (RA) as a Genre

The rapid academic development worldwide has aroused an increasing enthusiasm of scholars from a variety of disciplines to share and exchange research ideas and findings on various research genres, such as book reviews, conference proceedings articles, conference presentations, and research articles. Among them, research article has been the subject of most scholarly attention (Yang & Allison, 2003). Research article (RA) is a standard product of knowledge manufacturing industry (Knorr-Cetina, 1981). RAs are available and transmitted in the form of either paper or electronic version, maintaining a steadily essential position in disseminating academic knowledge. With the globalization, English has become the predominant language of research and scholarship (Swales, 1990, 2004). English RAs have become one of the main channels for global to present and enhance scientific knowledge. The definition of RA given by Swales (1990) is:

> "*The research article is taken to be a written text (although often containing non-verbal elements), usually limited to a few thousand words, that reports on some investigation carried out by its author or authors. In addition, the RA will usually relate the findings within it to those of others, and may also examine issues of theory and/or methodology*." (p. 93)

According to Swales (2004), RA can be classified into three main types, i.e., empirical (experimental) or data-based RA, theoretical RA, and review RA. Empirical (experimental) or data-based RAs (ERAs) report research findings obtained from direct observation or a variety of experimental studies (Weissberg & Buker, 1990). Such studies are usually replicated. They own a relatively fixed construction, Introduction, Methods, Results, and Conclusion. However, not all of these RAs adopt the headings of Introduction, Methods, Results and Conclusion. They may include variations such as

"Empirical Design", "Research Design" or "Data" for the "Methods" section. Studies with these headings are regarded as ERA. Nevertheless, some disciplines, due to the intrinsic nature, may not be suitable in conducting experiments.

According to Lester and Lester (2006), theoretical RA tracks the development of a theory, compares theories or discusses disputes surrounding a theory, and makes analytical deduction from the problems and issues discussed for the purposes of solving the problems. It is worth noting that in the field of Biostatistics and Engineering, however, some RAs do belong to ERA category. For example: some studies simply reporting findings through equations generated by computer modeling or graphic simulation seems to fall into the category of logical argumentative theoretical RA (Lin, 2020).

The third type, "Review", could be a review of a literature or comments on a topic or a literary work. The former does not need to provide original data because it focuses on analysis and discussion of the secondary sources such as journal articles and monographs; the latter reviews or comments on the literary or literature work, functioning as an evaluation or a critique.

2.2.1 Previous Studies on RA

2.2.1.1 Previous Studies on Individual Section of RA

2.2.1.1.1 The Introduction Section

As the first section of a RA, the Introduction is indispensable in providing an overview of the whole article. Being a step-by-step and highly conventional genre, the Introduction carries the unique communicative purpose of creating academic research space. Swales (1990) points out that the Introduction put forward the innovation of the research, thus having a strong role in promoting academic papers. Lim (2012) also indicates that the Introduction of English academic papers is directly related to convincing international peers to recognize the innovative significance of the research, thus affecting the publication of papers in international journals. Therefore, as a unique discourse, the Introduction is receiving an increasingly amount of attention from academic English research and teaching. It is necessary to study the structure of the Introduction. However, "Introductions are known to be troublesome, and nearly all academic writers admit to having more difficulty with getting started on a piece of academic writing than they have with its continuation" (Swales, 1990, p. 137). The Introduction seems to be a difficult and challenging section for both native and non-native writers to start with, for its key role is to create a research space, to make claims for the centrality and significance of the research, and to uncover the research gap to be filled by the study being reported. Scholars, in this opening section, could provide background information, rationale behind the study, research purposes and research questions, and the approaches and methodology to be adopted. The communicative purposes of the Introduction section, being quite apparent, are to make a connection between the findings of previous studies and the present research. It connects previous studies in the relevant field of research with present work that is being reported (Bhatia, 1993). In view of the essentiality and difficulty of the Introduction in relation to the whole research article, it has attracted increasing attention of genre practitioners and scholars.

Compared with the other sections in a RA, the Introduction is one that receives the most attention and interests. A large amount of studies have conducted genre analysis on this section. The most pioneering genre study was Swales' (1981) analysis of the Introductions of forty-eight RAs from the discipline of Physics, Medicine and Social science. Four moves proposed by Swales of the study are: Move 1: *Establishing a territory*; Move 2: *Summarizing previous research*; Move 3: *Establishing a niche*; and Move 4: *Occupying the niche*. However, Swales (1990) attempts to modify the four-move model when some researchers found it isn't fit for short Introductions in their corpus. By merging the first two moves, a three-move structure-Create a Research Space (CARS) model-lands on the field of genre study and is widely recognized by genre practitioners since it properly seizes the characteristics of RA Introduction.

The CARS model is comprised of three moves. i.e., Move 1: *Establishing a territory*; Move 2: *Establishing a niche*; and Move 3: *Occupying the niche.* Move 1: *Establishing a territory* introduces the general topic of the research, states the importance of the research and reviews previous research. Move 2: *Establishing a niche* is a key move in RA Introduction since it connects Move 1 and Move 3 by presenting the necessity of the present research. In Move 2, researchers present their own opinion on the need for the present research by indicating shortcomings of previous research, pointing out the gap and raising questions about the existing research. Move 3: *Occupying the niche* is the only place in the RA Introduction where the authors express and enjoy their own accomplishment, pride and commitment (Swales, 1990). This move introduces the present research by stating the research purposes, announcing the present research, announcing the principal findings and then finally by indicating the RA structure.

Ever since Swale's CARS model was unveiled, it has been widely studied and validated in subsequent studies on the Introduction section in a wide range of disciplines. Indeed, it has helped us realize that move structures of different disciplines are not necessarily different. However, the CARS model should be developed or expanded to include a more discipline-specific and subtle consideration in terms of rhetorical purposes and expectations of RAs. The revised CARS model (Swales, 2004) consists of three moves as well. Move 1: *Establishing a territory*, Move 2: *Establishing a niche*, and Move 3: *Presenting the present work*. The model revised provides a broader description of the communicative purposes of Move 1 and Move 2. Move 3 typically reflects variations happening in Introductions across different disciplines, and indicates the possible cyclical patterns of occurrence of the move types. In addition, whether a move is obligatory or optional depends on its frequency of occurrence.

Kanoksilapatham (2012) carries out a contrastive study on the rhetorical organization of 180 RA Introductions among the fields of Civil Engineering, Software Engineering and Biomedical Engineering. The study aims at identifying the generic structures of Introductions in the three Engineering disciplines and generic variations among them. The findings of the study indicate a frequent occurrence of all the three moves. The move order of Moves 1-3 is prevalent in all three subdisciplines. The cyclical pattern of Move 1 and Move 2 is found common in longer Introductions. There are also step variations across these subdisciplines. These findings show that each subdiscipline is a discourse community with its own inherent cultural and pragmatic norms and values. Raising awareness of this knowledge enables genre practitioners to maximize the efficiency of international communication.

Graves et al. (2014) make an investigation on the rhetorical structure of introductory sections of RAs in Mathematics. The corpus contains 30 RAs from five journals targeting a readership of research mathematicians and practitioners. Six RAs from each journal are obtained by using a stratified random sampling method. Applying both the 1990 and 2004 CARS models, this study notes several departures from patterns identified in other disciplines such as the repeated moves and the dynamic and flexible move order that organizes arguments in Discrete Mathematics RAs: the authors organize the moves according to the nature of the problem being solved and their goal of convincing the readers. The study also proposes that Move *P* (mathematical concepts) is an independent and frequently used action in Mathematics.

Three pedagogical implications are drawn from this study. First, the study suggests making some revision to the existing models for generic structure of RAs to fit for conventions and practices of Mathematics. For example, in Mathematics, the necessity of establishing a niche (by counter-claiming or publicly indicating a gap) is optional, because the reader assumes that the gaps and the results obtained from logical derivation are valid. Mathematical writing is not an impersonal absolutist practice despite the existence of a general fallacy; on the contrary, variations can be seen in discipline practice. Thus, the second pedagogical implication arises: the existing theories could be adapted to ensure that they explain the variations in conventions in non-IMRD-based discipline for the needs of some students to be successful participants in these areas. The third implication, based on the cycled move structure, is that instructors must help students realize the necessity of move order determined by the nature of the problem in their research work.

This study uses a critical perspective to analyze how the process of mathematical knowledge creation shapes its RA structure and arguments. It addresses the power of genre studies in exploring disciplinary discourses through its strong methodological approach that reveals the epistemological conventions that appear particularly incomprehensible to even discourse analysts. At the same time, the researchers gain the understanding that genre analysis of texts in a challenging subject matter could make it more accessible and less intimidating.

Some other studies choose to focus on one move of RA Introductions. Lim (2012) explores how the move- 'establishing research niches' in the introductory sections is completed through rhetorical steps and linguistic choices. The corpus contains 30 RAs obtained from three high impact management journals. The findings show that authors tend to use a wide range of persuasive communicative resources and linguistic mechanisms for speaking less of previous research and promoting their present research. In addition, the study also discusses how to minimize the difficulty in drawing a line between these different but inter-related rhetorical steps in specific contexts. Its significance lies in that it is possible to train novice writers to employ varying linguistic choices in close relation to the rhetorical steps or sub-steps under different circumstances to reach communicative purposes.

Moghaddasi and Graves (2017), similarly, examine the rhetorical move establishing the niche in RA Introductions in Discrete Mathematics. The study identifies 5 steps in this discipline in niche establishment and specifying significance of the study: 1) retrieve a problem; 2) indicate an absence of or insufficient research; 3) raise a question; 4) add to what is known; and 5) counter claim. In addition, the study also identifies two unique methods of establishing a niche: readers inferring the niche and retrieving a problem. This study modifies the CARS model to fit for writers in Discrete Mathematics, who would obtain benefits in writing classes for understanding the crucial features of constructing RA Introduction.

In conclusion, RA Introduction has gained much interests from genre scholars and practitioners. Swales' CARS models (1990, 2004) have been widely used as a starting point for analyzing RA Introduction from various disciplines. Later, some studies also use this influential model for the Introduction of other academic discourses such as dissertations or even other sections of RAs.

2.2.1.1.2 The Methods Section

The second section, the Methods, provides descriptions of the understudied population, material and instruments, research procedures. In other words, this section informs readers that in what way the research is going to be conducted and offers explanations or justifications for these procedures. Methods functions as an epicenter, "the core from which radiate the content and organization of each of the other sections" (Smagorinsky, 2008, p. 394). It is an obvious bridge between the relevant literature review and new results and findings. Basically, it is factual. The Methods include details about the progress of procedural steps and provides sufficient specifications for replication research (Cotos & Link, 2017). This section is believed to be content-oriented and straightforward. Due to this nature, comparatively less attention has been given to the Methods section (e.g., Bruce, 2008), which is an essential component of both quantitative and qualitative studies. Swales (2004) states that the main headings for the Methods section could be *The Study*, *Method*, *Data and Methodology*, *Methodology*, and *Setting and Methodology*. There are lexicons such as 'methods' 'collect' and 'data' which could provide clues indicating data collection part of the Methods section (Nwogu, 1997).

Besides the features mentioned above, communicative purposes, contents and structural organization all contribute to identification of the Methods section. They are presenting data collection method and procedure, informing experimental or variable measurement procedures, and data analysis procedures. This section aims at notifying the readers of the methods used in the study as well as providing evidentiary support for reliability and validity of results to be reported in the Results section. According to Nwogu (1997) and Kanoksilapatham (2005), the order of constructing the Methods section is from data collection, experiment measurement to data analysis.

Exploration into the Methods section is important and necessary because it often functions as a bridge that connects a particular research method to previous research procedures, and such neighboring sections as Introduction and Results (Lim, 2006). Without a reasonable Methods section, authors could not make possible the convincing of the readers of the validity of the approaches adopted to reach findings.

Besides, the Methods section also does a good job reflecting the appropriateness of a research design by quoting other established methods and techniques. The established research designs are usually cited in the Methods section for attracting professional reader's interests. According to Bazerman (1988), readers of RAs often practice selective reading by referring to names of approaches, techniques and previous researchers. Through these citations, the study may attract readers' interests, who might be enlightened or inspired to do the future research. Authors can also use the Methods section to enhance the credibility of their research results in the subsequent Results section, to suppress potential criticisms, and to avoid possible doubts about their results and related explanations.

Lim (2006) identifies the communicative functions of the Methods sections in management RAs as reflected in rhetorical moves and constituent steps. The study consists of two phases of analysis, the first being investigating the selected 20 RAs' rhetorical organizations and the second examination on the linguistic features that realize the individual moves and constituent steps. Three major moves with twelve steps are identified, i.e., Move 1: *Describing data collection procedure/s*; Move 2: *Delineating procedure/s for measuring variables*; and Move 3: *Elucidating data analysis procedure/s*. Move boundaries are identified according to the linguistic clues and obvious markers. This study also invites four specialist informants to provide their views on the generic structure that comprises the rhetorical moves and constituent steps of the Methods section in Management RAs. The interviews mainly do the job of triangulating the findings of the study with the informants' description and interpretation of rhetorical structure in the Methods section. In addition, this study also conducts an analysis to study the relationship between rhetorical categories and salient linguistic features. The pedagogical significance of the study reveals that before studying linguistic features in relation to communicative functions we should first acknowledge the importance of establishing a connection between ESP and general English. The study provides trainees who intend to acquire the possible generic knowledge of the Methods section. Moreover, novice writers could study the occurrence of all the possible rhetorical categorizations and seriously consider how they could achieve communicative intentions through rhetorical structure and linguistic options.

Peacock (2011) reports a communicative move structure through textual analysis on a large corpus of 288 RA Methods across eight disciplines including Physics, Biology, Chemistry, Environmental Science, Business, Language and Linguistics, Law, and Public and Social Administration. This investigation does not apply any rhetorical move-step framework. Instead, it examines the elements or moves of the Methods sections. Reliability of data analysis is ensured by both inter-rater and intra-rater agreement. The results show that seven moves are presented in most RAs in this order: *Overview*, *Location*, *Research Aims/Questions/Hypotheses*, *Subjects/Materials*, *Procedure*, *Limitations*, and *Data analysis*. Significant variations are found among three sub-corpora: Science sub-corpus, Non-science sub-corpus and Environmental science sub-corpus. In particular, three most frequent moves of Science sub-corpus include: *Procedure*, *Materials* and *Data analysis*, with the most typical move structure being 1) *Materials*, 2) *Procedure*, 3) *Materials,* 4) *Procedure,* 5) *Procedure* and 6) *Data analysis*. In contrast, three most frequent moves in the non-science sub-corpus are *Procedure*, *Subjects* and *Data analysis.* The mostly-adopted move structure was 1) *Subjects*, 2) *Procedure*, 3) *Location*, 4) *Procedure* and 5) *Data analysis*. Moreover, 1) *Location*, 2) *Overview*, 3) *Procedure*, 4) *Limitations*, 5) *Procedure,* 6) *Data analysis*, 7) *Procedure* and 8) *Data analysis* are the moves identified in the Environmental Science sub-corpus due to its relatively longer Methods sections. The rhetorical conventions and knowledge demonstrated in this study are surely beneficial for ESP and EAP practitioners in different disciplines in both the fields of teaching and research.

Pramoolsook et al. (2015) investigate RA rhetorical organization and variation of the Methods sections in two sub-disciplines of Business, i.e., Management and Marketing. Twenty RA Methods sections are collected, with 10 for each corpus. The results show that only 30% of the Methods sections in the Management corpus seems to fit for Lim's (2006) model. For the Marketing corpus, the Methods sections have greater diversity of move patterns. The study calls for a need for explicit instruction of writing conventions of the Methods section. In addition, it also provides guidance in realization of the rhetorical differences between these two sub-disciplines for more effective sub-discipline-specific writing.

Cotos et al. (2017) conduct a top-down analysis, in the tradition of Swalesian genre theory, of the rhetorical organization of nine-hundred RA Methods sections in thirty academic fields. The main purposes of the study are to identify characteristic moves and steps, describe their functional and content realizations, and investigate their occurrence within and across 30 disciplines. The study proposes, tests and validates a rhetorical move/step model, which is termed as Demonstrating Rigor and Credibility (DRaC).

The data analysis contains three phases. The first phase is for model development, including the inductive analysis of exemplary texts, segmentation of exemplary texts; categorization into functional semantic units, delineation of tentative moves and steps and first equalization. The second phase is for model testing, which includes pilot coding, generation of descriptive definitions, input from disciplinary consultants and second equalization. The last phase is model validation including creation of coding protocol, annotation of Methods corpus, concurrent accounts of coding reliability, third equalization, and valuation by disciplinary consultants and quantification of occurrence.

The analysis of the large-scale Methods corpus resulted in a descriptive model that contains three moves and sixteen steps. Move 1: *Contextualizing study method*. It provides settings or background information for the research approach. Move 2: *Describing the study* provides all the details in experimental procedures prior to data analysis, including clarifying conditions, data, instruments, etc. Move 3: *Establishing credibility* convinces readers of the quality of analysis by providing reasonable explanation of data analysis procedure.

The significance of the DRaC model lies in that it would provide references in genre-based writing pedagogy. Teachers could adopt the move/step in DRaC to help students understand how the moves and steps contribute to achieving their corresponding communicative purposes. Being aware of the distribution of the moves and steps, they would be able to arrange the obligatory and optional moves in their Methods section through integrating appropriate rhetorical strategies.

Cotos et al. (2017) is large-scale multi-disciplinary study on rhetorical structure of RA Methods section. Undoubtedly, it provides useful knowledge for genre scholars to practice the subsequent studies. It also offers those scholars, teachers and students a highly-detailed framework for RA Methods section.

Lim (2017) examines experimental procedural descriptions in the Methods sections of Research Reports published in high impact journals on language education. This study, different from Lim (2006), focuses mainly on exploring language resources needed to realize the major rhetorical functions of the Methods section. Thirty-two experimental Research Reports concerning language education are selected from eight international journals indexed in Scopus for preliminary move-step analysis to arrive at a generic structure of the Methods sections. When distinguishing the move 'Experimental procedural descriptions', the author uses typographical features, division of sections and subsections, and linguistic features to distinguish between moves, because the move may occur in different parts of a Methods section (Mauranen, 1993; Connor et al., 1995; Lim, 2008a, 2008b, 2009). Similar to Lim (2006), this study also gathers qualitative data from specialist informants for triangulating the discourse analyses. Detailed move-step analysis and analysis of lexico-grammatical choices are the following phases. It offers writers two layers of instructions in writing experimental procedures. One is concerned with content: learners need to arrange their procedure in a logical sequence for a comprehensive account of points they make. The other is regarding to language usage. Learners should be introduced to groups of structures demonstrating relationships between language resources and rhetorical functions.

In sum, comparatively scant attention has been given to RA Methods section. However, there are still valuable findings concerning rhetorical structure and language use obtained from the section. It is suggested that more subsequent and further research could be conducted to meet the research needs of genre scholars, and to offer teachers and students rhetorical guidance for their genre-specific Methods section writing.

2.2.1.1.3 The Results Section

The Results section plays a key role in demonstrating results, findings and commenting on them. This section might also restate research purposes, research questions, data collected and analyzed by providing visual supports such as figures and tables. As stated in Salager-Meyer (1994), the Results section is quite a straightforward unfolding of findings as it presents a clear description of the results, describes the process of manipulating the data obtained during the experimental stage, and makes limited claims about the statistical tests. Rhetorically, the Results convey new knowledge through presentation, explanation and interpretation of data, thus constituting the core of RA. Therefore, it represents a carefully constructed discourse to convince readers of the validity of the scientific facts that form the basis of specific knowledge claims (Hyland, 1998).

Genre-based studies focusing on the Results section receive less attention compared to the Introduction and the Methods. The influential studies on this section include Brett (1994), Williams (1999), Yang and Allison (2003), and Lim (2010).

Brett (1994) examines the Results section of twenty sociology RAs by using Swales' (1990) approach and identifies three major moves: *metatextual*, *presentation* and *comment*. *Metatextual*, comprising a *Pointer* and *Structure of Section,* is the textual segments that guide the readers to other sections of writing. *Presentation* move refers to objectively reported statements that highlight the results or the ways in which the results were obtained. It consists of *Procedural* and *Hypothesis Restated*. *Comment* move refers to statements of interpretation, opinion or comment on the results presented. *Comment* move contains *Explanation of Finding*, *Comparison of Finding with Literature*, *Evaluation of Finding or Hypothesis*, *Further Question(s) Raised by Finding*, *Implications of Finding* and *Summarizing*. Brett (1994) finds that the occurrence of the three moves is in cyclical pattern, which is Pointer (metatextual) followed by Statement of Finding (Presentation), and Substantiation of the Finding (Presentation). Moreover, he describes communicative functions and linguistic features such as grammatical form, and lexis of the three moves.

Posteguillo (1999) and Williams (1999) analyze the Results section in other disciplines by adopting Brett's (1994) model, which proves to be an adequate model for distinguishing rhetorical moves of the Results sections for interdisciplinary genre analysis.

Williams (1999) analyzes the Results section in eight medical RAs by using a modified move framework proposed by Brett (1994). One obvious modification is having added a fourth numerical subtype to the three subtypes of the Statement of Finding/Result (SOR), which makes the refined framework more applicable for analysis of the Results section in this genre-specific discipline. The adapted framework includes 10 moves: 1) *Pointer*, 2) *Structure of section*, 3) *Procedural*, 4) *Statement of findings/result*, 5) *Substantiation of findings*, 6) *Non-validation of findings*, 7) *Explanation of findings*, 8) *Comparison of findings with literature*, 9) *Evaluation of findings re hypotheses*, and 10) *Interpretation of findings*. Moreover, both linear and cyclical occurrences of the moves are identified in five to six subsections in the Results section of the Medical Science RAs. It also shows that the type of report and subject matter have an impact on rhetorical structure of presentation.

Both Brett (1994) and William (1999)'s models include reporting results, interpreting, evaluating and commenting on results, which seems to some degree overlap with the moves and steps in the Discussion or Conclusion section.

Yang and Allison's (2003) study focuses on the complex relationships between the Results, Discussion, Conclusion, and Implication sections. The corpus comprises twenty applied linguistic RAs. The findings show that reporting and commenting on results are identified in both Results and Discussions sections. However, different emphases between the two sections lie in that the Results section stresses more on 'Reporting results' while the Discussion sections attach more importance to 'Commenting on results'. The study generates a six-move model: Move 1: *Preparatory information*, Move 2: *Reporting results*, Move 3: *Commenting on results* (*interpreting results*, *comparing with the literature*, *evaluating results*, *accounting for results*), Move 4: *Summarizing results*, Move 5, *Evaluating the study* (*indicating limitations*, *indicating significance*), Move 6: *Deductions from the research* (*recommending further research*). The moves in Results are found to be in cyclical pattern and also more flexible, which corresponds to the findings of some previous research on this section such as Brett (1994) and William (1999).

Lim (2010) adopts a mixed-method genre-based study to explore in Research Reports the effects of disciplinary and methodological differences on the occurrences of comments in the Results sections and the linguistic mechanism employed to achieve the writer's major communicative intentions. A total of thirty Research Reports gathered from Applied Linguistics and Education are analyzed. The inter-rater reliability proves to be outstanding according the testing results from Kappa statistics. Four commentary steps are identified: *Step 1: Explaining the finding/s; Step 2: Evaluating the findings Step; 3: Comparing findings with literature; and Step 4: Making recommendations for future research.* The study reveals some interesting differences between disciplines and important similarities between different methodologies. In the corpus of Research Reports in Applied Linguistics (ALRSs), only first three commentary steps are common, while in the corpus of Education Research Reports (ERSs), 53% of the ERSs are found without comments, showing a consistency with Williams (1999) that 50% of the Medical Research Reports are stripped of comments. The finding that comments are not included in more than 50% of ERSs may be determined by the research community or the targeted reader rather than the research methods. The study encourages novice writers in Applied Linguistics to write relevant comments while the researchers in Education are discouraged from excessive evaluative comments in their RSs. It also helps EAP instructors design relevant teaching materials demonstrating the ways in presenting their comments using different language mechanisms.

Mat Hussin and Nimehchisalem (2018) conduct a piece of research, based on Yang and Allison's (2003) model, on the move structures used by the final-year ESL undergraduates in their Results and Discussion chapters. They adapt Yang and Allison's (2003) model by combining the two sections and arrive at "Results and Discussion" as one heading to be presented in one chapter. The adapted model consists of seven moves with specific communicative purposes. The moves are: *1) Preparatory/Background information*, *2) Reporting results*, *3) Summarizing results*, *4) Commenting on results*, *5) Summarizing the study*, *6) Evaluating the study*, and *7) Deduction from the research.* Ten Results and Discussion chapters are selected by purposeful sampling due to the nature of a qualitative approach. The findings show that the moves 'Reporting results' and 'Commenting on results' are more common than the other moves such as 'Preparatory/Background information' and 'Summarizing results'. The findings could provide guidance for lecturers to design instructional materials for teaching academic writing and to raise students' awareness of rhetorical structures for producing satisfactory Results and Discussion chapters.

In conclusion, reporting results and commenting on results are two main moves found in the Results sections in a variety of disciplines. However, disciplinary variations (e.g., variations between Applied Linguistics and Education in Lim (2010)) also exist and should be explored more. In addition, the moves in the Results sections may both occur in linear and cyclical pattern.

2.2.1.1.4 The Discussion Section

The Discussion section aims to summarize the results and findings, discuss and interpret the significance of findings, relate the findings to previous studies, and bring contributions to theories or teaching and learning practices. This section "mirror-images the Introduction by moving from specific findings to wider implications" (Swales, 1990, p. 133). It connects previous studies with the present work, provides possible explanations, and suggests the need for further research and possible perspectives for future investigation (Paltridge & Starfield, 2007). The Discussion section is the place where researchers strive to support their claims (Basturkmen, 2012; Kanoksilapatham, 2015). It is the effectiveness of this section that determines the extent to which a RA is successful in attracting readers and meeting the expectations of the research community (Kanoksilapatham, 2015). Thus, it is considered as an indispensable part in RA. Previous studies on move structure of the Discussion section focus mostly on discipline-specific features, disciplinary variations and cultural variations.

Belanger's study (1982, cited in Swales 1990) analyzes ten Neuroscience Discussion sections by employing Swales' (1981) model of RA Introductions, revealing the findings of a five-move model: 1) *General introduction*, 2) *Summarizing results and stating conclusions with references to previous research*, 3) *What results suggest with references to previous research and/to the current work*, 4) *Further questions with possible explanations or with references*, and 5) *General conclusions*. It has been observed that Moves 2, 3 and 4 are in cyclical pattern based on the research questions.

Hopkins and Dudley-Evans' (1988) influential research on rhetorical structure of the Discussion sections from two genres: master's dissertation in Biology and conference proceedings in Agricultural Science (Irrigation and Drainage). An 11-move model is proposed: 1) *Background information*, 2) *Statement of results*, 3) *(Un)expected outcomes*, 4) *Reference to previous research*, 5) *Explanation of unexpected results*, 6) *Exemplification*, 7) *Deduction*, 8) *Hypothesis*, 9) *Reference to previous research*, 10) *Recommendation*, and 11) *Justification*. The moves are discovered to occur in a cyclical pattern. The second move *Statement of results* accompanies the discussions of each result.

Holmes (1997) investigates disciplinary variations in the Discussion in three Social Science disciplines: History, Political Science and Sociology. Based on Hopkins and Dudley-Evans' (1988) model, the study arrives at an eight-move sequence. Thirty RAs with 10 from each discipline are analyzed, revealing that move patterns found to be quite different from those of Natural Sciences. Completely obligatory moves are not found in the Social Science Discussion sections, while in the Chemical Engineering RA Discussions, the four moves, *Information*, *Statement of results*, *Comparison with previous results* and *Deduction*, always occur. Moreover, Chemical Engineering Discussion sections contain more move cycles, defined as segments of text beginning with Move 1 (Background information) or Move 2 (Statement of results), and are more complex than their soft science counterparts.

Peacock (2002) explores both disciplinary and NS/NNS variations in the Discussion section across seven disciplines—Physics, Biology, Environmental Science, Business, Language and Linguistics, Public and Social Administration, and Law. Thirty-six RAs from each discipline, making up a total of 252 RA Discussion sections selected from six leading journals are analyzed using Dudley-Evans' (1994) model. Results reveal several differences in move numbers, types and move cycles. For disciplinary variations, certain moves in some disciplines obviously occur more or fewer than the other disciplines. Move cycles occur more often in Law, Language and Linguistics, but occur significantly less in Environmental Science and Physics. For NS/NNS variation and move numbers, the study indicates NNS writers, compared to NS writers, tend to use much less Move 7 *Claim*, Move 8 *Limitation*, and

Move 9 *Recommendations* in all the seven disciplines studied. Moreover, NNS authors in all three sciences show stronger tendency to use the move cycle 4+6 (*[un]expected outcome+explanation*) than NS authors do.

Amirian et al. (2008) examine rhetorical structure of the Discussion sections in terms of linguistic/cultural variations by investigating 20 RA Discussions in Applied Linguistics in English L1 and Persian L1 as well as English L2 by Persian speakers based on Hopkins and Duddle-Evans' model (1988). Their findings display significant variations among the three groups. English L2 writers tend to combine the Results and Discussion section, while English L1 counterparts prefer each part to be separated. It is noted that in English Discussion sections by Persian L1 writers lack logical sequence of different moves. The Moves *Reference to previously mentioned statement* and *Expressing wish for further research* in the Persian corpus are not found in the English L1 corpus. The study proposes a model containing three sections: I. Introduction (*Presenting background*, *Reference to previous research* and *Statement of aims*); II. Body (*Findings*, *Explanations* and *References to previous research*), and III. Conclusion (*Restatement of findings*, *References to previous research*, *Limitations of the study* and *Recommendations for further research*).

Basturkmen (2012) conducts a study on the Discussion sections of RAs in Dentistry with reference to schematic framework of Discussion sections in Applied Linguistics developed from her previous research (Basturkmen, 2009). The steps in 'Commenting on results' moves are closely examined to understand how arguments about the meaning and significance of results in the Dentistry Discussions are constructed. Ten RAs are selected from a leading journal- the British Dental Journal. Through careful analysis, the study shows that the framework is applicable to the RAs to a large extent, except for that some adaptations are needed. Re-occurring result-comment sequences are found in Dentistry Discussions, which is in consistency with previous studies' findings of cycles of moves on the Discussion section (Holmes, 1997; Peacock, 2002; Swales, 1990; Yang & Allison, 2003). It also indicates three steps in the moves 'Commenting on results' (*Explaining, Comparing results to previous research* and *Evaluating results*) that occur in the Dentistry Discussions, suggesting that the Dentistry writers drew on the same types of steps as Applied

Linguists. This finding is consistent with Lim's (2010) finding of the same type of steps in commentary moves (in the Results sections) in two disciplines (Applied Linguistics and Education). The study gives an inspiration that analysis of move, step, sub-step and combination of these elements may be a better indicator in understanding disciplinary variations in research report genres.

Amnuai and Wannaruk (2013a) investigate the rhetorical move structure of English Applied Linguistics RA Discussions published in Thai and international journals. A total of 60 RA Discussions are analyzed by employing Yang & Allison's (2003) move model. The results show that no linear sequence of the moves is found in any Discussion. The most cyclical move in both datasets is Move 4 *Commenting on results*. The obvious discrepancy between the two corpora is the use of Move 6 *Evaluating the study* and Move 7 *Deductions from the research*. That is, Thai authors have great tendency to generalize their study (Move 7) to academic discourse communities more than the international authors, who, instead, appear to evaluate their study (Move 6) more than the Thai authors.

Soodmand Afshar et al. (2018) also explore disciplinary variations on generic structure of RA Discussion sections. One hundred and four Applied Linguistics and Chemistry RA Discussions are analyzed based on Basturkmen's (2009, 2012) frameworks. By combining both quantitative (frequency and chi-square analyses) and qualitative approach (semi-structured interviews), the study shows significant variations in the two disciplines in employing moves, steps, and sub steps. The variations mainly are in the optional moves: Move 2, Move 5 and Move 6. Move 2 *Summarizing results* occurs in almost half of the Discussion sections in Applied Linguistics, while it only occurs once in those of Chemistry, which corroborates with the occurrence in Dentistry RA Discussion. Move 5 *Evaluating the study* and Move 6 *Implications for further research and pedagogic implications* seem to be optional but common in the Applied Linguistics. However, they are rare in Chemistry Discussions.

In conclusion, previous genre-based research on the Discussion section has received much attention from different perspectives, ranging from disciplinary investigation, disciplinary and NS/NNS variations, to cultural/linguistic variations. However, there is still a need to call for research on English RA Discussions by different groups of writers. Specifically, the lack of studies on rhetorical variations derived from distinct characteristics of different cultural groups encourages more relative and in-depth investigation.

2.2.1.1.5 The Conclusion Section

The Conclusion section, unlike other section, was not usually reached out by genre scholars since they had the tendency to include them in the Discussion section (Nwogu, 1997; Swales, 2004; Maswana et al., 2015). Moreover, this section is usually blended for analysis with other sections such as *Implications*, *Pedagogical implications*, *Limitations*, and *Suggestions for further research*. The purposes of the Conclusion section, according to Yang and Allison (2003), are summarizing the general findings and highlighting overall tendencies, including suggesting future research and recommending implications for teaching and learning. Yang and Allison (2003) is one of the notable studies on genre analysis of the Conclusion section. Meanwhile, they analyze and propose move frameworks for the RA Results, Discussion, and Pedagogical implications in Applied Linguistics field. Their findings based on the analysis of 20 Conclusion sections suggest 3 moves in the Conclusion: *Move 1 Summarizing the study*, *Move 2 Evaluating the study*, and *Move 3 Deductions from the research*. Among them, *Move 2* is realized by three steps 1) *Indicating significance/advantage*, 2) *Indicating limitations*, and 3) *Evaluating methodology*. *Move 3* is realized by two steps: 1) *Recommending further research* and 2) *Drawing pedagogical implication*.

Lin and Evans (2012) touch upon structural patterns in 433 empirical RAs in 39 disciplines in the fields of Engineering, Applied Sciences, Social Sciences and Humanities. They reveal that the IMRD structure is not the default option for such studies. One of the most frequently adopted structural patterns is Introduction-Literature Review-Method-Results and Discussion-Conclusion (ILM[RD]C), implying that the Conclusion is a necessary section. This study also reveals a key finding when discussing the relationship between the Results, Discussion, and Conclusion that the Conclusion section tends more to be present in RAs in which the Results and Discussion are merged. Lin and Evans (2012) claim that the separate sections outside the IMRD framework such as the Conclusion section merit closer attention.

Both Adel and Moghadam's (2015) and Ghazanfari et al.'s (2016) studies are based on Yang and Allison's (2003) model. Adel and Moghadam (2015) initiate a comparative analysis of the moves in RA Conclusion sections in Psychology, Persian Literature and Applied Linguistics. The results from the analysis of thirty articles based on Yang and Allison's (2003) framework show that the move-step structure of the Conclusion in each corpus was dependent on the rhetorical purposes of each discipline. Similarly, Ghazanfari et al. (2016) explore the move-step structure of RA Conclusion sections in English Language Teaching (ELT) and Nursing fields. The results show that there are almost no significant differences of employing the moves and steps between the two groups.

Ye (2019) investigates RA macrostructure and rhetorical moves of Energy Engineering RAs written by Chinese expert writers. The results suggest that 86% of the RAs choose the IM[RD]C macrostructure, and Chinese researchers not only actively conform their RAs to the international academic community but also flexibly employ rhetorical strategies. What's more, following Lim's (2014) criteria, moves and steps that occur in 100% of the corpus are obligatory, those occur in 51-99% of the corpus are quasi-obligatory, and those occur in less than 50% of the corpus are optional. The results of the move-step structure reveal three moves and seven steps in the Conclusion section: *Move 1 reviewing the present study*, *Move 2 Evaluating the present study* which are obligatory and *Move 3 Promoting future research* which is optional. This study not only offers a move-step model for Chinese researchers in RA writing, but also provides suggestions for English instructors to design their class.

To sum up, the Conclusion section is the section that receives less attention from genre scholars than the other sections. The studies concerning this section mainly deal with comparative analysis for L1/L2 distinction (Najar Vazifehdan & Amjadiparvar, 2016; Zamani & Ebadi, 2016) or disciplinary variation (Adel & Moghadam, 2015; Ghazanfari et al., 2016). In addition, Yang and Allison (2003) is prevalently selected as a model for move analysis in previous studies.

2.2.2 Previous Studies on the Whole RA

Previous studies draw on rhetorical structure of individual RA section, among which the Introduction receives the most attention. However, studying all the sections as a whole enables genre researchers and practitioners to gain a complete picture of characteristics of move structure in the target disciplines. Among the studies, Nwogu (1997) explores the rhetorical structure of the whole Medical RAs by using Swales' model (1981, 1990). He conducts a preliminary analysis on 30 RAs with IMRD pattern from five medical journals in order to reveal RA schematic structure in the Medicine. 'Representativity, reputation and accessibility' are criteria for compiling the corpora. A subsequent detailed analysis of fifteen Medical RAs randomly selected is followed, which indicates that the rhetorical structure of Medical RAs contains eleven schematic moves. The Introduction section includes 3 moves: Move 1: *Presenting background information*; Move 2: *Reviewing related research*; and Move 3: *Presenting new research*. The Methods section consists of three moves as well: Move 4: *Describing data-collection procedure*; Move 5: *Describing experimental procedures*; Move 6: *Describing data-analysis procedures*. Move 7: *Indicating consistent observation*; and Move 8: *Indicating non-consistent observation* are two constituent moves in the Results section. The Discussion section comprises three moves. Move 9: *Highlighting overall research outcome*; Move 10: *Explaining specific research outcome*; and Move 11: *Stating research conclusions*. Among the eleven moves, Moves 1, 6 and 8 are optional, and the rest are conventional. Nwogu's (1997) study provides insights on how the genre studies can be integrated to the entire RA sections as a whole. However, limitations for the study still exist. According to Kanoksilapatham (2003), the fifteen RAs subjectively selected from five medical journals might not represent the understudied field. Moreover, the limited RA number is not sufficiently supportive for the claims. Additionally, possible impact of idiosyncratic stylistic features of particular journals might be resulted from the unequal number of articles selected from each of the five journals. Thus, the findings of the study, to some degree, might not be able to be generalized to other disciplines.

Posteguillo's (1999) study focuses on schematic organization of RA Introduction, Results, and Discussion/Conclusion in the field of Computer Science. Models for analysis of the Introduction, Results, and Discussion sections are Swales (1990), Brett (1994), and the models adapted by Swales (1990) from Peng (1987) and Hopkins and Dudley-Evans (1988), respectively. Posteguillo (1999) is unable to include the Methods section due to its unidentifiability in Computer Science RAs. The sections following the Introduction are termed as “Preliminaries”, “Algorithms”, or “Analysis of a Problem”. The Methods, Results, and Discussion are often blended between the Introduction and Conclusion in Computer Science RAs (Chang & Kuo, 2011). The findings show that the RA Introduction generally conforms to Swales’ (1990) model except for some differences in steps. Cyclical patterns are found in the Introduction, Results, and Conclusion. For example: *Procedural-Pointer-Statement of data* or *Procedural-Pointer-Evaluation of data* are typical cyclical patterns in the Results.

Kanoksilapatham (2005) explores the complete rhetorical structure of Biochemistry RAs. Similar to Nwogu (1997) and Posteguillo (1999), she extends Swales’ (1990) model to other sections of RAs in Biochemistry. Twelve articles are randomly selected from top five Biochemistry journals, making up a corpus of sixty Biochemistry RAs. A two-level rhetorical structure consisting of 15 distinct moves is identified. Three moves for the Introduction, four for the Methods, four for the Results, and four for the Discussion.

The study expands the application of move analysis to Biochemistry RAs in their entirety, contributing to the knowledge of how writing in disciplines can be understood as having predictable structures. It provides an in-depth understanding of a move analysis on the formation of a distinctive section of a RA. In addition to the theoretical contributions to discourse analysis, this study offers pedagogical implications for reading and writing instruction. The rhetorical structure can be presented in the classroom to raise learners’ consciousness of discipline specific reading skills so as to empower them to become proficient academic readers. Moreover, the rhetorical structure also provides the inexperienced writers with a basis for meeting the conventions or expectations of the discourse community.

ElMalik and Nesi (2008) compare RAs produced by British and Sudanese medical researchers. Twenty RAs published in highly-regarded international journals are analyzed. The findings show all twenty RAs almost conform to the conventional IMRD structure. Move 1 is obligatory in both British and Sudanese articles; however, obvious differences are found in the realization of the rhetorical move functions. For example, Sudanese writers, compared to their British counterparts, employ more passives and tend to employ less nominalization to depersonalize their claims.

Li and Ge (2009) investigate structural and linguistic evolution of Medical RAs written in English based on Nwogu's (1997)11-move model. Each of the two corpora contains twenty-five RAs published from 1985 to 1989, and 2000 to 2004, respectively. Chi-square test or Mann–Whitney U test is used to compare results yielded with those of previous research. Findings show some changes through this chronological study: Moves 1 and 6 changes from 'optional' to 'obligatory', while Move 9 changes from 'obligatory' to 'optional'. As for verb tense, the frequency of the past simple tense significantly increases in Move 3 as well as the present simple tense in Move 10. Nevertheless, the frequency of the present perfect tense significantly decreases in Moves 3 and 10. The findings of this study could help Medical RA writers better understand the structural and linguistic development of Medical RAs, thus assisting them to produce English Medical RAs more acceptable for international medical journals.

Kanoksilapatham (2015) investigates textual organization of RAs of three Engineering sub-disciplines. Three corpora containing 180 full length high quality RAs from Civil, Software, and Biomedical Engineering are complied. The analysis, through multiple chi-square tests and the frequencies of occurrence of all moves and steps, reveals the influence of the sub-disciplines on the textual organization variations across the corpora. No significant statistical differences are found at the move level in Introduction, Methods, Results and Discussion sections. However, variations in textual structures can be captured at the step level. For instance, two significant statistical textual differences of Move 4 (Step 2: *Specifying protocolized procedures* and Step 4: *Providing procedural background*) in the Methods section focusing on procedure description are quite revealing. The relatively higher occurrence of Step 2 and no use of Step 4 in Civil Engineering (CE) corpus indicate that research procedures are reasonably established. Conversely, Software Engineering (SE) shows opposite for the rates of the two steps, featuring a myriad of research procedures which contain a variety of methodological approaches to addressing the diverse nature of studies in the field. Biomedical Engineering (BE) corpus shows the frequencies of the two steps are 50% and 51%, respectively. This study reveals the significant role of steps in distinguishing textual features of the three Engineering sub-disciplines. The differences revealed from the sets of steps in each individual section attribute to different RA constructions across the three sub-disciplines. These differences can be interpreted in accordance to the authors' goals and the nature of the studies within the sub-disciplines.

Maswana et al. (2015), using Swales' move framework (1990), investigate the complete structure of Engineering RAs from 5 subdisciplines: Structural Engineering, Environmental Engineering, Electrical Engineering, Chemical Engineering, and Computer Science. Different from previous studies, this study includes non-IMRD structure RAs and identifies moves based on contents. Six engineering researchers participate in the coding process. The analysis of 67 RAs indicates that the Abstract, Introduction, and Concluding sections and some of their moves are conventional across all the subdisciplines. Limited subdisciplinary similarities such as the use of Move 5 and Step 2 are observed in Environmental, Electrical, and Chemical Engineering. No common move patterns throughout the RAs across the subdisciplines are identified due to the differences in the nature of research in each field. The paper presents a subdisciplinary variation that reflects part of the real-world practice of the discipline of Engineering, which should be taken into consideration when teaching engineering English. It provides pedagogical supports such as course development, and learning from other subdiscipline's writing.

Kwan (2017) examines the macro-structures (MSs) of RAs in Information Systems (IS). Different from most MS studies seeking for a unified MS model to represent the discipline under investigation, the study examines MS variability based on three assumptions. First, the MS of RAs is related to the epistemological paradigms. Second, a discipline may have multiple paradigms, and it is not practical to assume a unified discipline-specific MS. Thirdly, it is necessary to examine their MSs according to their paradigms, respective research objects and research methods. A total of 60 RAs in Behavioral Science and Design Science are analyzed, and the results show distinct macro-structural variations across the two corpora. Behavioral Science Research (BSR) model reflects the research inquiry of positivism and hypothetical deduction, which is similar to Holmes' (1997) hypothesis of Sociology and Political Science. Design Science Research (DSR) model is similar to the three sub-models proposed by Posteguillo (1999) for Computer Science RAs.

In sum, the studies described above explore the RAs' rhetorical structure in their entirety within and across different disciplines, ranging from Medicine, Computer Science, and Biochemistry to an array of engineering subdisciplines. Most of them arrive at their own proposed models that reveal disciplinary or cultural/linguistic variations. The findings of the studies not only make great contributions to both genre theory and teaching practice, but also motivate future further studies from different disciplines or perspectives.

2.2.3 Electronic Engineering Research Article (EERA)

Research article in electronic engineering discipline has its own features as far as the structure is concerned. Three characteristics of the EERAs were identified by the researcher of the present research. Firstly, most EERAs examined were completed by more than one author. Since the author's L1 status is a main criterion and concern during data collection, the researcher of the present study noticed this feature. This is due to the fact that all members in a team make contribution to the research, which is a common feature in electronic engineering field. Secondly, the organizational structure of EERAs is not in complete accordance with the RA structure identified in previous studies, which comprises Introduction, Methods, Results, and Discussion sections, i.e. IMRD. EERAs conventionally include Introduction, Conclusion and most of them would have one combined Results and Discussion section rather than having these two elements in two separate sections. In addition, EE researchers tend to adopt topical headings over such functional headings as "Methods" or "Methodology". Finally, EERAs contain a large number of visuals (tables and figures) that support the author's claims. Figure 2.1 below shows an example of an EERA.

Four-element MIMO Antenna System for UWB Applications

LingSheng YANG, Ming XU, Chun LI

Jiangsu Key Laboratory of Meteorological Observation and Information Processing, Research Center of Applied Electromagnetics, NanJing University of Information Science & Technology, China

ylsinchina@163.com, {2450559561, 945926942}@qq.com

Submitted March 28, 2018 / Accepted December 10, 2018

Abstract. *A four element multiple input multiple output (MIMO) antenna system for UWB applications is presented. The system consists of two identical slot dipoles and two identical planar monopoles. Polarization diversity between different kinds of antennas can realize lower coupling between antenna elements, and by using a couple of inverted L-shaped stubs and an inverted Z-shaped stub as decoupling structures, isolation can be further improved. For both simulation and measurement, higher than 17 dB isolation between antenna elements can be obtained through the whole UWB band (3.1–10.6 GHz). The envelope correlation coefficient, antenna gain, efficiency and other performances are also provided.*

Keywords

MIMO, UWB, polarization diversity, planar monopole, slot dipole

1. Introduction

Since the Federal Communications Commission (FCC) released the band of 3.1 GHz to 10.6 GHz for commercial communication applications in 2002, UWB technology has drawn a lot of interest in various applications [1]. However, when UWB systems work in multipath environments, serious signal fading can be caused due to the obligatory low radiation power [2]. MIMO technology has multiple antennas in both transmit and receive sides which enhances data capacity and reliability without extra power or bandwidth, and can perfectly solve this problem [3], [4].

For UWB-MIMO system, how to maintain acceptable isolation (no less than 10 dB) between antenna elements through the wide operational band is a challenging task. Many researches has been reported recently [5–19]. Two-element MIMO antenna system is reported in [5], without using common ground and separate the two elements about $0.37\lambda_0$ from each other, no less than 15 dB isolation can be realized. Wideband neutralization line inserted between two monopoles to enhance the isolation between 3.1–5 GHz is proposed in [6]. Extruding T-shaped stub which changes the surface current in ground plane and increases the isolation is used in [7]. In [8], high isolation (no less than 10 dB) is achieved by etching a slot on the center of the ground plane between two evolved meandering monopoles. Stage slots among antenna elements are used to reduce the coupling [9], and higher than 15.5 dB isolation can be realized through the UWB band. Polarization diversity is also an effective way in obtaining lower mutual coupling between antenna elements. In [10–18], antenna elements are placed perpendicular to each other to exploit polarization diversity and achieve high isolation. While in [19], polarization diversity between leaf-shaped slot antenna and similar shaped monopole is used to obtain good isolation in UWB high band (7.25–10.25 GHz).

In this paper, a four-element MIMO antenna system for UWB application is proposed. Polarization diversity of different kinds of antennas and specially designed decoupling structure make the mutual coupling between either elements lower than –17 dB in the whole operational band (3.1–10.6 GHz). The total dimension of the antenna system is $70 \times 41 \times 0.8$ mm^3, which is suitable for UWB portable devices.

2. Antenna Design

Figure 1 shows the geometry of the proposed MIMO antenna system. The system is built on a 0.8 mm thick FR4 substrate with relative permittivity 4.4 and loss tangent 0.02. All antenna elements are fed by tapered microstrip lines, which can improve the impedance matching in the UWB band. Two identical CPW-fed slot dipoles with L-shaped stubs and rectangular-shaped stubs for impedance matching are placed on the top side of the substrate (fed by port1 and port2), while two identical microstrip-fed planar monopoles (fed by port3 and port4) are set at the bottom of the substrate. The decoupling structure consists of two inverted L-shaped stubs and an inverted Z-shaped stub is also located on the top side of the substrate. We used the electromagnetic simulation software HFSS [20] to do the simulation. The parameters were changed one by a time, the optimized parameters are listed in Tab. 1.

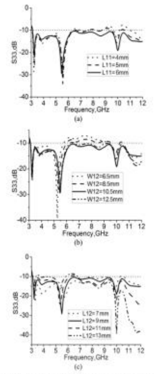


Fig. 3. Simulation results of S33 with the change of (a) L11, (b) W12 and (c) L12.

For Ant.3 and Ant.4, when (L11+L12+r2+L8) is fixed, which is about one-fourth wavelength at 3.1 GHz, the change of any of the components will not affect the lower frequency of the monopoles. As plotted in Fig. 3(a) and 3(b), the increase of L11 improves the impedance matching of higher than 5 GHz band. The change of W12 affects the higher than 6 GHz band of the antennas, while the change of L12 has an influence on the whole operation band (Fig. 3(c)).

The functions of the attached L-shaped and rectangular-shaped stubs, and the decoupling structures can be explained by designing the UWB-MIMO system in four evolution steps which are plotted in Fig. 4. Since when the overall size is decided, the monopoles can maintain well matched through the whole band, we mainly focused on impedance matching of the slot dipoles. While high isolation can be obtained by polarization diversity between different kinds of antennas, only the isolation between the monopoles cannot meet the 10 dB criterion through the whole band. The decoupling structures are designed to solve this problem.

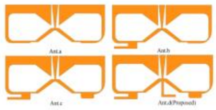


Fig. 4. Design steps (Ant.a-d).

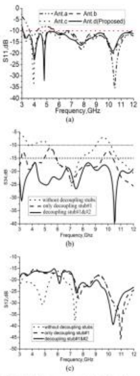


Fig. 5. Simulated S parameters: (a) S11 in four evolution steps, (b) change of S34 with the decoupling structures, (c) change of S12 with the decoupling structures.

As can be seen in Fig. 5(a), for Ant.a, at frequencies lower than 5.7 GHz, the antenna is not well matched. By adding an impedance matching L-shaped stub (Ant.b), impedance matching can be improved except for frequency from 5.1 to 5.7 GHz. One rectangular shaped stub is added to further fine tune the antenna. For Ant.c and Ant.d, they both can cover the whole UWB band under –10 dB impedance matching criterion. The function of the decoupling structures in isolation improvement is plotted in Fig. 5(b).

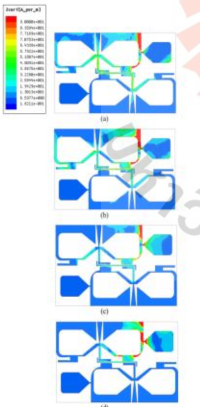


Fig. 6. Surface current distributions of the proposed UWB MIMO antenna when element#3 is fed at (a) 3.5, (b) 4, (c) 5.8, and (d) 8GHz.

With only a pair of inverted L-shaped stubs (decoupling stub#1), the isolation between the monopoles can be improved to higher than 10 dB. By adding an inverted Z-shaped stub, LC resonances structure between two kinds of stubs occurs, and the isolation can be further enhanced to higher than 17 dB. In Fig. 5(c), we can see with and without the decoupling stubs, the isolation between Ant.1 and Ant.2 is higher than 15 dB. The decoupling structures have no positive impact on the isolation except for around 5.8 GHz and higher than 8 GHz, but the effect is still weak compared to the influence on S34.

Figure 6 depicts the surface current distributions of the proposed UWB MIMO antenna at 3.5, 4, 5.8, and 8 GHz to further investigate how the pair of inverted L-shaped stubs and inverted Z-shaped stub increase the isolation. For monopoles, the metal contours of the slot-dipoles are used as their ground, when surface current flows on the ground, strong coupling occurs. In Fig. 6, it can be seen that through the UWB band, when Ant.3 is fed, the surface current is mainly trapped by the decoupling structures, so the mutual interference between the monopoles is alleviated.

3. Results and Discussion

Figure 7 shows the top and bottom pictures of the fabricated antenna system. The proposed antenna system was measured by using Agilent 85058E vector network analyzer.

As shown in Fig. 8(a), both the simulated and measured bandwidths can cover the UWB band, for the sake of clarity, we only put the results of two antennas here. The measured isolation between antennas is higher than 17 dB (Fig. 8(b)). For Ant.1 with Ant.2, since the radiation characteristics for the slot dipoles change with frequency, the isolation changes with frequency, too. Especially for frequencies between 6.5-8.5 GHz, the mutual coupling becomes relatively strong. For Ant.1 with Ant.3 or Ant.1 with

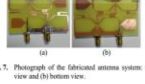


Fig. 7. Photograph of the fabricated antenna system: (a) top view and (b) bottom view.

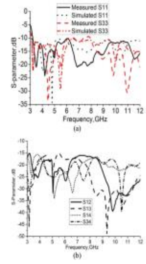


Fig. 8. (a) Reflection coefficients of the MIMO antenna system. (b) Measured isolation between MIMO antenna elements.

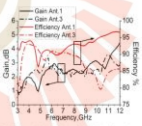


Fig. 9. Gain and radiation efficiencies for the proposed MIMO antenna system.

Ant.4, high isolation occurs because of the polarization diversity. Meanwhile, since the radiation characteristics for both kinds of antennas change with frequency, the isolation changes with frequency, too. Generally, if strong radiation of two antennas is pointing to each other, the mutual coupling will be strong. For Ant.3 with Ant.4, the change of electromagnetic property of the decoupling structures with frequency causes the changes of mutual coupling between the two antennas.

The measured gains and simulated efficiencies against frequency are presented in Fig. 9. The measured gain varies from 1.4–3.9 dBi for the slot dipole and 1–3.7 dBi for the monopole. The simulated efficiencies are no less than 80% for both kinds of antennas.

Figure 10 shows the radiation pattern of Ant.1 and Ant.3 at 5 GHz. Beside polarization diversity, pattern diversity can also be found from the simulated 3D radiation pattern. When Ant.1 is excited, radiation nulls are along the Y-axis, while for Ant.3, the radiation nulls are along the X-axis. The strong radiation between two antenna elements avoids pointing to each other. But for Ant.3 and Ant.4, the strong radiation is directed to each other. This explains why the isolation between Ant.3 and Ant.4 is the lowest. Similar performances between antenna elements can be found at other frequencies.

The measured and simulated 2D radiation patterns for Ant.1 and Ant.3 at 5 GHz and 8 GHz are plotted in Fig. 11 and Fig. 12. The radiation patterns are measured when the target antenna is excited and other three antennas are terminated with the 50ohm load. Differences are mainly caused by the fabrication error.

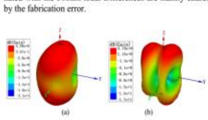


Fig. 10. Simulated 3D radiation pattern of (a) Ant.1 and (b) Ant.3 at 5 GHz.

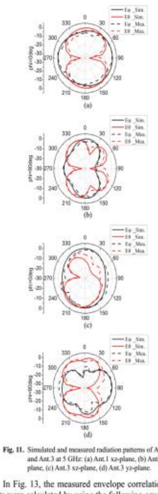


Fig. 11. Simulated and measured radiation patterns of Ant.1 and Ant.3 at 5 GHz: (a) Ant.1 xz-plane, (b) Ant.1 yz-plane, (c) Ant.3 xz-plane, (d) Ant.3 yz-plane.

In Fig. 13, the measured envelope correlation coefficients were calculated by using the following equation [21] and the results are lower than 0.015, which shows good isolation between antenna elements.

$$\rho_e = \frac{\left|\iint_{4\pi}(\Gamma \cdot E_{\theta_i}^{*} + E_{\varphi}(\Omega)\cdot E_{\varphi_j}^{*})\mathrm{d}\Omega\right|^2}{\iint_{4\pi}(\Gamma \cdot G_{\theta}(\Omega) + G_{\varphi}(\Omega))\mathrm{d}\Omega \cdot \iint_{4\pi}(\Gamma \cdot G_{\theta_j}(\Omega) + G_{\varphi_j}(\Omega))\mathrm{d}\Omega} \quad (1)$$

where $G_{\theta}(\Omega) = E_{\theta}(\Omega)\cdot E_{\theta}^{*}(\Omega)$ and $G_{\theta}(\Omega) = E_{\theta}(\Omega)\cdot E_{\theta}^{*}(\Omega)$, Γ is the reflection coefficient. E_θ and E_φ are the θ and φ polarized realized active electric field patterns of the antennas. G_θ and G_φ are the θ and φ polarized components of the antennas' realized active power gain patterns and Ω is the solid angle.

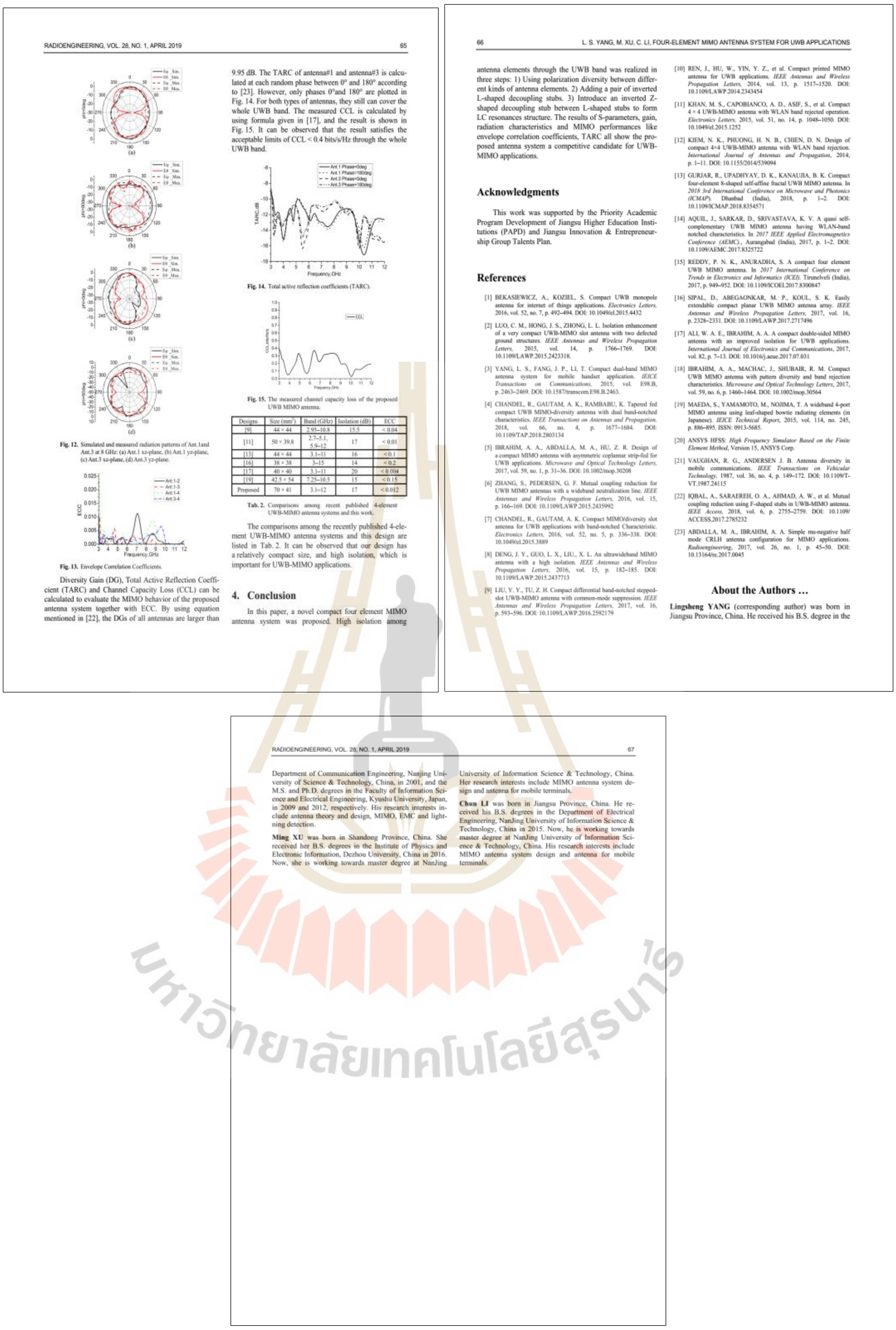


Figure 2.1 Example of EERA (Yang et al. (2019))

As can be seen from Figure 2.1, this seven-paged EERA contains 15 figures and 2 tables, illustrating their dominant position in contributing the whole communicative purpose of the RA. Furthermore, visual or visual elements are not the main focus in genre analysis, the present study, thus, aims to investigate this aspect of EERAs. Visual communication and visual studies in the ESP field are introduced in the following sections.

2.3 Visual Communication

The current research does not only focus on RA move-step structure, but also draws attention to visual-textual move (VTM) in these RAs. This means the researcher examines visuals and their associated textual moves. "Visual" in RAs refers to figures such as charts, graphs, diagrams, photos and tables, which provide significant support for the arguments and enhancement for persuasive power in the text. For many authors, they write their articles with support of visuals; while expert readers may 'read the visuals before the rest of the article' (Huckin, 1987). Besides, Miller (1998) indicates that graphs and tables could provide direct access to the data that could make the corresponding argument particularly convincing. Visuals could make the large amount of data appearing in small spaces possible. The description of the nature becomes more precise and convincing if they come with figures and numbers, because our visual discrimination is 'far better than our linguistic system at dealing with complex ratios and continuous variation in space, line, shape, and color' (Lemke, 1998). Roth et al. (2005) describe that visual images can be employed and should be a focus of ESP research in their volume *Critical Graphicacy: Understanding Visual Representation Practices in School Science.* They also promote visual images to be used to present data, illustrate abstract concepts, organize complex sets of information, facilitate the integration of new knowledge with existing knowledge, enhance information retention, mediate thinking processes, and improve problem solving. In a word, visuals in academic papers provide information or data for validity of the findings, allowing readers to know how the data are gathered and to interpret the data themselves.

The role visuals play is so essential in contributing the whole communicative purposes of texts that it should not be neglected in a genre-based analysis.

Consequently, it is vital to explore the importance of visual elements, how they communicate with the audience, how they demonstrate rhetorical functions, and how they interact with textual language in the target RA within specific disciplines.

Visual analysis in ESP and EAP field, when combining with textual analysis, and even oral text and body languages, falls into the category of multimodal analysis. One of the examples is Rowley-Jolivet's (2002) multimodal genre research on videos of scientific conference presentations, in which she categorizes visuals as scriptural (i.e., text-based), graphical (e.g., graphs, diagrams, or maps), figurative (e.g., photographs), or numeric (e.g., equations or numeric tables). She further classifies scriptural and figurative visuals as polysemic (open to multiple semantic interpretations) and graphical and numerical visuals as monosemic (unambiguous in interpretation). The study, based on the Systemic Functional Linguistics (SFL) approach, proposes a taxonomy for analyzing multimodal genres.

The difference between genre and multimodal genre is that the former focuses on the textual contents, the latter focuses on multiple elements in texts such as textual and visual contents. Kress and van Leeuwen (2001) define multimodality as:

> *"the use of several semiotic modes in the design of a semiotic product or event, together with the particular way in which these modes are combined- they may for instance reinforce each other (say the same thing in different ways), fulfill complementary roles, (…), or be hierarchically ordered, as in action films, where action is dominant, with music adding a touch of emotive color and sync sound a touch of realistic presence"* (p. 20).

Thus, multimodal genre analysis approach is constructed based on the notion that the analyzed document is not only limited to single-mode linguistic artifacts (Bateman, 2014). Other semiotic modes, apart from the text, could contribute to the meaning making. Lemke (2005) believes that every written document is considered as multimodality. Visual elements do not obligatorily appear in all written documents. However, it is typical and common to come across visuals such as figures and tables in many published scientific and academic RAs. Visuals, along with texts, play a vital role in conveying the meaning and fulfilling communication.

Most multimodal genre analysis tends to adopt Systemic-Functional framework for understanding the multiple functions enacted by a single message. Within this framework, messages may be identified with three meaning-making functions (Halliday, 1994): *ideational*, *interpersonal*, and *textual*. The *Ideational* function conveys meaning about states of affairs or events in the world, such as an experimental result. The *Interpersonal* function conveys meaning about the attitudes and relations of the writers and readers or speakers and audience, such as the authority and credibility or the writers or the finding. Finally, the *Textual* function conveys meaning about the text, guiding the reader through the text's organization (Tardy & Swales, 2014).

Kress and van Leeuwen (1996) propose "grammar of visual design", in which they stress that the structures of visual image offer meanings as structures of linguistics does. The meanings are socially and culturally bound, indicating that different experiences and social interactions result in different interpretations. Since some texts do not only contain the text alone, but rather a combination of text and visual elements, they become more powerful telling a story. Visuals could significantly improve the ability of readers to understand such texts (Bateman, 2014). *Visual grammar* refers to the combination of texts and visuals used to communicate to the audience. It is a socio-semiotic method built on the theory of Halliday's functional grammar (1985, cited in Kress & van Leeuwen, 1996). This method intend to 1) provide useful descriptions of the main structures that have become conventions in the history of western visual semiotics and 2) analyze how they are used by contemporary image-makers to produce meaning.

> *Visual grammar describes a social resource of a particular group, its explicit and implicit knowledge about this resource, and its uses in the practices of that group. Then, it is a quite general grammar, a term is needed that can encompass oil painting as well as magazine layout, the comic strip as well as the scientific diagrams. It is a quite general grammar of contemporary visual design in 'Western' values, an account of the explicit and implicit knowledge and practices around a resource,*

consisting of the elements and rules underlying a culture-specific form of visual communication (Kress & van Leeuwen, 1996, p. 3).

This method allows audience to view people and things from different perspectives by describing semiotic resources.

2.4 Visual Studies in the ESP Field

Dubois (1980) studies slides in Biomedical presentation, which is probably considered as one of the pioneering pieces of research that investigates visuals and their meaning making potentials in academic genres. Later, Johns (1998) initiates a case study on the use of visual representation and visual-textual interactivity (VTI), that is, the ways in which language and visual representation interact within the specific context of Macroeconomics. Based on reviewing related literature on visual representation in several fields and the exploratory case study on one student, she finds that ESP researchers attempt to focus more on the written language than visual representation since the written language is what interests them most and is central to disciplinary values and argumentation. In addition, visual representations such as charts, graphs and tables are not central in disciplinary values. Only a small portion of studies deal with complex visual representations. Johns' (1998) case study tells researchers to keep close contact with experts for consulting them about values in their discipline and the way they read and use visual elements. It also enlightens us regarding teaching implications. Apart from the written words, visual representations and the texts used to describe them are needed to be considered for ESP classes. Teachers should encourage students to use visuals to represent and support their data, to help taking notes and revising for reading and writing.

Several visual studies are based on the Systemic Functional Linguistics (Miller, 1998; Rowley-Jolivet, 2004; O'Halloran, 2010; Morell, 2015). Miller (1998) explores the visuals in academic and popular press by using three metafunctions of systemic linguistics. He points out that the visuals' ability of displaying information in a compact space makes it an effective resource for advocating claims. In his view, authors do not only use verbal texts to build their own arguments, but also employ visuals such as figures and tables to reveal the results as the basis for the argument. Other than providing foundation of the argument, visuals also “clarify” through condensing new information for the “informed and potentially skeptical reader” (p. 43), which maximize academic genres’ persuasiveness. He also points out that in scientific RAs, visual exceeds text, because “many scientists write articles to highlight visual effects”, while “expert readers usually read visual effects first” (p. 29-30). Therefore, visuals not only support arguments in RAs, but also firstly draw readers’ attention to the arguments based on them.

Rowley-Jolivet (2004) conducts a social semiotic analysis of visual communication in a scientific research genre - the conference presentation. The data cover 2000 visuals (slides and transparencies) projected during 90 presentations given at international scientific conferences. By focusing on the spatial and temporal visual resources that create texture and cohesion, the study examines how logical relations, discourse structure and rhetorical claims are expressed visually in this particular communicative context. The study compares three different scientific disciplines-Geology, Medicine and Physics in terms of the visual resources. The findings show that visual communication is deeply rooted in disciplinary practice and the variations among them lie in their respective disciplinary epistemology, methodology and data type investigated. Rowley-Jolivet (2004) regards a discipline as a ‘social microcosm’, in which communicative members embrace their own visual convention. In other words, it is the epistemology, methodology, and data type that dominate and influence the use of visuals in each discipline.

O’Halloran (2010) applies Halliday’s metafunctions to investigate how mathematical knowledge is accumulated across three semiotic resources (language, images and mathematical symbols) and modalities (oral, visual, haptic and others) in the classroom. She argues that language, mathematical images (e.g., graphs, geometrical diagrams and forms of visual representation) and mathematical symbols are three semiotic resources or building blocks that construct mathematics texts. Each semiotic resource fulfils particular functions: language introducing theoretical concepts or a problem; image offering an overview of relations between mathematical participants; mathematical symbol formalizing the relations. Language and images are usually used to introduce and conceptualize mathematical concepts and problems, while symbol plays a role in formalizing these relationships and solving problems. She further argues that integration of semiotic resources contributes to 'immense semantic expansion' in mathematical texts which could exceed the sum of the meaning potentials of the three resources, a viewpoint emphasizing the importance of visuals to the argument.

Some rhetorical studies focus on how visual and text interact to describe and argue for the theory, so as to enhance the persuasiveness of the whole text and knowledge generation. Gross and Harmon (2014) identify different argument stages in which visuals exist and their respective semiotic meanings. They are 1) iconic (visuals represent the world); 2) symbolic (visuals represent aspects of the world); and 3) indexical (visuals indicate causal relationships in the world). According to Gross and Harmon (2014), the audience interprets this meaning by placing visuals in the context of argumentative structure. There is an emphasis on the readers' role in assigning meaning/function to visuals, which is different from Morell's (2015) perspective that the author sets meaning for visuals. Rather than a de-contextualized process, meaning construction is a contextualized visual reading process. Although Gross and Harmon (2014) put visuals in a secondary position, claiming that they cannot become arguments, the verbal-visual interaction is so crucial and interdependent that they are indispensable for building convincing arguments in natural sciences.

Hemais (2014) studies visual-textual relationships in marketing RAs by applying visual grammar. The finding shows that texts and visuals contribute together to making meaning and supporting research facts. She stresses that texts refine the meanings of theories, while visuals provide general meaning of theories, which is easier for readers to understand, a valuable finding in terms of visuals' function in RAs.

Visuals also provide evidence for new knowledge (Charles & Ventola, 2002; Morell, 2015). Morell (2015) examines multimodal academic discourse of conference oral presentations, including the verbal, written, nonverbal material (NVM) and body language modes. The study offers a Systemic Functional Linguistic (SFL) and multimodal framework for conference presentations to improve mixed-disciplinary ELF (English as a Lingua Franca) academics' awareness of ways or modes they apply at conferences in achieving effective communication. In analyzing conference presentations, she assigns three functions to non-verbal (that is, visual) materials (NVM): *illustrative*, *decorative*, *and expository*. *Illustrative* NVM includes verbal components, such as using a flow chart to illustrate a process. *Decorative* NVM creates the context or background, which usually occurs in the field of social science. *Expository* NVM provides evidence, a more common function in Science and Engineering. However, Morell (2015) finds the functions overlap even though she assigns the dominant function. For example, the decorative flow chart of a process can also be used as evidence to support a claim, which is the role expository function plays. This finding corroborates that of a previous study (Miller, 1998) on the function of visuals in arguments in academic texts. The analysis of texts and interviews shows that: (a) a deeper awareness of mode affordances and their combination can achieve enhanced performance; (b) visual modes can compensate for verbal defects; and (c) effective speakers tend to use multiple modes to convey specific meanings.

Many studies on visuals in linguistic-oriented ESP research are focused on Science. Examples include Dubois (1980) on Biomedicine, Miller (1998) on Biology, Morell (2015) on Technical Science and Social Science presentations; Lemke (2003), O'Halloran (2005, 2010), and Moghaddasi et al. (2019) on Mathematics.

Moghaddasi et al. (2019) is the most recent study on visual-verbal relations in Mathematics. The study connects visuals to the textual rhetorical moves, and argues that it is of great importance to identify the VTMs at the micro rhetorical level, because the data presented by visuals often constitutes new knowledge and is a core to RA arguments. After analyzing thirty RAs from Discrete Mathematics, the researchers find that visuals in two-thirds of the RAs fulfill three functions: ontological, argumentative, and epistemological. Ontological function in visuals is used for highlighting assumptions, defining concepts, or constructing complex mathematical objects. Argument function in visuals highlights the visual's role as evidence, explicitly supporting a stated claim, a function generally existed in visuals in Discrete Mathematics RAs. Epistemological function in visuals mainly occurs in announcements of results and proofs, and claiming new knowledge. Moghaddasi et al. (2019) also point out 'the distinction of the three functions are artificial because in many cases the visuals fulfill multiple roles' (p. 60). Finally, the study proposes a model for multimodal-move analysis, which shows how to use various visual and verbal moves to achieve the purposes of RAs, and explains how the verbal and visual elements in Discrete Mathematics provide the resources for discrete mathematicians to create and demonstrate new knowledge. Implications of the study suggest that genre practitioners could probably include the study of visuals in their discourse study, because it is not only verbal languages but also visual components contribute to completing meaning of texts. Additionally, the findings of the study may direct young researchers in knowing how to construct and integrate visuals effectively into arguments so as to both learn and enhance authorial credibility.

To sum up, previous studies on visuals and multimodality in academic genres mainly examine visual function and visual-verbal interaction in supporting writers' or speakers' arguments for data and enhancing the validity of their knowledge claims. Some studies focusing on international conference presentations (e.g., Rowley-Jolivet, 2004; Morell, 2015) reveal that visuals play a multifunctional role in strengthening arguments. The main field several visual studies land on is Science (Lemke, 1998; Gross, 2007; Graves, 2014; Gross & Harmon, 2014). Findings of the studies reveal that application of visuals may vary across disciplines.

The previous studies on visuals in academic setting provide in-depth insights for the critical meaning-making roles the visuals play. Among these studies, Moghaddasi et al. (2019) endow the researcher of the present study with an inspiration of conducting VTM analyses in EERAs written by three different writer groups. The reasons for choosing Moghaddasi et al. (2019) as the reference for the analyses and their framework will be discussed and described in detail in Chapter 3.

2.5 Contrastive Rhetoric Theory

The notion of contrastive rhetoric was born in 1966 when Robert B. Kaplan published his famous article *Cultural Thought Patterns in Intercultural Education*. In this article, he puts forward this idea that one's native language influences his thoughts, reinforcing the weak version of the Sapir-Whorf hypothesis (linguistic relativity). That is, language influences to some degree the way people think and view the real world, while the strong version (linguistic determinism) claims that language we speak determines our thought. In addition, he believes people with different linguistic backgrounds have their own writing habits and patterns within their specific cultural boundaries. His principle concern is the interference of the culture-bounded L1 thought and writing mode on the L2 writing. According to Connor (1996), Contrastive Rhetoric is defined as:

> *"An area of research in second language acquisition that identifies problems in composition encountered by second language writers and, by referring to the rhetorical strategies of the first language, attempts to explain them."* (p. 5)

Every language and culture has its unique rhetorical conventions, which interfere with their L2 writing. However, after approximately four decades of research and argument, contrastive rhetoric is now tending to focus more on cognitive and sociocultural variables of writing than the purely structural descriptions. Recent studies have expanded the notion of contrastive rhetoric and shifted it from focusing only on the impact of transfer from L1 to L2 writing to the interdisciplinary field of cross-language and cross-cultural research, gaining inspirations from theories and methods of such related disciplines as anthropology, translation, discourse analysis, composition and rhetoric studies (Connor, 1996, 2002, 2004).

Internal and external forces both make the shift of this perspective happen. Internal force, coming from criticism of contrastive rhetoric, requires it not to be confined within conventional linguistic parameters for analysis, and it needs to extend itself to other parameters such as processes and contexts of writing. For example: some scholars have criticized contrastive rhetoric for its reductionist, deterministic, prescriptive, and essentialist orientation (e.g., Leki, 1997; Spack, 1997; Zamel, 1997). From the perspectives of critical literacy and modern linguistic theory, language is neither historically fixed nor emergent out of nowhere; it needs to be understood as fluid, dynamic and constituted through cultural, political and social conditions (Fairclough, 1992, 2001; Pennycook, 1997, 2001).

Another internal force in traditional contrastive rhetoric is that it uses students' L2 academic essay to investigate their L1 rhetoric, leading to L1 being considered problematic and something that would be transferred negatively to their L2 writing. Connor (2004), however, after reviewing research in contrastive theory over the past four decades, advocates a new direction for this notion, which is renamed 'intercultural rhetoric'. Acknowledged with the dynamic nature of discourse and culture, she describes the need of intercultural rhetoric study into how writing in specific cultures is related to the ideological history and social structure of these cultures.

External factors such as development of discourse analysis and L1 composition research also drive contrastive rhetoric for promoting its theoretical scope. The analytical techniques in Systemic Functional Linguistics, New Rhetoric and so on can be applied to contrastive rhetorical research from different perspectives. For instance, the evaluative language analysis, or appraisal analysis in Systemic Functional Linguistics provides the discourse under investigation with a more distinct and wider picture. L1 composition research tends to regard the writing as an integrated process of generating, structuring, and translating ideas into text, as well as placing context, situation and audiences or readers into the whole picture.

Contrastive rhetoric provides valuable perspectives as well as great impacts on teaching students' L2 writing. Kaplan (1966) argues that ESL students' writing, especially their paragraph organization, exhibits the students' L1 cultural thought patterns. The diagrams proposed by Kaplan have been widely presented in teacher's handbook and are recognized and accepted by students and teachers.

Connor (2004) identifies four domains of contrastive rhetoric studies based on her investigation of these studies for the past 30 years. These domains are: text linguistics, analysis of writing as a cultural and educational activity, classroom based writing studies, and contrastive genre-specific studies. According to her, contrastive text linguistic studies, adopting written discourse analytic techniques, compare and contrast how texts are formed and interpreted in different languages and cultures. Several studies have conducted contrast on coherence and discourse patterns in different languages (e.g., Hinds, 1983, 1990; Eggington, 1987). Hinds (1990), one of the most influential studies, argues for an oriental writing style after examining the ways Japanese, Chinese, Thai, and Korean writers use to achieve coherence. He describes that the groups of writers tend to use a quasi-inductive style rather than an explicit or deductive style. The assumption was generated in his study in 1987, asserting Japanese is a reader-responsible language, which is opposite to the writer-responsible language such as English. He claims that Japanese, Chinese, Thai, and Korean readers are expected to think for themselves, make their own observation and draw their own conclusion. Nevertheless, native English writers usually convince their readers by presenting explicitly their idea, methods and conclusion.

Studies of writing as cultural and educational activities mainly attempt to investigate literacy development in L1 and cultures and its effects on the L2 literacy development. Scholars stress that written texts and their uses differ among cultural groups, which to a large extent attributes to the writing instruction (see e.g., Carson, 1992). In Carson's (1992) study, he explores how Chinese and Japanese speakers acquire their L1 in reading and writing and how the acquisition has impacts on their strategies and methods in learning to write and read in English. He takes social contexts such as the educational system and cognitive consideration into the whole picture. When describing the situation in China, he points out the school is the representative of Chinese education and maintain the order and authority to students. Students at school would be taught some basic societal values such as patriotism, the collectivism, group loyalty, and respect for authority. Clear expression of public meaning paves way for successful communication. Similarly in Japan, language is not considered as a channel primarily for expressing individual meaning.

Classroom-based contrastive studies are concerned with cross-cultural discourse patterns in process writing, collaborative revisions, and student-teacher conferences. Studies in this area prove the value of exploring beliefs and perceptions about literacy, and find that cultural misunderstanding emerges in such classroom situations as conversation, collaborative groups, and teacher-students conference. Hull et al.' s (1991) research results show that one feature common in classroom conversation in the United States, which is a teacher initiates, a student replies and the teacher gives evaluation, might not function well in other western cultures. Nelson and Carson (1998) reveal that Chinese ESL writers tend to maintain group harmony in collaborative writing, while Spanish always tend to be critical in the group.

When contrastive rhetoric is combined with genre analysis, it investigates generic variations of such academic and professional writings as journal articles, business reports, application letters, grant proposals, newspaper commentaries among different languages and cultures. For example, Feng (2008) investigates nine successfully funded Chinese research grant proposals written by nine Chinese scholars. Rhetorical moves and strategies of the proposals, plus interview data are analyzed. The findings show that some unique features of Chinese grant proposal writing are attributable to such local contextualities as research and literacy traditions, face concerns, social and political context, literacy and research traditions. Pak and Acevedo (2008) explore discourse patterns of some Spanish varieties in the United States and makes comparison with the findings with previous studies. Sentence and paragraph length and complexity, use of attribution to sources and other this genre-specific features are analyzed, leading to demonstration of regional differences among various Spanish-speaking regions. Suárez and Moreno (2008) conduct an English-Spanish cross-linguistic study of the rhetorical structure of Literature Book Reviews (BRs) based on two comparable corpora-Spanish and English. The findings show that Spanish literature BRs develop more descriptive moves, although they share similar overall patterns with English literature BRs. Wolfe (2008) examines rhetorical organizations of Russian and American business correspondence based on Hofstede's (1984) theory of cultural dimensions such as power distance, uncertainty avoidance and individualism, collectivism, which helps generate pedagogies for teaching intercultural rhetoric in English for Specific Purposes (ESP) business writing courses. Yang and Cahill (2008) examine the variations of 200 expository essays written by three groups of writers: 50 by Chinese writers, 50 by English writers and 100 by beginning and advanced English writers. The findings show that American writers tend to be greatly more direct than Chinese students. Directness is also an element that Chinese rhetoricians encourage when constructing expository essays.

Al-Khasawneh (2017) and Noorizadeh-Honami and Chalak (2018) conduct comparative analyses of RA abstract written by native and non-native English speakers in Applied Linguistics and Architecture, respectively. The corpora of these two studies contain altogether 20 and 60 RA abstracts, and the models adopted for analyses of the RA abstracts are Hyland's (2000) five-move framework and Swales' IMRD framework (1990). Al-Khasawneh (2017) finds out the disparities between native and non-native writers. The former follow the international convention of RA abstract structure while the latter do not. The findings of the study would help non-native writers improve their abstract writing linguistically and structurally.

Noorizadeh-Honami and Chalak (2018) find that the non-native writer group, Persian writers offer more information in the *Introduction* and *Discussion* moves than their English counterparts, who give more information in the *Methods* move. The study provides insights for Persian writers achieve publication in international prestigious journals.

These studies have generated findings that could describe and explain some characteristics of given genres. The rhetorical patterns of a specific genre are an essential component of a language. They do not remain unchanged but might shift over time and space as they are socially constructed and transmitted. Contrastive rhetoric studies demonstrate the differences in rhetorical structures and linguistic features among different languages and cultures. When doing contrastive rhetorical research, Scollon (1997) suggests that more attention should be given to rhetorical studies in their broader sense than to the text structure. Canagarajah (2002) also argues that contrastive rhetoric research should provide textual differences with more complete and complex explanations, which could be realized through genre analysis free from normative, rule-governed, and valueless descriptions of genre conventions.

2.6 Non-native Researchers' Writing RA for International Publication

Writing RAs for international publication has been a crucial and necessary issue for both native and non-native English researchers. Recently, there is a saying "Publish or perish", which sounds threatening but is totally true for researchers all over the world. Publishing RA in no matter what languages contributes to not only academic and career fulfillment, but also researchers' sense of self-progression that makes them feel more confident and complete. However, non-native researchers, compared with native counterparts, face more challenges in writing RAs for international publication.

Xu (2014) reviews RAs relating the international publication issue in three prestigious international journals published since 1995. The study reveals problems of international publication for non-native English researchers, including quality problems consisting of English writing and research methodology. In addition, it also mentions complex problems such as language, power, and political factor. Among them, language, one of the complex issues, has been recognized and acknowledged by many researchers in South Korea, Poland, Sudan, Thailand and other regions and countries. They believe that EAL (English as an Additional Language) scholars have certain writing difficulties in the aspects of rhetoric, organizational structure and presentation of research methods. Furthermore, the increasing number of non-native English reviewers does not indicate their acceptance of manuscripts that do not meet the English academic standards and conventions. The key to solve the problem is to achieve international academic recognition by adopting the writing styles conforming to the writing conventions of international academic community.

Tian and Lu (2016) conduct a study on the pressure faced by young scholars under 'tenure-track' contracts to publish in international journals. Semi-structured interview is the adopted instrument in the study to explore young scholars in one research-type university in Northwestern China. The study claims that in order to obtain national funding, universities, especially research-type universities, generally require teachers to publish papers in international academic journals especially those included in Science Citation Index (SCI) and Social Science Citation Index (SSCI). The number of articles published in these journals is considered to be not only an important indicator of the research capability and the ranking of a university, but also a determining factor for the teachers' career development and advancement.

In this study, thirteen informants with doctorates aged between 25 and 35 are invited to the semi-structured interview, during which some of them stress that writing in a second language obviously aggravates the pressure for publication. The informants from Science and Engineering fields feel that they are compelled to spend more time and energy on English writing even though all of them had successful publication experiences in SCI during their doctorates and most of them have already produced high-quality papers during the contract period. Writing in English for international publication is found in this study to be one of the main sources of pressure for these young scholars.

Cai (2018) suggests English writing for international publication to be a compulsory course for Chinese graduate students. He identifies the following English writing problems including inaccurate language expression, unacceptable organizational structure, old references, and untraceable citations. For tackling these problems, Cai (2018) designs a course “International Research Article Writing and Publishing” in Fudan University for graduate students from three science and engineering disciplines during the winter vacation of 2017. The course, designed based on theories of genre analysis, language corpus, and metadiscourse analysis, includes seven modules: 1) overall organizational structure; 2) the Results Section; 3) the Introduction section; 4) the Discussion section; 5) corpus application; 6) submission and publication; and 7) academic norms. The students speak highly of the course in the survey and in the interview conducted afterwards. The study suggests a valuable experience for the development of ESP and EAP courses. Instead of stressing specific words and contents, courses as such should emphasize organizational structure, rhetorical means and analysis and teaching of language expression. Besides, the study indicates that students from similar disciplines could enroll in such same courses for dealing with the hardship created by disparities among disciplines.

Wu and Wang (2018) investigate the innovative approaches within Journalism and Communication field in China to international publication. The study mentions the problem of English writing by citing Dr. Yue Wu from School of Journalism and Communication in University of Social Sciences of China who points out that it is far not enough to only use correct English vocabulary and grammar in the writing of SSCI papers. Proper expressions such as presenting research results acceptable to native English academic discourse community for conducting equal academic dialogue is the key to international publication.

Thai scholars seem to have the similar problems as Chinese scholars do. Phothongsunan (2016) examines challenges encountered by Thai university lecturers in terms of international publication. Eighteen informants from two universities are interviewed for their perception of publication in English. The findings show that there is the need for international publication since English is a language for international communication. Informants from the public university say that government authorities require them to publish internationally while those from the private university stress that their university's requirement for their publishing in English is to guarantee the RA quality. Besides, difficulties of writing RA in English identified are vocabulary shortage, and inadequate writing style. In addition, the informants also suggest that they should gain such research support from their universities as providing specific training programs and workshops as well as establishing an English center that could offer editing support.

Phothongsunan (2016) finds that some non-native scholars label themselves as "a linguistic disadvantage" owing to their lower English proficiency, which is embodied by a number of flaws in basic grammar, sentence structure, academic expressions and deviation from the conventional structure that the academic community expects to see. These language flaws might usually result in international publication failure. Thus, for dealing with the English RA writing problems in Thai setting, Phothongsunan (2016) develops an instructional model, consisting of the following three phases: survey of the problems and need, instructional model construction, and the revised model retesting. One hundred and twenty-five research assistants and researchers in Sciences participate in the investigation. The results show that the participants could effectively write their RAs after being trained with the instructional model despite the fact that there are still some Thai linguistic patterns hindering their English writing.

Rhekhalilit and Lerdpaisalwong (2019) conduct an investigation of the role of English in Thai academic publications by examining 346 and 317 RAs in Science and Humanities and Social Science published in 2005 and 2015. The findings indicate that despite Thai's major role among Thai scholars in academic exchange, the growing use of English is obvious, especially in the medicine field. The study analyzes the reasons for choosing between Thai and English as the publishing language. Respondents who prefer English indicate that they are familiar with English RAs. They think English could raise interests and confidence of the targeted readers as well as international quality of Thai academic journals. Thus, English is playing an increasingly important role in Thai academic publication.

In summary, English is identified as a current academic lingua franca and playing an increasingly important role in both China and Thailand. Nevertheless, Chinese and Thai, the non-native English speakers in the present study, both encounter similar problems in writing English RAs for international publication. The present study would provide some useful insights into move-step structure and VTM in the composition of EERAs.

2.7 Research Gaps in Previous Studies

Previous studies on rhetorical move structures and visuals in academic genres shed light on how communicative purposes of the discourses are achieved through adopting different moves and steps in various disciplines. For rhetorical structures of RAs, Swales' models (1981, 1990, 2004) have been extensively served as a reference for move analysis of especially RA Introduction section. A large number of studies explore disciplinary, cross-disciplinary features and variations in terms of rhetorical structures. On the other hand, visual analysis in academic setting also gains fruitful results. However, limitations in the previous studies indicate that research gaps are needed to be addressed and filled.

First, previous studies on RAs mainly emphasize move structures within one discipline (e.g., Kanoksilapatham, 2005) or seek for move variations across disciplines or subdisciplines (e.g., Ozturk, 2007; Peacock, 2011). Few studies focus on English RAs written by different regional and cultural groups within one discipline. It is worth investigating, within the same discipline, how much successful writers from different regional and cultural groups share rhetorical conventions and the kinds of variations that are acceptable to the all groups.

Second, most previous studies on RA rhetorical structures focus on individual sections (e.g., Ozturk, 2007; Hirano, 2009; Sheldon, 2011; Lim, 2012; Graves et al., 2014). Relatively few studies choose to investigate rhetorical structure of the whole RA. Similarly, previous studies tend to explore only macro-level move structure or micro-level linguistic features. They seldom conduct multiple-layer analysis by combining these two levels of investigation. This is partly due to limited space for publication. Moreover, larger scope leads to longer time of dedication to the research.

Third, previous studies on move analysis cover a wide range of fields or disciplines such as Medicine (e.g., Nwogu, 1997), Biochemistry (e.g., Kanoksilapatham, 2005), Chemistry (e.g., Stoller & Robinson, 2013) Computer Science (e.g., Posteguillo, 1999), Applied Linguistics (e.g., Hyland & Tse, 2012), and Sociology (e.g., Brett, 1994). Studies on Electronic Engineering RAs seem rare, even though the discipline falls into the category of Engineering. It is necessary to explore more on the rhetorical structures of this under-explored discipline for more valuable findings.

Fourth, the limited number of previous studies on whole RAs (e.g., Nwogu, 1997; Kanoksilapatham, 2005; 2015) usually include standard IMRD-structured RAs as their sample for analysis, which means they exclude the non-IMRD structures to a certain extent. This condition violates the representativeness of sample collection. To truly make the data representative so as to achieve reliability and validity of the results, data collection process should not go through absolute subjectivity.

Last but not the least, visual elements or visuals in academic genres are examined in a limited area such as international conference presentations and in such science field as Mathematics (e.g., Moghaddasi et al., 2019) and Biology (e.g, Miller, 1998). Studies on move analysis seem to ignore visuals as a part for achieving communicative purposes, that is, no genre-based studies integrate move and visual analysis into the academic setting. Genre research pioneers advocate visual analysis because they equally contribute to the RA's rhetoric.

The identified research gaps and the need of novice researchers from the three groups for scaffolding in EERA writing motivate the current study. A total of 36 RAs, that is, 12 from each group, are carefully and objectively selected to build the corpora. Considering the representativeness of a corpus, the present study does not purposefully exclude the non-IMRD RAs in this field. For example, some RAs might contain such headings as "theoretical background", "principle", etc. Moves under these unique headings are analyzed according to their content. In addition, visuals, which are often ignored in move analysis, are also investigated. The results and findings are compared among these three cultural groups in terms of VTM for getting more understanding within the discipline of rhetorical conventions for achieving the communicative purposes.

2.8 Summary

This chapter reviewed the related literature that frames concepts and theories for the present study. It started with defining genre and a review of the three traditions of genre studies. Next, previous studies on RA genre and visual in the ESP field were reviewed individually to target valuable findings and identify the gaps needed to be filled. Contrastive rhetorical theory was then introduced based on the second intention of the study for comparing RA move-step structure and VTM adopted by the three different regional and cultural writer groups. Finally, non-native researchers' writing RA for international publication was examined.

CHAPTER 3
RESEARCH METHODOLOGY

Mainly discussing the research methodology of the current study, this chapter first provides an overview of the study by briefly reviewing the purposes and research questions of the study. Then, research design and corpus compilation including selection of the target journals and research articles (RAs) are presented in the second and third sections. Thereafter, data analysis process is explained in the fourth section demonstrating in detail move-step and visual-textual move (VTM) analyses. Selection of frameworks, identification of move, step, VTM, as well as inter-rater reliability are included in this section. The fifth section describes interview data collection and analysis. A pilot study is finally conducted in the sixth section to explore the move-step structures and VTMs in the Results and Discussion (R&D) section of EERAs employed by Chinese, Thai and native English writers.

3.1 Overview of Research Objectives

To achieve the aim of the current research and to address the four research questions, two phases, with each carrying two layers of analysis, respectively, are designed. Specifically, move-step structure and visual-textual move (VTM) are the main themes of the two phases. For the first phase, the first layer of analysis is to investigate moves, steps and their structures of Electronic Engineering RAs (EERAs) of the three corpora of Chinese, Thai and native English writers, which addresses Research Question 1. It is then followed by a comparison of EERA move-step structures among the three corpora for addressing Research Question 2. The second phase is concerned with VTM investigation, which addresses the third and the fourth Research Questions. Therefore, this study aims to: 1) investigate the moves, steps, and move-step structures of the Introduction, Methods, Results and Discussion, and Conclusion sections of Electronic Engineering RAs (EERAs) written by Chinese (CH), Thai (TH), and native English speakers (NS), 2) find out the variations of the moves, steps and move-step structures of the

Introduction, Methods, Results and Discussion, and Conclusion sections of EERAs among the CH, TH, and NS corpora, 3) examine visual-textual moves (VTMs) in EERAs written by Chinese (CH), Thai (TH), and native English speakers (NS), and 4) find out the variations in terms of VTMs in EERAs among the CH, TH, and NS corpora.

Consequently, four corresponding research questions are proposed to serve the research purposes. They are:

1) What are the moves, steps and move-step structures of the Introduction, Methods, Results and Discussion, and Conclusion of Electronic Engineering RAs (EERAs) written by Chinese (CH), Thai (TH), and native English speakers (NS), respectively?

2) What are the variations of the moves, steps, and move-step structures of the Introduction, Methods, Results and Discussion, and Conclusion of EERAs among these three groups?

3) What are the visual-textual moves (VTMs) in EERAs written by Chinese (CH), Thai (TH), and native English speakers (NS), respectively?

4) What are the variations in terms of the VTMs among these three groups?

3.2 Research Design

In order to answer the research questions and achieve the purposes of the present study, move-step analysis, VTM analysis and contrastive analysis are conducted. Figures 3.1 and 3.2 present the research design, which contains two phases of analysis. The first phase contains two layers of analysis. One is move-step analysis of EERAs written by Chinese, Thai, and NS writers, the other being the contrastive analysis of move-step structure across the three corpora. Likewise, the second phase firstly investigates VTM in EERAs written by Chinese, Thai, and NS writers, which is followed by contrastive analysis of this aspect among the three corpora.

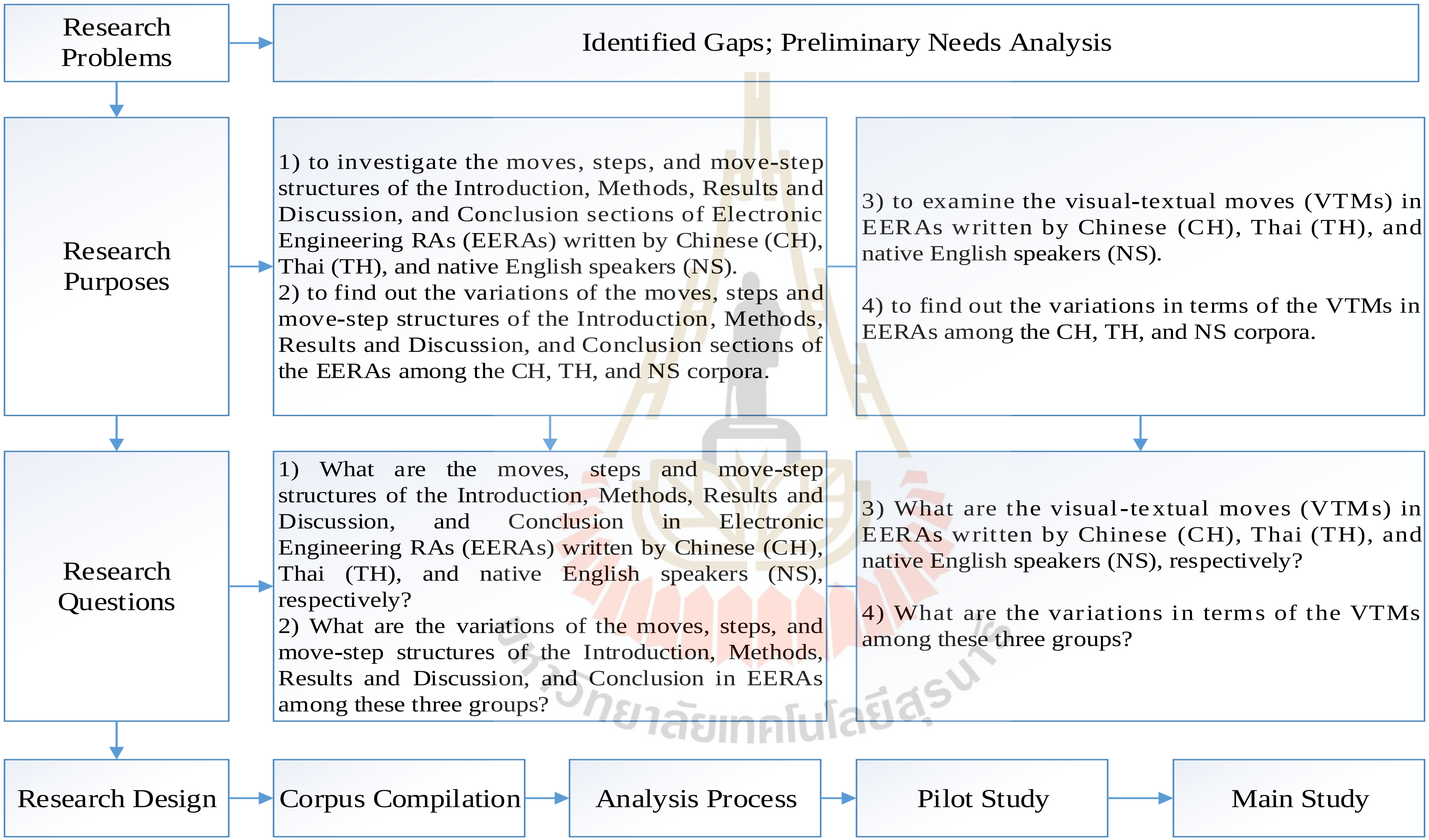


Figure 3.1 Research Design Flow Chart 1

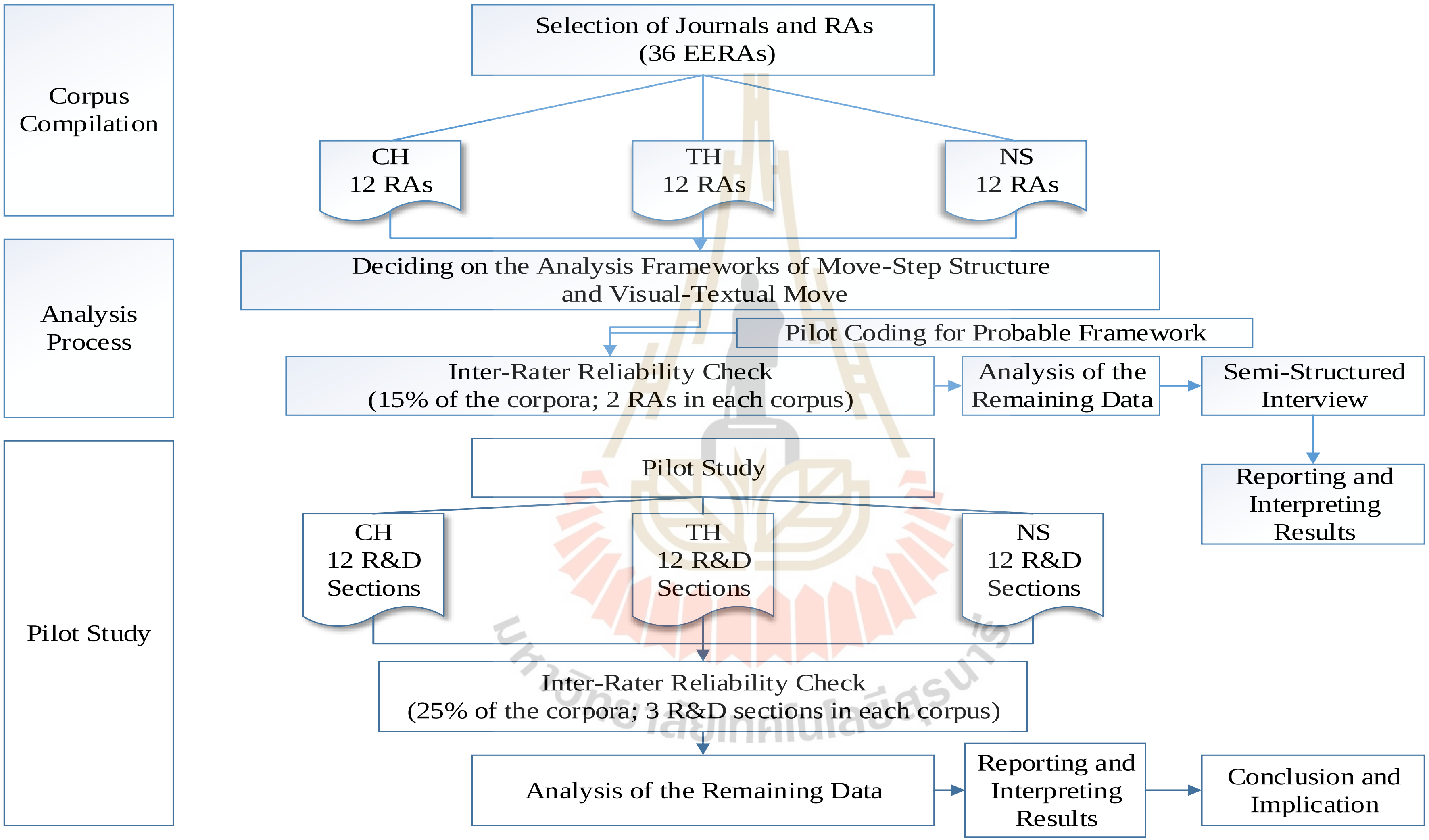


Figure 3.2 Research Design Flow Chart 2

3.3 Corpus Compilation

3.3.1 Corpus Size

The to-be-investigated journal articles were grouped based on the writers' nationality, so there were three corpora accordingly. The size of a specialized corpus is determined by the linguistic items under investigation (Flowerdew, 2004). Biber (2006) further explains that if the target feature is a frequent grammatical structure, such as, nouns or verbs, the size of the corpus can be smaller because these features occur frequently. However, if less common features are the target features, it is essential to work with a larger corpus. Another factor determining corpus size was to refer to previous studies concerning move-step and VTM analyses. The sample of previous studies on move-step analysis is normally around 15-60. For instance, Nwogu (1997) conducts research on RA schematic structures in the field of medicine through examining 30 RAs for initial analysis and 15 out of the 30 for detailed analysis. Posteguillo (1999) studies schematic organization in the field of Computer Science of RA Introduction, Results and Discussion/Conclusion with 40 RAs, while Yang and Allison (2004) explore macro-structural organization of 40 RAs in Applied Linguistics in relation to English language teaching. Kanoksilapatham's (2005) RA sample size is 60 in Biochemistry field. However, she also conducts a similar study (Kanoksilapatham, 2015) investigating RA rhetorical structures in three engineering sub-disciplines including Civil, Software and Biomedical Engineering with 60 RAs for each corpus, making the corpus size 180 RAs. It is admitted that this is a relatively large sample size for investigating RA rhetorical structures in their entirety. It is partly because of the large sample size, the statistical analysis tool chi-square test is applied for identifying significant statistical variations among these three engineering sub-disciplines. Besides Kanoksilapatham (2015), there is another exception with much larger sample, which is Lin and Evans' (2012) study. Covering 433 RAs in 39 disciplines in the fields of Engineering, Applied Sciences, Social Sciences and Humanities, their study focuses on the major generic structures of empirical RAs such as IMRDC, ILMRDC and ILMRD, etc. Stoller and Robinson (2013) investigate the move pattern of the whole article in 60 RAs in Chemistry. Kwan (2017) investigates macro-structure of 60 RAs (30 in Behavioral Science and 30 in Design Science) in the discipline of Information Systems. For the studies concentrating on the single section of the entire paper, the sample size tends to be larger. For example, Martín (2003) focuses on the rhetorical structures of 160 RA Abstracts in the discipline of Experimental Phonetics and Experimental Psychology. Sheldon (2011) conducts move structure analysis of RA Introductions in Applied Linguistics with a sample size of 54 RAs. Hyland and Tse's (2012) focus is on Bio Statements in 600 RAs in Applied Linguistics, Electrical Engineering and Philosophy field. Tessuto (2015) studies generic structure and rhetorical moves in 90 legal RAs, while Tanko's (2017) interest is in rhetorical moves and linguistic realizations in 135 RA abstracts within the discipline of Literary Studies or Literature.

Sample number in visual analysis or multimodal analysis of academic field varies greatly due to different research scopes and purposes. Rowley-Jolivet (2002) analyzes 2048 visuals projected in 90 papers given at five international conferences in three fields: Geology, Medicine, and Physics. Demopoulos et al. (2003) analyze 2089 visual images collected form science textbooks and additional 1630 visual images collected from the press articles. Graves (2014) examines two Nanotechnology RAs for relationships between visual and text. Thirty Discrete Mathematics RAs are involved in Moghaddasi et al.'s (2019) analysis of visual moves.

The number of the sample in the three corpora of the current study, thus, is determined by the researcher based on the previous studies and the scope of the study. Considering that the present study explores move-step structure and VTM in EERAs written by three groups of writers with different linguistic and cultural backgrounds, the researcher of the present study decides that the sample of each corpus is 12, with a total number of 36 EERAs.

3.3.2 Selection of Journals and RAs

Representativeness, reputation, and accessibility are fundamental criteria in selecting journals proposed by Nwogu (1997). In the current research, one disciplinary insider with a doctorate degree was invited to help recommend journals to be selected based on the criterion of being internationally recognized by researchers in Electronic Engineering discipline.

The EERAs to be selected should accord with the following criteria. First, the EERAs were identified to have the first author, and meanwhile more than half of the writers as Chinese, Thai and native English speaking researchers. Secondly, the EERAs were empirical studies in Electronic Engineering field. Thirdly, the EERAs were included in the journals indexed in SCOPUS. Finally, the EERAs represented the most recent trend, which means they were published in 2019 and 2020. However, the EERAs might not come from the same journals. In addition, neither the Impact Factor nor the Quartile in Category was a concern in the process of collecting EERAs based on the reason that SCOPUS is the world's largest database of peer-reviewed journal article abstracts and citations, which represents decent and satisfying quality. Another realistic reason for not taking all of the three criteria into account mentioned above was that the researcher and the disciplinary insider expert took the first round of gathering EERAs and eventually failed because it was impossible that an equal number of EERAs written by Chinese, Thai and NS writers came from the selected international journals. The disciplinary insider noted that these three groups of writers tended to target different journals. The EERA collection process was not as smooth as the researcher originally had expected. When putting together the criteria, especially the need to take the three groups of writers' L1 status into account, it became much more complicated. Therefore, the researcher and the insider expert went another round for gathering the EERAs needed. It was later decided that the EERAs did not have to come from the same journals, but journals in 2019 and 2020 instead.

For the first criterion, several clues were needed to guarantee that the authors' L1 status is Chinese, Thai and Native English speaking writers. As mentioned earlier in section 2.2.3, most EERAs are the product of joint efforts from two or even more authors. Therefore, two steps were adopted to guarantee their nationality and L1 status: 1) the first author's L1 status, and 2) more than 1/2 of the authors' L1 status. When Lu and Deng (2019) conduct a contrastive analysis of lexical bundles in Dissertation Abstracts by Chinese and L1 English doctoral students, they check to see if the authors' names are Chinese, which is straightforward. For L1 English doctoral students retrieved from MIT, they compile a list of the 3000 most common male and female first names (covering 88.6% and 88.5% of the male and female population, respectively) from the 1990 Census name files (United States Census Bureau, 2014) and then write a script to check whether the first name of the author of each abstract was on the list. In order to estimate the extent to which this method may lead to the inclusion of abstracts from L2 English writers, they randomly select 100 abstracts from the corpus of MIT and verify 97 authors' bachelor's degree institutions. The results show that nine of the 97 authors (9.3%) received bachelor's degrees from non-English speaking countries, indicating that a small portion of the Abstracts in the MIT corpus may have been written by authors with multiple language backgrounds. This method is similar to the approach Wood (2001) uses to determine the L1 status of the authors of published RAs in his study.

Another effort to guarantee in making sure the RA writers' L1 status is through examining the author's profile such as biography and affiliations. Most authors' information about their native or L1 status is not readily available, therefore the researcher decided to use the method in Lu and Deng (2019) of verifying the authors' bachelor degree institution to check the writer's L1 status. For RAs written by Chinese, as Lu and Deng (2019) say, Chinese names seem straightforward. However, there are also authors with Chinese name but, in fact, they might be born in other countries, suggesting Chinese might not be their L1. Faced with this situation, we resorted to information provided by the paper or related information searched and obtained from the Internet for ensuring their nationality and L1 status. For identifying Thai authors, we firstly determined their status through the information attached to the RAs. Later, a Thai Ph.D candidate in the English Language Studies Program to which this research belongs was invited to check the authors' names for their nationality.

The second criterion was to confine the study to empirical study in the field of Electronic Engineering. That means as long as a RA was within Electronic Engineering field, and at the same time it suggested an empirical study, the researcher could count it in. Specifically, these empirical EERAs were about the development of some certain design or model, and the research was mainly aimed to describe the design, and its simulating and validating process, and finally report and discuss the results of the designed models. These restrictions could control certain contextual factors, such as communicative purposes, participant type, etc., which might affect the rhetorical structure of the texts (Moreno, 2008). Besides, all the RAs should be included in SCOPUS, as well as in the year of 2019 and 2020 to guarantee the most recent trend and also to avoid diachronic change affecting the move-step structure and the VTMs of the texts.

There were two points worth mentioning. The structures of RAs were not confined only to the ones with clear headings of "Introduction", "Methods", "Results" and "Discussion", namely IMRD in short, since there were many non-IMRD RAs in the target discipline. Therefore, gathering RAs that solely conformed to the IMRD structure would certainly sabotage genuineness of data collection and limit the scope of data analysis. A case in point is Nwogu's (1997) exclusion of medical RAs without the "canonical" IMRD model: ''to qualify for selection, all papers had to have the traditional IMRD sections of the research article'' (p. 122). However, this valuable study was conducted more than three decades ago, suggesting that it was not ideal to only collect the IMRD-structured RAs because the RA organizational structures varied a great deal with the time going by and the evolution of the discipline. Another reason was that the exclusion of non-IMRD papers might prevent the present researcher from identifying emerging trends in RA organization in the discipline of Electronic Engineering. Under this circumstance, IMRD structure was not the only threshold for EERA collection.

To sum up, the selection of RAs was based on four conditions. The first one was the writers' L1 status and nationality; the second being empirical studies in EE field; the third and the fourth being coming from journals in SCOPUS and the year of 2019 and 2020, respectively. Based on the above criteria, and on the chance that RAs written by the three groups of writers were not necessarily included in the same journals, the researcher and the invited disciplinary insider have located 15 journals. They are: 1) *Applied Optics*, 2) *Computers and Electronics in Agriculture*, 3) *Energies*, 4) *IEEE Access*, 5) *IEEE Sensors Journal*, 6) *IEEJ Transaction on Electrical and Electronic Engineering*, 7) *International Journal of RF and Microwave Computer-Aided Engineering*, 8) *Measurement*, 9) *Optics Express*, 10) *Optik*, 11) *Plasmonics*, 12) *Wireless Personal Communications*, 13) *Microsystem Technologies*, 14) *Radioengineering*, 15) *Wireless Communications and Mobile Computing.* However, each of the three corpora did not use all these 15 journals and each journal might yield 1-2 EERAs to be included for the analysis. The total number of EERAs in each corpus was 12 and the total number of EERAs in the three corpora was 36. Table 3.1 shows the journals and the number of the EERAs included in the three corpora.

Table 3.1 Journals and the number of EERAs in the CH, TH and NS

	CH			TH			NS		
	Journals	No. of RAs	RA Code	Journals	No. of RAs	RA Code	Journals	No. of RAs	RA Code
1	Applied Optics	1	CH1	Applied Optics	2	TH1 TH2	Applied Optics	2	NS1 NS2
2	Computers and Electronics in Agriculture	2	CH2 CH3	Microsystem Technologies	2	TH3 TH4	Computers and Electronics in Agriculture	2	NS3 NS4
3	Energies	1	CH4	Energies			Energies		
4	IEEE Access	1	CH5	IEEE Access	1	TH5	IEEE Access	1	NS5
5	IEEE Sensors Journal	1	CH6	IEEE Sensors Journal	1	TH6	IEEE Sensors Journal	2	NS6 NS7
6	IEEJ Transactions on Electrical and Electronic Engineering			IEEJ Transactions on Electrical and Electronic Engineering	2	TH7 TH8	Wireless Communica-tions and Mobile Computing		
7	International Journal of RF and Microwave Computer-Aided Engineering	1	CH7	International Journal of RF and Microwave Computer-Aided Engineering	1	TH9	International Journal of RF and Microwave Computer-Aided Engineering	1	NS8
8	Measurement	1	CH8	Measurement			Measurement	1	NS9
9	Optics Express	2	CH9 CH10	Optics Express			Optics Express	2	NS10 NS11
10	Optik	1	CH11	Radioengin-eering	1	TH10	Optik		
11	Plasmonics	1	CH12	Wireless Personal Communica-tions	1	TH11 TH12	Plasmonics	1	NS12
	Total	12		Total	12		Total	12	

3.4 Move-Step Structure and Visual-Textual Move (VTM) Analyses

After all the three corpora have been compiled, they were ready for move-step and VTM analysis. In this study, moves, steps, and VTMs were identified manually and

Data analysis software *MAXQDA 2018* was used for helping store and sort these manually analyzed data.

The procedure of move-step analysis in the current study consists of the following 5 steps. The first step was to have an overview of structure of the 36 RAs in the three corpora. Tables 3.2-3.4 offer a summary of the sections in each RA in the three corpora identified by the clear headings of “Introduction”, “Methods”, “Results”, “Discussion” or “Results and Discussion” and “Conclusion”. All the EERAs contained the Introduction section and only one in the CH and two in the NS corpus respectively titled their last sections as “Summary” instead of “Conclusion”. The body part which included such conventional headings as “Methods”, “Results” and “Discussion” embodied a different trend in the corpora. Exactly the same headings such as “Methods” or “Methodology” were rarely seen and only appeared in 2 and 5 EERAs in the CH and NS corpus, respectively. It was found that EE researchers’ preference of topical headings over functional ones was obvious. The Results and Discussion were a combined section with the heading “Results and Discussion” (R&D) in most EERAs. Only a few cases had the separate “Results” and “Discussion” sections.

Table 3.2 Summary of CH EERA’s sections identified by headings

RA code	Introduction	Methods	Results	Discussion	Results & Discussion	Conclusion
CH1	√				√	√
CH2	√	√			√	√
CH3	√				√	√
CH4	√	√			√	√
CH5	√				√	√
CH6	√				√	√
CH7	√				√	√
CH8	√		√			√
CH9	√					√summary
CH10	√				√	√
CH11	√				√	√
CH12	√		√	√		√
	12	**2**	**2**	**1**	**9**	**12**

Table 3.3 Summary of TH EERA's sections identified by headings

RA code	Introduction	Methods	Results	Discussion	Results & Discussion	Conclusion
TH1	√				√	√
TH2	√					√
TH3	√		√			√
TH4	√				√	√
TH5	√		√			√
TH6	√				√	√
TH7	√		√			√
TH8	√				√	√
TH9	√				√	√
TH10	√				√	√
TH11	√				√	√
TH12	√					√
	12	0	3	0	9	12

Table 3.4 Summary of NS EERA's sections identified by headings

RA code	Introduction	Methods	Results	Discussion	Results & Discussion	Conclusion
NS1	√	√			√	√
NS2			√			√Summary
NS3	√				√	√Summary
NS4	√	√			√	√
NS5	√					√
NS6	√					√
NS7	√		√			√
NS6	√	√	√	√		√
NS8	√					√
NS9	√	√			√	√
NS10	√			√		√
NS11	√			√		√
NS12	√	√			√	√
	12	5	3	3	5	12

In order to facilitate the move-step and VTM analyses, the researcher invited the same disciplinary insider, who later also participated in inter-rater coding, to provide suggestions for identifying the contents of the body parts that were not named as "Methods", "Results", and "Discussion" sections based on their function. The results of discussion are shown in Tables 3.5-3.10. It turned out that all the EERAs in the three corpora contained "Methods" section, but with alternative topical headings. "Results and Discussion" was a prevalent heading, despite a few cases showing only "Results" or only "Discussion" or separate "Results" and "Discussion" sections.

Table 3.5 The identified EERA structures in the CH with conventional headings based on identification of contents and functions

RA code	Introduction	Methods	Results	Discussion	Results & Discussion	Conclusion
CH1	√	√			√	√
CH2	√	√			√	√
CH3	√	√			√	√
CH4	√	√			√	√
CH5	√	√			√	√
CH6	√	√			√	√
CH7	√	√			√	√
CH8	√	√	√			√
CH9	√	√	√			√summary
CH10	√	√			√	√
CH11	√	√			√	√
CH12	√	√	√	√		√
	12	**12**	**3**	**1**	**9**	**12**

Table 3.6 Summary of the EERA structures in the CH

CH	No. of RAs	RA Code
IMR&DC	9	CH1, CH2, CH3, CH4, CH5, CH6, CH7, CH10, CH11
IMRDC	1	CH12
IMRC	2	CH8,CH9
IMRD	0	
IMDC	0	

Table 3.7 The identified EERA structures in the TH with conventional headings based on identification of contents and functions

RA code	Introduction	Methods	Results	Discussion	Results & Discussion	Conclusion
TH1	√	√			√	√
TH2	√	√			√	√
TH3	√	√	√			√
TH4	√	√			√	√
TH5	√	√	√			√
TH6	√	√			√	√
TH7	√	√	√			√
TH8	√	√			√	√
TH9	√	√			√	√
TH10	√	√			√	√
TH11	√	√			√	√
TH12	√	√			√	√
	12	12	3	0	9	12

Table 3.8 Summary of the EERA structures in the TH

TH	No. of RAs	RA Code
IMR&DC	9	TH1, TH2, TH4, TH6, TH8,TH9, TH10, TH11, TH12
IMRDC	0	
IMRC	3	TH3, TH5, TH7
IMRD	0	
IMDC	0	

Table 3.9 The identified EERA structures in the NS with conventional headings based on identification of contents and functions

RA code	Introduction	Methods	Results	Discussion	Results & Discussion	Conclusion
NS1	√	√			√	√
NS2	√	√	√			√Summary
NS3	√	√			√	√Summary
NS4	√	√			√	√
NS5	√	√			√	√

Table 3.9 The identified EERA structures in the NS with conventional headings based on identification of contents and functions (Continued)

RA code	Introduction	Methods	Results	Discussion	Results & Discussion	Conclusion
NS6	√	√	√	√		√
NS7	√	√	√			√
NS8	√	√			√	√
NS9	√	√			√	√
NS10	√	√		√		√
NS11	√	√	√	√		√
NS12	√	√			√	√
	12	12	4	3	7	12

Table 3.10 Summary of the EERA structures in the NS

NS	No. of RAs	RA Code
IMR&DC	7	NS1, NS3, NS4, NS5, NS8, NS9, NS12
IMRDC	2	NS6, NS11
IMRC	2	NS2, NS7
IMRD	0	
IMDC	1	NS10

The second step was to find the most relevant frameworks, which would be explained in detail later in this section.

The third step was to develop the coding protocol through a pilot coding based on the selected frameworks. The pilot coding process is illustrated as follows. First was deciding on the amount of EERAs in the corpora going to be pilot-coded. The researcher and the invited coder decided they would cover 15% of the corpora, that is, 6 EERAs in total, with 2 in each corpus. The number 15% was decided because it was the whole RA that the researcher and the invited coder were to examine. The number would have been larger if the scope of study only covered one section of the EERAs in the three corpora. The results of the pilot coding would probably not remain unchanged as the main study goes. However, through pilot coding, the researcher and the inter-coder could have a chance to obtain an overview of the overall move-step structures and the VTMs of the EERAs in the three corpora. Next, they followed the selected frameworks to code the 6 EERAs for the purpose of creating a possible framework for the EERAs in the corpora. During the process, the researcher and the invited coder identified segments with the similar functional or semantic themes, group and label them for certain types of moves or steps.

The fourth step was to conduct inter-rater reliability check. The scope of inter-rater reliability check was 15% of the whole corpus. The researcher and the invited coder coded the full sets of texts individually. The inter-rater reliability relied on percentage agreement. The detailed process of conducting inter-rater reliability will be explained later in this chapter.

The fifth step was to code all the EERAs in the three pilot corpora, which included identifying segments with the similar functional and/or semantic themes; grouping and labelling them according to the moves and steps they belong to, and selecting representative segments as the illustrating examples. Table 3.11 below summarizes the methodology of the present research.

Table 3.11 Summary of the methodology of the present research

Research Questions	Frameworks and approaches	Procedures	Expected Results
1. What are the moves, steps and move-step structures of the Introduction, Methods, Results and Discussion, and Conclusion of Electronic Engineering RAs (EERAs) written by Chinese (CH), Thai (TH), and native English speakers (NS), respectively?	Kanoksilapatham (2005) Kanoksilapatham (2015) Maswana et al. (2015)	Move-step analysis; Inter-rater reliability check	Type of moves and steps Frequency of moves and steps Move cycle
2. What are the variations of the moves, steps, and move-step structures of the Introduction, Methods, Results and Discussion, and Conclusion of EERAs among these three groups?	Contrastive analysis	Comparing and contrasting the findings of the move-step analysis across the three corpora	Variations in terms of type and frequency of moves and steps, and the move cycles across the three corpora
3. What are the visual-textual moves (VTMs) in EERAs written by Chinese (CH), Thai (TH), and native English speakers (NS), respectively?	Gross & Harmon (2014) Moghaddasi et al. (2019)	VTM analysis; Inter-rater reliability check	Type of VTMs Frequency of VTMs

Table 3.11 Summary of the methodology of the present research (Continued)

Research Questions	Frameworks and approaches	Procedures	Expected Results
4. What are the variations in terms of the VTMs among these three groups?	Contrastive analysis	Comparing and contrasting the findings of the VTM analysis across the three corpora	Variations in terms of VTM across the three corpora

3.4.1 Move-Step Structure Analysis

3.4.1.1 Selection of Frameworks for Developing the Coding Protocol

Previous studies focusing on individual sections of RAs (e.g., Posteguillo, 1999; Williams, 1999; Lim, 2006; Ozturk, 2007; Bruce, 2009; Peacock, 2011; Basturkmen, 2012) have made contribution to knowledge of how particular sections are constructed. However, the knowledge found is, to some degree, fragmented, devoting not enough to the development of RA genre. Thus, it is better to understand RA composition in their entirety through examining all the sections. Consequently, the frameworks for full-length RAs are selected to examine the EERAs in the current study. Three full-length RA frameworks with IMRD structure were targeted: Kanoksilapatham's (2005) framework, framework adopted for move analysis in Kanoksilapatham's (2015) and Maswana et al.'s (2015) move classification. Kanoksilapatham's (2005) framework, based on Swales' (1990) analytical framework, is generated after the analysis of 60 Biochemistry RAs. Fifteen moves are included, three in Introduction, four in Methods, Results, and Discussion, respectively. This framework provides insight into the task of writing RAs in such fields as hard sciences (e.g., Biology and Chemistry), the natural sciences (e.g., Environmental Science and Ecology), and applied sciences (e.g., Biotechnology and Food Science) (Kanoksilapatham, 2005). Although it is not the framework for engineering discipline, it is likely to be helpful to analyze engineering RAs based on the fact that empirical studies in sciences and engineering may share common structural features. In addition, the sampling process of journals based on the Impact Factor in their study is relatively objective, which guarantees the reliability and validity of the results of the study.

The framework for distinguishing textual organizations across RAs from three engineering sub-disciplinary groups in Kanoksilapatham (2015) is also based on Swales (1990, 2004). Kanoksilapatham (2015) examines 180 full-length high quality RAs representing three sub-disciplines of Engineering (Civil, Software, and Biomedical). Considering move-step structure's dependent relationship with disciplines, the framework could also be regarded as one of the reference models for this study.

Maswana et al.'s (2015) move classification is a framework adapted from Nwogu (1997). It is used for analyzing the rhetorical structures of 78 engineering RAs from five disciplines: Structural Engineering, Environmental Engineering, Electrical Engineering, Chemical Engineering and Computer Science. Compared with Kanoksilapatham (2005, 2015), the selection of journals is less objective due to its research methodology. The journals are recommended by researchers at Kyoto University; the six invited engineering researchers, two in Environmental Engineering and one in each of the four remaining Engineering fields, choose RAs based on their research fields and interests. The invited engineering researchers code RAs based on a page count because of time constraint and the varied length of RAs. For data sampling process, it seems not objective enough to make generalization. However, inviting different insider experts from different Engineering fields could increase the preciseness of coding. In addition, the corpora include non-IMRD structured RAs, which reflects, to a large extent, a most distinguishing characteristic of RAs in the Engineering field. These two decisions make the findings of the study more reliable and valid. The framework seems to be an appropriate one in terms of its comprehensiveness and clarity.

To conclude, the coding protocol for the current study was developed through referring to these three full-length frameworks by employing the names and functions of some moves and steps. New moves and steps were added when necessary. However, the coding protocol for each section was subjected to probable modifications during respective analysis process. Table 3.12 below demonstrates the three move-step frameworks referred to by the present study.

Table 3.12 The three move-step frameworks referred to by the present study

Kanoksilapatham's (2005) Framework	Framework used in Kanoksilapatham (2015)	Maswana et al.'s (2015) Move Classification adapted from Nwogu (1997)
Introduction	Introduction	Introduction
Move 1: Announcing the importance of the field By Step 1: Claiming the centrality of the topic By Step 2: Making topic generalizations By Step 3: Reviewing previous research **Move 2: Preparing for the present study** By Step 1: Indicating a gap By Step 2: Raising a question **Move 3: Introducing the present study** By Step 1: Stating purpose(s) By Step 2: Describing procedures By Step 3: Presenting findings	**Move 1: Establishing a territory** Step 1: Claiming centrality Step 2: Making topic generalization Step 3: Reviewing previous studies **Move 2: Establishing a niche** Step 1: Indicating gaps Step 2: Adding to what is known Step 3: Presenting positive justification **Move 3: Presenting the present study** Step 1: Announcing purposes Step 2: Summarizing methods Step 3: Announcing principal outcomes Step 4: Claiming research values Step 5: Outlining article structure Step 6: Offering procedural justification Step 7: Clarifying terms Step 8: Describing study sites Step 9: Suggesting further research	**1. Presenting background information** 1.1 Reference to established knowledge in the field 1.2 Reference to main research problems. **2. Reviewing related research** 2.1 Reference to previous research 2.2 Reference to limitations of previous research **3. Presenting new research conducted by the author(s)** 3.1 Reference to research purpose 3.2 Reference to main research procedure and outcome
Methods	Methods	Methods
Move 4: Describing materials By Step 1: Listing materials By Step 2: Detailing the source of the materials By Step 3: Providing the background of the materials **Move 5: Describing experimental procedures** By Step 1: Documenting established procedures By Step 2: Detailing procedures	**Move 4: Describing procedures** Step 1: Announcing objectives Step 2: Specifying protocolized procedures Step 3: Detailing procedures Step 4: Providing procedural background Step 5: Justifying procedures Step 6: Describing research sites Step 7: Declaring ethical statements	**4. Identifying source of data and method adopted in collecting them** 4.1 Indicating source of data 4.2 Indicating data size 4.3 Indicating criteria for data collection 4.4 Indicating data collection procedure 4.5 Providing background details about the study is going to analyze.

Table 3.12 The three move-step frameworks referred to by the present study (continued)

Kanoksilapatham's (2005) Framework	Framework used in Kanoksilapatham (2015)	Maswana et al.'s (2015) Move Classification adapted from Nwogu (1997)
Results	Results	Results
By Step 3: Providing the background of the procedures **Move 6: Detailing equipment (optional)** **Move 7: Describing statistical procedures (optional)**	**Move 5: Featuring other methodological issues** Step 1: Describing materials and participants Step 2: Setting apparatus Step 3: Identifying data sources **Move 6: Reporting and consolidating findings** Step 1: Stating findings Step 2: Interpreting findings Step 3: Comparing findings Step 4: Explaining findings	**5. Describing experimental procedures** 5.1 Identifying main research apparatus 5.2 Recounting experimental process 5.3 Indicating criteria for success **6. Describing data analysis procedures** 6.1 Defining terminologies 6.2 Indicating process of data classification 6.3 Identifying analytical instrument and procedure 6.4 Indicating modification to instrument and procedure
Move 8: Stating procedures By Step 1: Describing aims and purposes By Step 2: Stating research questions By Step 3: Making hypotheses By Step 4: Listing procedures or methodological techniques **Move 9: Justifying procedures or methodology** By Step 1: Citing established knowledge of the procedure By Step 2: Referring to previous research **Move 10: Stating results** By Step 1: Substantiating results By Step 2: Invalidating results **Move 11: Stating comments on the results** By Step 1: Explaining the results By Step 2: Making generalizations or interpretations of the results	**Move 7: Summarizing procedures** Step 1: Briefing procedures Step 2: Justifying procedures Step 3: Defining terms Step 4: Referring to previous studies **Move 8: Reporting results** **Move 9: Commenting results** Step 1: Interpreting results Step 2: Explaining results Step 3: Comparing results Step 4: Exemplifying results Step 5: Cautioning limitations Step 6: Summarizing results Step 7: Directing future research	**7 Reporting results** 7.1 Restating data analysis procedures 7.2 Restating research questions 7.3 Stating general findings 7.4 Stating specific findings **8 Commenting on results** 8.1 Interpreting results 8.2 Comparing results with previous studies 8.3 Evaluating results (or research)

Table 3.12 The three move-step frameworks referred to by the present study (continued)

Kanoksilapatham's (2005) Framework	Framework used in Kanoksilapatham (2015)	Maswana et al.'s (2015) Move Classification adapted from Nwogu (1997)
Discussion	Discussion	Discussion (Conclusion)
Move 12: Contextualizing the study By Step 1: Describing established knowledge By Step 2: Presenting generalizations, claims, deductions, or research gaps **Move 13: Consolidating results** By Step 1: Restating methodology (purposes, research questions, hypotheses restated, and procedures) By Step 2: Stating selected findings By Step 3: Referring to previous literature By Step 4: Explaining differences in findings By Step 5: Making overt claims or generalizations By Step 6: Exemplifying **Move 14: Stating limitations of the study** By Step 1: Limitations about the findings By Step 2: Limitations about the methodology By Step 3: Limitations about the claims made **Move 15: Suggesting further research (optional)** (p. 289-291)	**Move 10: Reviewing the present study** **Move 11: Consolidating results** Step 1: Reporting results Step 2: Explaining results Step 3: Summarizing results Step 4: Interpreting results Step 5: Comparing results Step 6: Exemplifying results Step 7: Claiming values of results **Move 12: Stating limitations and future research** (p. 79-83)	**9. Highlighting overall results and their significance** 9.1. Stating the main results and significanc **b Explaining specific research outcomes** b1 Stating a specific outcome b2 Interpreting the outcome b3 Indicating significance of the outcome b4 Contrasting present and previous outcomes. b5 Indicating limitations of outcomes **c Stating research conclusions** c1 Indicating research implications c2 Promoting further research (p. 10)

Table 3.13 below shows the framework obtained from the pilot coding of 15% of the whole corpus by the researcher and the invited coder. By pilot coding the 2 random EERAs from each of the three corpora, the researcher firstly got a probable move-step structure framework for the EERAs. Secondly, the researcher

and the invited coder had an overview of the EERAs. Thirdly, the pilot coding was also regarded as a preparation for the inter-coder reliability check of both the pilot study and the main study. Nevertheless, the framework would suffer from probable modifications as the study continues since only 15% of the EERAs of the whole corpus were pilot coded with the reference to the three frameworks.

There was one point worth mentioning. Before the pilot coding, the researcher and the invited disciplinary expert examined the whole structures of all 36 EERAs in the corpora and they noticed that there was an obvious difference of the Results and Discussion sections from the previous studies. That is, in most EERAs in the three corpora, EE researchers tended to combine the "Results" and "Discussion" sections to be one instead of two. The researcher and the invited coder had a discussion about this issue and consequently decided to work out a framework with a combined "Results and Discussion" section. That is the reason for Table 3.13 to contain "Results and Discussion" as one combined section instead of "Results" and "Discussion". This section is labelled as "the R&D section" later in the pilot study.

Table 3.13 The probable proposed move-step framework for EERAs

Section	Move and Step
Introduction	1. Announcing the importance of the field
	1.1 Claiming the centrality of the topic
	1.2 Making topic generalization
	1.3 Reviewing previous research
	2. Preparing for the present study
	2.1 Indicating a gap
	2.2 Raising a question
	2.3 Stating limitations of previous research
	3. Introducing the present study
	3.1 Stating purposes
	3.2 Describing procedures
	3.3 Presenting findings
	3.4 Stating the novelty of the research
	3.5 Outlining article structure
	3.6 Justification of the present study
	3.7 Significance of the study

Table 3.13 The probable proposed move-step framework for EERAs (Continued)

Section	Move and Step
Methods	4. Introducing materials/models/methods
	4.1 Stating the location of research
	4.2 Specifying the materials
	4.3 Specifying the time
	4.4 Providing the background of the materials
	4.5 Announcing objectives
	4.6 Overview of the section
	5. Describing experimental procedures/design
	5.1 Describing principle of the proposed model or design
	5.2 Detailing procedures
	6. Describing data analysis procedures
	6.1 Defining terminologies
	6.2 Indicating analysis procedure
	6.3 Detailing analysis
	6.4 Significance of the design/model
	6.5 Summary of analysis
Results and Discussion	7. Preparatory information
	7.1 Summary of the section
	7.2 Specifying equipment or environment
	7.3 Explaining procedures
	7.4 Justifying procedures or methodology
	7.5 Summarizing results
	7.6 Defining terms
	8. Reporting results
	9. Commenting on results
	9.1 Interpreting results
	9.2 Comparing results
	9.3 Relating theories and previous studies
	9.4 Summarizing results
	9.5 Indicating research implications
	9.6 Suggesting further research
Conclusion	10. Stating research conclusions
	10.1 Stating methodology (purposes, RQs, procedures)
	10.2 Restating research findings
	10.3 Indicating research significance
	10.4 Suggesting further research
	10.5 Stating research conclusions

3.4.1.2 Move and Step Identification

Top-down and bottom-up are two approaches for move identification. In the top-down approach, as described in Biber et al. (2007), developing the analytical framework is the first step, which is followed by applying the framework to all texts in a corpus. The move type is determined by its communicative purposes (Kwan, 2006). However, it is linguistic features that the bottom-up approach relies on in determining move types. The present study adopts the top-down approach to move identification due to two reasons. First, according to Biber et al. (2007), “move analysis was developed as a top down approach to analyze the discourse structure of texts from a genre” (p. 15). Thus, a top down approach is in line with the theoretical definition of a move. Second, some previous studies (e.g., Zhang et al., 2012) indicate that textual boundaries are identified mainly through cognitive judgment compared with linguistic clues. Functional framework is primary in the top-down approach, with linguistic description serving as an interpreting role to investigate the extent to which move types also have systemic linguistic characteristics. The bottom-up approach, conversely, views linguistic descriptions as the primary factor in analyses.

The researcher adopted the top-down approach (Biber et al., 2007) in move identification, in which communicative purposes play a dominant role. Firstly, the function of each text segment was carefully looked at and its communicative purposes were evaluated. Second, one move contains at least one sentence. If one sentence serves for multiple functions or purposes, the most salient purpose is the main focus. Third, one move could contain one sentence, several sentences, one paragraph or even several paragraphs as long as they express the same communicative purposes. As pointed out by Holmes (1997) and Yang and Allison (2004), move identification involves a certain degree of subjectivity which is unavoidable. In this case, inter-rater reliability is of great necessity to be followed.

3.4.2 VTM Analysis

The process of analysis of the VTMs in the CH, TH and NS corpora included five steps. First was to find in the related literature the model or framework for analyzing VTM in academic genre field. The second step was to conduct the inter-rater reliability check, which was based on 6 RAs in the three corpora, 2 in each corpus. The third step was to identify all the VTMs in the three corpora. VTMs in the present study were identified mainly by pointers (e.g., as can be seen from *Figure 1*; *Figure 2* suggests that..., etc.). Texts without pointers but associated with visuals were also included as VTMs since the boundary of a VTM was determined by the theme and the communicative purposes of the texts. This means, as long as a text segment is pointing to a visual, it was labeled as a VTM. The fourth step was to identify the VTM sequences and the VTM patterns of each visual. A VTM sequence refers to a collection of all the VTMs associated with a visual. Through a VTM sequence, a VTM pattern could be obtained by taking the VTM types into account. For example, suppose one visual has 3 VTMs associated with it: *AR*, *D*, and *AR*, the VTM sequence is *AR+D+AR*, and the VTM pattern is *AR+D*. The last step was to describe the VTMs, the VTM patterns and provide examples illustrating them.

3.4.2.1 Selection of Frameworks

The present study adopts visual rhetoric (Gross & Harmon, 2014) and Moghaddasi et al. (2019) as analysis references. Moghaddasi et al. (2019) examine visuals that are pointed to by verbal language and those that are not. Visuals pointed by verbal language are associated with specific rhetorical moves: *Establishing Presumptions* (EP); *Announcing Results* (AR); *Proof* (P); and *Discussion* (D). The move *Establishing Presumptions* functions when mathematicians explain their assumptions about the mathematical objects. They use this move to define the objects. The move *Announcing Results* presents statement of results or new knowledge of the research. The move *Proof* aims at convincing readers of truthfulness of the proposed fact. *Discussion* is the move presenting examples as evidence to the proposed facts, which usually follows a result statement or proof. The three rhetorical functions of visual-verbal moves are *Ontological function*, *Argument function*, and *Epistemological function*. *Ontological function* presents fundamental objects of the study by defining concepts, or highlighting assumptions of operations. The moves that perform *Ontological function* generally appear in the Introduction section and the Results section to help construct specific concepts. *Argument function* of visuals is that these visuals can serve as evidence aiming at convincing readers of the validity of the writer's claim. Such visuals usually occur in the Introduction and the Results sections.

Epistemological function of visuals is to create new knowledge or epistemological facts. The visuals with this function often appear in the Results section.

When visuals are not associated with verbal moves, that is, visual moves replace verbal moves, or verbal language is absent, they are identified as Visual Moves (VMs) (Moghaddasi et al., 2019). Three VMs in Moghaddasi et al. (2019) are: 1) *Defining Visually* (DV); 2) *Representing the Outcome of the Operation* (ROO); 3) *Embodying the Operation* (EO). *Defining Visually* (DV) is equivalent to the visual-verbal move *Establishing Presumptions*. *Representing the Outcome of the Operation* (ROO) illustrates the outcome of a mathematical operation. *Embodying the Operation* (EO) depicts actional-operational process.

Based on analysis of visual moves of Mathematics RAs, Moghaddasi et al. (2019) propose a multimodal-move analysis framework as in Table 3.14 below.

Table 3.14 Moghaddasi et al.'s (2019) verbal and visual rhetorical moves in discrete mathematics

Functions of Visuals:	1. Ontological 2. Argument 3. Epistemological
Visual-Verbal Moves:	**Visual Moves**:
1. Establishing Presumptions (EP)	1. Defining Visually (DV)
2. Announcing Results (AR)	2. Representing the Outcome of the Operation (ROO)
3. Proof (P)	
4. Discussion (D)	3. Embodying the Operation (EO)

Rationale for using Moghaddasi et al.'s (2019) framework for visual move analysis was three folds. First, the framework is produced on the basis of examining the visual-verbal moves and visual moves in Discrete Mathematics RAs, which is based on how scientists illustrate meanings by using visual rhetoric (Gross & Harmon, 2014). Sciences and engineering are interrelated fields. Visual rhetoric theories in science, to a large extent, could be applied to writing in engineering field. Among the three functions that Morell (2015) assigns to non-verbal (i.e., visual) materials (NVM) in analysis of conference presentations, i.e. illustrative, decorative, and expository,

expository NVM is more common in sciences and engineering, fulfilling the role of evidence-providing. Therefore, the visual rhetoric in sciences and engineering shares one common function, which means, the theories could be borrowed to understand visuals in engineering RAs.

Second, Moghaddasi et al.'s (2019) study produces some novel insights into visual rhetoric in academic writing on the basis of systematic research design and methodology. For example, it uses a triangulated approach which integrates textual-visual and informant data, as well as metadisciplinary data in mathematics to analyze and interpret the collected visual data. Thus, the results and findings are valid and reliable with such a systematic and reasonable research design and implementation.

Third, Moghaddasi et al.'s (2019) study is the most recent study in terms of visual move analysis in RAs. Due to the scant attention given to visual elements in RAs, few studies in academic genres examine visuals that however "occupy up to a half a science research article" (Hyland, 2006, p. 53). Studies on multimodal analysis concentrate mostly on conference presentations, and studies on visuals in RAs are relatively small in number. Representing the most recent trend, Moghaddasi et al.'s (2019) study sets a model for the current study on the VTMs in the EERAs.

3.4.2.2 VTM Identification

Identification of VTM and VTM Sequence is similar to that of move and step. That is, to focus on the salient rhetorical function of each VTM. It relies heavily on the pointers (e.g., In Fig. 3, Fig w shows that...) of each textual segments. Texts identified as VTMs under investigation are usually those located around the pointers. Therefore, the boundary of a VTM is determined by the textual language associated with the visual that convey the same communicative purposes, no matter whether they are with or without pointers. That is to say, texts with corresponding pointers referring to a visual are considered as a VTM, while those without pointers but associated with the visual also need to be counted as a VTM. One visual might be associated with one or more sets of texts, which indicates that that particular visual could be linked to or explained by different VTMs. Visuals in EERAs in the three corpora demonstrate three functions identified in Graves (2014) and Moghaddasi et al., (2019): ontological, argumentative and epistemological function.

3.4.3 Inter-rater Reliability

Because qualitative move, step and VTM identification and analysis involve human judgment, they inevitably suffer from subjectivity. Inter-rater reliability should be applied to guarantee a higher degree of agreement in the move-step and VTM analyses. The inter-rater reliability in the present study includes inter-coder selection, inter-coder training, independent coding of each of the coders and assessment of inter-coder agreement.

Using multiple coders is believed to be not only for reliability check, but also for validity check as well in qualitative research (Biber et al., 2007). For inter-coder selection, the present study invited one EE researcher for move and step as well as VTM coding. The invited inter-coder was the disciplinary expert who assisted in finding EE journals and RAs. The reason for inviting an EE researcher as the inter-coder was to avoid inaccurate textual boundaries, thus to compensate disciplinary knowledge in the inter-coding process. The invited coder had experiences in publishing internationally and was regarded as an academic specialist with appropriate qualification, sufficient knowledge and capability to provide professional support in the coding process of the EERAs. Two coders (including the researcher of the present study) were engaged in the coding processes for guaranteeing reliability of move and step as well as VTM identification.

Coder training is crucial for achieving a higher inter-rater reliability. Coder training in the present study involved two sessions. In the first session, the researcher firstly introduced the general purposes and the research procedure of the study, explained the instructions about move coding, and let the invited inter-coder and herself become acquainted with the analytical frameworks for the moves, steps, and VTMs. The researcher used one sample text from the corpora to explain the coding process. The very first step was to make texts into segments. Types of moves and steps were to be determined later in the coding process. As mentioned earlier, each segmented text could only be ascribed to one move or step. However, if one segment functions as one move or one step under the same move category, it could be labelled twice. For VTM, the first step was to identify and categorize the visuals into different visual types. The second step was to find their associated textual segments. The third step was to code and label each textual segment with the corresponding VTM type. The coding of the VTMs was similar to that of move and step identification.

In the second session of coder training, all coders coded the same randomly selected RA individually. When they finished, the coding results were compared and questions or concerns about the coding results were discussed until an agreement was reached. Specifically, the disagreement on some certain coding results was settled by the involvement of a third inter-coder who did coding twice with the researcher of the present study at the beginning of the research. With one more inter-coder engaged in solving the disagreement, the results of the inter-rater reliability were better guaranteed. The segments of the text that did not correspond to the moves or steps or VTMs listed in the frameworks were labelled as new moves or steps or VTMs. For the moves and steps, the cut-off frequency of obligatory, conventional and optional move and step were 80% and 50%. That is, if the occurrence of one move or step is ranged from 80% to 100%, it is considered as an obligatory move or step; if in the range of 50%-79%, it is considered as conventional. The moves or steps whose frequency of occurrence is less than 50% fall into the category of optional moves or steps. The 50% criteria was adopted from Maswana et al. (2015) for distinguishing between conventional and optional moves and steps, while 80% was adopted for distinguishing between obligatory and conventional moves and steps because the number of the EERAs in each corpus is relatively small.

Finally, 6 out of 36 articles (15% of the corpora), with two from each corpus, were coded independently by the two coders for measuring inter-rater reliability. The present study adopted percentage agreement as its measurement of inter-rater reliability. The results of inter-rater reliability are shown in Table 3.15. The sufficient inter-coder agreement suggests that the next step is coding of the entire dataset.

Table 3.15 The results of inter-rater reliability for the CH, TH, and NS

Corpus	Task	Percentage agreement	Mean
CH	Move and step	93%	
	Visual	98.7%	96%
	VTM	95.2%	
TH	Move and step	92.6%	
	Visual	100%	95%
	VTM	92.3%	
NS	Move and step	91%	
	Visual	98%	94%
	VTM	93.5%	
Mean			95%

3.5 Interview Data

The interview data coming from semi-structured interviews are for triangulation purpose. The researcher invited two Chinese disciplinary informants to participate in the post semi-structured interviews, which took place after the completion of the move-step and VTM analyses of the whole EERA. The interviewees were the disciplinary experts who assisted in targeting the EERAs in the data collection process and contributed to the inter-coding in the pilot study. They were one lecturer with a doctorate degree and one Ph.D candidate in the EE discipline in a Chinese university. Years of writing EERAs and publication experiences made them qualified for this interview.

The interview questions were based on the results and findings of the analyses of move-step structure and the VTMs in each section of the EERAs. They were produced after the completion of all the analyses and were attached as an appendix to this dissertation. The interviewees were expected to help confirm the findings of the research, to provide explanations to the main findings, and to reinforce the discussion.

The interview was conducted online and in Chinese and it lasted approximately for one hour and a half for each interviewee. It was recorded but not transcribed.

However, the main idea of each main theme was grouped and analyzed. In addition, the analysis results were shared with the informants for validation.

3.6 Pilot Study

Pilot study is the preliminary study conducted before the major study aiming at: 1) testing the feasibility of the present research design, 2) practicing the key procedures and 3) predicting problems. The feasibility of the research design mainly refers to the reliability and validity of results, or specifically whether the selected frameworks (e.g. Kanoksilapatham, 2005) and modified coding framework or analysis methods are applicable. Pilot study cannot guarantee success of the major study, but it could increase the possibility of success. Thus, a pilot study for the later major study is of great necessity.

Baker (1994) assumes that 10-20% of the sample size used in the major study is considered to be a reasonable number to join the pilot. The researcher of the present study took the Results and Discussion (R&D) section in the 36 EERAs from the Chinese corpus (CH), the Thai corpus (TH) and the Native English Speakers corpus (NS) for pilot study to test the appropriateness and effectiveness of the methods and the frameworks adopted, which are Kanoksilapatham (2005, 2015), Maswana et al. (2015), Gross & Harmon (2014), and Moghaddasi et al. (2019). When the inter-coder and the researcher conducted the pilot coding for a probable framework of the move-step structures of the EERAs, they found that the writers in this field tended to combine the Results and the Discussion sections. Therefore, the Results and the Discussion sections were coded and analyzed as one combined section "R&D". The other reason for choosing the R&D section for pilot study is that the theme of the second layer of analysis of this study, namely, VTM, appears more frequently in this section. The pilot study is to address the following research questions.

1) What are the moves, steps and move-step structures of the Results and Discussion (R&D) section in Electronic Engineering RAs by Chinese, Thai, and native English speaking writers?
2) What are the variations of the moves, steps, and move-step structures of the R&D section among these three corpora?

3) What are the VTMs in the R&D section of EERAs by Chinese, Thai, and native English speaking writers?
4) What are the variations of the VTMs in the R&D section among these three corpora?

To answer Research Question 1, move-step analysis was employed to examine the moves, steps and move-step structures based on the three selected framework (Kanoksilapatham, 2005; Kanoksilapatham, 2015; and Maswana et al., 2015) and the probable proposed framework yielded from the pilot coding, which was subject to possible modifications as the coding proceeded. The moves and steps, their frequency, and move cycles were presented and analyzed. To answer Research Question 2, comparisons among the three corpora were made in terms of occurrence of the moves, steps and the move cycles. Research Question 3 was answered by adopting Gross and Harmon (2014) and Moghaddasi et al. (2019) in analyzing the VTMs. The results mainly showed what kind of VTMs were prevalent in the EERA R&D sections. Comparison of VTMs was made among the three corpora to answer Research Question 4.

3.6.1 Data Analysis

The R&D sections of the 36 EERAs in the CH, TH, and NS corpora, that is, all the 12 R&D sections from each corpus were taken out for the pilot investigation. These three groups of corpora were under examination for both the move-step structure and the VTMs. Firstly, three frameworks (Kanoksilapatham, 2005; Kanoksilapatham, 2015 and Maswana et al., 2015) were used as references for developing a proposed coding protocol appropriate for the move-step structure of the EERAs in the three corpora, a process that involved the researcher and the invited disciplinary expert examining 15% of the whole corpus (2 EERAs in each corpus). VTMs were identified according to Moghaddasi et al. (2019). However, modifications of the models or frameworks might be possible to better suit the RAs in EE discipline. Secondly, since move, step, and VTM identification was realized through manual work, it was unavoidable that they suffer from a certain degree of subjectivity. In this case, inter-rater reliability checking involving two coders working together was employed to guarantee a higher reliability of the study. Specifically, the researcher and the invited inter-coder coded 25% of the sample, i.e. the R&D sections from 3 randomly selected EERAs in each corpus, independently. The inter-rater reliability was counted by using percentage agreement, which is shown in Table 3.16. The differences of coding results between the two coders were discussed until an agreement was reached. After the sufficient inter-coder agreement was obtained, the researcher coded and analyzed the whole corpus. The final aims of the analysis were to reveal the moves, steps, move-step structures, VTMs as well as their variations among the three corpora. For move-step analysis, this study adopted the cut-off point (50%) for classifying moves and steps in Maswana et al. (2015) for conventional and optional moves and steps. Additionally, the cut-off frequency for obligatory and conventional moves and steps was 80%. That is, if the occurrence of one move or step was ranged from 80% to 100%, it was considered as an obligatory move or step; if in the range of 50% - 79%, it was considered as the conventional. The moves and steps whose frequency of occurrence was less than 50% fell into the category of the optional. The reason for setting 80% and 50% as the cut-off points for reference was that the number of EERAs in each corpus is relatively small.

Table 3.16 The results of inter-rater reliability of the R&D section

	Boundaries			Total	Agreement	Percentage Agreement
	CH (5, 6, 8)	TH (2, 10, 12)	NS (3, 9, 11)			
Move and step	88	62	108	258	235	91%
Visual	36	22	22	80	78	97.5%
VTM	42	26	35	103	98	95.1%

3.6.2 Results and Discussion

The results and discussion of the pilot study, the R&D section, which was originally demonstrated in Chapter 3 in the researcher's proposal, is relocated to become Chapter 6 since it is conventional to organize this dissertation in the order of Introduction, Methods, Results and Discussion, and Conclusion.

For representation of moves and steps in each section, the researcher decided to use integers and decimals to represent moves and steps, respectively. The integers such as 1, 2, or 3 represent the moves, while the decimals 1.1, 1.2, 2.3, 3.4 represent the steps of each move. Specifically, *Step 3.4* was a step under *Move 3*; *Step 1.1* and *Step 1.2* were steps of *Move 1*.

3.6.3 Implication

The implication of the pilot study on the move-step structures and VTMs of the EERA R&D section proves that it is feasible and significant to conduct such analyses. It has proposed a move-step structure framework for the EERA R&D section. The VTMs and their patterns shed light on understanding of the visuals' rhetorical functions. In addition, EE researchers, when using textual language to address the visuals, could employ the VTMs and the VTM patterns suitable for achieving different communicative purposes. The comparison among the three writer groups in terms of the move-step structure and the VTMs revealed their different rhetorical tendencies in writing EERAs, which, to a certain degree, provide examples for novice writers for reference to achieve publication success. The same methodology, therefore, is proposed to be conducted on the remaining sections of the three corpora: the Introduction, Methods, and Conclusion sections.

3.7 Summary

This chapter offered a detailed description of the research design and procedure for addressing the four Research Questions. Corpus compilation including corpus size determination, criteria, and justification for selection of journals and EERAs were discussed. This chapter also provided a thorough analysis procedure of both move-step structure and VTM, including targeting frameworks for pilot coding, identification of the moves, steps and VTMs, conducting inter-rater reliability check and the interview data that would be obtained after finishing the whole analysis. Last but not the least, it ended with the pilot study on the Results and Discussion section of EERAs of the three corpora. The findings of the pilot study suggested that not only the research design in addressing the four Research Questions was feasible and reliable, but also the researcher had the sufficient capability of conducting the main study.

CHAPTER 4
RESULTS AND DISCUSSION
OF THE INTRODUCTION SECTION

This chapter presents the results of analyzing the move-step structures of 36 EERAs from the CH, TH, and NS corpora. Visual-textual move analysis is not included in this chapter since visuals in the EERA Introduction sections were extremely rare that it is infeasible to conduct analysis, make generalizations and comparisons. Thus, only move-step analysis is presented. First, description of the moves and steps is provided and illustrated with examples. Secondly, comparison of move-step structures which include moves and steps, move patterns and move cycles are presented.

4.1 Overview of the Introduction Section

The probable move-step framework proposed at the beginning of the study has been modified to some extent as the coding process proceeded. Tables 4.1-4.2 demonstrate the earlier move-step framework generated from the pilot coding at the beginning of the present study and the revised move-step framework for the EERA Introduction section, respectively. As mentioned in Section 3.6.2 in Chapter 3, integers and decimals were used to represent moves and steps, respectively. Specifically, integers such as 1, 2, and 3 represent the moves, and the decimals 1.1, 1.2, 3.3, and 3.4 represent the steps of each move.

It was found that the original *Step 1.3 Reviewing previous research* in Table 4.1 should be categorized under *Move 2 Preparing for the present study* since EE researchers of the whole corpus were identified with the tendency to critically comment on the previous research immediately after they presented them. Thus, the researcher of the present study moved this step under Move 2, which comprises three steps: *Step 2.1 Reviewing previous research*, *Step 2.2 Stating limitations of previous research*, and *Step 2.3 Indicating a gap*. Likewise, some steps under Move 2 and Move 3 were deleted or blended to the other steps because they were no longer suitable for the remaining data. For example, *Step 3.2 Describing procedures* was revised to *Summarizing methods* since procedures were usually synthesized in the methods based on the coding. Steps such as *Raising a question* and *Stating the novelty of the research* in Table 4.1 were deleted since they were no longer identified. Table 4.2 presents the modified framework for EERA move-step structure, which includes three moves, showing consistency with Kanoksilapatham (2005, 2015) and Maswana et al. (2015). There are 2, 3, and 5 steps under *Moves 1*, *2* and *3,* respectively.

Table 4.1 The probable move-step framework proposed previously for the EERA Introduction section

Move	Step
1. Announcing the importance of the field	1.1 Claiming the centrality of the topic
	1.2 Making topic generalization
	1.3 Reviewing previous research
2. Preparing for the present study	2.1 Indicating a gap
	2.2 Raising a question
	2.3 Stating limitations of previous research
3. Introducing the present study	3.1 Stating purposes
	3.2 Describing procedures
	3.3 Presenting findings
	3.4 Stating the novelty of the research
	3.5 Outlining article structure
	3.6 Justification of the present study
	3.7 Significance of the study

Table 4.2 The revised framework for the EERA Introduction section

Section (N=36)	Move and Step	%	Status
Introduction	**1. Announcing the importance of the field**	100	Obl
	1.1 Claiming centrality	86.1	Obl
	1.2 Making topic generalization	86.1	Obl
	2. Preparing for the present study	83.3	Obl
	2.1 Reviewing previous research	83.3	Obl
	2.2 Stating limitations of previous research	61.1	Con
	2.3 Indicating a gap	13.9	Opt

Table 4.2 The revised framework for the EERA Introduction section (Continued)

Section (N=36)	Move and Step	%	Status
	3. Introducing the present study	100	Obl
	3.1 Stating purposes	77.8	Con
Introduction	3.2 Summarizing methods	66.7	Con
	3.3 Presenting findings	27.8	Opt
	3.4 Indicating significance	11.1	Opt
	3.5 Outlining article structure	30.6	Opt

Note: Obl: obligatory; Con: conventional; Opt: optional

Tables 4.3-4.4 show the summary of all the moves and steps identified in the whole corpus. Apart from all of the three moves being obligatory moves, there are 3 obligatory, 3 conventional, and 4 optional steps. *Moves 1*, *2*, and *3* were all obligatory moves. First, in the obligatory category, *Move 1* and *Move 3* occurred in 100% of the EERAs, showing total agreement with Kanoksilapatham (2005, 2015). Although endowed with obligatory status, *Move 2* only occurred in 83.3% of the corpus, corroborating Kanoksilapatham (2005, 2015) in statistics of the less important role than *Move 1* and *Move 3* within the conventional category. Other obligatory steps such as *Step 1.1* and *Step 1.2* occurred in 86.1% of the whole corpus, while *Step 2.1* occurred in 83.3% of the whole corpus. Second, the conventional category covered 3 steps: *Step 3.1 Stating purposes*, *Step 3.2 Summarizing methods*, and *Step 2.2 Stating limitations of previous research*, with respective occurrence of 77.8%, 66.7% and 61.1% of 36 EERAs, confirming that *Step 3.1* was more conventional than *Steps 3.2* and *2.2*. Finally, the optional category included four steps: *Step 3.5 Outlining article structure*, *Step 3.3 Presenting findings*, *Step 2.3 Indicating a gap*, and *Step 3.4 Indicating significance*. It was observed that *Steps 3.5* and *3.3* were about two times more prevalent than *Steps 3.3* and *2.3* in this category, according to Tables 4.3-4.4.

The results shown in Tables 4.3-4.4 demonstrate similarity and difference from the previous studies. On one hand, Kanoksilapatham (2005) found that all of the three moves in her Biochemistry Introductions were conventional by setting 60% of occurrence as the cut-off frequency. Thus, there was only the distinction between conventional and optional moves. Despite the status of the moves and the steps (obligatory, conventional, and optional), the statistics in the present study were in certain consistency with Kanoksilapatham (2005, 2015) since *Move 1* and *Move 3* occurred in 100% of the whole corpus, while *Move 2* occurred less frequently. On the other hand, an obvious difference was also identified. *Step 2.3 Indicating a gap* occurred much less than that of the three engineering writer groups in Kanoksilapatham (2015). Specifically, the occurrence frequencies were 86.05%, 91.84% and 76.47% in Civil Engineering, Software Engineering, and Biomedical engineering RAs, respectively. However, the same step was identified in 5 EERAs, accounting only for 13.9% of the whole corpus in the present study. The big discrepancy of the statistics of the same step under the same move might be due to different proposed move-step frameworks and different disciplinary conventions for writing RAs. Based on the analysis, *pointing out the limitations of the previous studies* was identified and regarded as a more common step than directly *mentioning the gaps*. “It is more concrete and precise to inform the readers of the drawbacks of the previous studies from critically reviewing the literature than from generally stating the research gaps.” said Informant B in the interview. Thus, the results showed that *Step 2.3 Indicating a gap* was by no means prevalent in the whole corpus since the function it shoulders was achieved by *Step 2.2 Stating limitations of previous research* to a large degree. Although the use of *Step 2.3* was quite departed from Kanoksilapatham (2005, 2015), the employment of *Steps 2.1* and *2.2* was in agreement with Maswana et al. (2015), in which *Step 2.1 Reference to previous research* did not necessarily lead to the use of *Step 2.2 Reference to limitations of previous research*. The latter was found to be commonly adopted in only two out of five engineering disciplines: Environmental Engineering and Computer Science.

Table 4.3 The number of EERAs in which move or step occurs in the whole corpus

	Move/Step	No. of RAs (RA=36)	%	Status
Move	**1. Announcing the importance of the field**	36	100	Obl
	3. Introducing the present study	36	100	Obl
	2. Preparing for the present study	30	83.3	Obl
Step	1.2 Making topic generalizations	31	86.1	Obl
	1.1 Claiming centrality	31	86.1	Obl
	2.1 Reviewing previous research	30	83.3	Obl
	3.1 Stating purposes	28	77.8	Con
	3.2 Summarizing methods	24	66.7	Con
	2.2 Stating limitations of previous research	22	61.1	Con
	3.5 Outlining article structure	11	30.6	Opt
	3.3 Presenting findings	10	27.8	Opt
	2.3 Indicating a gap	5	13.9	Opt
	3.4 Indicating significance	4	11.1	Opt

Table 4.4 The total occurrence of all the moves and steps in the whole corpus

	Move/Step	Occurrence (RA=36)	%
Move	**2. Preparing for the present study**	73	15.2
	1. Announcing the importance of the field	54	11.3
	3. Introducing the present study	54	11.3
Step	2.1 Reviewing previous research	84	17.5
	2.2 Stating limitations of previous research	44	9.2
	1.2 Making topic generalizations	44	9.2
	1.1 Claiming centrality	34	7.1
	3.1 Stating purposes	33	6.9
	3.2 Summarizing methods	28	5.8
	3.5 Outlining article structure	11	2.3
	3.3 Presenting findings	10	2.1
	2.3 Indicating a gap	6	1.3
	3.4 Indicating significance	5	1
Total		**480**	**100**

4.2 Description of Moves and Steps

Move 1: Announcing the importance of the field is the move which stresses the critical role of both the general field and the specific and understudied field. In other words, it mainly provides information of the field and the topic from the perspectives of their significance and impact. This move, similar to *Establishing a Territory* in Swales' (2004) modified CARS model, states the background of the research territory or the broad topic by providing explanations of the current state of the general research area. As expected, this move usually occurred at the beginning of the Introduction section, which was realized by two steps: *Step 1.1 Claiming centrality* and *Step 1.2 Making topic generalization*. This is different from Kanoksilapatham (2005, 2015) which included *Reviewing previous research* as the third step of *Move 1*, while the researcher of the present study found that the step *Reviewing previous research* was identified as the first step of the second move of the Introduction section. Locating *Reviewing previous research* under *Move 2 Preparing for the present study* instead of *Move 1 Announcing the importance of the field* was a decision made during the coding process since the researcher of the present study found this step to usually occur before or in company with *Step 2.2 Stating limitations of previous research*. Therefore, the researcher of the present study chose not to separate them under two different moves. Moreover, *Move 1* focuses more on the centrality of the topic, while *Move 2* concentrates more on the specific limitations of previous studies and research gaps, which could serve as a preparatory step to introduce the proposed topic.

Step 1.1: Claiming centrality highlights that the research field or topic is important and worth investigating by providing the overviews of the research topic. Usually, adjectives such as *important*, *vital*, *significant*, *promising* are employed by EE authors to claim the centrality of the research topic. This step occurred in 31 out of 36 EERAs, indicating the obligatory status. Examples 1 and 2 are the illustrations of *Step 1.1*.

(1) *Optical activity, the ability to rotate the orientation of linearly polarized (LP) light from its original direction, is of vital significance in modern photonics.* (CH11)

(2) *Among the various sensing devices developed, integrated optical waveguide and optical fiber-based sensing platforms <u>are widely used</u> [8, 9]. These systems with simple and fast fabrication techniques <u>can play a very important role</u> in the development of biosensor chips [10, 11], chemical sensors, organic light-emitting diodes (LEDs), and organic solar cells [12, 13].* (TH2)

Step 1.2: Making topic generalization presents general knowledge of the research topic, including the current situation, consensus, practice or description of the understudied field. Compared with *Step 1.1 Claiming centrality*, this step is more specific and detailed in introducing the topic. EE researchers tended to integrate detailed current techniques or methods into the step. It usually occurred after *Step 1.1*. Examples 3 and 4 demonstrate this step.

(3) *AO is used for compensating extrinsic aberrations induced by imaging through samples with varying thickness and refractive index. This correction requires accurate knowledge of the phase to be corrected, which is usually sensed directly with a Shack–Hartmann wavefront sensor or reconstructed using phase-retrieval methods [5]. Phase information provides feed- back to a wavefront compensator, such as a deformable mirror (DM) or spatial light modulator [5].* (NS2)

(4) *Compared with a single THz detector, THz array detectors possess the advantages of high efficiency and high speed in imaging and detection, making them a research hotspot [9, 10]. To realize a wide application of THz array detectors, packaging of the THz array detectors is the key, which remains an urgent problem to be addressed.* (CH9)

Move 2: Preparing for the present study provides clear and cogent arguments for the particular research topic, stressing its value and importance. It draws scientists' attention to weakness in the existing literature and asserts that a particular research question requires an answer (Kanoksilapatham, 2005). This move can be achieved by reviewing the previous research and pointing out limitations of the research and the specific gaps, by challenging widely accepted hypotheses, or by raising an assumption or a need. This move occurred in 30 EERAs, which accounted for 83.3% of the whole corpus. Therefore, it is identified as an obligatory move.

Step 2.1: Reviewing previous research contextualizes the study within the existing literature (Kanoksilapatham, 2015). In other words, this step synthesizes prior research that further supports the need to study the research problem. Rather than being a literature review, this is more of a reflection of important and key studies that have touched upon but probably not completely addressed the research problems. Methods or techniques in prior studies were critically reviewed. Apart from signal words such as "*literature*" or "*studies*" being identified in some EERAs, citations are also prevalent in this step. This step occurred in 30 out of 36 EERAs, i.e. 83.3% of the whole corpus, indicating the obligatory status. Examples 5 and 6 illustrate this step.

(5) *<u>Literatures</u> [8–13] present the broadband slot antennas. As reported in [8], [9], the complicated feeding network and L-shaped horizontal and vertical tuning stubs are used. Moreover, other proposed slot antennas, such as in [10], [11], with the fractal slot and the 3-D slot loop respectively, have been demonstrated. Also, some slot antennas with hybrid slots [12], [13] have been presented for broadband operation.* (TH10)

(6) *<u>Recent studies</u> have also shown that bionano hybrid materials resulting from the bio-mediated synthesis of metal nanoclusters (NCs) retain the electronic/optical properties of the metal clusters, while preserving the natural bioactivity of the biological molecules [6–8]. This additional feature makes the bio-mediated metal NCs a true multifunctional platform, extending its application space.* (NS12)

Step 2.2: Stating limitations of previous research describes the drawbacks or disadvantages of the research field or topic that are identified through reviewing the literature. This step is usually signaled by logical connecting conjunctions such as "*however*", "*nevertheless*", and adverbs such as "*too*", and adjectives such as "*difficult*" in Example 8 that could convey the authors' attitude and opinion towards the previous research. There were 22 EERAs identified with this step, showing the conventional status. Examples 7 and 8 demonstrate this step.

(7) *<u>However</u>, since the SSP method only detects the uniformity or irregularity of the reflecting surface of the object, it is incapable of determining the scale and depth of the detected object.* (CH4)

(8) *These antenna structures are still very complicated, and their sizes are also too large. It can be concluded that all the above mentioned antennas have a complex structure that is difficult to design and implement, resulting in high costs.* (TH7)

Step 2.3: Indicating a gap is a step that mainly stresses that the research topic in focus has been scarcely explored by previous research, thus leaving a blank for the research being presented to fill in. Compared with *Step 2.2 Stating limitations of previous research* that is more pointed to each individual previous study being reviewed, this step is less specific and usually shown as a concluding remark. This step is usually signaled by logical connecting conjunctions such as "*however*", "*nevertheless*", etc. Examples 9 and 10 show the illustrations of *Step 2.3*.

(9) *However, from the previous research, there are few investigate on delay of received signal in SFN, path loss estimation in SFN and analysis of SFN parameters.* (TH12)

(10) *However, to the best of our knowledge, few studies on the optical chirality of dielectric metasurfaces have been reported [27, 28].* (CH11)

Move 3: Introducing the present study is the move to announce how the present study could fill in the gaps identified in *Move 2* or contribute new knowledge in contrast to previous studies on the understudied topic. This move is realized through stating the purposes of the present study, summarizing research methods, revealing results or findings, and specifying contributions or significance of the present study. This move occurred in all of the EERAs in the whole corpus, indicating its obligatory status.

Step 3.1: Stating purposes describes the present study from its objectives or aims. In addition to the nouns such as "*purpose*" and "*aim*" which clearly suggest this step, prepositions such as "*to*" and "*for*" are used to lead to the activities which are the purposes of the study. Occurred in 28 EERAs, i.e. 77.8% of the whole corpus, this step was categorized as conventional. Examples 11 and 12 illustrate *Step 3.1*.

(11) *The purpose of this paper is to propose time- and frequency-domain models for an energy-synchronous DAM technique used to transmit broadband on-off-keyed (OOK) signals from an electrically small monopole antenna and*

to compare these models to measured far fields produced by a DAM transmitter. (NS5)

(12) *Therefore, in this work, a CPW with IDC-loaded ELC resonator microwave sensors to detect nitrate and phosphate concentration was fabricated and investigated to verify the chemical sensor concept.* (TH6)

Step 3.2: Summarizing methods is brief descriptions of the main methods to be employed in the study being reported. Authors would also compare their methods with ones in the previous studies or describe how the methods were generated, inherited and adapted from literature. In addition, the procedure of the study being reported might be indicated in this step. This step occurred in 24 out of 36 EERAs, accounting for 66.7% of the corpus, thus it is a conventional step. Examples 13 and 14 demonstrate this step.

(13) *Inspired by the wideband design in Reference 9 as well as the miniaturization approach in Reference 11, a miniaturized planar half elliptical UWB dipole is proposed and studied. However, different from the design in Reference 9 where an elliptical dipole was proposed, a half elliptical dipole fed by a microstrip line loaded with an elliptical patch is first designed. In addition, enlightened by the miniaturization method used in Reference 11, a concaved arm is also introduced near the half elliptical dipole to reduce the antenna dimension.* (CH7)

(14) *In this research, a paper-based piezoresistive pressure sensor has been fabricated by our developed patterning method. Furthermore, the performance test of this paper-based pressure sensor has been conducted in order to compare to a com- mercially available silicon-based pressure sensor.* (TH4)

Step 3.3: Presenting findings reveals the principle results or findings of the present study. The findings were usually reported by using the statistics and comparison with previous studies. This step is not a commonly adopted in the Introduction sections based on the number of EERAs identified with this step being 10, less than 50% of the whole corpus, suggesting the optional status. Examples 15 and 16 demonstrate the function of *Step 3.3*.

(15) *In our multi frequency design, we achieved a waveguide coupling efficiency of <u>94%</u>, an antenna efficiency of <u>64%</u>, and an average enhancement of <u>144</u>. The proposed design is potentially compatible with electrical injection and top down fabrication.* (NS10)

(16) *With a very thin layer of 1 μm lactose deposited on the proposed structure, a visible change in the spectrum was observed. This spectral feature was due to the intrinsic characteristic absorption of lactose. <u>Compared to</u> the investigations of previous reports [15,19], the thickness of analyte was 1 μm, which was much thinner than that used in these reports.* (CH1)

Step 3.4: Indicating significance refers to the effects of the research on the research field or the contributions of the present research to the field. It strengthens the importance of the research being presented. Such nouns as "*significance*" and "*contribution*" were identified as linguistic choices in this step. Since only 4 out of 36 EERAs presented this step, it was categorized as optional. Examples 17 and 18 demonstrate the function of *Step 3.4*.

(17) *Therefore, the <u>contribution</u> of this research are consisted of the measurement modeling of DTTV–SFN propagation in thailand, the delay characteristics of DTTV–SFN propagation in Thailand, path loss estimation, and the pre- diction model for received SFN parameter in the delay time within guard interval. The results were measure and record by spectrum analyzer.* (TH12)

(18) *The main <u>contribution</u> of this article is to present a propagation study for the five aforementioned wireless communication links by means of measurements in the real train environment at three frequencies: 2.4 GHz, 2.6 GHz and 5.7 GHz, which cover both the outdoor-to-indoor and indoor-to-indoor scenarios in railways.* (CH8)

Step 3.5: Outlining article structure is the statement of how the articles are organized, which is the last step identified in *Move 3* in the Introduction section. Usually the noun "*section*" signals this step. There were 11 EERAs identified with this step, suggesting it was optional. Examples 19 and 20 are the illustrations of *Step 3.5*.

(19) *Section 2 presents simulations that show the potential of AO control with diffractive objects. Section 3 describes the experimental setup and results, and Section 4 summarizes this study.* (NS2)

(20) *The design and simulation of the single-step elevated waveguide are explained in the next section. The fabrication process and experimental results are discussed in section three.* (TH2)

4.3 Comparison of Move-Step Structures

4.3.1 Moves and Steps

Tables 4.5-4.7 show a summary of the comparisons among the three corpora. From Table 4.5, we could know that *Move 1 Announcing the importance of the field* and *Move 3 Introducing the present study* occurred in all EERAs in the three corpora, showing a similarity among the three corpora. *Move 2 Preparing for the present study* demonstrates a variation among the three corpora even though the statistics of these three moves shown in Table 4.5 does not suggest great discrepancy. Table 4.6 summarizes similarities and differences of obligatory, conventional and optional moves and steps among the CH, TH and NS corpora. From Table 4.6 which was generated from Table 4.5, we could find two variations among the three corpora. First, the most obvious variation was that the NS corpus showed obvious differences from the CH and TH corpora. This could be specifically seen from the number of moves and steps in the obligatory and conventional categories in each corpus. All of the three moves are obligatory in the CH and TH, whereas in the NS corpus, *Move 1* and *Move 3* are identified as obligatory while *Move 2* was conventional. In addition, there are 5, 3, and 1 obligatory steps in the CH, TH and NS, respectively. It could be learned that a variation existed in *Move 2*. Chinese and Thai employed *Move 2* more than NS writers. This, however, is a finding that is deviated from that of Loi (2010) and Amnuai and Wannaruk (2013b). The former, comparing RA Introductions in Chinese and English, found that *Move 2* (Establishing a niche) is more frequently employed in English Introductions (80% of the corpus) than Chinese ones (65%). The latter, focusing on comparing applied linguistics RA Introductions in international and Thai Journals, revealed that Thai writers were reluctant to employ *Move 2* (Establishing a niche) since in Thai culture, the writers seem to refrain from making comments on other people's work due to the fear of face-threatening. Instead, they tended to "indicate the gap by stating the absence of such studies in their context (Amnuai & Wannaruk, 2013b, p. 79)." In a word, the findings of *Move 2* in the present study did not show Chinese and Thai EE researchers' reluctance in employing this move. On the contrary, they tended much more to actively use this move for referring to the shortcomings of previous studies, laying a solid foundation for their study being presented. Second, small variations were discovered between the CH and TH corpora. *Steps 1.2 Making topic generalizations* and *3.2 Summarizing methods* were obligatory in the CH but conventional in the TH, whereas *Step 3.3 Presenting findings* was conventional in the CH but optional in the TH. To conclude, the variations among the three corpora were *Move 2 Preparing for the present study*, *Step 2.1 Reviewing previous research*, *Step 3.1 Stating purposes*, *Step 3.2 Summarizing methods* and *Step 3.3 Presenting findings. Move 2* was considered as obligatory in the CH and TH, while it was conventional in the NS, so were *Step 2.1* and *Step 3.1*. *Step 3.2* was regarded as obligatory in the CH but conventional in the TH and NS. *Step 3.3* was considered as conventional but it was optional in the TH and NS.

Table 4.5 The number of EERAs in which move or step occurs in the CH, TH and NS

Move/Step	CH (RA=12)		TH (RA=12)		NS (RA=12)	
	No. of RAs	%	No. of RAs	%	No. of RAs	%
1. Announcing the importance of the field	12	100	12	100	12	100
1.1 Claiming centrality	12	100	10	83.3	9	75
1.2 Making topic generalizations	11	91.7	9	75	11	91.7
2. Preparing for the present study	10	83.3	11	91.7	9	75
2.1 Reviewing previous research	10	83.3	11	91.7	9	75
2.2 Stating limitations of previous research	8	66.7	7	58.3	7	58.3
2.3 Indicating a gap	1	8.3	3	25	0	0
3. Introducing the present study	12	100	12	100	12	100
3.1 Stating purposes	10	83.3	11	91.7	7	58.3
3.2 Summarizing methods	10	83.3	6	50	8	66.7
3.3 Presenting findings	7	58.3	0	0	3	25
3.4 Indicating significance	3	25	1	8.3	0	0
3.5 Outlining article structure	3	25	5	41.7	3	25

From table 4.6, we could see three different ways of organizing the EERA Introduction. The employment of the obligatory moves and steps showed that Chinese and Thai writers tended to include more moves or rhetorical functions than the NS writers did since more moves and steps than the NS corpus were identified as obligatory. Informant A confirmed that when they began writing their RAs, they would adopt all of the three moves for constructing a comprehensive and informative Introduction section with various strategies or ways of employing the steps under each move. NS writers, compared with Chinese and Thai counterparts, were more concise and focused on certain rhetorical functions in their Introduction. Different RA composition methods demonstrated by different writer groups suggested that several factors such as the writer's preferences, readers' needs, diversity of social background, and journal's requirements could all have an impact on the overall organization of EERA.

Despite variations, similarities among the three corpora could be revealed from the optional category. Except for *Step 3.3 Presenting findings*, all the steps in this category showed similarity. That is to say, *Step 2.3 Indicating a gap*, *Step 3.4 Indicating significance* and *Step 3.5 Outlining article structure* were not prevalent in an obvious way in all the three corpora.

Table 4.6 The similarities and differences of obligatory, conventional and optional moves and steps among the CH, TH and NS

Move/Step	CH	TH	NS
Obligatory (≥80%)	**1. Announcing the importance of the field** 1.1 Claiming centrality 1.2 Making topic generalizations **2. Preparing for the present study** 2.1 Reviewing previous research **3. Introducing the present study** 3.1 Stating purposes 3.2 Summarizing methods	**1. Announcing the importance of the field** 1.1 Claiming centrality 1.2 Making topic generalizations **2. Preparing for the present study** 2.1 Reviewing previous research **3. Introducing the present study** 3.1 Stating purposes	**1. Announcing the importance of the field** 1.2 Making topic generalizations **3. Introducing the present study**

Table 4.6 The similarities and differences of obligatory, conventional and optionalmoves and steps among the CH, TH and NS (Continued)

Move/Step	CH	TH	NS
Conventional (50%-79%)	2.2 Stating limitations of previous research 3.3 Presenting findings	2.2 Stating limitations of previous research 3.2 Summarizing methods	1.1 Claiming centrality **2. Preparing for the present study** 2.1 Reviewing previous research 2.2 Stating limitations of previous research 3.1 Stating purposes 3.2 Summarizing methods
Optional (<50%)	2.3 Indicating a gap 3.4 Indicating significance 3.5 Outlining article structure	2.3 Indicating a gap 3.3 Presenting findings 3.4 Indicating significance 3.5 Outlining article structure	2.3 Indicating a gap 3.3 Presenting findings 3.4 Indicating significance 3.5 Outlining article structure

Table 4.7 The occurrence of all the moves and steps in the CH, TH and NS

Move/Step	CH (RA=12)		TH (RA=12)		NS (RA=12)		Whole corpus	
	Occurrence	%	Occurrence	%	Occurrence	%	Occurrence	%
1. Announcing the importance of the field	17	10.6	14	9.9	23	23	54	11.2
1.1 Claiming centrality	13	8.1	11	7.7	10	10	34	7.1
1.2 Making topic generalizations	14	8.8	11	7.7	19	19	44	9.1
2. Preparing for the present study	22	13.8	19	13.4	32	32	73	15.2
2.1 Reviewing previous research	25	15.6	26	18.3	33	33	84	17.5
2.2 Stating limitations of previous research	16	10	17	12	13	13	45	9.6
2.3 Indicating a gap	1	0.6	4	2.8	0	0	5	1
3. Introducing the present study	16	10	16	11.3	22	22	54	11.2
3.1 Stating purposes	11	6.9	12	8.5	10	10	33	6.9
3.2 Summarizing methods	11	6.9	6	4.2	11	11	28	5.8
3.3 Presenting findings	7	4.4	0	0	3	3	10	2.1
3.4 Indicating significance	4	2.5	1	0.7	0	0	5	1
3.5 Outlining article structure	3	1.9	5	3.5	3	3	11	2.3
Total	**160**	**100**	**142**	**100**	**179**	**100**	**481**	**100**

4.3.2 Move Patterns

Table 4.8 shows the summary of the beginning move or step in each corpus. From this table, it could be seen that all EERAs in the three corpora adopted *Move 1 Announcing the importance of the field* as the beginning move and *Move 3 Introducing the present study* as the ending move. However, differences could be found from the steps under *Move 1* and *Move 2*. *Step 1.1 Claiming centrality* were the beginning move in 11, 10, and 9 EERAs in the CH, TH and NS corpus, respectively, which demonstrated similarity rather than variation. Claiming importance of the field and providing evidence that could support the research topic served as the most prevalent beginning activities of the EERA Introduction. Ending moves are of greater variety than the beginning moves. In the CH, *Step 3.3 Presenting findings* occurred as the ending move in 5 EERAs, and *Step 3.5 Outlining article structure* in 3 EERAs. In the TH, *Step 3.5 Outlining article structure* and *Step 3.2 Summarizing methods* served as the ending moves in 5 and 4 EERAs, respectively. *Step 3.2 Summarizing methods*, *Step 3.1 Stating purposes* and *Step 3.5 Outlining article structure* were the ending moves in 4, 4, and 3 EERAs in the NS corpus, respectively. Therefore, *Step 3.5* was seen as a common ending move and it also was a similarity identified among the three corpora, although the number of EERAs adopting this move was only 11, less than a third of the whole corpus. In addition, *Step 3.3*, *Step 3.2*, and *Step 3.1* could all serve as the ending move for EERA Introduction. The present findings of the beginning and ending moves are in consistency with Loi (2010) in that *Move 1* and *Move 3* were the major moves that the Chinese and English writers used to begin and end their Introductions, respectively.

Table 4.8 The beginning move/step and ending move/step of the Introduction section

CH		TH		NS	
CH1	1.2-...-3.4	TH1	1.1-...-3.1	NS1	1.1-...-3.2
CH2	1.1-...-3.1	TH2	1.1-...-3.5	NS2	1.1-...-3.5
CH3	1.1-...-3.5	TH3	1.1-...-3.2	NS3	1.1-...-3.1
CH4	1.1-...-3.2	TH4	1.1-...-3.2	NS4	1.2-...-3.1
CH5	1.1-...-3.5	TH5	1.1-...-3.2	NS5	1.2-...-3.5
CH6	1.1-...-3.2	TH6	1.1-...-3.1	NS6	1.1-...-3.1

Table 4.8 The beginning move/step and ending move/step of the Introduction section (Continued)

CH		TH		NS	
CH7	1.1-...-3.3	TH7	1.1-...-3.5	NS7	1.1-...-3.2
CH8	1.1-...-3.5	TH8	1.2-...-3.5	NS8	1.2-...-3.5
CH9	1.1-...-3.3	TH9	1.2-...-3.1	NS9	1.1-...-3.1
CH10	1.1-...-3.3	TH10	1.1-...-3.5	NS10	1.1-...-3.3
CH11	1.1-...-3.3	TH11	1.1-...-3.2	NS11	1.1-...-3.2
CH12	1.1-...-3.3	TH12	1.1-...-3.5	NS12	1.1-...-3.2

4.3.3 Move Cycles

Table 4.9 shows the identified move cycle in the whole corpus, Move cycles *1.1 Claiming centrality -1.2 Making topic generalizations* and *2.1 Reviewing previous research -2.2 Stating limitations of previous research* were the most popular two cycles in the whole corpus since they occurred in 25 and 22 EERAs, respectively, accounting for 69.4% and 61.1% of the whole corpus. The total occurrence in the right table shows that move cycle *2.1-2.2* occurred much more frequently than *1.1-1.2*. Move cycle *3.1-3.2* appeared in 11 EERAs, less than one third of the whole corpus. The other move cycles identified included *1.1-2.1*, *3.2-3.3*, *2.1-2.3*, *2.1-3.1*, *3.1-3.2-3.3*, and *3.1-3.5*. Among them, *Move cycle 1.1-2.1* occurred the most frequently, accounting for 16.7% of the whole corpus. The remaining cycles were the least frequently employed ones.

Table 4.9 Summary of move cycles in the Introduction section in the whole corpus

	Move cycle	No. of RAs	%		Move cycle	Occurrence	%
1	1.1-1.2	25	69.4	1	2.1-2.2	43	41
2	2.1-2.2	22	61.1	2	1.1-1.2	26	24.8
3	3.1-3.2	11	30.6	3	3.1-3.2	11	10.5
4	1.1-2.1	6	16.7	4	1.2-2.1	6	5.7
5	3.2-3.3	4	11.1	5	2.1-2.3	5	4.8
6	2.1-2.3	4	11.1	6	2.1-3.1	4	3.8
7	2.1-3.1	4	11.1	7	3.2-3.3	4	3.8
8	3.1-3.2-3.3	3	8.3	8	3.1-3.2-3.3	3	2.9
9	3.1-3.5	3	8.3	9	3.1-3.5	3	2.9
					Total	**105**	**100**

Tables 4.10-4.11 show the comparison of the move cycles among the three corpora. Variations and similarities could be seen from these tables. First, move cycles *2.1-2.2* and *1.1-2.1* demonstrated similarity based on the number of RAs in which each move cycle occurred in each corpus. Move cycle *2.1-2.2*, with occurrence of 16, 15, and 12 as shown in Table 4.11, occurred in 8, 7 and 7 EERAs in the CH, TH, and NS corpus, respectively. This implied that it was a conventional move cycle in the Introduction section. Move cycle *1.1-2.1* occurring in 2, 3, and 1 EERA in the CH, TH, and NS corpus, respectively, implying that it was acceptable but not common that *Step 1.2 Making topic generalizations* was absent between *Steps 1.1* and *2.1*. Second, small variations could be found through the two move cycles *1.1-1.2* and *3.1-3.2*. Move cycle *1.1-1.2* occurred in 10 EERAs, accounting for 83.3% of the EERAs in the CH. but it occurred in 7 and 8 EERAs in the TH and NS corpora. Despite demonstrating a small discrepancy, these numbers suggested that Chinese writers tended more to adopt *Step 1.2 Making topic generalizations* after *Step 1.1 Claiming centrality* since they considered that presenting current situation or consensus of the understudied field should immediately follow the claim of the importance and significance of the field, a recognized writing convention in this discipline, according to Informant A. The cycle also occurred commonly in the TH and NS corpora, but not as frequently as it did in the CH corpus. However, this finding showed an agreement with Swales' (2004) CARS model in the sequential order of *Steps 1.1* and *1.2*. Move cycle *3.1-3.2* occurred in 5 and 4 EERAs in the CH and TH corpus, respectively, but it only occurred in 2 EERAs in the NS corpus. This indicated that compared with the NS writers, Chinese and Thai counterparts tended to adopt *Step 3.2 Summarizing methods* to provide brief information concerning the main methods and procedures after the introduction of their research topic. Third, move cycles *2.1-2.3, 3.2-3.3, 2.1-3.1, 3.1-3.5,* and *3.1-3.2-3.3*, all of them being not universal in EERAs, indicated more of a similarity among the three corpora. To sum up, the results in Tables 4.10-4.12 confirmed that the EERA Introductions were composed of move cycles started by *Move 1* (i.e., 1-2-3, 1-3), showing great consistency with the findings of Loi (2010).

Table 4.10 The number of EERAs in which move cycles occur in the CH, TH and NS

Move cycle	CH (RA=12)		TH (RA=12)		NS (RA=12)	
	No. of RAs	%	No. of RAs	%	No. of RAs	%
2.1-2.2	8	66.7	7	58.3	7	58.3
1.1-1.2	10	83.3	7	58.3	8	66.7
3.1-3.2	5	41.7	4	33.3	2	16.7
1.1-2.1	2	16.7	3	25	1	8.3
2.1-2.3	1	8.3	3	25	0	0
3.2-3.3	3	25	0	0	1	8.3
2.1-3.1	1	8.3	1	8.3	2	16.7
3.1-3.5	0	0	3	25	0	0
3.1-3.2-3.3	3	25	0	0	0	0

Table 4.11 The occurrence of move cycles in the CH, TH and NS

Move cycle	CH		TH		NS		Whole corpus	
	Occurrence	%	Occurrence	%	Occurrence	%	Occurrence	%
2.1-2.2	16	39	15	39.5	12	46.2	43	41
1.1-1.2	10	24.4	8	21.1	8	30.8	26	24.8
3.1-3.2	5	12.2	4	10.5	2	7.7	11	10.5
1.1-2.1	2	4.9	3	7.9	1	3.8	6	5.7
2.1-2.3	1	2.4	4	10.5	0	0	5	4.8
3.2-3.3	3	7.3	0	0.0	1	3.8	4	3.8
2.1-3.1	1	2.4	1	2.6	2	7.7	4	3.8
3.1-3.5	0	0	3	7.9	0	0	3	2.9
3.1-3.2-3.3	3	7.3	0	0	0	0	3	2.9
Total	**41**	**100**	**38**	**100**	**26**	**100**	**105**	**100**
Average	**3.4**		**3.2**		**2.2**		**2.9**	

Table 4.12 The summary of Move sequence of the Introduction in the CH, TH and NS

Move sequence	CH		TH		NS		Whole corpus	
	No. of RAs	%	No. of RAs	%	No. of RAs	%	No. of RAs	%
1-2-3	8	66.7	11	91.7	7	58.3	26	72.2
1-3	2	16.7	1	8.3	3	25	6	16.7
1-2-1-3	1	8.3	0	0	0	0	1	2.8
1-2-1-2-3	1	8.3	0	0	1	8.3	2	5.6
1-3-2-3	0	0	0	0	1	8.3	1	2.8
Total	**12**	**100**	**12**	**100**	**12**	**100**	**36**	**100**

To summarize the findings of the Introduction section: three moves and ten steps were discovered across the corpus. The results indicated that the Introductions of Chinese and Thai EE researchers were comparable. These two groups of authors tended to employ the same moves and steps that outnumbered those used by NS writers, demonstrating Chinese and Thai writers' inclination to construct a more complete Introduction that included more communicative goals. NS writers, on the other hand, were revealed to focus on fewer communicative goals in supporting their Introduction.

4.4 Summary

This chapter offered results and discussion of the move-step structure for the EERA Introduction sections. First, the move-step structure framework based on three referential frameworks (Kanoksilapatham 2005, 2015; Maswana et al., 2015) and generated at the beginning of study was revised to better suit the EERAs in the three corpora. Thus, a three-move and ten-step Introduction move-step framework was generated. Second, description of all the three moves and ten steps was provided. Finally, comparisons of move-step structures and move cycles were presented.

CHAPTER 5

RESULTS AND DISCUSSION OF THE METHODS SECTION

This chapter presents the results of analyzing 36 Methods sections from CH, TH and NS corpora in terms of move-step structure and visual-textual move (VTM). Firstly, it starts with the overview of the whole Methods section. Secondly, inter-rater reliability check is conducted afterwards to guarantee the reliability of the coding process. Thirdly, the results and discussion of move-step analysis, which include description of the moves and steps and comparison of move-step structures among the three corpora, are presented. Finally, results and discussion of VTM analysis including description and comparison of VTMs are demonstrated.

5.1 Overview of the Methods Section

Among the four sections of the EERAs, the Methods section received the least scholarly attention due to its methodological diversity. However, this section has its own unique generic features. For example, different from Social Science RAs, EERA mainly describes a novel design by specifying its material, theories, and its working principles using detailed analysis process, while RAs in the Social Science field would contain data collection and analysis. The principal distinction between them is that the former is to describe an equipment, device, or intangible program designed by the researchers themselves and the latter tends to employ the data that are readily available.

This is one of the reasons that the Methods section is titled with varied headings.

The headings of the Methods section, which are listed in Table 5.1, are of the greatest variety among all the sections in the three corpora. The number of headings with "Method" or "Methods" is relatively small, with only 2, 1, and 5 cases in the CH, TH and NS corpora, respectively. That is, EE researchers tended less to use general functional headings (e.g., *Instruments and methods* in CH1; *Theory and method* in TH1; *Methods, equipment, and procedures* in NS3). Instead, they seemed to employ specific functional headings more such as *Proposed monitoring system design* in CH3, *Magnetic probe design* in CH9, *Device fabrication* in NS9. For the employment of the headings, Informant B confirmed that they would regard all of identified headings presented in Table 5.1 as subsections in Methods or Methodology. Moreover, they would tend less to employ general functional headings such as "Methods" and "Methodology" since these terms lack specificity for their design. The specific topical headings, as the informant explained, helped EE authors present main and key arguments in a systemic and coherent way, which was admitted as a disciplinary feature specific to this discipline. Table 5.1 presents the headings of the Methods sections of all the 36 EERAs. As can be seen from the table, the unshaded columns, i.e., the specific functional headings, greatly outnumbered the shaded columns, i.e., the specific functional headings.

Table 5.1 Original heading of the Methods section in the three corpora

	CH		TH		NS
	Original heading		**Original heading**		**Original heading**
CH1	Structure and Simulations	TH1	Theory and method Experiment	NS1	Method
CH2	Materials and methodology	TH2	Design and fabrication	NS2	Theory and simulation
CH3	Proposed monitoring system design Proposed RFID sensor design	TH3	Theoretical background	NS3	Methods, equipment, and procedures
CH4	Materials and Methods	TH4	Experimental	NS4	Materials and methods
CH5	Antenna configuration	TH5	Lens antenna design and fabrication	NS5	Experimental validation
CH6	Chip design and system implementation	TH6	Materials and experimental set-up	NS6	Sensor design
CH7	Antenna design and analysis	TH7	Antenna Design	NS7	System design

Table 5.1 Original heading of the Methods section in the three corpora (Continued)

	CH		TH		NS
	Original heading		Original heading		Original heading
CH8	Experimental setup	TH8	Antenna Design	NS8	Theory, Design and simulations
CH9	Antenna design for THz array detectors	TH9	Magnetic probe design	NS9	Instruments and methods
CH10	Construction and analysis of equivalent uniform elliptical array (UEA) model	TH10	Antenna Design and Parametric Studies	NS10	Design background Inverse design
CH11	Design and analysis	TH11	Theoretical Background	NS11	Device fabrication Measurement
CH12	Antenna Configuration Operating Principles	TH12	DTTV–SFN Propagation Measurement System	NS12	Experimental Methods

5.2 Results and Discussion

5.2.1 Results and Discussion of Move-Step Analysis

In the earlier stage of the current study, the researcher conducted a pilot coding of the whole EERAs, which was considered as a necessary step for the purposes of not only preparing a preview of inter-rater coding, but also, more importantly, yielding a probable move-step framework of the EERA. As the researcher anticipated, modifications of this framework did take place as the coding proceeded, covering all of the Methods sections of the whole corpus. The researcher thus adapted the framework yielded from the pilot coding and generated a move-step framework containing 3 moves and 9 steps. The modifications were presented in Tables 5.2-5.3. Table 5.2 is the probable proposed move-step framework for EERA Methods section, which was obtained at the beginning of the research. Table 5.3 shows the revised move-step framework for EERA Methods section based on the analysis of all of the 36 EERA Methods sections.

Table 5.2 The probable move-step framework proposed previously for the EERA Methods section

Move	Step
1. Introducing materials/models/methods	1.1 Stating the location of research
	1.2 Specifying the materials
	1.3 Specifying the time
	1.4 Providing the background of the materials
	1.5 Announcing objectives
	1.6 Overview of the section
2. Describing experimental procedures/design	2.1 Describing principle of the proposed model or design
	2.2 Detailing procedures
3. Describing data analysis procedures	3.1 Defining terminologies
	3.2 Indicating analysis procedure
	3.3 Detailing analysis
	3.4 Significance of the design/model
	3.5 Summary of analysis

Table 5.3 The revised framework for the EERA Methods section

Section (N=36)	Move and Step	%	Status
Methods	**1. Introducing materials/instruments**	66.7	Con
	1.1 Specifying time/location	11.1	Opt
	1.2 Specifying materials/instruments	63.9	Con
	1.3 Justifying materials/instruments	25	Opt
	2. Describing experimental procedure/design	97.2	Obl
	2.1 Indicating principles, theories or previous studies	69.4	Con
	2.2 Detailing procedure	80.6	Obl
	3. Demonstrating data or design analysis	58.3	Con
	3.1 Indicating analysis procedure	5.6	Opt
	3.2 Detailing analysis	52.8	Con
	3.3 Referring to theories and previous research	5.6	Opt
	3.4 Suggesting implication	2.8	Opt

Note: Obl: obligatory; Con: conventional; Opt: optional

The analysis of the whole corpus of the 36 Methods sections based on the cut-off frequency set in the research methodology of the present study showed that there were one obligatory and two conventional moves, and one obligatory, three conventional, and five optional steps. In the move category, *Move 2 Describing experimental procedure/design* was obligatory, *Move 1 Introducing materials/instruments* and *Move 3 Demonstrating data/design analysis* were conventional. Meanwhile, in the step category, *Step 2.2 Detailing procedure was* the only obligatory step, whereas *Step 1.2 Specifying materials/instrument, Step 2.1 Indicating principles, theories or previous studies*, and *Step 3.2 Detailing analysis* were conventional. The remaining steps, *Step 1.1 Specifying time/location*, *Step 1.3 Justifying materials/instruments*, *Step 3.1 Indicating analysis procedure*, *Step 3.3 Referring to theories and previous research*, and *Step 3.4 Suggesting implication*, fell into the optional category.

First, within the obligatory category, *Move 2 Describing experimental procedure/design* occurred in 35 out of 36 RAs, accounting for 97.2% of the whole corpus. The steps under *Move 2* demonstrated the highest occurrence among all of nine steps, implying that EE researchers considered the procedure of experimental design an indispensable gesture for the Methods section. Second, the conventional category was found to cover certain steps under all of the three moves. *Step 2.1 Indicating principles, theories or previous studies* maintained the highest frequency in the number of RAs in which the move or step occurred, as shown in Table 5.4, which was 69.4% of all the RAs in the whole corpus. Meanwhile, *Move 1*, *Step 1.2*, *Move 3*, and *Step 3.2* in the conventional category did not demonstrate great discrepancies in statistics, as shown in Tables 5.4 and 5.5. On the contrary, the optional category demonstrated a different picture. The highest frequency was 8 out of 36 RAs, while the lowest was only 2 RAs. *Step 1.3 Justifying materials/instruments* was the only step that occurred more than 20% of the 36 RAs, implying some EE researchers would prefer to provide justifications for the materials or instruments. The other four optional steps were closer in percentage, for which the explanation could be that these optional steps were the least preferred or they were only suitable and applicable for certain and particular research design or methods.

Table 5.4 The number of EERAs in which each move or step occurs in the whole corpus

	Move/Step	No. of RAs in which the move or step occurs (RA=36)	%	Status
Move	**2.Describing experimental procedure/design**	35	97.2	Obl
	1. Introducing materials/instruments	24	66.7	Con
	3. Demonstrating data/design analysis	21	58.3	Con
Step	2.2 Detailing procedure	29	80.6	Obl
	2.1 Indicating principles, theories or previous studies	25	69.4	Con
	1.2 Specifying materials/instruments	23	63.9	Con
	3.2 Detailing analysis	19	52.8	Con
	1.3 Justifying materials/instruments	9	25	Opt
	1.1 Specifying time/location	4	11.1	Opt
	3.1 Indicating analysis procedure	2	5.6	Opt
	3.3 Referring to theories and previous research	2	5.6	Opt
	3.4 Suggesting implication	1	2.8	Opt

Table 5.5 The total occurrence of all the moves and steps in the whole corpus

	Move/Step	Occurrence (RA=36)	%
Move	**2.Describing experimental procedure/design**	147	25.7
	3. Demonstrating data/design analysis	71	12.4
	1. Introducing materials/instruments	55	9.6
Step	2.2 Detailing procedure	104	18.2
	3.2 Detailing analysis	67	11.8
	2.1 Indicating principles, theories or previous studies	56	9.8
	1.2 Specifying materials/instruments	46	8
	1.3 Justifying materials/instruments	13	2.3
	1.1 Specifying time/location	5	0.9
	3.1 Indicating analysis procedure	4	0.7
	3.3 Referring to theories and previous research	3	0.5
	3.4 Suggesting implication	1	0.2
Total		572	100

5.2.1.1 Description of Moves and Steps

Move 1: Introducing materials/instruments functions as a preparatory or an opening move in the Methods section by providing information related to the materials, instruments or apparatus playing a key role in the model design. Apart from announcing time and location of conducting the research, making an entrance for the materials or instruments and providing rationale for choosing these materials or instruments are also included in this move. Therefore, it could be realized through either one or a combination of the steps under this move: *Step 1.1 Specifying time or location*, *Step 1.2 Specifying materials/instruments*, and *Step 1.3 Justifying materials/instruments*. Occurring in 24 out of 36 EERAs, or 66.7% of the whole corpus, *Move 1* was identified as a conventional move.

Step 1.1: Specifying time/location usually is the step that the authors employ to depict specific time when and location where the research took place. Usually located at the beginning of this section, this step is particularly used for the proposed design and/or methods which regard time and location as having an impact on the research procedure and results. Only 4 out of 36 EERAs, or 11.1% of the whole corpus, employed this step, suggesting its optional status. Two examples of *Step 1.1* are presented below.

(1) *The study was conducted in an east-west oriented greenhouse in Hangzhou (120°09′E, 30°14′N), southeast of China.* (CH2)

(2) *Field trials were conducted in central New York at farmer fields in Ledyard (42.698°N, 76.605°W) and Genoa (42.678°N, 76.602°W), and at the Musgrave Research Farm in Aurora (42.733°N, 76.659°W). Sidedress N rate trials were carried out in 2017 at Ledyard and in 2018 at Genoa. Timing of N application experiments at Aurora were conducted in 2017 and 2018.* (NS4)

Step 1.2: Specifying materials/instruments occurs when authors are introducing the materials that compose the design or the model. When EE researchers build a new design or model, they tend to introduce the material employed for the establishment of a strong argument, making a reinforced credibility of the design. Usually this step involves figures, which could show a clearer picture of the design or model. In addition, this step is also associated with the nouns such as *device*, *parameters*, *equipment* or other particular nouns referring to specific materials or devices, or adjectival phrases such as *be equipped with*. This step occurred in 23 EERAs, or 63.9% of the whole corpus, which suggests its conventional status. Examples 3 and 4 illustrate *Step 1.2*.

(3) *We used an IR LED with an emission maximum wavelength kmax = 1.65 lm, (Lms16LED-R, Alfa Photonics, Latvia) and an IR sensitive photodiode (PD) (Lms24-05-PA, Alfa Photonics, Latvia) having a spectral response over the range from 1.1 to 2.3 mm equipped with embedded preamplifier.* (NS9)

(4) *Hemispherical lenses are the simplest 3D structures for lens antenna designs while still offering various advantages such as circular polarization properties and broadband characteristics. In this work, the 3D full-wave EM simulation package CST Studio Suite was used to design the 220-320 GHz hemispheric lens antennas based on Monocure 3DR3582C photopolymer. The values of all necessary parameters are shown in Table 1. Fig. 2(a) and (b) depict the front and back side of the hemispheric lens, respectively, with the mechanical and electrical design parameters labeled.* (TH5)

Step 1.3: Justifying materials/instruments refers to the information that claims the reasons for the employed materials or instruments. EE researchers have the tendency to provide rationale or justification of using certain materials or instruments, implying that these materials or instruments do not involve random selection. Usually, this step would involve causative words or phrases such as *for*, *because of*, *due to*, etc. This step was identified to occur in 25% of the whole corpus, i.e., 9 EERAs, indicating its optional status. Examples 5 and 6 illustrate the function of *Step 1.3*.

(5) *Ammonia (NH_3) has been used as a key indicator of the meat decomposition processes with microorganisms for inspecting the meat freshness [5], [15], [29].* (CH6)

(6) <u>For</u> *simplicity, a graphical method (optiwave program) is introduced, from which outputs such as WGM and Eth are obtained.* (TH3)

Move 2: Describing experimental procedure/design is the major move since Electronic Engineering is a science about the devices and processes (Vodovozov, 2010). Thus, experimental procedure or design serves as a fundamental role in building persuasive arguments. This move mainly provides a detailed description of the experimental procedure or design, specifically how the experiment is carried out or how a design works. For realization of this move, two steps including: *Step 2.1 Indicating principles, theories or previous studies* and *Step 2.2 Detailing procedure* are identified. *Move 2* and its steps are with the highest occurrence percentage in the Methods section. With the occurrence in 35 EERAs, *Move 2* was categorized in the obligatory status.

Step 2.1: Indicating principles, theories or previous studies. Principle and theory are basic rules that could provide explanation of how a certain program or design happens or functions. This is usually a step that has the justification purpose. Meanwhile, the authors may relate to previous studies to support the claims of their design or model. In this step causative conjunctions or phrases such as *since*, *because of*, etc., are commonly captured. Occurring in 25 EERAs, i.e., 69.4% of the whole corpus, *Step 2.1* is with a conventional status. Examples 7 and 8 are illustrations of this step.

(7) *The N sidedress rate recommended for the Genoa location was 112 kg N ha−1 versus 100 kg N ha−1 in Ledyard (<u>Ketterings et al., 2003a</u>).* (NS4)

(8) <u>Since</u> *the projector is a digital LCD screen, the image of each layer is composed of pixels that result in a formation of small rectangular bricks called voxels, which causes light scattering. <u>Since</u> the light scattering can be utilized for sensing applications, the measurement for the rough surface was carried out to show the feasibility of using it towards sensing applications.* (TH2)

Step 2.2: Detailing procedure introduces the way, the order of implementing the design or the details of data arrangement. This is the most frequent step since it occurred in 29 out of 36 EERAs, i.e., 80.6% of the whole corpus, suggesting its obligatory status. Examples 9 and 10 below illustrate the function of *step 2.2*.

(9) *GO/BSA Hybridization and Reduction to rGO Fresh solutions of 1 mg/ml GO and 25 mg/ml BSA were prepared in milliQ DDI water immediately prior to conjugation. The GO solution was briefly sonicated for 5 min in an ultrasonic bath to break up any aggregates. Total volumes of 1 mL GO, 3 mL BSA, and 6 mL DDI H2O were injected into a glass beaker and brought up to pH 12 with 1 M NaOH. The mixture was stirred at high speed 50 °C for 24 h, transitioning from a light brown to dark black solution with the reduction of GO. Excess BSA was removed through centrifugal filtration (Amicon Ultra-15, MWCO 150 kDa) at 10,000 rpm for 15 min, and the final purified rGO/BSA hybrid material was suspended to 5 mL in milliQ DDI water and stored at 4 °C.* (NS12)

(10) *The fabricated paper-based pressure sensor with a 7 mm 97 mm square sensing diaphragm has been characterized by applying various pressures in a range of 0– 18kPa and deflection at the center of the sensing diaphragm has been measured. Prior to the deflection measurement the Young's modulus of the paper substrate with parafilm coating has been measured to be E = 180.8 MPa (data not shown).* (TH4)

Move 3: Demonstrating data/design analysis is the move that focuses on detailed data analysis such as how the data is analyzed or how the design functions with the assistance of authorial interpretation. This move is realized through four identified steps: *Step 3.1 Indicating analysis procedure*, *Step 3.2 Detailing analysis*, *Step 3.3 Referring to theories and previous research*, and *Step 3.4 Suggesting implication*. This move, compared with *Move 2: Describing experimental procedure/design*, tends more to reveal the working principles of the design by taking it to real implementation, while *Move 2* inclines more to describe the design process.

Move 3 is the move that occurred the least among the three moves. With the occurrence in 21 EERAs, i.e., 58.3% of the whole corpus, it was identified as a conventional move.

Step 3.1: Indicating analysis procedure. Sometimes authors simply illustrate the analysis procedure before detailed analysis. The occurrence frequency of this step, 5.6%, suggesting that it is optional, is much less frequent than the steps under *Move 2* because the process has already been depicted and described within that move, and it may seem redundant applying this step. Examples 11 and 12 demonstrate *Step 3.1* as shown below.

(11) *The NDVI values determined by the GreenSeeker were compared to those obtained with the UAV-mounted camera using a linear model. The coefficients of determination (R2) were plotted for each sensing time using multiple comparison analysis. All statistical analyses were done with JMP Pro 12 (SAS Institute, Cary, USA).* (NS4)

(12) The analog voltage pulses from the IR PD which were collected by the mC system through the RF input high speed ADC (input channel 1) were designated 'raw pulses' for clarity. We constructed a data processing program for the ARM cortex A9 processor of the mC system to perform digital smoothing on the raw pulses. (NS9)

Step 3.2: Detailing analysis is the step through which the authors provide in-depth analysis of the design by giving explanation to illustrate the working principle of the design, sometimes via statistics obtained from algorithm such as equations. This step, occurring in 52.8% of all the EERAs, was the most frequently employed step among the steps under *Move 3*, and it was the only conventional step under *Move 3*. Examples 13 and 14 below are the illustration for *Step 3.2*.

(13) *Adding a via fence around the CBCPW-to-stripline via can also improve the transmission and reflection coefficients as reported in previous works.30,31 The simulation results of adding via fence at a distance r1, r1 = w1/2 + s + λg/4, from the transition*

via are shown in Figure 6. It can be observed that the transmission coefficient is slightly improved and the reflection coefficient is greatly enhanced at the higher frequency band from 14 to 20 GHz with a via fence around the transition. (TH9)

(14) *When the wind speed is greater than 0, it is necessary to consider the forced convection between the PV panel and ambient air, which is influenced by the speed and direction of wind. If the wind speed is equal to 0, it is essential to consider the natural convection of the PV panel.* (CH2)

Step 3.3: Referring to theories and previous research is the step that is employed by the EE researchers to refer to theories and previous research for the purpose of facilitating their interpretation. In EE discipline, theories or previous research serve as the support for analysis. This step occurred in only 2 EERAs, suggesting an optional status. Examples 15 and 16 serve as the illustrations for this step.

(15) *Exponential regression analysis was performed to determine the relationship among the NDVI readings and final yield (grain and silage) consistent with previous research on relationships between NDVI and crop yield (Raun et al., 2005; Teal et al., 2006, Tagarakis et al., 2017).* (NS4)

(16) *The thermal model developed by Hoang et al. (2014) only considers the factor of natural convection on PV panels.* (CH2)

Step 3.4: Suggesting implication is the step that briefly states what the design could imply or suggest. Benefits of the design is usually introduced in this step. This step is among the least frequent steps, which occurred only in 1 EERA, i.e., 2.8% of the whole corpus. Thus, this step was recognized as optional. Examples 17 demonstrates the function of this step.

(17) *The mechanical flexibility of the overall system is good enough for the packaging application. For real applications, the die can be directly bonded on plastic films with mature high throughput processes to improve the flexibility and also reduce cost.* (CH6)

5.2.1.2 Comparison of Move-Step Structures

5.2.1.2.1 Moves and Steps

Tables 5.6-5.7 demonstrate the summary of the occurrence of each move and step in the CH, TH, and NS corpora. According to Table 5.6, *Move 1 Introducing material or instrument* occurs in 91.7%, 66.7% and 41.7% of the CH, TH and NS corpus, respectively, suggesting an obvious variation. *Move 2 Describing experimental procedure/design* occurs in 91.7%, 100% and 100% of the EERAs in the CH, TH and NS corpus, respectively, demonstrating similarity. *Move 3 Demonstrating data/design analysis* also displays similarity rather than variation by occurring in 58.3%, 50% and 66.7% of the EERAs in the CH, TH, and NS corpus, respectively. Table 5.7 shows the total occurrence of the moves and steps. The most frequently found move and step in both CH and NS corpora are *Move 2 Describing experimental procedure/design* and *Step 2.2 Detailing procedure*, with the occurrence percentages of 20.4% and 13.6%, and 37% and 28.4%, respectively. However, *Move 3 Demonstrating data/design analysis* and *Step 3.2 Detailing analysis* are the most frequently employed move and step in the TH corpus, with the respective occurrence percentage of 18.5% and 19.1%.

Table 5.6 The number of EERAs in which move or step occurs in the CH, TH and NS

Move/Step	CH (RA=12)		TH (RA=12)		NS (RA=12)	
	No. of RAs	%	No. of RAs	%	No. of RAs	%
1. Introducing material or instrument	11	91.7	8	66.7	5	41.7
1.1 Specifying time or location	2	16.7	0	0	2	16.7
1.2 Specifying materials/instruments	11	91.7	7	58.3	5	41.7
1.3 Justifying materials or instrument	4	33.3	4	33.3	1	8.3
2.Describing experimental procedure/design	11	91.7	12	100	12	100
2.1 Indicating principles, theories or previous studies	9	75	10	83.3	6	50
2.2 Detailing procedure	8	66.7	9	75	12	100
3. Demonstrating data/design analysis	7	58.3	6	50	8	66.7
3.1 Indicating analysis procedure	0	0	0	0	2	16.7
3.2 Detailing analysis	7	58.3	6	50	6	50
3.3 Referring to theories and previous research	1	8.3	0	0	1	8.3
3.4 Suggesting implication	1	8.3	0	0	0	0

Table 5.7 The occurrence of each move and step in the CH, TH and NS

Move/Step	CH (RA=12)		TH (RA=12)		NS (RA=12)		Whole corpus	
	Occurrence	%	Occurrence	%	Occurrence	%	Occurrence	%
1. Introducing material or instrument	27	14.1	19	11	10	4.8	56	9.8
1.1 Specifying time or location	2	1.1	0	0	3	1.4	5	0.9
1.2 Specifying materials/instruments	23	12	16	9.3	7	3.4	46	8
1.3 Justifying materials or instrument	6	3.1	6	3.5	1	0.5	13	2.3
2.Describing experimental procedure/design	39	20.4	31	17.9	77	37	147	25.7
2.1 Indicating principle, theory or previous study	19	10	17	9.8	19	9.1	55	9.6
2.2 Detailing procedure	26	13.6	19	11	59	28.4	104	18.2
3. Demonstrating data/design analysis	23	12	32	18.5	16	7.7	71	12.4
3.1 Indicating analysis procedure	0	0	0	0	4	1.9	4	0.7
3.2 Detailing analysis	23	12	33	19.1	11	5.3	67	11.7
3.3 Referring to theories and previous research	2	1.1	0	0	1	0.5	3	0.5
3.4 Suggesting implication	1	0.5	0	0	0	0	1	0.2
Total	**191**	**100**	**173**	**100**	**208**	**100**	**572**	**100**

The similarities and variations of all the moves and steps among the three corpora are concluded in Table 5.8. The main difference among the moves is in the status of moves and steps. There were altogether 7, 7, and 5 obligatory and conventional moves and steps in the CH, TH and NS corpus, respectively. The most obvious variations observed lied in *Move 1 Introducing material* and one of its steps *Step 1.2 Specifying materials/instruments*, for they were considered as obligatory in the CH corpus but regarded as conventional and optional in the TH and NS corpus, respectively. According to Informant A, the adoption of this move was of great necessity in this section since these descriptions could serve as sufficient and powerful arguments for their design. When the researchers were writing their EERAs, they tended to include in great detail every component, spare part, and material so as to establish a solid foundation for their arguments. Thai researchers considering this move as conventional one also indicated that this move was one of the important moves in the Methods section. On the contrary, *Move 1* being counted as the only optional move in the NS corpus was probably because material description was not regarded as the necessarily separate move since EE researchers could mention them in *Move 2 Describing experimental procedure/design*.

Other than variations, similarities were observed in all the three categories. First, *Move 2 Describing experimental procedure/design* was considered as obligatory across the three corpora, implying its important status in this section for all the three writer groups. Second, *Move 3 Demonstrating data/design analysis* and *Step 3.2 Detailing analysis* were both regarded as conventional across the three corpora. *Step 1.1 Specifying time/location*, *Step 1.3 Justifying materials/instruments*, *Step 3.1 Indicating analysis procedure*, *Step 3.3 Referring to theories and previous research*, and *Step 3.4 Suggesting implication* were all counted as optional steps across the three corpora.

Table 5.8 The similarities and differences of obligatory, conventional and optional moves and steps among the CH, TH and NS

Move/Step	CH	TH	NS
Obligatory (≥80%)	**1. Introducing materials/ instruments** 1.2 Specifying materials/instruments **2. Describing experimental procedure/design**	**2. Describing experimental procedure/design** 2.1 Indicating principles, theories or previous studies	**2. Describing experimental procedure/design** 2.2 Detailing procedure
Conventional (50%-79%)	2.1 Indicating principles, theories or previous studies 2.2 Detailing procedure **3. Demonstrating data/design analysis** 3.2 Detailing analysis	**1. Introducing materials/ instruments** 1.2 Specifying materials/instruments 2.2 Detailing procedure **3. Demonstrating data/design analysis** 3.2 Detailing analysis	2.1 Indicating principles, theories or previous studies **3. Demonstrating data/design analysis** 3.2 Detailing analysis

Table 5.8 The similarities and differences of obligatory, conventional and optional moves and steps among the CH, TH and NS

Move/Step	CH	TH	NS
Optional (<50%)	1.1 Specifying time/location 1.3 Justifying materials/ instruments 3.1 Indicating analysis procedure 3.3 Referring to theories and previous research 3.4 Suggesting implication	1.1 Specifying time/location 1.3 Justifying materials//instruments 3.1 Indicating analysis procedure 3.3 Referring to theories and previous research 3.4 Suggesting implication	**1. Introducing materials/instruments** 1.1 Specifying time/location 1.2 Specifying materials/instruments 1.3 Justifying materials/instruments 3.1 Indicating analysis procedure 3.3 Referring to theories and previous research 3.4 Suggesting implication

5.2.1.2.2 Move Patterns

Table 5.9 shows the summary of the beginning and ending move or step in each corpus. The tendency of using *Move 1 Introducing materials/instruments*, specifically *Step 1.2 Specifying materials/instruments* as the beginning step was obvious in the CH and TH corpora as the majority of EERAs in the two corpora, i.e., 8 and 7 EERAs adopted this step at the beginning of the Methods section, respectively. This indicated that Chinese and Thai EE researchers preferred to start with the material and instrument introduction, showing consistency with the results of Kanoksilapatham (2005), who revealed in her study that *Move 4 Describing materials* occurred in 100% of the RAs. Meanwhile, in the NS corpus, *Move 1* and *Move 2* showed an equal number in serving as the beginning move. That is, half of the corpus adopted *Move 1*, the other half employed *Move 2*. To be specific, it was *Steps 1.2* and *2.2* respectively that occupied the beginning section in the same number of EERAs in the NS corpus. Thus, it was also acceptable to begin the Methods section flexibly with *Move 2* since some EERAs, due to their subject matter, did not have to necessarily announce the materials or instruments based on their little impact on the research process and results. Another reason for EE researchers not adopting *Move 1* as the beginning move was that sometimes they integrated *Move 1* into *Move 2* to a small degree. However, the text segment was only identified as *Move 2* through its salient communicative purpose. That is to say, both *Move 1* and *Move 2* were acceptable in serving as the beginning move.

The picture of the ending moves across the three corpora demonstrated similarity rather than variation. *Move 2* and *Move 3* were both adopted as the ending moves since there were nearly an equal number of *Move 2* and *Move 3* occupying the end of the Methods section, which implied that experimental procedure description and data or design analysis demonstration could both be taken into consideration when the Methods section was about to end. The flexibility of adopting the beginning and the ending moves implied that the authors might adjust RA structures according to the topical matter, methodology, or even the publication requirement of the target journal.

Table 5.9 The beginning move/step and ending move/step of the Methods section

CH		TH		NS	
CH1	1.2-...-3.2	TH1	2.2-...-2.2	NS1	2.2-...-3.2
CH2	1.1-...-3.2	TH2	1.2-...-3.2	NS2	2.1-...-2.2
CH3	1.2-...-2.2	TH3	1.3-...-2.2	NS3	1.1-...-2.2
CH4	1.2-...-2.2	TH4	1.2-...-2.1	NS4	1.1-...-3.1
CH5	1.2-...-3.2	TH5	1.2-...-2.2	NS5	1.2-...-3.2
CH6	1.2-...-2.2	TH6	1.2-...-1.2	NS6	2.2-...-2.2
CH7	2.1-...-3.2	TH7	2.1-...-3.2	NS7	2.2-...-2.2
CH8	1.2-...-2.2	TH8	1.2-...-3.2	NS8	2.1-...-3.2
CH9	2.2-...-3.2	TH9	1.2-...-3.2	NS9	1.2-...-3.1
CH10	1.2-...-3.2	TH10	1.2-...-3.2	NS10	1.2-...-2.2
CH11	2.1-...-2.2	TH11	2.1-...-2.1	NS11	2.2-...-3.2
CH12	1.2-...-2.1	TH12	2.2-...-3.2	NS12	1.2-...-2.2

5.2.1.2.3 Move Cycles

Generally speaking, the Methods section was a less cyclical section. There are mainly 7 types of move cycles identified and they are demonstrated in Table 5.10. The move cycles are *1.2-2.2*, *2.2-3.2*, *2.1-3.2*, *1.2-2.1*, *1.2-1.3-2.2*, *2.1-2.2-*

3.2, and *1.2-1.3*. The top four most frequently occurred move cycles *1.2-2.2*, *2.2-3.2*, *2.1-3.2*, and *1.2-2.1*, are all cycles across different move categories. EE researchers, when constructing their RAs, had the inclination to follow the conventional sequential order of *Move 1- Move 2* and *Move 2-Move 3*, in spite of the moves being represented by different steps. Move cycles *1.2 Specifying materials/instrumentss-2.2 Detailing procedure* and *2.2 Detailing procedure -3.2 Detailing analysis* were the two cycles prevalent in the whole corpus, demonstrating a seemingly universal rule that material and instruments were usually firstly introduced before clarifying the experimental procedure or design and data analysis.

Table 5.10 Summary of move cycles in the Methods section in the whole corpus

	Move cycle	No. of RAs	%		Move cycle	Occurrence	%
1	1.2-2.2	10	37	1	1.2-2.2	11	26.2
2	2.2-3.2	8	29.6	2	2.2-3.2	8	19.1
3	2.1-3.2	6	22.2	3	2.1-3.2	7	16.7
4	1.2-2.1	6	22.2	4	1.2-2.1	6	14.3
5	1.2-1.3-2.2	3	11.1	5	2.1-2.2-3.2	4	9.5
6	2.1-2.2-3.2	3	11.1	6	1.2-1.3-2.2	3	7.1
7	1.2-1.3	3	11.1	7	1.2-1.3	3	7.1
					Total	**42**	**100**

Variations and similarities of the employment of the move cycles could be informed from Tables 5.11-5.12. Despite a noticeable discrepancy shown by the average number of move cycles per article, which were 1.6 in the CH, 1.1 in the TH and 0.8 in the NS, another obvious variation captured among the three corpora was move cycle *1.2 Specifying materials/instruments-2.1 Indicating principles, theories or previous studies.* It was employed in 4 and 2 EERAs in the CH and TH corpora, respectively, while it did not occur at all in the NS corpus. The occurrence of *Step 2.1* after *Step 1.2* was probably because it could serve as a solid theoretical foundation as well as a transition functioning as a rationale for the procedure to be later unveiled. The other move cycle that did not occur in the NS corpus was *1.2-1.3*, and it demonstrated the lowest occurrence in the CH and TH corpora as well, thus being regarded as a similarity. Other move cycles showed the apparent agreement across the three corpora. Thus, it could be concluded that move cycles among the three corpora is of similarity rather than difference.

Table 5.11 The number of EERAs in which move cycles occur in the CH, TH and NS

Move cycle	CH (RA=12)		TH (RA=12)		NS (RA=12)	
	No. of RAs	%	No. of RAs	%	No. of RAs	%
1.2-2.2	4	33.3	3	25	3	25
2.2-3.2	3	25	2	16.7	3	25
2.1-3.2	3	25	2	16.7	1	8.3
1.2-2.1	4	33.3	2	16.7	0	0
2.1-2.2-3.2	1	8.3	1	8.3	1	8.3
1.2-1.3	2	16.7	1	8.3	0	0
1.2-1.3-2.2	1	8.3	1	8.3	1	8.3

Table 5.12 The occurrence of move cycles in the CH, TH and NS

Move cycle	CH		TH		NS		Whole corpus	
	Occurrence	%	Occurrence	%	Occurrence	%	Occurrence	%
1.2-2.2	4	21.1	3	23.1	4	40	11	26.2
2.2-3.2	3	15.8	2	15.4	3	30	8	19.1
2.1-3.2	3	15.8	3	23.1	1	10	7	16.7
1.2-2.1	4	21.1	2	15.4	0	0	6	14.3
2.1-2.2-3.2	2	10.5	1	7.7	1	10	4	9.5
1.2-1.3	2	10.5	1	7.7	0	0	3	7.1
1.2-1.3-2.2	1	5.3	1	7.7	1	10	3	7.1
Total	**19**	**100**	**13**	**100**	**10**	**100**	**42**	**100**
Average	**1.6**		**1.1**		**0.8**		**1.2**	

5.2.2 Results and Discussion of VTM Analysis

5.2.2.1 Overview

It is undoubtedly to say that visuals occupy a great amount of space in EERAs, illustrating their key role in assisting writers with their argument establishment.

This feature of EERA is too obvious to be ignored, and it is therefore considered as one conventional characteristic. The culture of this graphic discipline is found to include a great variety of charts or graphs. The visuals in the Methods section were identified to have the similar visual types and distribution as that of the R&D section. According to Table 5.13, altogether 189 visuals appeared in the Methods section, the second largest visual-filled section, following the R&D section. It can also be seen from Table 5.13 that the TH corpus keeps the highest number of visuals, 81 in total. The CH and NS are with 69 and 39 visuals, respectively.

Table 5.13 Summary of the visuals in the CH, TH and NS

Visual	CH (RA=12)	TH (RA=12)	NS (RA=12)	Total
Number of Tables	9	11	6	26
Number of Figures	60	70	33	163
Total number of Visuals	69	81	39	189
Average number of Visuals	5.8	6.8	3.3	5.3

Close to the number of visuals identified in the R&D section, 11 types of visuals were found to support the arguments in the Methods section. They were 1) *line graph*, 2) *schematic diagram*, 3) *picture*, 4) *photo*, 5) *table*, 6) *block diagram*, 7) *scatterplot*, 8) *circuit chart*, 9) *contour plot*, 10) *3D graph*, and 11) *radiation graph*. Among the 11 visual types, eight of them were identified with the similar rankings of frequency to their rankings in the R&D section. *Line graph*, which was the most popular visual adopted in the R&D section, maintained its dominant place in the Methods but with a lower frequency of occurrence. *Schematic diagram* was found to become one of the dominant visuals that EE researchers employed for illustration of their proposed design or model. *Schematic diagram* is the topological representation claiming that space is a metaphor for something else (Gross & Harmon, 2014). The newly found visual types, *block diagram* and *circuit chart*, were found to be similar as *schematic diagram* for regarding space metaphorically. *Block diagram* is a kind of schematic diagram in which the main functions or parts are represented by blocks, and the wired connections between the blocks indicate the relationship between the blocks. It is often used in hardware design, circuit design, software design, and process flowchart. The function of *block diagram* is generally to compare the architectural and conceptual description, usually without detailed description of implementation. *Circuit chart*, another representation for space being a metaphor for the functional relationships that exist among the semiotic components along the virtual circuit starting at one point and ending at another point (Gross & Harmon, 2014), was also identified, however with limited occurrence in the three corpora. In a word, *schematic diagram*, together with *block diagram* and *circuit chart*, is metaphorically demonstrating functional relationships that exist among the components (Gross & Harmon, 2014). *Contour plot*, the last type of newly identified visuals, is to connect the points with the same height of the surface into a loop and directly project them to the plane to form a horizontal curve. However, this type of visual was only identified in 2 EERAs in the NS corpus.

Other visuals such as *picture*, *photo*, *table*, *scatterplot*, *3D graph*, and *radiation graph* almost stayed in the same rankings as they did in the R&D section. The results of the comparison among the three corpora could be seen from Tables 5.14-5.15, which show that the top three visuals among the three corpora are the same: *schematic diagram*, *picture*, and *line graph*. The employment of the visuals is more of a similarity rather than a variation. The reason that schematic diagram, picture, and line graph are the most popular ones was explained by Informant A as "Generally, these three kinds of visuals could reflect the main disciplinary philosophy of EE field. The RAs are mainly about the design and development of electronic devices or programs. Thus, these visuals are used to serve as virtual or real evidences of the design that could effectively strengthen the authors' argument, so that these visuals are counted as the most popular ones in our discipline."

Table 5.14 Summary of the number of RAs in which each visual occurs

Visual	CH (RA=12)		TH (RA=12)		NS (RA=12)		Whole corpus	
	No. of RAs	%	No. of RAs	%	No. of RAs	%	No. of RAs	%
1 Schematic diagram	11	91.7	10	83.3	8	66.7	29	80.6
2 Picture	8	66.7	9	75	2	16.7	18	52.8
3 Line graph	4	33.3	7	58.3	4	33.3	15	41.7
4 Photo	4	33.3	2	16.7	5	41.7	11	30.6
5 Table	5	41.7	7	58.3	4	33.3	16	44.4

Table 5.14 Summary of the number of RAs in which each visual occurs (Continued)

Visual	CH (RA=12)		TH (RA=12)		NS (RA=12)		Whole corpus	
	No. of RAs	%	No. of RAs	%	No. of RAs	%	No. of RAs	%
6 Block diagram	1	8.3	2	16.7	1	8.3	4	11.1
7 Scatterplot	1	8.3	1	8.3	0	0	2	5.6
8 Circuit chart	1	8.3	1	8.3	1	8.3	3	8.3
9 Contour plot	0	0	0	0	2	16.7	2	5.6
10 3D graph	0	0	1	8.3	1	8.3	2	5.6
11 Radiation graph	1	8.3	1	8.3	0	0.0	2	5.6

Table 5.15 Summary of the occurrence of each visual

Visual	CH (RA=12)		TH (RA=12)		NS (RA=12)		Whole corpus	
	Occurrence	%	Occurrence	%	Occurrence	%	Occurrence	%
1 Line graph	15	18.5	36	40	6	13.6	57	26.5
2 Schematic diagram	24	29.6	17	18.9	12	27.3	53	24.7
3 Picture	18	22.2	13	14.4	5	11.4	36	16.7
4 Photo	10	12.3	4	4.4	10	22.7	24	11.2
5 Table	9	11.1	11	12.2	6	13.6	26	12.1
6 Block diagram	1	1.2	3	3.3	1	2.3	5	2.3
7 Scatterplot	1	1.2	3	3.3	0	0	4	1.9
8 Circuit chart	2	2.5	1	1.1	1	2.3	4	1.9
9 Contour plot	0	0	0	0	2	4.5	2	0.9
10 3D graph	0	0	1	1.1	1	2.3	2	0.9
11 Radiation graph	1	1.2	1	1.1	0	0	2	0.9
Total	**81**	**100**	**90**	**100**	**44**	**100**	**215**	**100**

5.2.2.2 Description of VTMs

5.2.2.2.1 VTMs

The four VTMs, i.e., *Establishing presumptions* (EP), *Announcing results* (AR), *Discussion* (D), and *Displaying apparatus or site* (DAS) were identified in the Methods section. Among them, the three VTMs *EP*, *AR*, and *D* were inherited from Moghaddasi et al. (2019), another VTM in Moghaddasi et al. (2019) *Proof*

(P) was excluded since it was not identified in the three corpora of the EERAs. However, *DAS* was the newly added VTM in this framework. As can be seen from table 5.16, *EP* is the most frequent VTM and its occurrence in the 35 EERAs is 97.2%, indicating nearly all visuals in the Methods section participate in building the notations and concepts for every experimental action. VTM *AR,* with RA occurrence of 24 and total occurrence of 107, accounted for 66.7% of the 36 EERAs and 28.3% of the total occurrence in the whole corpus. VTMs *D* and *DAS* were also the last two VTMs in the Methods section, which coincided with their rankings in the R&D section.

Table 5.16 Summary of the VTMs in the whole corpus

VTM	No. of RAs in which the VTM occurs (RA=36)	%	Occurrence (RA=36)	%
Establishing presumptions (EP)	35	97.2	155	41.1
Announcing results(AR)	24	66.7	107	28.4
Discussion (D)	21	58.3	79	21
Displaying apparatus or site (DAS)	13	36.1	36	9.5
Total			378	100

1. *Establishing presumptions* (EP): VTM *EP* is employed to build foundations for the authors' claims by presenting the purpose, rationale, and procedure of each experimental action. Related concepts or notations are also introduced in this move. Examples 13 and 14 illustrate VTM *EP*. It can be seen from Example 13 that the authors informed readers of the purpose of "*embedding the designed RFID sensors in soil*" for "*high precision monitoring*" by employing the proposition "*for*". Then, the authors continued introducing the working principle and the experimental procedure. Example 14 clearly shows the rationale of the employment of certain experimental operation by using the phrase "*in order to…*" to reach the purpose of "*maximize the EM power coupling from the WR-3 feed to the lens antenna*".

(13) *The designed RFID sensors are embedded in soil <u>for</u> high precision monitoring. The patrol car, incorporating RFID reader and LoRa communication function, is*

responsible for collecting the information of embedded RFID sensors and communicate with the monitoring center. The monitoring center will store the received data and upload it to the cloud platform through wired or cellular mobile network. The cloud platform can analyses the data and make the corresponding decisions. (CH3)

(14) *In order to maximize the EM power coupling from the WR-3 feed to the lens antenna, an impedance matching section using a cavity with dimensions of a, b and m, as shown in Fig. 2(b), is introduced at the base of the antennas.* (TH5)

2. *Announcing results* (AR): presenting results is the main communicative purpose of this move. Numerical results accounted for a large proportion of results having been reported in EERAs. However, results could also be presented through visuals, e.g., the accomplished or in-process design or model. The noun "*results*" is the most apparent signal for this move. Examples 15 and 16 demonstrate VTM *AR*.

(15) *Besides, the phase angle and magnitude results of the combined three reflectors are depicted in Fig. 6.* (TH8)

(16) *Figure 3 (B) plots the S0 11 phase seen on the l00 feed for three different lengths. Phase variations of -13 and +16 compared to ∠S0 22 = ∠S0 33 = 180 can be seen at 60 GHz when the extremes of the search lengths are reached l00 = 2.96*λ*g, l01 = 3.04*λ*g.* (NS8)

3. *Discussion* (D): usually after presenting the results, authors would provide their explanation or interpretation, which tend to be more subjective than the results. Examples or evidences for validation of knowledge claims and relating the results to the previous studies and theories are also considered as means of interpretation and explanation. Examples 17 and 18 are illustrations of VTM *D*.

(17) *The application of AO systems would therefore be <u>ineffective</u> if the phase grating depicted in Fig. 1 introduces additional significant phase variations <u>due to</u> diffraction.* (NS2)

(18) *It is also observed in Figure 6 C,D that with the increase of the frequency, <u>less</u> currents are observed in the arm and <u>increased</u> currents move to the tapered area formed by the bottom part of the dipole where traveling wave distributions are spotted.* (CH7)

4. *Displaying apparatus or site* (DAS): this move introduces devices or components of devices, or it describes the experimental environment. Linguistic features suggesting this move include the phrases such as "*consist of*", "*is made of*", etc. numerical parameters are also used for detailed and specific descriptions of the devices and sites. Examples 19 and 20 are demonstrations for VTM *DAS*.

(19) *The wafer (NanoLN) consisted of a 500 μm thick silicon handle, a 4.7 μm thick thermal SiO2 layer, and a 600 nm thick x-cut LN thin-film (Fig. 2(a)).* (NS11)

(20) *The first component, a square plastic base made of polystyrene (PS), has a square cavity on one side as shown in Fig. 1b.*(TH4)

The number of VTM *EP* visuals displayed that visuals in the Methods section were mainly playing *Ontological* function by introducing materials, instruments, or experimental processes. Argumentative and epistemological functions were not the dominant functions for visuals in this section. Figure 5.1 shows the relationship between VTM and visual. In Figure 5.1, the functions of visuals could be displayed by their VTMs. VTM *AR* indicates a visual's epistemological function; VTM *D* indicates a visual's argumentative function*;* and VTMs *EP* and *D* both suggest a visual's ontological function. As the distinction of the functions of visuals is artificial (Moghaddasi et al., 2019), it is very likely that visuals fulfill a multifunctional role, which means that a visual could perform two, or even three functions. There are ample examples showing that a visual could display multiple functions simultaneously. A visual that plays an ontological role by illustrating the process of operation also plays an epistemological role by creating new knowledge through announcing results.

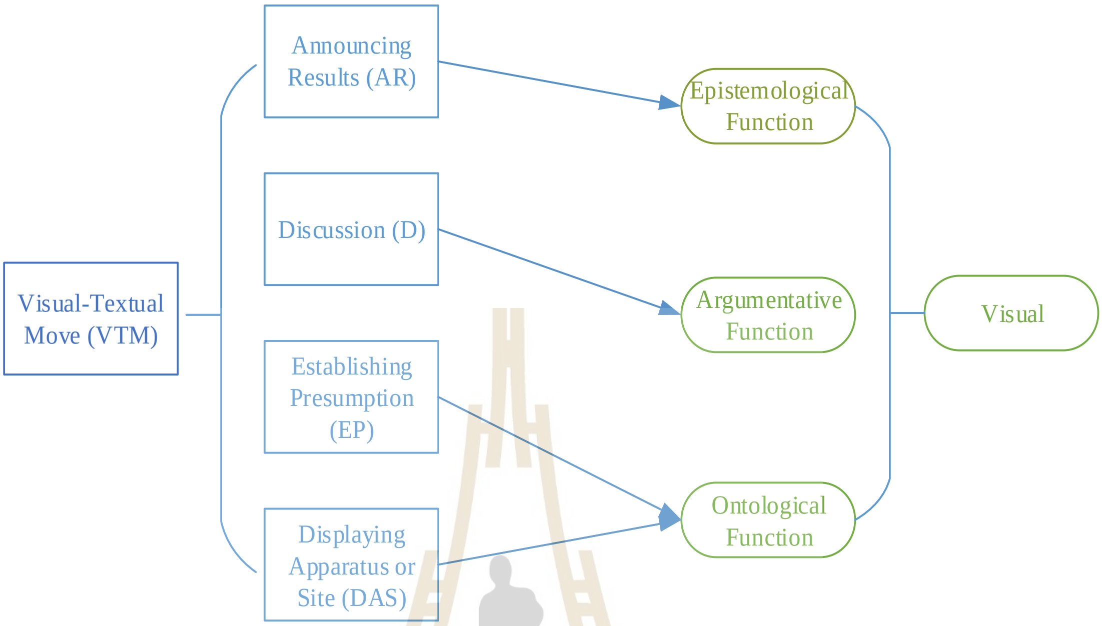


Figure 5.1 The relationship between VTM and visual

5.2.2.2.2 VTM Sequences and VTM Patterns

After all VTMs were identified, VTM sequence recognition was arranged for the preparation of categorizing VTM pattern of all of the visuals employed in the Methods section. Each visual was assigned to one VTM sequence and one VTM pattern Results showed that there were 40 VTM sequences identified in the whole corpus. Tables 5.17-5.18 provide the statistics for each VTM sequence. It can be obtained that VTM sequences *EP*, *AR*, *AR+D*, *EP+EP*, *AR+EP*, occupied the highest number of RAs in the whole corpus. The 40 VTM sequences were categorized into 9 VTM patterns, which is illustrated in Table 5.19. The categorization method was to only count in the VTM type, while the sequential order and occurrence frequency were left out of concern because the purpose of VTM analysis was to understand the rhetorical functions that a visual could perform. Sequential order and occurrence frequency were not the factors influencing the way that the visuals' functions were examined.

Table 5.17 The number of RAs in which each VTM sequence occurs

VTM Sequence	CH (RA=12)		TH (RA=12)		NS (RA=12)		Whole corpus	
	No. of RAs	%	No. of RAs	%	No. of RAs	%	No. of RAs	%
1 EP	7	58.3	9	75	8	66.7	24	66.7
2 AR	6	50.	8	66.7	2	16.7	16	44.4
3 EP+EP	5	41.7	5	41.7	1	0	11	30.6
4 AR+D	2	16.7	5	41.7	0	0	7	19.4
5 AR+EP	4	33.3	3	25	0	0	7	19.4
6 DAS	3	25	0	0	1	8.3	4	11.1
7 AR+D+AR+D	2	16.7	2	16.7	0	0	4	11.1
8 DAS+DAS	2	16.7	1	8.3	1	8.3	4	11.1
9 AR+D+D+D	0	0	3	25	1	8.3	4	11.1
10 AR+D+D	1	8.3	2	16.7	1	8.3	4	11.1
11 D	2	16.7	1	8.3	0	0	3	8.3
12 AR+EP+EP	3	25	0	0	0	0	3	8.3
13 EP+EP+EP	0	0	1	8.3	2	16.7	3	8.3
14 DAS+EP	2	16.7	0	0	1	8.3	3	8.3
15 AR+AR+D	1	8.3	0	0	1	8.3	2	5.6
16 EP+EP+EP+EP	1	8.3	0	0	1	8.3	2	5.6
17 AR+AR+EP	1	8.3	1	8.3	0	0	2	5.6
18 EP+EP+D	0	0	1	8.3	1	8.3	2	5.6
19 AR+AR	0	0	0	0	1	8.3	1	2.8
20 DAS+EP+EP+EP+EP	0	0	0	0	1	8.3	1	2.8
21 EP+EP+D+EP	0	0	0	0	1	8.3	1	2.8
22 EP+AR+AR	0	0	0	0	1	8.3	1	2.8
23 EP+EP+EP+D	0	0	0	0	1	8.3	1	2.8
24 EP+DAS+DAS+EP+DAS+DAS+EP	0	0	0	0	1	8.3	1	2.8
25 D+AR+EP	0	0	0	0	1	8.3	1	2.8
26 AR+EP+EP+EP+D	0	0	0	0	1	8.3	1	2.8
27 AR+D+EP+D	0	0	1	8.3	0	0	1	2.8
28 AR+D+EP+EP+EP	0	0	1	8.3	0	0	1	2.8
29 EP+D+EP+D+D+D	0	0	1	8.3	0	0	1	2.8
30 DAS+EP+EP+EP	0	0	1	8.3	0	0	1	2.8
31 AR+EP+EP+AR	0	0	1	8.3	0	0	1	2.8
32 EP+AR+D	0	0	1	8.3	0	0	1	2.8

Table 5.17 The number of RAs in which each VTM sequence occurs (Continued)

VTM Sequence	CH (RA=12)		TH (RA=12)		NS (RA=12)		Whole corpus	
	No. of RAs	%	No. of RAs	%	No. of RAs	%	No. of RAs	%
33 EP+EP+DAS+EP	1	8.3	0	0	0	0	1	2.8
34 EP+AR+EP+D+EP+EP	1	8.3	0	0	0	0	1	2.8
35 AR+EP+D	1	8.3	0	0	0	0	1	2.8
36 EP+AR+EP+EP	1	8.3	0	0	0	0	1	2.8
37 EP+D+EP+EP	1	8.3	0	0	0	0	1	2.8
38 EP+D	1	8.3	0	0	0	0	1	2.8
39 DAS+DAS+DAS+DAS+ DAS	1	8.3	0	0	0	0	1	2.8
40 DAS+DAS+DAS+DAS	0	0	1	8.3	0	0	1	2.8

Table 5.18 The occurrence of each VTM sequence in the three corpora

VTM Sequence	CH (RA=12)		TH (RA=12)		NS (RA=12)		Whole corpus	
	Occurrence	%	Occurrence	%	Occurrence	%	Occurrence	%
1 EP	13	18.8	14	17.3	15	38.5	41	22.2
2 AR	12	17.4	20	24.7	2	5.1	34	18
3 AR+D	6	8.7	16	19.8	0	0	22	11.6
4 EP+EP	6	8.7	5	6.2	1	2.6	13	6.3
5 AR+EP	4	5.8	5	6.2	0	0	9	4.8
6 DAS	5	7.2	0	0	4	10.3	9	4.8
7 D	3	4.3	2	2.5	0	0	5	2.6
8 AR+D+AR+D	2	2.9	3	3.7	0	0	5	2.6
9 DAS+DAS	2	2.9	1	1.2	1	2.6	4	2.1
10 AR+D+D+D	0	0	3	3.7	1	2.6	4	2.1
11 AR+D+D	1	1.4	2	2.5	1	2.6	4	2.1
12 AR+EP+EP	3	4.3	0	0	0	0	3	1.6
13 EP+EP+EP	0	0	1	1.2	2	5.1	3	1.6
14 DAS+EP	2	2.9	0	0	1	2.6	3	1.6
15 AR+AR+D	1	1.4	0	0	1	2.6	2	1.1
16 EP+EP+EP+EP	1	1.4	0	0	1	2.6	2	1.1
17 AR+AR+EP	1	1.4	1	1.2	0	0	2	1.1

Table 5.18 The occurrence of each VTM sequence in the three corpora (Continued)

VTM Sequence	CH (RA=12) Occurrence	CH (RA=12) %	TH (RA=12) Occurrence	TH (RA=12) %	NS (RA=12) Occurrence	NS (RA=12) %	Whole corpus Occurrence	Whole corpus %
18 EP+EP+D	0	0	1	1.2	1	2.6	2	1.1
19 AR+AR	0	0	0	0	1	2.6	1	0.5
20 DAS+EP+EP+EP+EP	0	0	0	0	1	2.6	1	0.5
21 EP+EP+D+EP	0	0	0	0	1	2.6	1	0.5
22 EP+AR+AR	0	0	0	0	1	2.6	1	0.5
23 EP+EP+EP+D	0	0	0	0	1	2.6	1	0.5
24 EP+DAS+DAS+EP+DAS+DAS+EP	0	0	0	0	1	2.6	1	0.5
25 D+AR+EP	0	0	0	0	1	2.6	1	0.5
26 AR+EP+EP+EP+D	0	0	0	0	1	2.6	1	0.5
27 AR+D+EP+D	0	0	1	1.2	0	0	1	0.5
28 AR+D+EP+EP+EP	0	0	1	1.2	0	0	1	0.5
29 EP+D+EP+D+D+D	0	0	1	1.2	0	0	1	0.5
30 DAS+EP+EP+EP	0	0	1	1.2	0	0	1	0.5
31 AR+EP+EP+AR	0	0	1	1.2	0	0	1	0.5
32 EP+AR+D	0	0	1	1.2	0	0	1	0.5
33 EP+EP+DAS+EP	1	1.4	0	0	0	0	1	0.5
34 EP+AR+EP+D+EP+EP	1	1.4	0	0	0	0	1	0.5
35 AR+EP+D	1	1.4	0	0	0	0	1	0.5
36 EP+AR+EP+EP	1	1.4	0	0	0	0	1	0.5
37 EP+D+EP+EP	1	1.4	0	0	0	0	1	0.5
38 EP+D	1	1.4	0	0	0	0	1	0.5
39 DAS+DAS+DAS+DAS+DAS	1	1.4	0	0	0	0	1	0.5
40 DAS+DAS+DAS+DAS	0	0	1	1.2	0	0	1	0.5
Total	69		81		39		189	

Table 5.19 Summary of the VTM sequences categorized into the VTM patterns

	VTM pattern	VTM sequence (N=40)
1	EP	1. EP; 3. EP+EP; 13. EP+EP+EP; 16. EP+EP+EP+EP;
2	AR	2. AR; 10. AR+AR
3	AR+D	4. AR+D; 7. AR+D+AR+D; 9. AR+D+D+D; 10. AR+D+D; 15. AR+AR+D
4	EP+AR	5. AR+EP; 12. AR+EP+EP; 17. AR+AR+EP; 22. EP+AR+AR; 31. AR+EP+EP+AR; 36. EP+AR+EP+EP
5	DAS	8. DAS+DAS; 39. DAS+DAS+DAS+DAS+DAS; 40. DAS+DAS+DAS+DAS
6	EP+DAS	14. DAS+EP; 20. DAS+EP+EP+EP+EP; 24. EP+DAS+DAS+EP+DAS+DAS+EP; 30.DAS+EP+EP+EP; 33. EP+EP+DAS+EP
7	EP+AR+D	25. D+AR+EP; 26. AR+EP+EP+EP+D; 27. AR+D+EP+D; 28. AR+D+EP+EP+EP; 32. EP+AR+D; 34. EP+AR+EP+D+EP+EP; 35. AR+EP+D
8	EP+D	18. EP+EP+D; 21. EP+EP+D+EP; 23. EP+EP+EP+D; 29. EP+D+EP+D+D+D; 37. EP+D+EP+EP; 38. EP+D
9	D	11. D

Note: the ID number of each VTM sequence was based on Table 5.17

Among the 40 VTM sequences identified in the Methods section across the three corpora, 22 VTM sequences occurred only once. They were therefore considered as miscellaneous sequences. However, with the lowest occurrence, each one of them was categorized as one VTM pattern in Table 5.19. Table 5.20 shows the summary of the 9 VTM patterns in the whole corpus. VTM pattern *EP* was in the first place of the number of RAs in which it occurred as well as the total occurrence, which indicated that visuals in the Methods section tend more to function ontologically. In addition, VTM patterns *AR*, *AR+D*, *EP+AR,* and *DAS* ranked the second, third, fourth, and fifth among all the VTM patterns, suggesting that visuals also participated in supporting two rhetorical functions simultaneously. VTM patterns *EP+DAS, EP+D, EP+AR+D,* and *D* occurred the least based on the smallest statistics shown on both the left and right columns in Table 5.20 below.

Table 5.20 Summary of the VTM patterns in the whole corpus

	VTM pattern	No. of RAs in which the VTM pattern occurs (RA=36)	%		VTM pattern	Occurrence (Visual=189)	%
1	EP	27	75	1	EP	59	31.2
2	AR	16	44.4	2	AR+D	37	19.6
3	AR+D	11	30.6	3	AR	35	18.5
4	EP+AR	11	30.6	4	EP+AR	17	9
5	DAS	9	25	5	DAS	15	7.9
6	EP+DAS	7	19.4	6	EP+DAS	7	3.7
7	EP+D	7	19.4	7	EP+AR+D	7	3.7
8	EP+AR+D	6	16.7	8	EP+D	7	3.7
9	D	3	8.3	9	D	5	2.6
					Total	189	100.00

5.2.2.2.3 Analysis of Visuals with VTMs

As shown from the analysis above, VTM and VTM pattern *EP* were the most prevalent one in the Methods section, which was of difference from that of the Results and Discussion section where *AR* was the dominant VTM and VTM pattern. Each of the nine VTM patterns identified in the Methods section was provided with one example, reproduced with their figure and VTMs, for analysis.

1) VTM pattern *EP*

Example 1 (Fig. 1, NS10) VTM sequence: *EP*

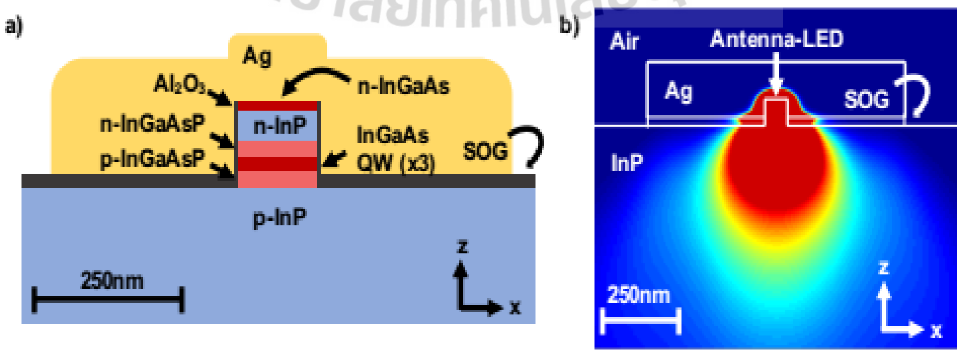


Fig. 1. (a) Vertical cross section schematic and (b) power flow of optical antenna-LED on a bulk InP substrate. The XZ cross section depicts the LED length and height.

injection [7]. As shown in Fig. 1(a), the cavity-backed slot antenna is self-aligned to an InP/InGaAs/InP ridge (length: ~130nm, width: 20nm, height: 140nm), where the height and length were chosen to tune the resonance frequency to best match the LED material spectrum, while maximizing the radiated power for the fundamental antenna mode. The antenna is (VTM *EP*)

The first example shows the most dominant VTM pattern *EP*. In the Methods section, the authors addressed the visuals mainly to describe and argue for their methods or methodology, and it was vital for them to provide evidence by using visuals because the readers inclined to believe what they see with their own eyes (Graves, 2014). The schematic graph is a demonstration of the proposed technology and specifically a virtual representation of the antenna with specific data and parameter labelled on them, which could strengthens the arguments put forward in the Methods section. This coincided with what Graves (2014) claimed that many readers would be extremely immersed in the technology and methods that generate the data that they tend to regard these graphs as unmediated representations of reality.

The text related to Figure 1 in NS 10 was identified as VTM *EP* based on the information it provides and the meaning it conveys. *EP* was a VTM that authors employ to explain their assumptions about the purpose, rationale and procedure of each experimental action. Usually the authors explained their design for certain reasons. Phrases such as "*to tune…*" and "*to best match…*" were the keywords for this VTM. This is only one example of VTM pattern *EP* with one VTM *EP* shown in the VTM sequence. Based on the identification of VTM sequences, there were also VTM sequences *EP+EP*, *EP+EP+EP*, and *EP+EP+EP+EP*, all of which belong to this VTM pattern. They were the same in the demonstration of the ontological function of the visuals.

2) VTM pattern *AR*

Example 2 (Fig. 5, TH5) VTM sequence: *AR*

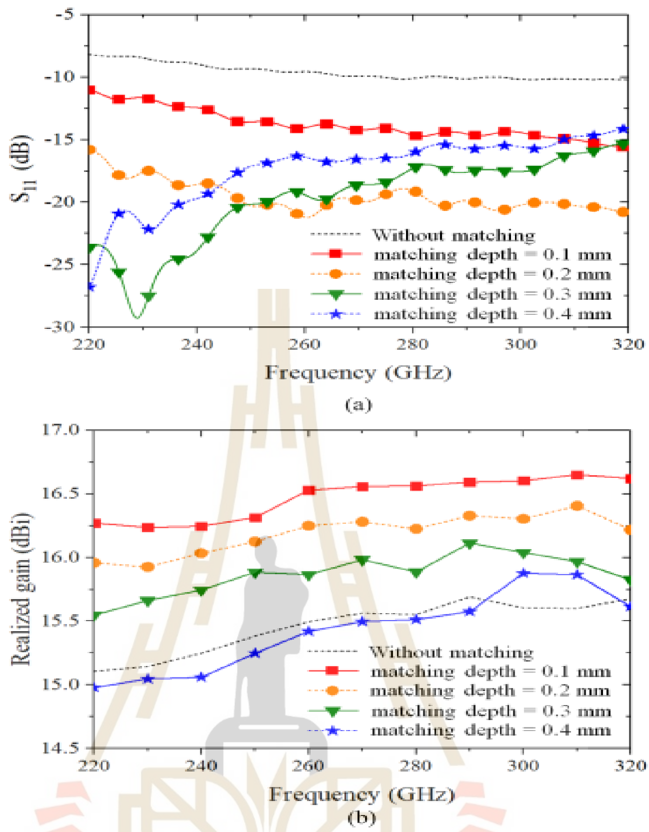


FIGURE 5. Simulated parametric study of the matching section depth, *m*, for (a) reflection coefficients (S_{11}) and (b) realized gain of antenna at 0°.

0.1–0.4 mm with a step of 0.1mm. Figs. 5 (a) and (b) show the simulation results of the reflection coefficients and realized gain, as functions of matching section depth, at the radiation direction at 0°, respectively. From the simulation results, (VTM *AR*)

Following VTM *EP*, *AR* is the next dominant VTM in the Methods section. The occurrence of VTM *AR* was in the first place in the R&D section, which was in agreement with the communicative purpose of the section. However, *AR* was also a prevalent VTM in Methods following *EP*. In Example 2, there is only one VTM *AR* being identified. The line graph in Figure 5 in TH5 shows the results of a fabrication of an antenna in a subsection with the heading of "*Lens Antenna Fabrication*" within the Methods section "*Lens antenna design and fabrication*". However, there were results reported by means of visuals within this section, and this was also a common feature of EE discipline since the number of VTM *AR* and VTM *D* was not small at all. The highlighted textual segment was identified as VTM *AR* based on the noun phrase "*the simulation results of…*", suggesting the visual's epistemological function of producing new facts under the conditions of "*as functions of…*" and "*at the radiation direction at …*". New knowledge or new facts produced in this section provide solid support for the researchers to conduct the following methodological procedure.

3) VTM pattern *AR+D*

Example 3 (Fig. 5, CH5) VTM sequence: *AR+AR+D*

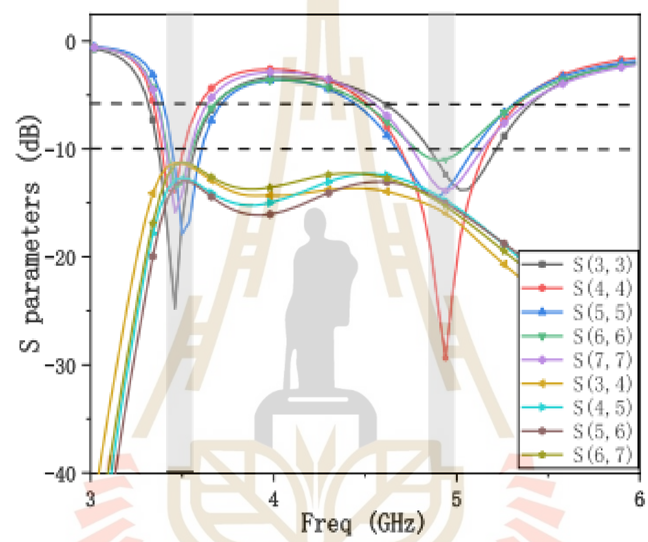


FIGURE 5. Simulated S-parameters of Ant 3 to Ant 7.

of the main board, as shown in Fig. 1(a). The simulated S-parameters of the 5G module's five left hand side antennas are presented in Fig. 5. Owing to the symmetry of the (VTM *AR*)

generally identical to those of Ant3 to Ant7. For brevity, Fig. 5 only presents the results of Ant3 to Ant7. As can (VTM *AR*)

Fig. 5 only presents the results of Ant3 to Ant7. As can be seen in this figure, the simulated reflection coefficients (S_{33}, S_{44}, S_{55}, S_{66}, and S_{77}) of five antennas are less than −6 dB (3:1 VSWR) in the bands of 3.31 ∼ 3.70 GHz and 4.46 ∼ 5.40 GHz, covering the 3.5-GHz band and 4.9-GHz band for 5G applications. The isolation between each pair of (VTM *D*)

VTM pattern *AR+D* ranked the third among all the VTM patterns. This two-VTM combination pattern was also commonly identified since creating new knowledge and facts might be a necessary and indispensable step for the following methodological procedure, as discussed in Example 2. In addition to VTM *AR* alone, VTM *D* was identified to be the usual company of AR. This VTM pattern that commonly occurs in the R&D section is also popular in the Methods section. Figure 5 in CH5 in Example 3 was identified with three sets of texts associated with it. The first textual segment was identified as VTM *AR* according to the meaning it conveys through the sentence "*the simulated S-parameter of ...are presented*" by informing the readers of the parameter gained from the figure. The second textual segment associated with the figure was also identified as VTM *AR* by the signal word "*results*". The last set of textual segment, following the second one, served as discussion by providing explanation or interpretation of the results shown in Figure 5. The phrase "*are less than*" and the V-ing clause "*covering...*" suggested the argumentative function of the figure. Therefore, the figure demonstrates two rhetorical functions: epistemological and argumentative. This pattern covers VTM sequences such as *AR+D+AR+D*, *AR+D+D*, *AR+D+D+D*, etc.

4) VTM pattern *EP+AR*

Example 4 (Fig. 3, NS8) VTM sequence: *EP+AR+AR*

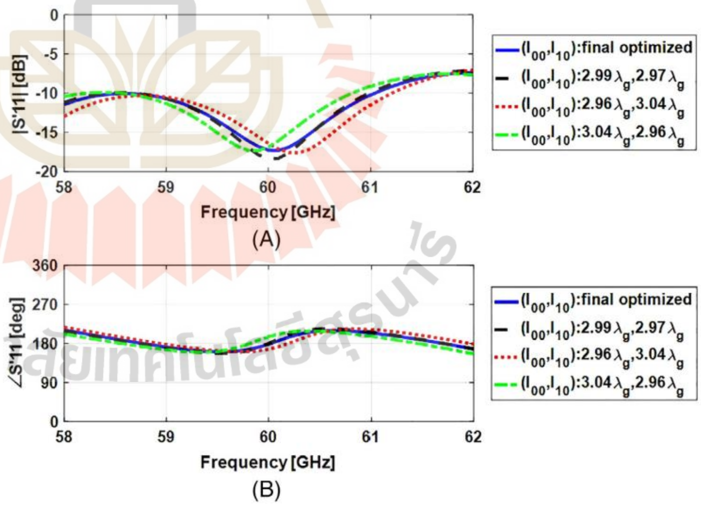


FIGURE 3 Plot of S'_{11} (A) magnitude, and (B) phase, corresponding to the transition feed l_{00} for key combinations of searched feed lengths

Figure 3 plots the magnitude and phase for S'_{11} (corresponding to feed l_{00}) as a sample, because this is the case with the most sensitivity to the feed length. In general, (VTM *EP*)

Figure 3(B) plots the S'_{11} phase seen on the l_{00} feed for three different lengths. Phase variations of $-13°$ and $+16°$ compared to $\angle S'_{22} = \angle S'_{33} = 180°$ can be seen at 60 GHz when the extremes of the search lengths are reached $l_{00} = 2.96\lambda_g$, $l_{01} = 3.04\lambda_g$. The best performing combination occurred at (VTM *AR*)

$l_{00} = 2.99\lambda_g$, $l_{01} = 2.97\lambda_g$. Final dimensions for l_{00} and l_{01} were found for the fully integrated antenna system (solid blue curves in Figure 3), yielding values of $2.993\lambda_g$ and $2.976\lambda_g$, respectively, which are very close to the best performing search combination (dashed black curve in Figure 3). (VTM *AR*)

Figure 3 in NS8 in Example 4 was identified as VTM sequence *EP+AR+AR* falling into the VTM pattern *EP+AR*. Seventeen visuals were found to be in this category. As can be seen from sets of texts referring to the figure, the first set of text was identified as VTM *EP* since it informs the readers of a state of "*the magnitude and phase*" of the case "*most sensitivity to the feed length*". The second set of text was also regarded as VTM *EP* since it mainly reports the direct results yielded from "*three different lengths*". The last set of text was identified as VTM *AR* since the V-ing phrase "*yielding values of...*" expresses clearly most salient communicative purpose of announcing results. Visuals with VTM pattern EP+AR demonstrate both epistemological and argumentative functions.

5) VTM pattern *DAS*

Example 5 (Fig. 2, CH2) VTM sequence: *DAS*

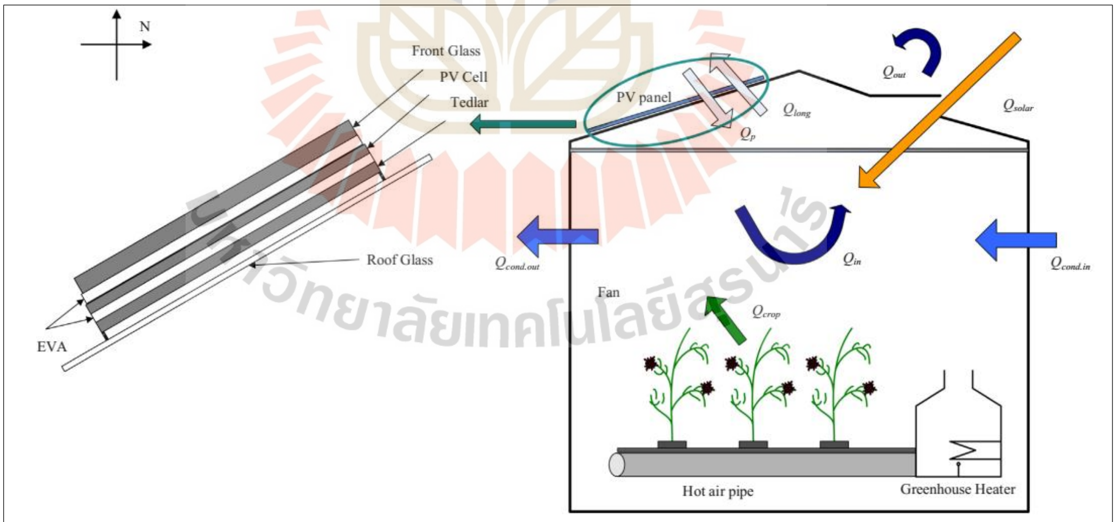


Fig. 2. The heat transfer in the PVIG and PV panels.

Tripanagnostopoulos, 2006). The PV panel is divided into 6 layers, including the front glass, the upper EVA, the ARC, the PV cell, the back EVA and the Tedlar-based back sheet (Fig. 2). The PV panels mounted (VTM *DAS*)

There were fourteen visuals demonstrating epistemological function through informing readers of their devices or apparatuses of the experimental setups. Figure 2 in Example 5 illustrates "*the heat transfer in the PVIG and PV panels*" by providing a schematic graph with several arrows of different colors and shapes pointing to different directions, which illustrates the working principle of "*the PVIG and PV panels*". This schematic graph, being a metaphor for the real experimental scene, helps the readers construct and directly perceive the real process. There was only one set of text pointing to this visual since it introduces the composition of "*the PV panel*" by using the phrases "*is divided into…*" and "*including…*", so it was identified as VTM *DAS*.

6) VTM pattern DAS+*EP*

Example 6 (Fig. 4, NS6) VTM sequence: *DAS+EP*

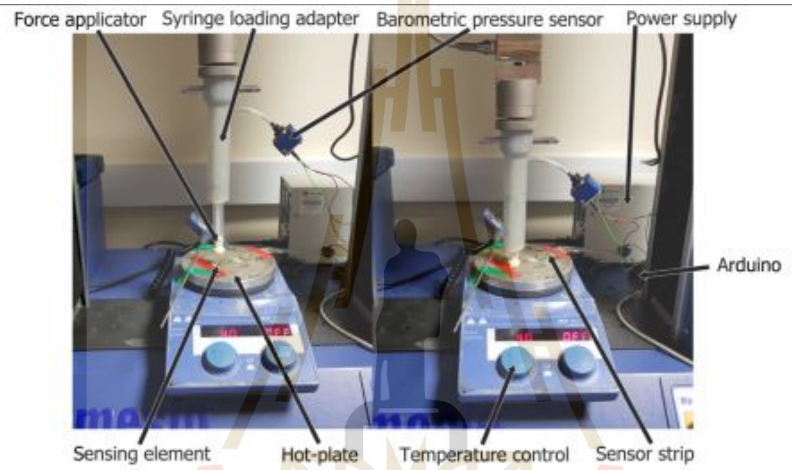


Fig. 4. The syringe loading adapter attached to the MecMesin machine head applying load to a sensor on a hot-plate. Left displays the syringe extended and right displays the syringe compressed.

cation adapter. The adapter is comprised a 3D printed column

fitted with a syringe, attached to a barometric pressure sensor [see Fig. 4]. The sensor allowed chamber pressure to be (VTM *DAS*)

The effect of elevated temperature on the response of the sensors was explored by heating the sensors with a hot-plate [see Fig. 4] to temperatures of 20°C, 30°C and 40°C. (VTM *EP*)

Fig. 4 in NS6 in Example 6 is the representation of equipment in the photo where we could see the actual equipment in the experimental site, rather than the iconic apparatus depicted in Example 5. Gross & Harmon (2014) claimed that photos allowed the readers to witness what the researchers had seen in the field or laboratory. The two photos in Figure 4 represent different modes under operation. Two sets of texts were identified as VTM *DAS* and VTM *EP*, respectively. The first set of text only introduces the components of "*the adapter*" by using the verb phrase "*is comprised*". The second set of text mainly informs the readers that "*the response of the sensors*" could be obtained by integrating the three steps "*to temperatures of 20 ℃, 30 ℃, and 40 ℃*" into the experiment. That means, both of the two VTMs *DAS* and *EP* perform ontological function for the visual.

7) VTM pattern *EP+AR+D*

Example 7 (Fig. 2, CH11) VTM sequence: *EP+AR+EP+D+EP+EP+EP*

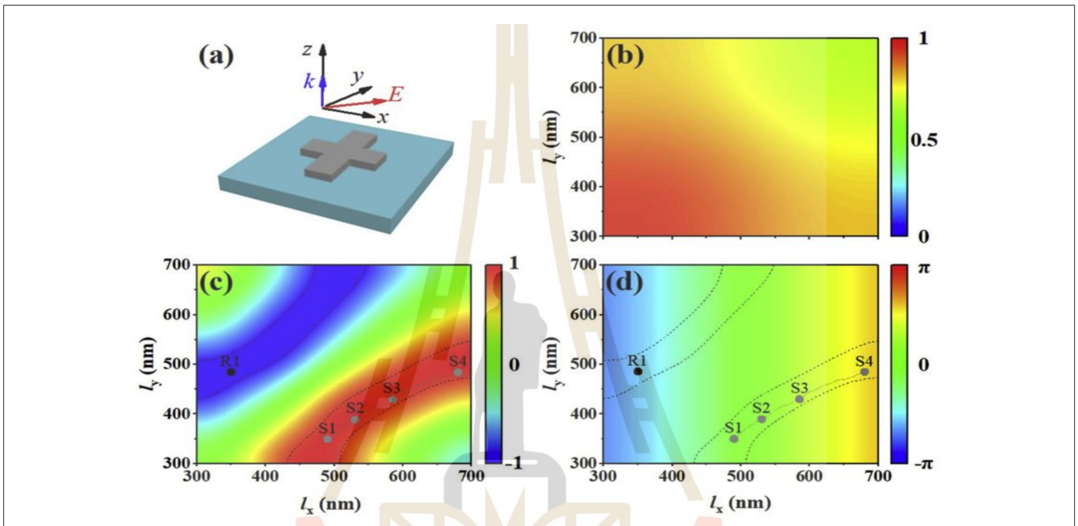


Fig. 2. (a) Illustration of a single cross-shaped antenna unit and polarization angle of the incident LP light. (b) Transmission magnitude, (c) ellipticity, and (d) corresponding phase variations along the *x*-direction (φ_x) for 45°-polarized light as a function of arm lengths (l_x and l_y) ranging from 300 nm to 700 nm. Simulations were conducted at a wavelength of 1550 nm.

z-axis was defined as a perfectly matched layer. Optical constants for silica and silicon were obtained from Palik [31]. Excitation was provided using 45°-LP light, normally incident along the *z*-axis (as depicted in Fig. 2(a)), with a wavelength of 1550 nm. Following (VTM *EP*)

Fig. 2(a) illustrates an antenna unit and the polarization direction of the incident light. (VTM *AR*)

Fig. 2(a) illustrates an antenna unit and the polarization direction of the incident light. The simulated transmission magnitude, calculated ellipticity, and phase difference along the *x*-direction for the incident 45°-LP light are depicted as a function of the two arm lengths (l_x and l_y) in Figs. 2(b)–(d). It can be observed that the magnitude of transmission is greater than 60 % for the range of arm (VTM *EP*)

It can be observed that the magnitude of transmission is greater than 60 % for the range of arm lengths considered (300–700 nm). (VTM *D*)

determined by the phase retardation between the two CP states along the *x*-direction. For continuous control of the polarization angle of light, it is necessary to strictly select the parameters of the cross-shaped antenna from Fig. 2(d) to yield the appropriate phase variations. (VTM *EP*)

Based on the above considerations, we first fixed the parameters of the cross-shaped antenna at l_{x1} = 350 nm and l_{y1} = 490 nm (denoted by R1 in Fig. 2(d)), yielding a phase variation of $\varphi_{x1} = -\pi/2$. Subsequently, to generate the LP light with polarization angles (VTM *EP*)

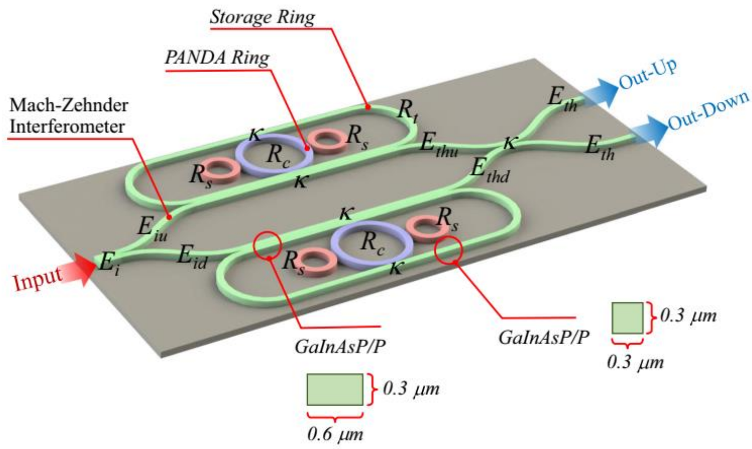
(denoted by R1 in Fig. 2(d)), yielding a phase variation of $\varphi_{x1} = -\pi/2$. Subsequently, to generate the LP light with polarization angles of 45°, 60°, 75° and 90°, a series of cross-shaped antennas with parameters set as l_{x2} = 490 nm and l_{y2} = 350 nm (S1), l_{x2} = 530 nm and l_{y2} = 390 nm (S2), l_{x2} = 585 nm and l_{y2} = 430 nm (S3), and l_{x2} = 680 nm and l_{y2} = 480 nm (S4), as shown in Fig. 2(d), corresponding to phase variations of φ_{x2} = 0, $\pi/6$, $\pi/3$, and $\pi/2$, respectively. (VTM *EP*)

In the whole corpus, seven visuals were identified with the three VTMs: *AR*, *EP*, and *D*. In Example 7, the visual containing four images a, b, c, and d. Image (a) is a three-dimensional graph of a single cross-shaped antenna unit. Images (b), (c), and (d) are the different parameters revealed from the optical spectrums. Seven sets of texts were identified to be associated with Figure 2 in CH11. VTM *EP* was assigned to the first set of text based on the V-ing phrase "*using…*" to announce the methods the researchers adopted. The second set of text, also referring the Image (a) in this figure, presents "*the antenna unit*" and "*the polarization direction*", which was interpreted as a form of presenting results. It was therefore identified as VTM *AR*. VTM *EP* was assigned to the third set of text because the parameters displayed through the three Images (b), (c), and (d) were "*depicted as a function of the two arm length*", informing the readers of the operation and calculating process. The fourth set of text was VTM *D* since "*can be observed that…*" signals the researchers' interpretation of the Images. VTM *EP* was assigned to the fifth set of text due to the communicative purpose of the sentence "*For…, it is necessary to …*" which is mainly to introduce the rationale of an action to the readers. The sixth set of text was also recognized as VTM *EP* owing to the operational process being introduced based on certain considerations mentioned earlier. The last set of text was identified as *EP* since the purpose of the subsequent operational action was signaled by the infinitive marker "*to…*". The analysis of VTMs of Example 7 suggested this visual is multifunctional, demonstrating all ontological, epistemological as well as augmentative functions at the same time.

8) VTM pattern *EP+D*

Example 8 (Fig. 1, TH3) VTM sequence: *EP+EP+D*

Fig. 1 Schematic of on-chip inline successive pumping of light in a Mach–Zehnder Interferometer



The electrical field output ($E_{(WGM)}$) of the WGM beam which can be generated within the system as shown in Figs. 1, 2, is given by (Phatharacorn et al. 2017; Phatharacorn et al. 2018). (VTM *EP*)

are obtained. Next, by using Eqs. (3) and (4), the optical input field (E_{in}) and output field (E_{th}) of the closed loop Panda-ring system, as shown in Fig. 1, are obtained [further details of this are found in the literature (Amiri et al. 2012; Phatharawaramet et al. 2010)]. (VTM *EP*)

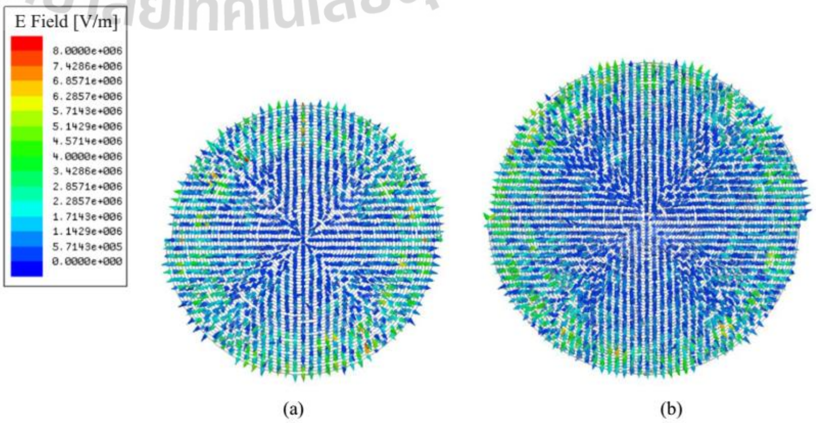
From Fig. 1, it can be seen that the throughput port output can be observed, due to the resonant condition. (VTM *D*)

The VTM pattern *EP+D* was identified for seven visuals in the whole corpus. Example 8 is the visual with the VTM sequence *EP+EP+D*. The first set of text was identified as VTM *EP* based on the attributive clause "*which can be generated ...by...*" suggesting the methods employed by previous studies "*Phatharacorn et al. (2017) and Phatharacorn et al. (2018)*". The second set of text, similarly introducing the methods signaled by propositional phrase "*by using Eqs. (3) and (4)*", was identified as another VTM *EP* for the figure. The last set of text was recognized as VTM *D* since it interpreted the results and provided the reason with the phrases "*it can be seen that...*" and "*due to...*", respectively. The visual of this VTM pattern displays two rhetorical functions *ontological* and *argumentative* at the same time.

9) VTM pattern *D*

Example 9 (Fig. 2, CH12) VTM sequence: *D+D*

Fig. 2 E-field distributions of the spiral radiation patch at 8.5 THz in State I (**a**) and 6.3 THz in State II (**b**)



As shown in

Fig. 2a, b, along the direction of the feeding branches, there is a strong field distribution on the spiral radiation patch.

(VTM *D*)

Besides, there also exist the coupling within adjacent spiral arms and current flowing along the spiral arms. The electric

(VTM *D*)

VTM pattern *D* in Example 9 reveals that visuals in the Methods section could perform argumentative function alone. In the first set of text, the "*field distribution*" observed was interpreted as "*strong*" and the second set of text continued with further interpretation "*there also exist…*" for the E-field distributions. Therefore, both sets of texts were recognized as VTM *D*. Five visuals in the whole corpus were under the category of VTM pattern *D*.

5.2.2.3 Comparison of VTMs and VTM Patterns

5.2.2.3.1 Comparison of VTMs

Tables 5.21-5.22 demonstrate that VTM *EP* holds the highest occurrence in the highest number of RAs in the whole corpus. It occurred in 35 EERAs with the occurrence of 155, implying that the visuals' main communicative purpose in the Methods section was to establish presumptions such as informing readers of the experimental rationale, justification, and procedure of their proposed model and design. However, a variation among the three corpora was found in VTM *EP*, too. From Table 5.21, *EP* occurred the most frequently in the CH and NS corpora, while it ranked the second in the TH corpus, where VTM *AR* occurred the most frequently. It could be noticed that the occurrence of the VTMs *EP* and *AR* in the CH and TH did not show as much discrepancy as the NS corpus did. That is, VTM *EP* was identified to occur 45 times and VTM *AR* 58 times in the TH corpus, showing Thai EE researchers' preference of *AR* as well as *EP* for supporting the visuals in their EERAs. The CH corpus implied a similar picture as the TH corpus. Though with the occurrence of 37, which is approximately half occurrence of VTM *EP*, VTM *AR* was found in 10 out of 12 EERAs, showing not great differences in the researchers' adoption of these two VTMs for their visuals. The NS corpus, however, showed a different picture from the CH and NS corpora by clearly showing its tendency of VTM *EP*, since both Table 5.21 and Table 5.22 reveal the occurrence of VTM *EP* in the NS corpus is 47, while *AR*, *D*, and *DAS* occurred 12, 11, and 12 times, respectively. The number of RA in which these three VTMs occurred was 5, 5, and 3, respectively. This implied NS researchers' strong tendency toward employing visuals to help establish a theoretical foundation for their proposed design or model. Chinese and Thai researchers tend to employ both EP and AR when relating to their visuals.

Table 5.21 The occurrence of VTMs in the Methods section in the three corpora

VTM	CH (RA=12)		TH (RA=12)		NS (RA=12)		Whole corpus (RA=36)	
	Occurrence	%	Occurrence	%	Occurrence	%	Occurrence	%
1 Establishing presumptions (EP)	63	46	45	28.5	47	57.3	155	41.1
2 Announcing results(AR)	37	27	58	36.7	12	14.6	107	28.4
3 Discussion (D)	20	14.6	48	30.4	11	13.4	79	21
4 Displaying apparatus or site (DAS)	17	12.4	7	4.4	12	14.6	36	9.5
Total	137	100	158	100	82	100	377	100

Table 5.22 The number of RAs in which each VTM occurs in the Methods section in the three corpora

VTM	CH (RA=12)		TH (RA=12)		NS (RA=12)		Whole corpus (RA=36)	
	No. of RAs	%	No. of RAs	%	No. of RAs	%	No. of RAs	%
1 Establishing presumptions (EP)	12	100	12	100	11	91.7	35	97.2
2 Announcing results(AR)	10	83.3	9	75	5	41.7	24	66.7
3 Discussion (D)	7	58.3	9	75	5	41.7	21	58.3
4 Displaying apparatus or site (DAS)	7	58.3	3	25	3	25.0	13	36.1

5.2.2.3.2 Comparison of VTM Patterns

When examining the individual VTMs and their occurrence, the overall condition of VTM employment in the whole section could be understood. When exploring VTM pattern, we could acknowledge the situation adopted by EE researchers to refer to each visual. In other words, each visual's VTM pattern could be obtained and demonstrated. As categorized in section 5.2.2.2.2, the nine VTM patterns were 1) *EP*, 2) *AR*, 3) *AR+D*, 4) *EP+AR*, 5) *DAS*, 6) *EP+DAS*, 7) *EP+AR+D* 8) *EP+D* and 9) *D*. Among the three corpora, VTM pattern *EP* is the most prevalent for EE researchers to support their visuals in the Methods section. This pattern occurred in 8, 10, and 10 RAs in the CH, TH, and NS, respectively, which is one similarity identified among the three corpora. What's more, the CH and TH were found to demonstrate similarity rather than difference based on the statistics in Tables 5.23-5.24. It could be observed that both of the writer groups tended to employ VTM pattern *EP* and *AR* as textual support for their visuals, indicating most visuals in the Methods section in the CH and TH corpora perform solely ontological and epistemological functions. Other VTM patterns except for *AR+D* and *EP+AR* also demonstrate similarity.

The variations among the three corpora observed was mainly the difference between the first two corpora, CH and TH, and the third NS corpus since both the CH and TH corpora showed their tendency of employing three to four VTM patterns when associating with the visuals. Specifically, the frequencies of VTMs *EP*, *AR*, *AR+D*, and *EP+AR* show more of similarity between the CH and the TH. The only subtle difference of VTM patterns is found between *AR+D* and *EP+AR*. The former occurred in less than 50% of EERAs in the CH but exactly the half in the TH, whereas the latter occurred in 50% of the EERAs in the CH but less than 50% in the TH. Compared with the CH and the TH, the NS corpus showed an obvious inclination towards one VTM pattern *EP* since the three VTMs *AR*, *AR+D*, *EP+AR* occurred only in 2, 2, and 1 EERA in the NS corpus. Other VTM patterns were not popularly adopted in the NS corpus. To sum up, Chinese writers tend to adopt VTM patterns *EP*, *AR*, and *EP+AR*; Thai researchers tend to employ VTM patterns *EP*, *AR*, and *AR+D*; NS writers tend to use VTM pattern *EP* to support the visuals in the Methods section.

Table 5.23 The number of RAs in which each VTM pattern occurs in the Methods section in the three corpora

	VTM pattern	CH (Visual=69)		TH (Visual=81)		NS (Visual=39)		Visual=189	
		No. of RAs	%	No. of RAs	%	No. of RAs	%	Total	%
1	EP	8	66.7	10	83.3	9	75	27	75
2	AR	6	50	8	66.7	2	16.7	16	44.4
3	AR+D	3	25	6	50	2	16.7	11	30.6
4	EP+AR	6	50	4	33.3	1	8.3	11	30.6
5	DAS	5	41.7	2	16.7	2	16.7	9	25
6	EP+DAS	3	25	1	8.3	3	25	7	19.4
7	EP+AR+D	2	16.7	2	16.7	2	16.7	6	16.7
8	EP+D	2	16.7	2	16.7	3	25	7	19.4
9	D	2	16.7	1	8.3	0	0	3	8.3

Table 5.24 The occurrence of VTM patterns in the Methods section in the three corpora

	VTM pattern	CH (Visual=69)		TH (Visual=81)		NS (Visual=39)		Visual=189	
		Occurrence	%	Occurrence	%	Occurrence	%	Total	%
1	EP	20	29	20	24.7	19	49	59	31.2
2	AR	12	17.4	20	24.7	3	7.7	35	18.5
3	AR+D	10	14.5	24	29.6	3	7.7	37	19.6
4	EP+AR	9	13.	7	8.6	1	2.6	17	9
5	DAS	8	11.6	2	2.5	5	12.8	15	7.9
6	EP+DAS	3	4.4	1	1.2	3	7.7	7	3.7
7	EP+AR+D	2	2.9	3	3.7	2	5.1	7	3.7
8	EP+D	2	2.9	2	2.5	3	7.7	7	3.7
9	D	3	4.4	2	2.5	0	0	5	2.6
	Total	**69**	**100**	**81**	**100**	**39**	**100**	**189**	**100**
	No. of RAs	**12**		**12**		**12**	**12**	**36**	

To summarize the findings of the Methods section, three moves and nine steps were found throughout the corpus. The differences among the three corpora were one move and three steps. The results revealed that *Move 1* and

Step 1.2 were adaptable. They were deemed the most important by Chinese writers to include in the Methods section. Thai researchers thought they were mildly important; NS authors thought they were less important than *Moves 2 Describing experimental procedure* and *3 Demonstrating data or design analysis*. Furthermore, Chinese writers regarded *Steps 2.1* and *2.2* as two equally fairly significant techniques, with Chinese scholars selecting for one of them rather than both. Thai researchers favored *Step 2.1*, but NS prefers *Step 2.2*.

Establishing presumptions (EP), *Announcing findings* (AR), *Discussion* (D), and a new VTM *Displaying apparatus or site* (DAS) were indicated in the Methods section. The VTM patterns in this section were 1) EP, 2) AR, 3) AR+D, 4) EP+AR, 5) DAS, 6) EP+DAS, 7) EP+D, 8) EP+AR+D, and 9) D. Visuals in the Methods section mostly served ontological function. Chinese and NS researchers were found to be more similar in that they used visuals to perform ontological function or to assist in informing their readers of their specific methods, whereas Thai researchers were found to be different in that, in addition to the ontological function that the visuals played, they were also used for reporting and commenting on the results of some experimental procedures.

5.2.3 The Interaction between Move-Step Structure and VTM

Move-step structure and VTM are two different aspects that help build the communicative purposes of the EERA genre. The former refers to the textual language-based organizational pattern, while the latter is related to visuals serving as evidentiary support to the textual language. The present study, after having finished analyzing the move-step structure and VTM of the Methods and the R&D sections, found that the interaction between move-step structure and VTM was their consistency in supporting each sections' main functions. In other words, the main communicative purpose of each section was the joint contribution of both the moves, the steps, and the visuals since the RA in the EE discipline, to a large extent, tended to contain both of the two semiotics: written English and non-verbal material. The findings of the Methods and R&D sections in terms of the move, steps, and VTMs demonstrated obvious consistency in the main communicative purpose. Specifically, the Methods section was mainly to inform readers of the employed methodology as well as argue for its reasonableness.

The moves and steps identified in this section in all of the three corpora including *Move 1 Introducing material or instrument*, *Move 2 Describing experimental procedure*, and *Move 3 Demonstrating data or design analysis* all perform the main informing role of this section. VTMs, assisting to understand visuals' rhetorical functions, were found to support this informing role since *Establishing presumptions* (EP) was the most dominant VTM in the Methods section, suggesting visuals' main ontological role, in which definitions and operations were usually introduced and demonstrated (Moghaddasi et al., 2019). This consistency of the moves, steps and the visuals was also displayed in the R&D section. The moves and steps in the R&D section such as *Move 2 Reporting results* and *Move 3 Commenting on results* were identified to be in agreement with the main communicative purposes of announcement and explanation of the results in this section. Likewise, *Announcing results* (AR) and *Discussion* (D) were the two dominant VTMs that supported the visuals in this section, implying visuals' main epistemological and argumentative roles for both creating new knowledge and supporting claims by evaluating the results. Hence, the moves, steps and VTMs working together could play a more active role in meaning making.

5.3 Summary

This chapter has provided the results and discussion from analyzing the moves, steps, move-step structure, and VTMs of the Methods section based on the three move-step frameworks (Kanoksilapatham 2005, 2015; Maswana et al., 2015) and the VTM framework (Moghaddassi et al., 2019). The results of move-step structure analysis showed that there were three moves and nine steps in the newly proposed move-step structure. Also, the results showed the variations existed in the employment of the moves, steps in the newly proposed move-step structure among the EERAs composed by Chinese, Thai, and Native English speaking writers. VTM and VTM pattern analysis revealed that in the Methods section, visuals tended more to participate in ontological function.

CHAPTER 6

RESULTS AND DISCUSSION
OF THE RESULTS AND DISCUSSION SECTION

Since the Results and Discussion (R&D) section was previously included in Chapter 3 as the pilot study in the researcher's proposal, its data analysis process and the inter-rater reliability were decided by the researcher to remain in Chapter 3. The results and discussion of the R&D section, however, are presented in this chapter. Firstly, it provides an overview of the R&D section in EERAs. Secondly, the results and discussion of move-step analysis including the description of the moves and steps and the comparison of move-step structures among the CH, TH, and NS corpora are presented. Finally, results and discussion of VTM analysis which consist of description and comparison of VTMs are demonstrated.

6.1 Overview of the Results and Discussion (R&D) Section

Table 6.1 shows a summary of the headings of the R&D sections in EERAs across the three corpora. There were 8, 7 and 5 EERAs in the CH, TH and NS respectively maintaining the conventional section heading "Results and Discussion". Few cases with alternative functional headings (e.g., Results; Discussion; Experimental Validations) or content headings (e.g., Simulated Results; Implementation and Experimental Results; Experimental Results and Discussion). In addition, there were also 3 cases arranging Results and Discussion as two separate sections (CH12, NS6, and NS11). Despite the heading differences, the sections shared the common characteristics of the R&D section, which were reporting results and commenting on results. Therefore, all these sections were categorized as *Results and Discussion* in the proposed framework.

Table 6.1 Original heading and heading category of the R&D section in the three corpora

CH			TH			NS		
	Original heading	Heading category		Original heading	Heading category		Original heading	Heading category
CH1	Results and Discussion	R&D	TH1	Results and Discussion	R&D	NS1	Results and Discussion	R&D
CH2	Results and Discussion	R&D	TH2	Results and Discussion	R&D	NS2	Experimental Results	R
CH3	Results and Discussion	R&D	TH3	Simulation results	R	NS3	Results and Discussion	R&D
CH4	Results and Discussion	R&D	TH4	Results and Discussion	R&D	NS4	Results and Discussion	R&D
CH5	Results and Discussion	R&D	TH5	Measurement Results	R	NS5	Experimental validation	R&D
CH6	Results and Discussion	R&D	TH6	Results and Discussion	R&D	NS6	Results Discussion	RD
CH7	Results and Discussion	R&D	TH7	Implementation and Experimental Results	R	NS7	Measurement Results	R
CH8	Experimental results	R	TH8	Results and Discussion	R&D	NS8	Antenna Measurement	R&D
CH9	Analysis of array antennas in flip chip packaging; Experimental results of Nb_5N_6 THz array detectors integrated with double- slot antennas	R	TH9	Results and Discussion	R&D	NS9	Results and Discussion	R&D
CH10	Experimental Results and Discussion	R&D	TH10	Results and Discussion	R&D	NS10	Discussion	D
CH11	Results and Discussion	R&D	TH11	Simulation Results and Discussion	R&D	NS11	Measurement Discussion	R&D
CH12	Simulated Results; Parametric Discussion	R&D	TH12	DTTV–SFN Propagation Evaluation and Discussions R&D	R&D	NS12	Results and Discussion	R&D

6.2 Results and Discussion

6.2.1 Results and Discussion of Move-Step Analysis

In this section, moves, steps and their frequency, as well as move sequence and move cycle are discussed. From the analysis, it was found that there were three moves in the R&D section in the EERAs in the three corpora, *Move 1: Preparatory information*, *Move 2: Reporting results*, and *Move 3: Commenting on results*. Except for Move 2, both Move 1 and Move 3 have six steps. The proposed framework for the R&D section is shown below in Table 6.2.

Table 6.2 The revised framework for the EERA R&D section

Section (N=36)	Move and Step	%	Status
Results and Discussion	**1. Preparatory information**	91.7	Obl
	1.1 Introducing the section	5.6	Opt
	1.2 Specifying equipment or site	5.6	Opt
	1.3 Explaining principles	19.4	Opt
	1.4 Justifying procedures or methodology	72.2	Con
	1.5 Summarizing procedures	58.3	Con
	1.6 Defining terms	2.8	Opt
	2. Reporting results	100	Obl
	3. Commenting on results	100	Obl
	3.1 Interpreting results	100	Obl
	3.2 Comparing results	16.7	Opt
	3.3 Relating to theories and previous studies	11.1	Opt
	3.4 Summarizing results	50	Con
	3.5 Indicating research implications	8.3	Opt
	3.6 Suggesting further research	2.8	Opt

Note: Obl: obligatory; Con: conventional; Opt: optional

Tables 6.3-6.4 below show the respective condition of the number of EERAs in which the move or step occurs and total occurrence of each move and step, their percentage and their status. Three moves and one step were obligatory, i.e. *Move 2: Reporting results*, *Move 3: Commenting on results* and *Step 3.1: Interpreting results* which occurred in all the EERAs in the three corpora. *Move 1: Preparatory information* occurred in 33 EERAs, i.e. 91.7% of the whole corpus, so it was also regarded as an obligatory move. Conventional moves and steps included *Step 1.4: Justifying procedures or methodology*, *Step 1.5: Summarizing procedures*, and *Step 3.4: Summarizing results* since their respective occurrence percentages were 72.2%, 58.3% and 50%. The remaining steps, including *Step 1.3: Explaining principles*, *Step 3.2: Comparing results*, *Step 3.3: Relating to theories and previous studies*, *Step 3.5: Indicating research implications*, *Step 1.1 Introducing the section*, *Step 1.2 Specifying equipment or site*, *Step 1.6 Defining terms*, and *Step 3.6 Suggesting further research*, were all optional steps. In Table 6.3, even though the frequency cut-off point is 50%, meaning that if each move or step falls into the range of 0%-49%, it could be considered as optional. However, there is also noticeable variations between the higher and low percentages within the category of optional moves and steps. For example, *Step 1.3: Explaining principles, Step 3.2: Comparing results*, and *Step 3.3: Relating to theories and previous studies* differs from *Step 3.5: Indicating research implications*, *Step 1.1 Introducing the section*, *Step 1.2 Specifying equipment or site*, *Step 1.6 Defining terms*, and *Step 3.6 Suggesting further research* in the occurrence of the number of RAs. The former group occurred in 10%-20% of the EERAs of the whole corpus, while the latter group occurred in less than 10% of the 36 EERAs. These numbers suggest that the EE researchers set priority to some steps that they consider more important, while some of the optional steps were regarded as less dispensable in building and strengthening their claims. Likewise, the same picture is shown in Table 6.4.

Table 6.3 The number of EERAs in which each move or step occurs in the whole corpus

	Move/Step	No. of RAs in which the move or step occurs (RA=36)	%	Status
Move	2. Reporting results	36	100	Obl
	3. Commenting on results	36	100	Obl
	1. Preparatory information	33	91.7	Obl

Table 6.3 The number of EERAs in which each move or step occurs in the whole corpus (Continued)

	Move/Step	No. of RAs in which the move or step occurs (RA=36)	%	Status
Step	3.1 Interpreting results	36	100	Obl
	1.4 Justifying procedures or methodology	26	72.2	Con
	1.5 Summarizing procedures	21	58.3	Con
	3.4 Summarizing results	18	50	Con
	1.3 Explaining principles	7	19.4	Opt
	3.2 Comparing results	6	16.7	Opt
	3.3 Relating to theories and previous studies	4	11.1	Opt
	3.5 Indicating research implications	3	8.3	Opt
	1.1 Introducing the section	2	5.6	Opt
	1.2 Specifying equipment or environment	2	5.6	Opt
	1.6 Defining terms	1	2.8	Opt
	3.6 Suggesting further research	1	2.8	Opt

Table 6.4 The total occurrence of all the moves and steps in the whole corpus

	Move/Step	Occurrence (RA=36)	%
Move	3. Commenting on results	191	21.4
	2. Reporting results	180	20.2
	1. Preparatory information	141	15.8
Step	3.1 Interpreting results	175	19.6
	1.4 Justifying procedures or methodology	84	9.4
	1.5 Summarizing procedures	61	6.8
	3.4 Summarizing results	21	2.4
	1.3 Explaining principles	12	1.3
	3.2 Comparing results	8	0.9
	3.3 Relating to theories and previous studies	5	0.6
	1.2 Specifying equipment or environment	4	0.5
	1.6 Defining terms	4	0.5
	3.5 Indicating research implications	4	0.5
	1.1 Introducing the section	2	0.2
	3.6 Suggesting further research	1	0.1
Total		893	100

6.2.1.1 Description of Moves and Steps

Move 1: Preparatory information provides background information such as principle and/or methodology in order to prepare for presenting the results. Functioning as a transfer between sections, it makes presenting results less abrupt by straightly presenting the results. There are six steps in this move: *Introducing the section*, *Specifying equipment or environment*, *Explaining principles*, *Justifying procedures or methodology*, *Summarizing procedures*, and *Defining terms*. *Move 1* can be accomplished when there is at least one of the six steps occurring in this section. According to the cut-off occurrence rate in this study (≥80%: obligatory; 50%-79%: conventional; <50%: optional), *Move 1 Preparatory information* is an obligatory move in the three corpora.

Step 1.1: Introducing the section is put at the very beginning of the section. By providing an overview of the section through reemphasizing the purposes or methods, it functions as a brief introduction to the section. Only 2 EERAs in the TH corpus employ this step, suggesting that it is optional. An example of *Step 1.1* is presented below.

(1) *In this section, the result of the DTTV–SFN propagation with the proposed measurement model will be discussed. The measured results will be evaluated by power delay profile, path loss, the comparison between spectrum variation and delay, CNR and delay, modulation error ratio and delay, and noise margin and delay.* (TH12)

Step 1.2: Specifying equipment or site occurs when writers need to specify the devices, apparatuses, or equipment involved in the experiment and the site or environment in which the research or experiment takes place. This is a step employed especially in studies that stress the role of the equipment, device or site, since they are part of methodology that have a certain impact on the results or findings of the study. The low frequency of occurrence of this step indicates that this optional step occurs in a few EERAs in the three corpora. The following Examples 2 and 3 demonstrate *Step 1.2*.

(2) *In order to verify the communication performances of the designed RFID sensor, this paper adopts a special RFID tester of VISN-R1200 from JX Instrumentation, China. The test environment is shown in Fig. 7. The Bosch VCL4003 climate box is used to test the temperature and humidity performances of the proposed wireless sensor. The RFID sensor tag designed in this paper is fabricated with discrete components. The base material of the sensor is FR4 and it covers the area of 12 × 8 cm2.* (CH3)

(3) *A box with a measurement of 30.5 cm per side is created and its top inside wall and four side walls are lined with an absorbing material20 to serve as the anechoic chamber. The absorber linings are foam sheets with a thickness of 6.35 mm (1.27λ0) and rated to reduce reflections by more than 20 dB in 40-110 GHz range. A sheet of absorber foam was cut to create an opening for the AUT and positioner arm while covering the floor of the chamber, AUT input cables, output cables from the horn antenna, and AUT connectors.* (NS8)

Step 1.3: Explaining principles is another optional step of *Move 1*. The laws, rules or theories that the research is based on would be illustrated or explained before reporting the relevant results, a process that lays foundation and convinces the readers of reasonableness of the experimental methodology and validity of the results. The occurrence of this step is only 12 in the whole corpus. To illustrate the function of *Step 1.3*, two excerpts are chosen as examples below.

(4) *Propagation is affected by the distance-dependent attenuation plus the large-scale shadowing and small-scale fading. The largescale shadowing is the result of large obstructions, and the small-scale fading arises due to the constructive and destructive combination of multipath components.* (CH8)

(5) *The inline successive pumping scheme operates when a fraction of the power is coupled into the panda ring resonator. The* E_{in}

value of the panda ring arises from that fraction of the power and circulates in the optical system. Ultimately the resonant output is achieved at the throughput port, at the inline MZI. (TH3)

Step 1.4: Justifying procedures or methodology occurs much more frequently in the three corpora than the three previous steps. This step is achieved through demonstrating to the readers the rationale of selecting a certain experimental method or the reason of conducting the research by adopting a series of processes. In addition, writers in this discipline tend to adopt mathematical algorithm such as equations to prove their rationality of relevant process. The total occurrence of *Step 1.4* is 84, the second highest step among all the steps. Twenty-six EERAs demonstrate this step. Examples 6 and 7 listed below demonstrate *Step 1.4*.

(6) *Several tower waveguide structures are printed with different dimensions to determine the optimum parameters needed to ensure the highest confinement within the guiding region.* (TH2)

(7) *Sequences of OOK signals were transmitted at three data rates characterized by the number of carrier cycles N per symbol. The values of N=10, 5, 3 correspond to nominal fractional bandwidths B 20%, 40%, 66%, respectively. For each measurement, the channel H_{ch} was estimated using the channel sounding sequence and modeled signals were calculated according to (1) or (2), depending on the mode of operation. For clearer interpretation, both modeled and measured data are presented after channel inversion (i.e., multiplication by H^{-1}). To avoid amplification of noise near the edges of the receiving antenna's bandwidth, the filter H_{rx} is not removed in this way. Proper synchronization for the DAM switching control is established experimentally.* (NS5)

Step 1.5: Summarizing procedures is another frequent step in the EERAs in the three corpora. In this step, writers describe a process or series of acts involved in a particular work or an experiment intending to achieve a result. This step sometimes follows *Step 1.4 Justifying procedures or methodology*. In this case, the process seems more appropriate and convincing to the reviewers and readers when there are sounding reasons provided. Examples 8 and 9 are for the demonstration of *Step 1.5*.

(8) *In this case, the transmitter was placed in front of the second car and kept 3 m from the train door. The receiver was moved inside the train along the corridor of the first two cars. Then the operator moved outside and acquired the reference power level near the door and then re-entered the train. These measurements were repeated at both 2.4 GHz and 5.7 GHz.* (CH8)

(9) *After the images of fabricated elevated waveguides were analyzed, the attenuation/loss is measured across the fabricated samples. Four different samples were tested with different waveguide features from 80 to 200 μm at different positions having the same length using the powermeter at its output end as shown in the Fig. 8.* (TH2)

Step 1.6: Defining terms is one of the optional steps in *Move 1*. It has the least frequency of occurrence in the three corpora. It provides the definition of technical terms that the writers assume necessary and worthy of explanation. To illustrate the function of *Step 1.6*, Example 10 is given below.

(10) *The return loss characteristic (S_{11}) refers to the intensity of electromagnetic wave reflected when the electromagnetic wave is transmitted through the antenna.* (CH3)

Move 2: Reporting results is the dominant move, with 100% occurrence frequency, in the R&D section in the three corpora. This move is to demonstrate or depict results and findings, usually in the form of statistics. In the EERAs of the whole corpus, the obligatory status of *Move 2 Reporting results* is based on the results and findings of every stage of a testing of a model or an experiment, thus maintaining the second dominant position among all the moves and steps. Moreover, visuals including tables and figures participated in reporting results. Examples 11 and 12 demonstrate *Move 2* as shown below.

(11) *In Table 2, the comparison of delay characteristic in each positions are presented. The received signal time delay from station 1 are ranging from 20.23 to 54.52 μs and the average time delay is 38.94 μs.* (TH12)

(12) *The lowest loss was measured on micro-ring resonators with etch depth of 400 nm, bending radius of 80 μm, and waveguide width of 2.0 μm near the center of the wafer, which had an intrinsic quality factor of 1.8 million, corresponding to a propagation loss of 0.21 dB/cm.*(NS11)

The purpose of ***Move 3: Commenting on results*** has the purpose to establish the meaning from the statistical results reported and the examples demonstrated in *Move 2*. This move includes information and interpretations that go beyond the ‘‘objective’’ results (Yang & Allison, 2003). This may engage the various ways to interpret the results in the context of the study, to illustrate the contribution of the findings to the field (usually in comparison with relevant literature), the potential or underlying causes of the results, or comments on the strength, limitations of the results (Yang & Allison, 2003). Specifically, this move could be realized through the following steps: *Step 3.1 Interpreting results*, *Step 3.2 Comparing results*, *Step 3.3 Relating to theories and previous studies*, *Step 3.4 Summarizing results*, *Step 3.5 Indicating research implications* and *Step 3.6 Suggesting further research*.

Step 3.1: Interpreting results is the most frequent step that appears in *Move 3 Commenting on results*. All the 36 EERAs in the three corpora contain this step owing to the fact that Electronic Engineering writers tend to provide reasons and explanations for the results yielded in each stage of the study. This is different from Yang and Allison’s (2003) findings on the Results section. They find that *Interpreting results*, which is *Step 1* of *Move 3 Commenting on results*, ranks the second after *Step 2 Comparing results with literature*. Disciplinary disparity might be one of the reasons that contribute to this difference of the finding. Examples 13 and 14 below illustrate the function of *Step 3.1*.

(13) *The sensing signal increased almost 13 times using our proposed antenna array for lactose detection. These results showed that the sensing performance of this structure working at reflection mode was even better than that at transmission mode. This was mainly due to the fact that the resonance in reflection mode had a higher quality factor and larger local field enhancement.* (CH1)

(14) *At 3.5 GHz, the electromagnetic wave, propagating due to antenna radiator, passes through the first reflector and reflects at the second reflector as shown in Fig. 14(b), resulting in the partly electromagnetic wave energy slightly absorbed on the second reflector. Thus, the electromagnetic wave reflects and is absorbed on the first reflector at the 5.25 GHz, as shown in Fig. 14(c).* (TH8)

Step 3.2: Comparing results is another form of commenting on results. The current results and findings are compared with those in the previous studies in the literature, which also shows the writer's own understanding of the connection between the previous and current research. Usually, the phrases such as "*comparing…with…*", "*compared with…*", "*be consistent with…*" are the obvious clues for this step. In addition, in-text citation might also suggest the employment of this step. The relatively low frequency of occurrence suggests that this step is optional. Examples 15 and 16 below illustrate the function of *Step 3.2*.

(15) *<u>Comparing</u> the probe performance <u>with</u> the previous works, the calibration factor of a LTTC probe is about 60 dBS/m which is higher than the proposed probe since the LTTC magnetic pick- up area is smaller but the smaller pick-up area has better magnetic field spatial resolution.* (TH9)

(16) *These results <u>are consistent with</u> findings by <u>Pinter (1986)</u> who concluded that dew effects can mask actual reflectance differences between soil types, cultivars, growth stages, stress levels, or other factors that can affect yield. In 2018, the NDVI*

values at 7 am were not impacted, as dew was not present the day of the flight. (NS4)

Step 3.3: Relating to theories and previous studies is a step where the writers introduce previous relevant studies in terms of their methodology, results, and findings, which would be commented on or adopted for the current research. The reason for EE researchers using this step is that they might need theories, methods, or results of the previous studies to back up their current study by either indicating their strengths or drawbacks. Thus, the persuasion seems more convincing to the reviewers and readers. In-text citation is an apparent indication for this step. Examples 17 and 18 are illustrations of this step.

(17) *Traditional soil sampling method (Hedayati-Dezfooli and Leong, 2019) shows high accuracy performance, but it is time-consuming and laborious, and is not suitable for real-time monitoring. The soil environmental monitoring system based on wired communication (Zhang et al., 2015) exhibits the advantages of huge data transmission and fast transmission speed, but its deployment process is complex and maintenance cost is high.* (CH3)

(18) *Fig. 7 shows that JPL's radar is thus an effective probe of this phenomenon, which has been used by Kollias et al. in [29] to infer vertical wind velocities.* (NS7)

Step 3.4: Summarizing results provides a short statement regarding the main points of the results and findings. It functions as a small conclusion of the present research or part of research. This step usually appears at the end of the R&D section. Examples 19 and 20 below are the illustrations for *Step 3.4*.

(19) *It is noticed that the proposed antenna may not be the most compact design in the literature; however, this article provides a simple and practical solution for UWB antenna miniaturization. Comparisons with some previously reported planar compact designs are shown in Table 2. It is noticed that the proposed miniaturized antenna features a more compact*

electrical size and better or comparable bandwidth among all the designs. (CH7)

(20) *With these characteristics, the proposed antenna is acceptable for use in indoor base stations with triple-frequency bands, directional radiation patterns, high gain, and high power handling.* (TH7)

Step 3.5: Indicating research implications offers possible effect or practicability deducted from the results or findings of the current research. Electronic Engineering is a discipline that has close relation with people's daily lives, therefore, some EE researchers apply this step to indicate that their proposed model or method is beneficial for resolving certain problems existing in the field or in people's lives. Example 21 is the illustration for *Step 3.5*.

(21) *Our demonstration has also opened up new opportunities for high throughput wafer-scale testing capabilities that dramatically sped up the development of silicon photonics [30] using probes and grating couplers [31]. This work (Figs. 1(a), 1(b)) has also shown that metalization processes, as expected, are insensitive to the change on the optical waveguide layer. This enables the possibility of ultrahigh speed electro-optic devices characterized at wafer level in the near future, which is key to shortening the development cycle of LN PICs.* (NS11)

Step 3.6: Suggesting further research is a step for researchers to recommend a theme or a direction for future research relevant to current study. It is accounted as optional since only one EERA was detected to have this step. Example 22 below illustrates this step.

(22) *The extra loss due to the windows may be different for different trains and different environments in which the train is operated, hence inducing a different amount of wave reentering. However, these are topics for future research.* (CH8)

6.2.1.2 Comparison of Move-Step Structures

6.2.1.2.1 Moves and Steps

Table 6.5 summarizes similarities and variations among the CH, TH, and NS corpora in the frequency of occurrence of Moves 1-3. *Move 1: Preparatory information* occurred 100% in the CH (4.25 per section), 83.3% in the TH (2.58 per section), and 91.7% in the NS (3.91 per section). *Move 2: Reporting results* occurred 100% in the three corpora, but with the average occurrence per section 5.83, 3.33 and 5.83 in the CH, TH, and NS, respectively. *Move 3: Commenting on results,* with the average occurrence per section 5.92, 3.33 and 6.67 in the CH, TH, and NS, respectively, indicated 100% for the frequency of occurrence in the three corpora. Thus, Moves 1, 2 and 3 were all obligatory moves. The apparent variations lied in the two steps under *Move 1* and *Move 3*, which were *Step 1.4 Justifying procedures or methodology,* and *Step 3.4 Summarizing results*. *Step 1.4* was regarded as an obligatory step in the CH and NS corpora; while it was a conventional step in the TH corpus. *Step 3.4 Summarizing results* in the CH was viewed as an optional step; however, it was considered conventional in the TH and NS. The other steps under *Move 1* and *Move 3* in the three corpora demonstrated similarities rather than variations, that is, the same step fell into the same categories in the three corpora.

Table 6.5 The differences of obligatory, conventional and optional moves and steps among the CH, TH and NS

Move/Step	CH	TH	NS
Obligatory (≥80%)	**1. Preparatory information** 1.4 Justifying procedures or methodology **2. Reporting results** **3. Commenting on results** 3.1 Interpreting results	**1. Preparatory information** **2. Reporting results** **3. Commenting on results** 3.1 Interpreting results	**1. Preparatory information** 1.4 Justifying procedures or methodology **2. Reporting results** **3. Commenting on results** 3.1 Interpreting results
Conventional (50%-79%)		1.4 Justifying procedures or methodology 3.4 Summarizing results	3.4 Summarizing results
Optional (<50%)	3.4 Summarizing results		

The variations identified among the three corpora were *Step 1.4 Justifying procedures* and *Step 3.4 Summarizing results* based on Table 6.6. Only half of the corpus i.e. 6 EERAs employed this step in the TH corpus. Usually, this step in the three corpora was accompanied by *Step 1.5 Summarizing procedures*. The writers in EE discipline tended to firstly provide rationales or reasons for the following procedures so that they could sound reasonable. This was one characteristic of this discipline that every step of the experiment process should be based on some reasons such as mathematical algorithm, or well-founded setup for testing or experiment. Ten EERAs in both the CH and NS corpora respectively demonstrated this step. According to Table 6.7, the total number of moves and steps in the TH corpus differed significantly from that of the CH and NS. That explained, to a certain degree, the reason for *Step 1.4* missing in some EERAs in the TH. Firstly, it was the length of the whole RAs that influences the adoption of certain moves and steps. Secondly, *Step 1.4 Justifying procedures or methodology* appearing less frequently than *Step 1.5 Summarizing procedures* in the R&D section in the TH could be attributed to the reason that it had already appeared in the Methods section. Thus, due to the conciseness this step could be omitted.

Table 6.6 The number of EERAs in which move or step occurs in the CH, TH and NS

Results and Discussion Section	CH (RA=12)		TH (RA=12)		NS (RA=12)	
Move/Step	No. of RAs	%	No. of RAs	%	No. of RAs	%
1. Preparatory information	12	100	10	83.3	11	91.7
1.1 Introducing the section	0	0	1	8.3	1	8.3
1.2 Specifying equipment or environment	1	8.3	0	0	1	8.3
1.3 Explaining principles	3	25	1	8.3	3	25.0
1.4 Justifying procedures or methodology	10	83.3	6	50	10	83.3
1.5 Summarizing procedures	7	58.3	7	58.3	7	58.3
1.6 Defining terms	1	8.3	0	0	0	0
2. Reporting results	12	100	12	100	12	100
3. Commenting on results	12	100	12	100	12	100
3.1 Interpreting results	12	100	12	100	12	100
3.2 Comparing results	1	8.3	3	25	2	16.7

Table 6.6 The number of EERAs in which move or step occurs in the CH, TH and NS (Continued)

Results and Discussion Section	CH (RA=12)		TH (RA=12)		NS (RA=12)	
Move/Step	No. of RAs	%	No. of RAs	%	No. of RAs	%
3.3 Relating to theories and previous studies	1	8.3	1	8.3	2	16.7
3.4 Summarizing results	5	41.7	6	50	7	58.3
3.5 Indicating research implications	0	0	1	8.3	2	16.7
3.6 Suggesting further research	1	8.3	0	0	0	0

Step 3.4 Summarizing results appeared in 5 EERAs in the CH, and in 6 and 7 EERAs in the TH and NS, respectively. The numbers of EERAs in the three corpora did not show great difference. However, according to the cut-off point, this step in the CH was considered optional, while it was regarded as conventional in the TH and NS. In the CH, this step occurred more frequently than the other optional steps, suggesting a summary or short statements for the results and findings discovered a more prevalent step. In EERAs, according to one informant, there were many results yielded from different steps of one experiment or even different experiments or tests, which indicated that this move was necessary for those researchers who synthesized the results. Other differences were not noticeable across the three corpora.

Table 6.7 The occurrence of each move and step in the CH, TH and NS

Move/Step	CH (RA=12)		TH (RA=12)		NS (RA=12)		Whole corpus (RA=36)	
	Occurrence	Average Occurrence per section	Occurrence	Average Occurrence per section	Occurrence	Average Occurrence per section	Occurrence	Average Occurrence per section
1. Preparatory information	51	4.25	31	2.58	59	4.92	141	3.91
1.1 Introducing the section	0	0	1	0.08	1	0.08	2	0.06
1.2 Specifying equipment or environment	2	0.17	0	0	2	0.17	4	0.11
1.3 Explaining principles	4	0.33	1	0.08	7	0.58	12	0.33
1.4 Justifying procedures or methodology	38	3.17	16	1.33	30	2.5	84	2.33
1.5 Summarizing procedures	16	1.33	18	1.5	27	2.25	61	1.69
1.6 Defining terms	4	0.33	0	0	0	0	4	0.11

Table 6.7 The occurrence of each move and step in the CH, TH and NS (Continued)

Move/Step	CH (RA=12)		TH (RA=12)		NS (RA=12)		Whole corpus (RA=36)	
	Occurrence	Average Occurrence per section	Occurrence	Average Occurrence per section	Occurrence	Average Occurrence per section	Occurrence	Average Occurrence per section
2. Reporting results	70	5.83	40	3.33	70	5.83	180	5
3. Commenting on results	71	5.92	40	3.33	80	6.67	191	5.3
3.1 Interpreting results	69	5.75	34	2.83	72	6	175	4.86
3.2 Comparing results	1	0.08	3	0.25	4	0.33	8	0.22
3.3 Relating to theories and previous studies	1	0.08	1	0.08	3	0.25	5	0.42
3.4 Summarizing results	5	0.42	7	0.58	9	0.75	21	0.58
3.5 Indicating research implications	0	0	1	0.08	3	0.25	4	0.11
3.6 Suggesting further research	1	0.08	0	0	0	0	1	0.03
Total	**333**		**193**		**367**		**893**	

6.2.1.2.2 Move Patterns

Table 6.8 shows that *Move 1* and *Move 2* respectively accounted for half of the CH as the beginning move; *Move 1* was the beginning of this section for 8 EERAs, while *Move 2* for 4 EERAs in the TH. In the NS, there were 9 cases where *Move 1* begins this section. Three cases for *Move 2* acted as the beginning move. More than half of the EERAs across the three corpora preferred *Move 1* to be the beginning move, which indicated writers' tendency to begin the R&D section by introducing preparatory knowledge of the study such as justifying their methodology and specifying their procedure. This strategy could make this section sound less abrupt by functioning as a transition from the Methods section than those cases beginning with *Move 2* as their beginning move.

The ending moves across the three corpora was *Move 3* in 11 cases and *Move 2* in one case in the CH; *Move 3* in 10 cases and *Move 2* in 2 cases in the TH, and *Move 3* in all the 12 cases in the NS. *Move 3: Commenting on results* was regarded as the prevalent closing move by most EERA writers. Thus, the differences in terms of the beginning move/step and ending move/step across the three corpora were not highly noticeable.

Table 6.8 The beginning move/step and ending move/step of the R&D section

CH		TH		NS	
CH1	2-...-3.4	TH1	1.5-...-3.4	NS1	1.3-...-3.1
CH2	1.4-...-3.4	TH2	1.4-...-3.1	NS2	1.5-...-3.4
CH3	1.2-...-3.4	TH3	1.3-...-3.4	NS3	2-...-3.1
CH4	2-...-3.1	TH4	2-...-3.1	NS4	2-...-3.4
CH5	2-...-3.1	TH5	1.4-...-2	NS5	1.1-...-3.4
CH6	2-...-3.1	TH6	2-...-3.1	NS6	1.5-...-3.5
CH7	2-...-3.4	TH7	2-...-3.4	NS7	1.4-...-3.1
CH8	1.4-...-2	TH8	2-...-3.1	NS8	2-...-3.4
CH9	1.4-...-3.1	TH9	1.5-...-2	NS9	1.3-...-3.4
CH10	1.4-...-3.1	TH10	1.4-...-3.4	NS10	1.4-...-3.2
CH11	1.4-...-3.1	TH11	1.4-...-3.4	NS11	1.5-...-3.5
CH12	2-...-3.1	TH12	1.1-...-3.1	NS12	1.4-...-3.1

6.2.1.2.3 Move Cycles

As indicated by the frequency of the moves and steps, the R&D section is highly cyclical, one of the common characteristics of all EERAs in the three corpora. As can be seen from Tables 6.9-6.10, in total, 122 move cycles falling into 9 types were identified in the three corpora. The average number of move cycles per article was 4.5 in the CH, 2.4 in the TH and 3.3 in the NS. Not all the 9 types of move cycles appeared in all the three corpora, i.e. 8, 7, and 7 types of move cycles, were found in the CH, TH and NS, respectively.

Table 6.9 The number of EERAs in which move cycles occur in the CH, TH and NS

Move cycle	CH (RA=12)		TH (RA=12)		NS (RA=12)	
	No. of RAs	%	No. of RAs	%	No. of RAs	%
2-3.1-2-3.1	4	33.3	1	8.3	2	16.7
1.4-3.1	4	33.3	0	0	0	0
1.5-3.1	2	16.7	0	0	0	0
3.1-3.4	2	16.7	2	16.7	2	16.7
1.5-2-3.1	1	8.3	2	16.7	2	16.7
1.4-2-3.1	5	41.7	3	25	4	33.4
2-3.1	12	100	8	66.7	10	83.3
2-3.1-3.4	0	0	2	16.7	1	8.3
1.4-1.5	1	8.3	2	16.7	1	8.3

Table 6.10 The occurrence of move cycles in the CH, TH and NS

Move cycle	CH		TH		NS		Whole corpus	
	Occurrence	%	Occurrence	%	Occurrence	%	Occurrence	%
2-3.1-2-3.1	6	11.1	1	3.5	2	5.2	9	7.4
1.4-3.1	5	9.3	0	0	0	0	5	4.1
1.5-3.1	2	3.7	0	0	0	0	2	1.6
3.1-3.4	2	3.7	2	6.9	2	5.2	6	4.9
1.5-2-3.1	2	3.7	2	6.9	2	5.2	6	4.9
1.4-2-3.1	10	18.5	4	13.8	6	15.4	20	16.4
2-3.1	25	46.3	16	55.2	25	64.1	66	54.1
2-3.1-3.4	0	0	2	6.9	1	2.6	3	2.5
1.4-1.5	2	3.7	2	6.9	1	2.6	5	4.1
Total	54	100	29	100	39	100	122	100
Average	4.5		2.4		3.3		3.4	

Move cycles including *2-3.1* and *1.4-2-3.1* demonstrated similarity across the three corpora. They both were the top 2 cycles in each corpus. The *move cycle 2-3.1* was the most dominant one, which occurred in all the 12 RAs and accounted for 46.3 % of all the move cycles in the CH. Even though the *move cycle 2-3.1* occurred in fewer RAs than those in the CH, it remained the highest number of the RAs, i.e. 8 in the TH and 10 in the NS, respectively. The occurrence percentage of all the nine move cycles in the TH and NS corpus was 55.2% and 64.1%, even higher than that in the CH. The high percentage and occurrence indicated that this move cycle was conventional across the three corpora. The *move cycle 1.4-2-3.1* was another frequent cycle across the three corpora, indicating *Step 1.4* was the most frequent step happening before the *move cycle 2-3.1*.

Apart from the similarity mentioned above, move cycles occurring less frequently across the three corpora were *1.5-3.1*, *3.1-3.4*, *1.5-2-3.1*, *2-3.1-3.4* and *1.4-1.5*, with the occurrence of less than 2 RAs per corpus. It was found that the move cycles in the R&D section appeared to be complex since each cycle often comprised a combination of moves and steps. One cycle could appear twice or more in one paragraph. The researcher also identified the repetitive cycle of *2-3.1* in the whole corpus and found that this move cycle appeared in 4 RAs in the CH, 1 and 2 RAs in the TH and NS corpus, respectively.

The obvious difference of move cycle across the three corpora was the total number of move cycles identified and the number of occurrence of certain move cycles. EERAs in the CH demonstrated 54 occurrence of move cycle, the highest number across the three corpora, followed by 39 in the NS and 29 in the TH. Chinese researchers tended to employ more move cycles than the other two groups, and this might be due to their research methodology that requires more results to be reported and commented on. A delicate difference was occurrence of the *move cycles 2-3.1-2-3.1* and *1.4-3.1*. They both appeared in 4 RAs in the CH. However, the *move cycle 2-3.1-2-3.1* occurred in 1 and 2 in the TH and NS, respectively. The *move cycle 1.4-3.1* did not occur at all in both the TH and NS. The reason why *1.4-3.1* occurred in 4 RAs, i.e. 5 times in the CH, could be that EE researchers referred to the results by pointing to the visuals inserted in the RAs, making possible *Move 3* be directly followed by *Move 1*. For instance:

(24) *Since 12 measuring electrodes are arranged on the cutterhead, according to the measuring method described in Section 2.1, 11 voltage data can be obtained by supplying power to one measuring electrode at a time, and 132 voltage data can be*

obtained by supplying power to these 12 measuring electrodes in turn. **(Step 1.4)** *As can be seen from Figures 5 and 6, when the same amount of current is supplied to the exciting electrode and the guard electrode, the farther away the low resistivity anomalous body is from the cutterhead, the greater the voltage measured by each measuring electrode*. **(Step 3.1)** (CH4)

The findings suggested the *move cycle 2-3.1* was the core across the three corpora since most move cycles identified revolved around it such as the *move cycles 1.4-2-3.1*, *1.5-2-3.1* and *2-3.1-2-3.1*. The findings also revealed that the most frequent step that happened before the *move cycle 2-3.1* is *Step 1.4*, while the most common step appearing after it was *Step 3.4* and the move cycle itself: *2-3.1*. This is consistent with Yang and Allison (2003) in that the sequence of moves and steps in each cycle follows the order shown in their proposed framework, that is, if *Move 1* is absent, then *Move 2* is the initial element in a cycle, followed by *Move 3*.

6.2.2 Results and Discussion of VTM Analysis

6.2.2.1 Overview

One hundred percent of the corpora was found to contain visuals, suggesting they were conventional in EERAs. The visuals project both disciplinarity and specificity (Moghaddasi et al., 2019). Electronic Engineering discipline demonstrates a high preference for graphical culture; namely, visual genre (Kostelnick, 2007). Within its visual genre, visuals such as line graph, bar graph, scatterplot, photo, picture and table are prevalent. These visuals might be popular in other disciplines too. However, visuals such as circuit diagram and radiation graph are typical visuals specific to EE discipline. The great number of visuals employed in the three corpora indicated that EE discipline was highly dependent on visuals. Table 6.11 presents the total and average number of visuals in the R&D section in the CH, TH and NS, respectively. As can be seen from Table 6.11, the total number of visuals (figures + tables) was 89, 72, and 68, while the average number of visuals per article was 7.4, 6 and 5.7 in the R&D section of the CH, TH, and NS, respectively.

Table 6.11 Summary of the visuals in the CH, TH and NS

Visual	CH (RA=12)	TH (RA=12)	NS (RA=12)	Total
Number of Tables	12	9	8	29
Number of Figures	77	63	60	200
Total number of Visuals	89	72	68	229
Average number of Visuals	7.4	6	5.7	6.4

Different from Moghaddasi et al. (2019), visuals in EE field include both the visuals presenting tangible and intangible information. For example, the experimental devices, equipment, site or arrangement of analysis methods might be presented through visuals such as photos, pictures and schematic diagrams, thus participating in the argument for the relative claim. The intangible objects in EE field, as those in Discrete Mathematics (Moghaddasi et al., 2019), are granted with physical presence through visuals. These visuals represent powerful specific concepts and operations within the discipline, bringing readers to the core of reasoning and theories (Angot-Pellissier, 2015). They embody the abstract concepts, complex relations or the products of carefully designed experiments. Visuals in EERAs are a series of observable entities that concretize EERAs' abstract ideas.

Table 6.12 Summary of the number of RAs in which each visual occurs

Visual	CH (RA=12)		TH (RA=12)		NS (RA=12)		Whole corpus	
	No. of RAs	%	No. of RAs	%	No. of RAs	%	No. of RAs	%
1 Line graph	12	100	11	91.7	10	83.3	33	91.7
2 Picture	8	66.7	2	16.7	4	33.3	14	38.9
3 Photo	4	33.3	7	58.3	6	50	17	47.2
4 Table	6	50	6	50	3	25	15	41.7
5 Schematic diagram	4	33.3	4	33.3	5	41.7	13	36.1
6 Scatterplot	3	25	1	8.3	1	8.3	5	13.9
7 Bar graph	2	16.7	1	8.3	1	8.3	4	11.1
8 Radiation graph	4	33.3	4	33.3	0	0	8	22.2
9 3D graph	0	0	3	25	1	8.3	4	11.1
10 Area chart	0	0	1	8.3	1	8.3	2	5.6
11 Histogram	0	0	0	0	2	16.7	2	5.6
12 Circle chart	0	0	0	0	1	8.3	1	2.8

Table 6.13 Summary of the occurrence of each visual

Visual	CH (RA=12)		TH (RA=12)		NS (RA=12)		Whole corpus	
	Occurrence	%	Occurrence	%	Occurrence	%	Occurrence	%
1 Line graph	43	43.9	30	40	27	30.7	100	38.3
2 Picture	14	14.3	4	5.3	15	17.1	33	12.6
3 Photo	8	8.2	9	12	16	18.2	33	12.6
4 Table	12	12.2	9	12	8	9.1	29	11.1
5 Schematic diagram	5	5.1	7	9.3	8	9.1	20	7.7
6 Scatterplot	6	6.1	5	6.7	1	1.1	12	4.6
7 Bar graph	4	4.	1	1.3	6	6.8	11	4.2
8 Radiation graph	6	6.1	4	5.3	0	0	10	3.8
9 3D graph	0	0	4	5.3	3	3.4	7	2.7
10 Area chart	0	0	2	2.7	1	1.1	3	1.2
11 Histogram	0	0	0	0	2	2.3	2	0.8
12 Circle chart	0	0	0	0	1	1.1	1	0.4
Total	**98**	**100**	**75**	**100**	**88**	**100**	**261**	**100**

The visuals identified in the three corpora were 1) line graph, 2) picture, 3) photo, 4) table, 5) schematic diagram, 6) scatterplot, 7) bar graph, 8) radiation graph, 9) 3D graph, 10) area graph, 11) histogram, and 12) circle graph. As can be seen from Table 6.12 above, dominant visuals in EERAs across the three corpora are line graph, table, picture and photo. There were 33 RAs identified with line graphs, and their total occurrence in the whole corpus was 100. Line graph was the top dominant visual in this discipline. According to Gross and Harmon (2014), line graph functions as representation of data trend. This visual basically consists of horizontal and vertical axes on either two or four side, labels defining the object of measurement, tick marks defining the units of measure; dots, circles or squares symbolizing data points, and solid, dashed, or dotted lines tracing the best fits to data or equations. The perception of the data engages recognition of individual data points through scanning and matching. The result is a proposition in the form of "At point *x*, the value of *y* is *z*."

Picture, photo, table and schematic diagram were visuals following line graph in EERAs. Their occurrences were 33, 33, 29 and 20 in the whole corpus, accounting for 12.6%, 12.6%, 11.1%, and 7.7% of all visuals, respectively. Scatterplot, bar graph, radiation graph, 3D graph, area chart, histogram, and circle chart had the lower occurrence compared to the four types of visuals mentioned above.

6.2.2.2 Description of VTMs

6.2.2.2.1 VTMs

Visual Move (VM) in Moghaddasi et al. (2019) refers to visuals without textual language support. Textual language "elaborating or restating the meaning of the visual" is absent in these cases (Moghaddasi et al., 2019, p. 62). In Discrete Mathematics RAs, Moghaddasi et al. (2019) find that there are several cases where visual moves replace textual moves. These visuals could provide definitions for the objects and instantiate them. Therefore, *Defining visually* (DV) is one of the moves that visuals in Mathematics RAs initiate. The other two VMs are *Representing the outcome of the operation* (ROO) and *Embodying the operation* (EO).

Different from Moghaddasi et al. (2019), visuals in EERAs in the three corpora were all associated with textual language, which were categorized as visual-textual moves (VTMs). Moghaddasi et al. (2019) name these moves Visual-Verbal Move. The researcher adapted the term from *Visual-Verbal Move* to *Visual-Textual Move* because she considered textual language as the written form of a language, while verbal language should be in the spoken form. VM, commonly identified in Moghaddasi et al. (2019), was absent in the corpus of the present study, which made VTMs the focus of the present study.

Identification of VTMs, to a large extent, depended on the pointers (e.g., In Fig. 1, Fig 3 shows that…), which were the indicator of existence of a VTM. Texts identified as VTMs under investigation were usually those located around the pointers. Therefore, the boundary of a VTM was determined by the textual language associated with the visual that conveyed the same communicative purposes, no matter whether they were with or without pointers. That is to say, texts with corresponding pointers referring to a visual were considered as a VTM, while those without pointers but associated with the visual also need to be counted as a VTM. One visual might be associated with one or more sets of texts, which indicated that that particular visual could be linked to or explained by different VTMs. Four VTMs adapted from Moghaddasi et al. (2019) were identified in the R&D sections of the EERAs within the three corpora. They were *Establishing presumptions* (EP), *Announcing results* (AR), *Discussion* (D), and a new VTM *Displaying apparatus or site* (DAS).

1. *Establishing presumptions* (EP): EE researchers use this move to explain their assumptions about the purpose, rationale and procedure of each experimental action, and introduce notations or concepts. In *EP*, EE researchers would provide their justifications, reasons or purposes for their following action in one or one stage of experiment. Usually they achieve this goal by using the infinitive "*to …*," and propositional phrase "*for…*" Examples 23 and 24 demonstrate the function of VTM *EP*.

(23) *As shown in Fig. 6, a warm white light LED is used by exciting it with the LED driver for maximum intensity to launch the light in the input portion of the ridge section.* (Fig. 6, TH2)

(24) *For this, the analytical signal-to-noise ratios (ratios of the averaged absorbance values obtained from Fig. 6 to the corresponding absorbance noise values (A/DA)) were compared with the instrumental signal-to-noise ratio (SNR) shown in Fig. 7A.* (Figs. 6 and 7, NS9)

2. *Announcing results* (AR): This move presents statements of results (i.e., new knowledge) (Moghaddasi et al., 2019). EE researchers use this move to present numerical results, parameter of new models, comparison of the proposed model with models in previous studies, and findings of the present study. The most obvious signals for VTM *AR* are verbs such as "*show*" and "*observe*", and the nouns such as "*results*". The announced results reveal the objective observations or facts from the figure or table. Examples 25 and 26 below demonstrate the function of VTM *AR*.

(25) *For each thickness, a reflection peak originated from the characteristic absorption of lactose in the location of the resonance of the antenna array was observed. Figure 6(b) shows the dependence of reflectance at the peak on the lactose thickness. The reflectance at*

the peak increased obviously as the thickness increased, and an ExpGrow curve was used for fitting the relation of these two parameters (shown as the black dashed line). (Fig. 6, CH1)

(26) *Figures 3, 4 show the results of the pumping outputs with the relationship between the coupling gaps and output intensity of the WGM output seen in Fig. 5.* (Figs. 3, 4, and 5, TH3)

3. *Discussion* (D): This move usually follows a result statement (Moghaddasi et al., 2019). It may present examples or evidences for validating knowledge claims, link the results to the previous studies, or provide explanation or interpretation of the results. Linguistic signals for VTM *D* are the explanatory verbs such as "*illustrate*" and "*demonstrate*", modal verbs, adjectives and adverbs that show the researchers attitude or opinion such as "*can*", "*cannot*", "*clear*" and "*clearly*", and evaluative phrases such as "*be inconsistent with*" and "*in good agreement with*", etc. Examples 27 and 28 below illustrate the function of VTM *D*.

(27) *Fig. 3(a) shows the farfield distribution of light scattered by a unit cell (Es) consisting solely of R1, illustrating that the RCP light is clearly generated as a result of the interaction of the incident LP light with the antenna.* (Fig. 3, CH11)

(28) *Figure 16A shows the high fluctuation of jS21j that is contributed by electric field, E (ϑ = 90) and it cannot maintain at a smoother level as in the probe with via fence.* (Fig. 16, TH9)

4. *Displaying apparatus or site* (DAS): This move refers to statements for describing devices, equipment, or apparatus, and experimental or test environment. This VTM is featured by the verb phrases such as "*be used to*", "*consist of*", and nouns such as "*device*", "*setup*", etc. Examples 29 and 30 below show the function of VTM *DAS*.

(29) *Figure 12 shows the schematic diagram of the vapor sensing experiment setup, where a warm white LED is used to strike at the face of the waveguide with the optical fiber and the light is collected with the same and is recorded using powermeter device.* (Fig. 12, TH5)

(30) *As seen in Figure 5, the positioning rig consists of an antenna-under-test (AUT) holding platform that fits into a base with graduated notches for accurately rotating the prototype by 5 increments in ϕ-direction, from 0 ≤ ϕ ≤ 360.* (Fig. 5, NS8)

Table 6.14 Summary of the VTMs in the whole corpus

VTM	No. of RAs in which the VTM occurs (RA=36)	%	Occurrence (RA=36)	%
Announcing results (AR)	36	100	173	44.6
Discussion (D)	31	86.1	126	32.5
Establishing presumptions (EP)	23	63.9	63	16.2
Displaying apparatus or site (DAS)	18	50	26	6.7
Total			**388**	**100**

As can be seen from Table 6.14, the most frequent VTM is *AR*, and 100% of the EERAs employed this move to illustrate their visuals. It also had the highest occurrence (173) in the whole corpus. The second most employed VTM is *D*, which occurred in 86.1% of 36 EERAs and had the occurrence of 126. VTMs *EP* and *DAS* occurred in 63.9% and 50% of all the EERAs, and their total occurrence in the whole corpus was 63 and 26, respectively.

Visuals in EERAs in the three corpora demonstrate three functions identified in Graves (2014) and Moghaddasi et al., (2019): ontological, argumentative and epistemological function. Many of the visuals in the R&D section, when associated with texts for introducing material, preceding labelled definitions, or constructing specific concepts, perform ontological function by making the abstract concepts and processes present and tangible. They create the fundamental objects studied in the RAs. Thus, the VTMs *EP* and *DAS* suggest the visual's ontological function. Argumentative function in visuals in EERAs of the three corpora serves as evidence in supporting a stated claim, mainly through advancing possible explanations for potential causes and strategies for solutions. Therefore, VTM *D* indicates the argumentative function of visuals. Visuals and the VTMs work together as a strategically pervasive means in EERAs. Visuals function epistemologically by participating in the result announcement in the R&D section of the EERAs. Consequently, VTM *AR* implies the epistemological function of the visuals.

6.2.2.2.2 VTM Sequences and VTM Patterns

After the VTMs in the whole corpus were identified, it was necessary to continue investigating the VTM sequence for each visual, through which the VTM pattern could be yielded and concluded. One visual might be associated with one or several VTMs. VTM sequence refers to a collection of all the VTMs related to one visual in a sequential order. For example, if a visual is associated with 5 sets of texts that are identified as VTMs *D*, *AR*, *D*, *AR*, and *D*, respectively, the VTM sequence of the visual is identified as *D+AR+D+AR+D*. From the VTM sequence of a visual, information including the number of the VTMs, their sequential order, and the VTM type could be obtained. Identification of the VTM sequence for each visual is a necessary step to categorize VTM pattern, which only takes the VTM types into account because each VTM type demonstrates the same communicative purpose and rhetorical function. Therefore, the VTM sequence *D+AR+D+AR+D* is under the category of the VTM pattern *AR+D*. Every visual in the three corpora has one VTM sequence and one VTM pattern.

The results of identification showed that there were 34 VTM sequences for 229 visuals. Even with a large number, this identification of VTM sequence was the preparatory step for ultimately obtaining the VTM patterns of the visuals in the whole corpus. Tables 6.15-6.17 show a summary of all the VTM sequences. Each visual (figure or table) was assigned to one VTM sequence. The left table shows the number of RAs in which each VTM sequence occurs and the right one shows the total occurrence of each VTM sequence. The top ten VTM sequences in terms of occurrence are 1) *AR*; 2) *AR+D*; 3) *DAS*; 4) *D*; 5) *EP*; 6) *EP+AR*; 7) *EP+D*; 8)

EP+AR+D; 9) *D+D*; 10) *EP+AR+D+EP*. To explain the meaning of the following tables, the VTM sequence *AR* and its numbers in the left table indicate that visuals in 25 RAs are identified with only one VTM *AR*. In other words, no other VTMs are identified with these visuals. While the VTM sequence *AR* in the right table shows that there are 67 visuals in the whole corpus identified with the only one VTM *AR*. Again, among the 34 VTM sequences identified in the R&D section across the three corpora, 21 VTM sequences occurred only once. They were therefore considered as miscellaneous sequences. Since each sequence represents one visual, there were 21 visuals identified to occur with the least occurrence. However, they will all be categorized as the corresponding VTM patterns that they belong to. It is the VTM pattern rather the VTM sequence that is under examination in order to understand the visuals' rhetorical functions.

Table 6.15 Summary of the VTM sequences of all the visuals in the whole corpus

	VTM sequence	No. of RAs in which each VTM sequence occurs (RA=36)	%		VTM sequence	Occurrence (Visual=229)	%
1	AR	25	69.4	1	AR	67	29.3
2	AR+D	21	58.3	2	AR+D	42	18.4
3	DAS	18	50	3	DAS	24	10.5
4	D	13	36.1	4	D	22	9.6
5	EP+AR	9	25	5	EP	16	7
6	EP	9	25	6	EP+AR	10	4.4
7	EP+D	7	19.4	7	EP+D	9	3.9
8	EP+AR+D	4	11.1	8	EP+AR+D	5	2.2
9	D+D	2	5.6	9	D+D	4	1.8
10	AR+AR	2	5.6	10	EP+AR+D+EP	2	0.9
11	EP+AR+D+EP	2	5.6	11	AR+AR	2	0.9
12	D+D+D+D	2	5.6	12	D+D+D	2	0.9
13	AR+D+AR	2	5.6	13	D+D+D+D	2	0.9
14	EP+D+D	1	2.8	14	AR+D+AR	2	0.9
15	AR+D+D+D	1	2.8	15	AR+D+D+D	1	0.4

Table 6.15 Summary of the VTM sequences of all the visuals in the whole corpus (Continued)

	VTM sequence	No. of RAs in which each VTM sequence occurs (RA=36)	%		VTM sequence	Occurrence (Visual=229)	%
16	EP+AR+D+EP+AR	1	2.8	16	EP+EP+AR	1	0.4
17	EP+DAS+EP	1	2.8	17	EP+DAS+EP	1	0.4
18	AR+D+AR+AR	1	2.8	18	AR+D+AR+AR	1	0.4
19	EP+AR+AR	1	2.8	19	EP+AR+AR	1	0.4
20	EP+EP+AR	1	2.8	20	AR+AR+AR+AR+AR	1	0.4
21	AR+AR+AR+AR+AR+ AR	1	2.8	21	AR+AR+AR+AR+AR+AR	1	0.4
22	DAS+DAS+EP+DAS+ EP+DAS	1	2.8	22	DAS+DAS+EP+DAS+EP +DAS	1	0.4
23	EP+EP+D	1	2.8	23	EP+EP+D	1	0.4
24	AR+AR+AR+AR+AR	1	2.8	24	AR+AR+EP+EP	1	0.4
25	AR+AR+EP+EP	1	2.8	25	AR+AR+D	1	0.4
26	EP+D+EP+D	1	2.8	26	EP+D+EP+D	1	0.4
27	AR+AR+D	1	2.8	27	EP+EP+AR+D	1	0.4
28	EP+EP+AR+D	1	2.8	28	AR+AR+EP+D	1	0.4
29	D+D+D	1	2.8	29	EP+AR+D+D+AR	1	0.4
30	AR+AR+EP+D	1	2.8	30	EP+AR+D+EP+AR	1	0.4
31	EP+AR+D+D+AR	1	2.8	31	AR+D+D+AR+D+D+D	1	0.4
32	AR+D+D+AR+D+D+D	1	2.78	32	EP+D+D	1	0.4
33	AR+D+AR+D	1	2.78	33	AR+D+AR+D	1	0.4
34	EP+AR+EP+D+AR+D	1	2.78	34	EP+AR+EP+D+AR+D	1	0.4
					Total	229	100

Table 6.16 The number of RAs in which each VTM sequence occurs

VTM Sequence		CH (RA=12)		TH (RA=12)		NS (RA=12)		Whole corpus	
		No. of RAs	%	No. of RAs	%	No. of RAs	%	No. of RAs	%
1	AR	10	83.3	10	83.3	5	41.7	25	69.4
2	AR+D	9	75.0	6	50	6	50	21	58.3
3	DAS	6	50	8	66.7	4	33.3	18	50
4	D	4	33.3	3	25	6	50	13	36.1
5	EP	2	16.7	4	33.3	3	25	9	25
6	EP+AR	7	58.3	0	0	2	16.7	9	25
7	EP+D	4	33.3	1	8.3	2	16.7	7	19.4
8	EP+AR+D	2	16.7	0	0	2	16.7	4	11.1
9	EP+AR+D+EP	0	0	0	0	2	16.7	2	5.6
10	D+D+D+D	0	0	0	0	2	16.7	2	5.6
11	AR+D+AR	1	8.3	0	0	1	8.3	2	5.6
12	D+D	0	0	1	8.3	1	8.3	2	5.6
13	AR+AR	1	8.3	1	8.3	0	0	2	5.6
14	EP+AR+EP+D+AR+D	1	8.3	0	0	0	0	1	2.8
15	AR+AR+EP+EP	0	0	0	0	1	8.3	1	2.8
16	AR+AR+EP+D	0	0	0	0	1	8.3	1	2.8
17	EP+AR+D+D+AR	0	0	0	0	1	8.3	1	2.8
18	EP+AR+D+EP+AR	0	0	0	0	1	8.3	1	2.8
19	EP+EP+AR	0	0	0	0	1	8.3	1	2.8
20	AR+AR+AR+AR+AR	0	0	0	0	1	8.3	1	2.8
21	AR+AR+D	0	0	0	0	1	8.3	1	2.8
22	EP+EP+AR+D	0	0	0	0	1	8.3	1	2.8
23	D+D+D	0	0	0	0	1	8.3	1	2.8
24	AR+D+D+AR+D+D+D	0	0	0	0	1	8.3	1	2.8
25	EP+D+D	0	0	0	0	1	8.3	1	2.8
26	AR+D+D+D	0	0	1	8.3	0	0.0	1	2.8
27	EP+DAS+EP	0	0	1	8.3	0	0	1	2.8
28	AR+D+AR+AR	0	0	1	8.3	0	0	1	2.8
29	EP+AR+AR	0	0	1	8.3	0	0	1	2.8
30	AR+AR+AR+AR+AR+AR	1	8.3	0	0	0	0	1	2.8
31	DAS+DAS+EP+DAS+EP+DAS	1	8.3	0	0	0	0	1	2.8
32	EP+EP+D	1	8.3	0	0	0	0	1	2.8
33	EP+D+EP+D	1	8.3	0	0	0	0	1	2.8
34	AR+D+AR+D	1	8.3	0	0	0	0	1	2.8

Table 6.17 The occurrence of each VTM sequence in the three corpora

VTM Sequence		CH (RA=12)		TH (RA=12)		NS (RA=12)		Whole corpus	
		Occurrence	%	Occurrence	%	Occurrence	%	Occurrence	%
1	AR	21	23.6	32	44.4	14	20.6	67	29.3
2	AR+D	22	24.7	11	15.3	9	13.2	42	18.3
3	DAS	10	11.2	10	13.9	4	5.9	24	10.5
4	D	7	7.9	4	5.6	11	16.2	22	9.6
5	EP	4	4.5	7	9.7	5	7.4	16	7
6	EP+AR	8	9	0	0	2	2.9	10	4.4
7	EP+D	6	6.7	1	1.4	2	2.9	9	3.9
8	EP+AR+D	3	3.4	0	0	2	2.9	5	2.2
9	D+D	0	0	2	2.8	2	2.9	4	1.8
10	EP+AR+D+EP	0	0	0	0	2	2.9	2	0.9
11	D+D+D	0	0	0	0	2	2.9	2	0.9
12	D+D+D+D	0	0	0	0	2	2.9	2	0.9
13	AR+D+AR	1	1.1	0	0	1	1.5	2	0.9
14	AR+AR	1	1.1	1	1.4	0	0	2	0.9
15	EP+AR+EP+D+AR+D	1	1.1	0	0	0	0	1	0.4
16	AR+AR+EP+EP	0	0	0	0	1	1.5	1	0.4
17	AR+AR+EP+D	0	0	0	0	1	1.5	1	0.4
18	EP+AR+D+D+AR	0	0	0	0	1	1.5	1	0.4
19	EP+AR+D+EP+AR	0	0	0	0	1	1.5	1	0.4
20	EP+EP+AR	0	0	0	0	1	1.5	1	0.4
21	AR+AR+AR+AR+AR	0	0	0	0	1	1.5	1	0.4
22	AR+AR+D	0	0	0	0	1	1.5	1	0.4
23	EP+EP+AR+D	0	0	0	0	1	1.5	1	0.4
24	AR+D+D+AR+D+D+D	0	0	0	0	1	1.5	1	0.4
25	EP+D+D	0	0	0	0	1	1.5	1	0.4
26	AR+D+D+D	0	0	1	1.4	0	0.0	1	0.4
27	EP+DAS+EP	0	0	1	1.4	0	0	1	0.4
28	AR+D+AR+AR	0	0	1	1.4	0	0	1	0.4
29	EP+AR+AR	0	0	1	1.4	0	0	1	0.4
30	AR+AR+AR+AR+AR+AR	1	1.1	0	0	0	0	1	0.4
31	DAS+DAS+EP+DAS+EP+DAS	1	1.1	0	0	0	0	1	0.4
32	EP+EP+D	1	1.1	0	0	0	0	1	0.4
33	EP+D+EP+D	1	1.1	0	0	0	0	1	0.4
34	AR+D+AR+D	1	1.1	0	0	0	0	1	0.4
	Total	**89**	**100**	**72**	**100**	**68**	**100**	**229**	**100**

VTM pattern identification was based on VTM sequence. One type of VTM, no matter how many times it occurred in the VTM sequence, was only counted as one VTM in the VTM pattern. In other words, it was only the VTM type that was taken into account in identifying a VTM pattern. In addition, the order of the VTMs in a VTM pattern was not considered as a problem. For example, the VTM sequences *AR+D* or *D+AR* were both counted into the category of the VTM pattern *AR+D*. Since the VTMs were recognized and analyzed for understanding the visual's rhetorical functions, the sequential order of the VTMs in the VTM sequences would not be a barrier. Consequently, there were 9 VTM patterns in the whole corpus. All the VTM sequences were categorized into the 9 VTM patterns shown in Table 6.18 below.

Table 6.18 Summary of the VTM sequences categorized into the VTM patterns

	VTM pattern	VTM sequence (N=34)
1	AR	1. AR; 11. AR+AR; 20. AR+AR+AR+AR+AR; 21. AR+AR+AR+AR+AR+AR;
2	AR+D	2. AR+D; 14. AR+D+AR; 15. AR+D+D+D; 18. AR+D+AR+AR; 25. AR+AR+D; 31. AR+D+D+AR+D+D+D; 33. AR+D+AR+D;
3	D	4. D; 9. D+D; 12. D+D+D; 13. D+D+D+D
4	DAS	3. DAS
5	EP	5. EP
6	EP+AR	6. EP+AR; 16. EP+EP+AR; 19. EP+AR+AR; 24. AR+AR+EP+EP
7	EP+AR+D	8. EP+AR+D; 10. EP+AR+D+EP; 15. EP+D+EP+AR; 27. EP+EP+AR+D; 28. AR+AR+EP+D; 29. EP+AR+D+D+AR; 30. EP+AR+D+EP+AR; 34. EP+AR+EP+D+AR+D
8	EP+D	7. EP+D; 23. EP+EP+D; 26. EP+D+EP+D; 32. EP+D+D
9	DAS+EP	17. EP+DAS+EP; 22. DAS+DAS+EP+DAS+EP+DAS

Note: the ID number of each VTM sequence was based on Table 6.15

As can be seen from Table 6.19 below, the nine VTM patterns identified for visuals in the whole corpus are 1) *AR*; 2) *AR+D*; 3) *D*; 4) *DAS*; 5) *EP*; 6) *EP+AR*; 7) *EP+AR+D*; 8) *EP+D*; and 9) *DAS+EP*. The most frequent VTM pattern is *AR*, accounting for 31% of all the visuals in the whole corpus. The second and third VTM patterns that are popular among all the visuals are *AR+D* and *D*. It is observed that 21.4% and 13.1 % of all visuals demonstrate these two VTM patterns, respectively. *DAS*, *EP*, and *EP+AR* are the fourth, fifth, and sixth VTM patterns identified with 10.5%, 7%, and 5.7% of all visuals, respectively. The last three VTM patterns are *EP+AR+D*, *EP+D*, and *DAS+EP*, with 5.2%, 5.2% and 0.9% as their respective percentage of all the visuals.

Table 6.19 Summary of the VTM patterns in the whole corpus

	VTM pattern	No. of RAs in which the VTM pattern occurs (RA=36)	%		VTM pattern	Occurrence (Visual=229)	%
1	AR	27	75	1	AR	71	31
2	AR+D	23	63.9	2	AR+D	49	21.4
3	DAS	18	50	3	D	30	13.1
4	D	14	38.9	4	DAS	24	10.5
5	EP+AR	11	30.6	5	EP	16	7
6	EP	9	25	6	EP+AR	13	5.7
7	EP+D	9	25	7	EP+AR+D	12	5.2
8	EP+AR+D	8	22.2	8	EP+D	12	5.2
9	DAS+EP	2	5.6	9	DAS+EP	2	0.9
					Total	**229**	**100**

6.2.2.2.3 Analysis of Visuals with VTMs

Visuals in EERAs are multimodal since they consist of two parts: the figure or table and the caption, and the texts associated with the figure or table. When analyzing the following examples, the visuals were reproduced with the figure, caption and their VTMs. Each of the nine VTM patterns was provided with one example.

1) VTM pattern *AR*

Example 1a (Fig. 22, CH5) VTM sequence: *AR*

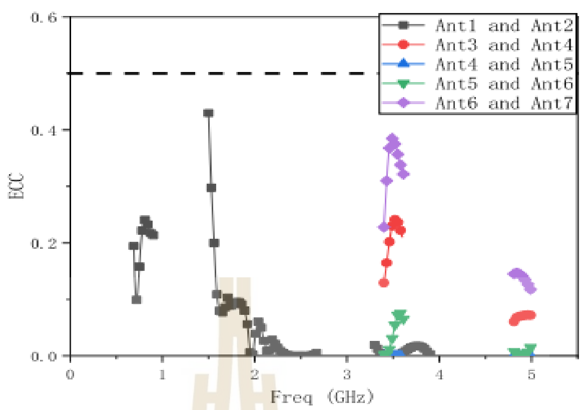


FIGURE 22. Calculated ECC of the proposed Twelve-port MIMO Antenna System.

Fig. 22 shows the calculated ECC of the proposed twelve-port MIMO antenna system. The values of the 4G antenna module are less than 0.42 and the values of the 5G antenna module are less than 0.4, over their operating bands. As the (VTM *AR*)

This visual belongs to scatterplot, which is often used in the field of statistics and data science, consisting of multiple data points plotted across two axes. Each variable depicted in a scatterplot would have multiple observations. Usually, different colors would be applied to signify more than two variables in a scatterplot. It is a great indicator of patterns that could be found between the two variables. In this scatterplot, there are five colors representing 5 different sets of antenna. On the other hand, scatterplot could help to see if variables were uncorrelated. Therefore, scatterplot could be a very useful type of graph that helps the reader see the data patterns or relationship between different sets of data. However, scatterplots are not suitable for observing time patterns.

The VTM of Fig. 22 in CH5 was the two sentences demonstrating one VTM *AR* since these two sentences achieved the same communicative purposes of reporting results of "*the calculated ECC of the proposed twelve-port MIMO antenna system*", which functioned epistemologically.

Example 1b (Fig. 3, NS9) VTM sequence: *AR+AR+AR+AR+AR*

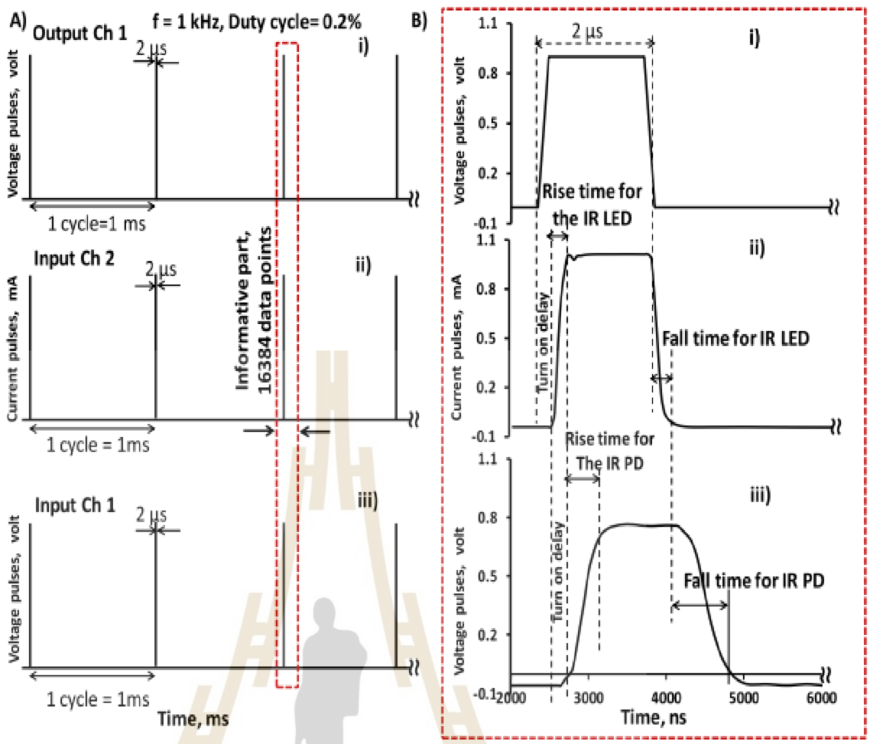


Fig. 3. A) Schematic representation of three types of pulsed signals generated and measured through i) output channel 1, ii) input channel 2 and iii) input channel 1 of the micro-controller system, informative parts (buffer size data points) are shown within the red dash lined rectangle. B) detail of each pulsed signal: (i) Step wise generated pulse defined by the µC system (Red Pitaya); (ii) current pulse to drive the IR LED, and (iii) the corresponding optical output pulses from the IR LED detected by the IR PD. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

parameters of the program. The stepwise pulses generated by the µC are shown in Fig. 3A (i) as a continuous stream and in Fig. 3B (i) as single pulse which was constructed by the following: 500 steps with 0 V to achieve the base line, 20 steps to achieve 0.9 V, 180 steps to make the pulse top with 0.9 V, 20 steps to bring the pulse signal down to 0 V and the remaining steps to fill the buffer at 0 V (1 step = 10 ns. The pulse generated was repeated with 1 kHz frequency, and the total time duration depends on the number of pulse data that need to be processed. The corresponding (VTM *AR*)

number of pulse data that need to be processed. The corresponding

converted currents pulsed from the V-to-I conversion unit, and measured in channel 2 of the µC are shown in Fig. 3 A (ii) and 3B (ii). These currents were used to drive the IR LEDs in pulse mode. (VTM *AR*)

IR radiation from the LED was detected by the IR PD and transformed from an optical pulse signal to voltage pulses (V_{out}) as measured in Channel 1 of the µC shown in Fig. 3A (iii) and 3B (iii). This (VTM *AR*)

From Fig. 3 B i) it is observed that the stepwise generated pulse from the µC system follows a smooth shape, with a sharp rise and fall as it is generated. However, when it was converted into current (VTM *AR*)

200 ns to generate the final optical output (~2A). After detecting the response from the IR LED, the IR PD has a "rise time" and a "fall time" of 250 ns a shown in Fig. 3 B. The response delay appears due (VTM *AR*)

Example 1b shows a schematic diagram that presents data processing methods. Under Gross and Harmon's (2014) taxonomy, flowcharts, process diagrams, and circuit diagrams are representations in which space is a metaphor for something else, as opposed to ones in which space is space, such as terrestrial maps. This is the distinction between "topographical" and "topological" made by Kress and van Leeuwen (1996) in *Reading Images*. Similarly, schematic diagram in EERAs of the whole corpus falls into this category since it mainly depicts data processing, in which space is metaphoric. Comparing with line graph, which indicates trends or data patterns over real time, schematic diagram, flowchart, process diagram and circuit diagram are "models of events that just happen to take place in time", which means that "sequence" is all that matters.

In Example 1b, VTM *AR* occurred five times since five pieces of texts were found associated with Fig. 3 in NS9. All of them stated the observed facts of a testing action. The identified VTM sequence *AR+AR+AR+AR+AR* was categorized into the VTM pattern *AR*, which was the most prevalent pattern adopted by EE researchers in all the three corpora (as shown in Table 6.16). In the R&D section, most visuals, when mentioned by VTM, mainly firstly reported the results or findings, of which most were statistical. These results showed the obtained facts about a testing of a proposed model or an experiment.

2) VTM pattern *AR+D*

Example 2 (Fig. 6, CH11) VTM sequence: *AR+D+AR*

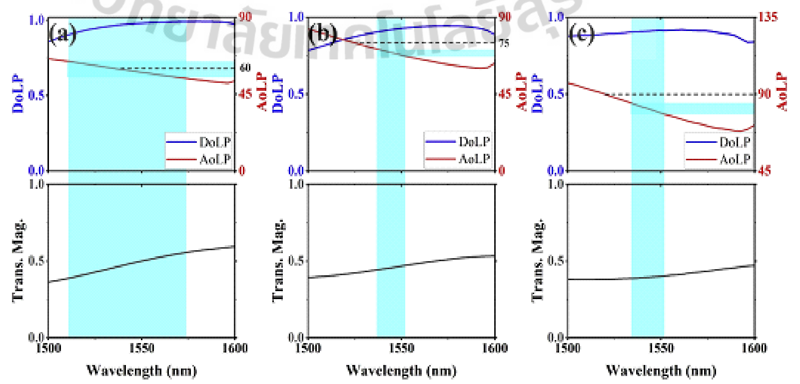


Fig. 6. Calculated DoLP (blue curve), AoLP (red curve), and the corresponding transmission magnitude (black curve) of light transmitted by the proposed polarization rotators in the (a) S2, (b) S3, and (c) S4 configurations. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

measure the polarization orientation of the transmitted light [14,16,18]. Fig. 6(a)–(c) depict the calculated AoLP and DoLP, and the corresponding transmission magnitude for S2–S4 when these metasurface configurations were illuminated by 45°-LP light with a wavelength ranging from 1500 – 1600 nm. The blue regions of these images indicate that AoLP varies from 64° to 54°, 71° to 68° and (VTM *AR*)

wavelength ranging from 1500 – 1600 nm. The blue regions of these images indicate that AoLP varies from 64° to 54°, 71° to 68° and 85° to 78° around 1550 nm (for S2, S3, and S4, respectively), and that the DoLP is greater than 0.9, values which are in good

agreement with the theoretical analysis. Although the AoLPs outside the blue region are inconsistent with theoretical predictions, they still reflect the optical activity of the designed structure when incident excitation is fixed as 45°-LP light. Finally, Fig. 6 also (VTM *D*)

they still reflect the optical activity of the designed structure when incident excitation is fixed as 45°-LP light. Finally, Fig. 6 also indicates that the transmission magnitudes for the three proposed configurations are greater than 0.4 in the three work bands considered (blue regions). (VTM *AR*)

This graph in Example 2 belongs to the category of line graph, in which a line or multiple lines showing single or multiple variables develop over time. Line graph was the most frequently used visual in the whole corpus. It was useful and effective because it could enable writers to easily highlight the magnitude of change of one or more variables over a time period. In Example 2, *DoLP* and *AoLP* are the two variables. Writers could take a line graph into account if they want to track the development of several variables at the same time.

Example 2 shows the second VTM pattern that is prevalent for visuals in the whole corpus to display: *AR+D*. There were 48 visuals, accounting for 21% of all visuals in the whole corpus, demonstrating these two communicative purposes. As mentioned before, VTM *AR* was for reporting facts observed and obtained through the visuals, while VTM *D* provided explanations, interpretations or comments for the obtained results, which usually were the opinion of the researchers themselves. Visuals with the VTM pattern *AR+D* had both epistemological and argumentative functions.

3) VTM pattern *D*

Example 3 (Fig. 10, TH9) VTM sequence: *D+D*

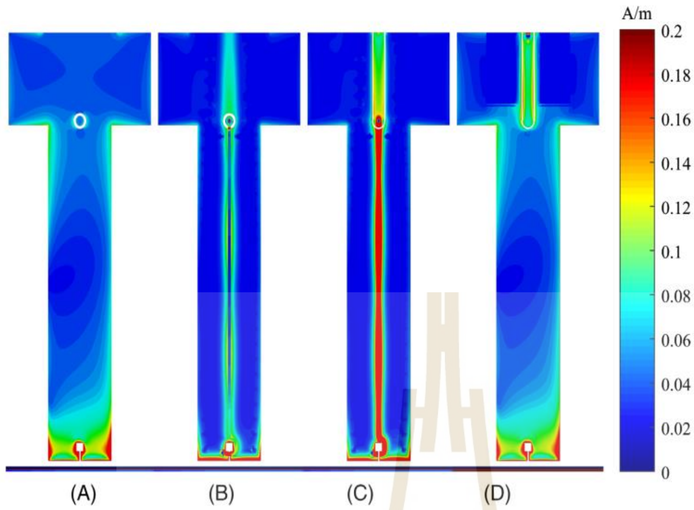


FIGURE 10 Magnetic field simulation of probe: (A) Outside bottom surface; (B) Inside bottom surface and stripline; (C) Inside top surface; and (D) Outside top surface

dle of frequency band 10 GHz. Figures 10 and 11 represent the two-dimensional magnetic field and electric field that are coupled from the microstrip on the bottom edge of the probe where the microstrip power is fed from left to right. The surface (VTM *D*)

current is also presented in Figure 12. From Figure 10, the magnetic field is coupled from the microstrip via the stripline loop on the probe edge and the currents flow into two paths: one is from stripline to bottom ground (Figure 12B) and another is from stripline to top ground (Figure 12C). The two electric field (VTM *D*)

Example 3 shows a picture. Photo, picture and drawing function as virtual witnesses that allow readers to see what the researcher saw in the field or laboratory (Gross & Harmon, 2014). Lacking prototypical structures except for the rectangular frame enclosing them is the main difference between photo, picture and drawing and other visual forms. These visuals help readers focus on the scientifically salient object. More than simple representations of the natural order, they are composed of carefully arranged scenes in which the audience's attention is focused on salient symbolic elements that conform to a larger cognitive structure (Lynch & Woolgar, 1990).

There were 12.7% of the visuals playing solely a role of Discussion since they were identified only with VTM *D*. It was identified twice for Fig. 10 in TH9. Both sets of texts provided interpretation that could not be obtained directly from the visual. That is to say, researchers offered an implied meaning for the visuals. Argumentative function was implied in the visuals with the VTM pattern *D*.

4) VTM pattern *DAS*

Example 4 (Fig. 3, NS5) VTM sequence: *DAS+DAS*

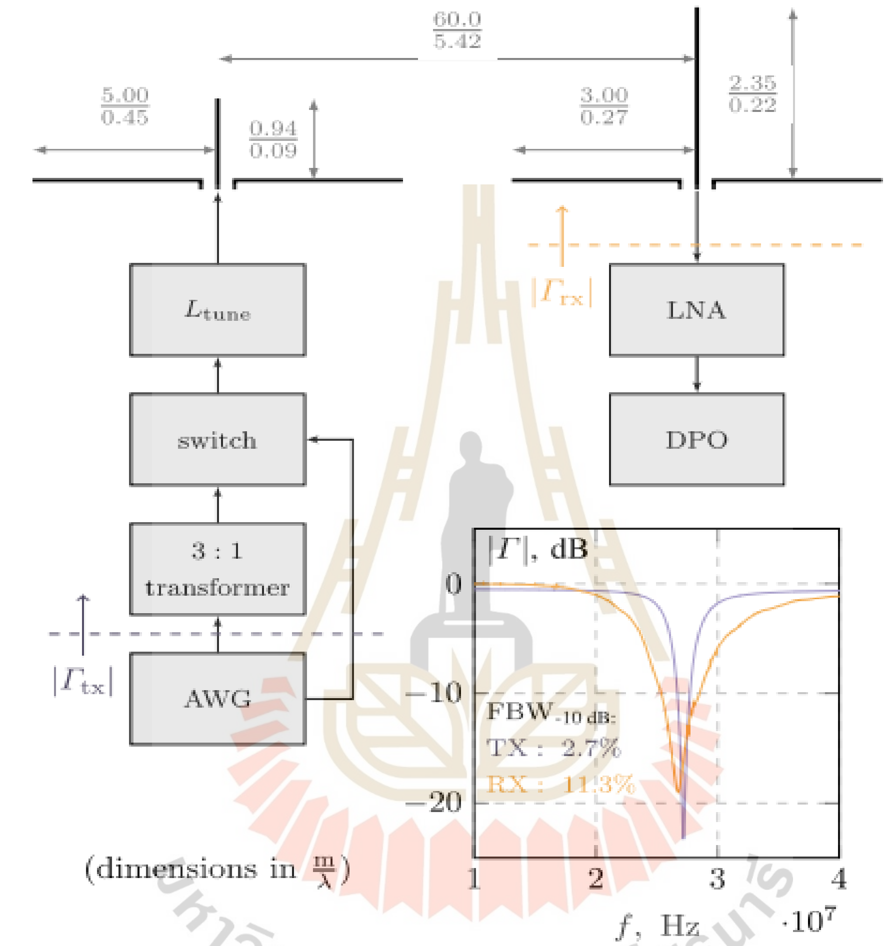


FIGURE 3. Schematic diagram of over-the-air experiment and measured transmitter and receiver reflection coefficient, as represented by S_{11}.

The measurement setup is drawn schematically in Fig. 3. The transmitting and receiving antennas are wire monopoles mechanically supported by freestanding, non-conducting masts. The antennas are fed at ground level and radials (VTM *DAS*)

well matched at the selected carrier frequency. The reflection coefficient Γ and −10 dB fractional bandwidth FBW$_{-10\ dB}$ of both antennas are shown in Fig. 3. Time-domain signals at (VTM *DAS*)

There were 24 visuals, 10.4% of all, only identified playing the role of "Displaying apparatus or site". These visuals demonstrated ontological function through introducing the devices with special features, sometimes with their parameters, for the specific tests or experiments. In the first set of text, the researchers introduced “*the measurement setup*”, while the parameters “*the reflection coefficient* and *fractional bandwidth*” were displayed in the second set of texts.

5) VTM pattern *EP*

Example 5 (Fig. 4, NS5) VTM sequence: *EP*

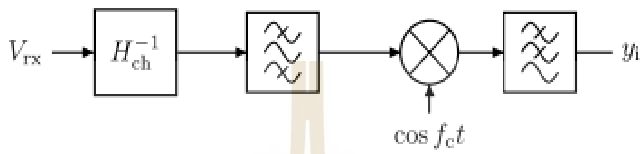


FIGURE 4. I/Q demodulation chain used to extract in-phase envelope y_i from a measured or modeled signal V_{rx}.

cessing. Measured data were coherently demodulated numerically and processed using the block diagram in Figure 4 to produce the in-phase envelope y_i. The initial bandpass filter is (VTM *EP*)

The emergence of the VTM pattern *EP* indicated that visuals could function ontologically by informing readers of the purposes, the procedures and the reason for conducting these procedures. The VTM pattern *EP* was mainly applied to invite readers to participate as the witness of appropriateness of the relevant procedures. In the text associated with Figure 4 of Example 5, the phrase “*to produce the in-phase envelope*” is the purpose, while “*Measured data were coherently demodulated numerically and processed using the block diagram*” is the means to achieve the purpose.

6) VTM pattern *EP+AR*

Example 6 (Fig. 17, CH3) VTM sequence: *EP+AR*

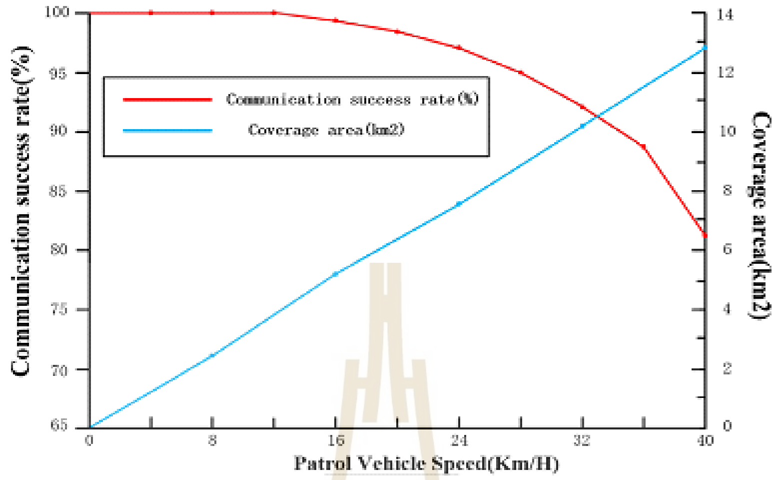


Fig. 17. Influence of soil moisture on received signal after improved sensor placement.

success rate of communication. Fig. 17 draws the data between the speed of the RFID patrol vehicle and the communication success rate and the patrol coverage in a graph, and obtains the optimal solution among them. The Fig. 17 shows that the optimum speed of patrol car is (VTM *EP*)

among them. The Fig. 17 shows that the optimum speed of patrol car is 33 km/h when the communication success rate is above 90% and the coverage area is above 10 km^2. (VTM *AR*)

EP+AR was the second VTM pattern that included two VTMs: *EP* and *AR*, thus showing two different functions at the same time. This kind of visual accounted for 5.7% of the whole corpus. The line graph in Example 6 was mentioned twice and assigned to two different VTMs. The first VTM, *EP*, suggesting ontological function, describes the line graph drawing process and its purpose. The second VTM, *AR*, mainly indicates the epistemological function of Fig. 17 in CH3 by showing the statistical results (*33 km/h*)" under certain condition "*When the communication success rate is above 90% and the coverage area is above 10 km²*".

7) VTM pattern *EP+AR+D*

Example 7 (Fig. 3, CH1) VTM sequence: *EP+AR+EP+D+AR+D*

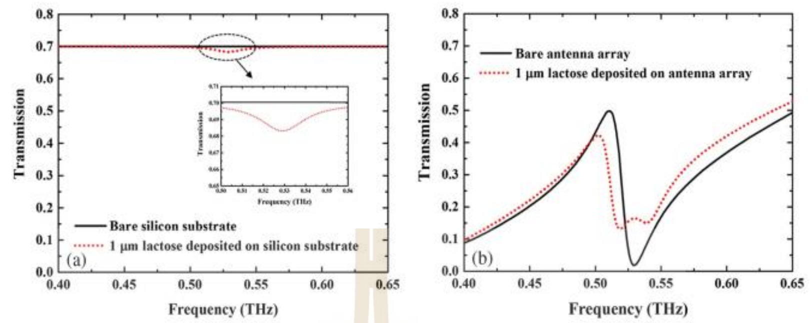


Fig. 3. (a) Transmission spectra of the silicon substrate before (black solid line) and after (red dotted line) 1 μm lactose deposition. (b) Transmission spectra of the antenna array before (black solid line) and after (red dotted line) 1 μm lactose deposition. For better comparison, the transmission spectrum of the bare antenna array was shifted to match the absorption frequency of the lactose-covered system.

To demonstrate the sensing performance of the antenna array used as a sensor for improving detection sensitivity, its sensitivity to lactose detection was compared with that of a silicon substrate, and the calculated results are plotted in Fig. 3. For (VTM EP)

substrate, and the calculated results are plotted in Fig. 3. For the silicon substrate, a tiny change in the transmission spectrum after the 1 μm lactose deposition is observed, as shown by the red dotted line in Fig. 3(a). To get a better view, we zoom in to (VTM *AR*)

red dotted line in Fig. 3(a). To get a better view, we zoom in to the region ranging from 0.50 THz to 0.56 THz, and the enlarged view is shown in the inset in Fig. 3(a). The visible (VTM *EP*)

enlarged view is shown in the inset in Fig. 3(a). The visible

change shows as a dip located at 0.529 THz; this is due to the fact that lactose absorbed the incident terahertz radiation. The tiny change was found to be 1.7%, which was defined as the difference of transmittance value at 0.529 THz of the sample (silicon substrate covered with lactose) to that of reference (bare silicon substrate). However, in the case of the antenna array, a (VTM *D*)

silicon substrate). However, in the case of the antenna array, a rather obvious change in the transmission spectrum after loading 1 μm lactose was observed, as shown by the red dotted line in Fig. 3(b). There was a distinct transmittance peak originated (VTM *AR*)

in Fig. 3(b). There was a distinct transmittance peak originated from the characteristic absorption of lactose in the location of the resonance of the antenna array. This phenomenon could be (VTM *D*)

Visuals in the whole corpus pointed by three types of VTMs were not many, but there were a few. The researcher found twelve visuals that could be grouped into the VTM pattern *EP+AR+D*. By displaying three types of communicative purposes, ontological, epistemological, and argumentative functions were embodied in these visuals. In Example 7, there were six sets of texts found to point to the visual Fig. 3 in CH1. The VTM sequence of this example was *EP+AR+EP+D+AR+D*. VTM *EP* occurred twice, VTM *D* three times, and VTM *AR* once. VTM *EP* prepared and provided illustration for the following procedure (*To demonstrate…*; *To get a better view…*). VTM *D* provided interpretation of the visual and reasons explaining the obtained results (*due to…*; *was defined as the difference of…; …originated from the…*). VTM *AR* mainly reported the results and findings (*a tiny change…is observed*; *a rather obvious change…was observed*). All VTMs worked together, making this particular visual multifunctional.

8) VTM pattern *EP+D*

Example (Fig. 3, NS1) VTM sequence: *EP+D+D*

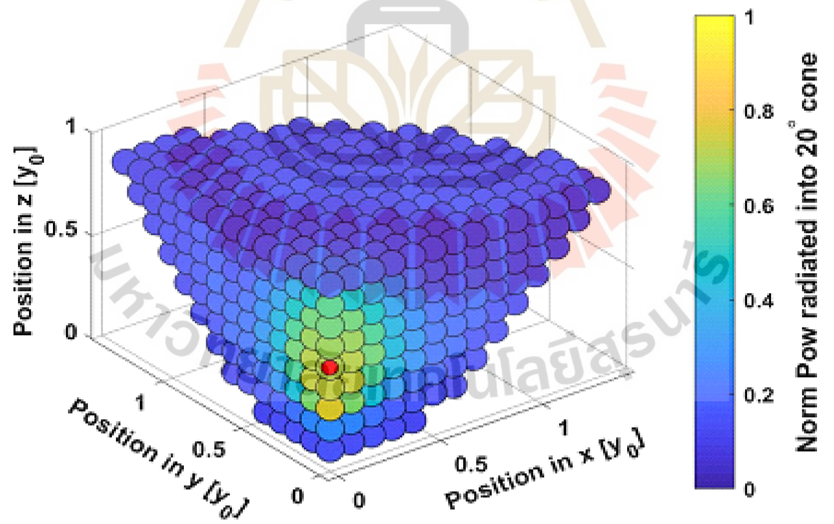


Fig. 3. Geometrical optics solution for power directed into a 20° half-angle cone for an isotropic emitter at varying positions within a finite parabolic reflector. As the solution is independent of the size of the reflector in the geometrical optics regime, the dimensions are given in terms of the vertex to opening distance y_0. Power values are normalized to the total emitted power. The red dot marks the focus of the paraboloid.

the geometrical optics solution. Figure 3 shows the variation in the power directed into a 20° half-angle cone as the source position is varied, simulated using the geometrical optics approximation. As expected, a region of efficient coupling into the (VTM *EP*)

extent of the paraboloid and the finite collection angle. While a source at the focus still optimizes emission on axis, emission into the cone is optimized when the source lies below the focal point as seen in Fig. 3. (VTM *D*)

Figs. 4(a)–4(c). As one might expect, the focusing behavior seen in Fig. 4(i) is less pronounced and less spatially localized than that seen in the geometrical optics regime of Fig. 3. (VTM *D*)

If a graph has (or appears to have) height, width and depth, it could be called a 3D (or three-dimensional) graph. It allows researchers and readers to see the three-dimensional relationship of the object from the top to the bottom, left and right, front and back. If a picture has height and width, but no depth, it is two-dimensional (or 2D). One of the basic differences between two-dimensional graphics and three-dimensional graphics is that two-dimensional graphics are good at conveying simple information quickly, while three-dimensional graphics can tell more complex stories, but they must carry more information at the same time.

The VTM pattern *EP+D* formed by 2 VTMs had the same occurrence as the VTM pattern *EP+AR+D*. Twelve visuals were labelled as the combination of the two VTMs *EP* and *D*. In Example 8, three sets of texts were identified to be connected with the visual Fig. 3 in NS1. VTM *EP* was shown when specific condition was introduced (*the power directed into a 20° half-angle cone as the source position is varied*). Interpretation of the observed results under a certain condition was initiated in the second set of text (*While*...; ...*is optimized when* ...). In the third set of text, the opinion on the results through a comparison with another visual was yielded (...*is less pronounced and less spatially localized than*...). Visuals belonging to this VTM pattern *EP+D* had both ontological and argumentative functions.

9) VTM pattern *DAS+EP*

Example 9 (Fig. 8, TH9) VTM sequence: *EP+DAS+EP*

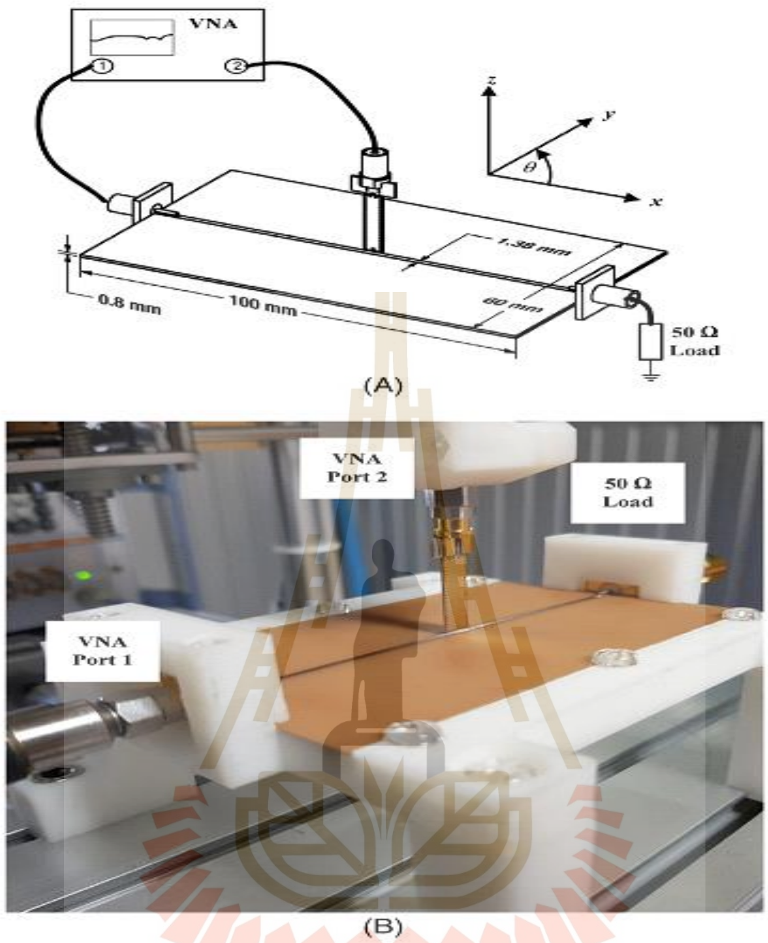


FIGURE 8 Illustration (A) and photograph (B) of the magnetic probe calibration set-up

prototype is shown in Figure 7. To characterize the probe accurately, a TEM source in TEM cell can be used as a source of the magnetic field for probe calibration but in this article, the low-cost calibration technic is conducted by using magnetic field generated from microstrip line and the measurement set-up is presented in Figure 8A.[32] A two-port (VTM *EP*)

thickness. The actual microstrip substrate is mounted on an *x*-*y* plane and the magnetic probe is mounted along *z* axis in the middle of the microstrip line as illustrated in Figure 8B.[13] The (VTM *DAS*)

while the magnetic field is minimum. The probe and microstrip as configured in Figure 8A are simulated to find the magnetic field, the electric field and the surface current. The input power (VTM *EP*)

The last example, Example 9, also shows two VTMs: *DAS* and *EP*. The VTM pattern *DAS+EP* was rare since there were only two visuals identified with these two VTMs. In the first and third sets of texts, VTM *EP* was identified which mainly showed us the purposes of the procedures (*To characterize*...and *to find...*). The second set of text, describing the devices and their components (*The actual microstrip substrate* and *the magnetic probe*), was identified as VTM *DAS*. Visuals with this VTM pattern *DAS+EP* demonstrated ontological function. Fig. 8 in TH9 contains one schematic diagram and one photo, which were regarded as witnesses of the device or the setup for convincing or pervasive effect. The VTM pattern *DAS+EP* was usually associated with such visuals as pictures, photos and schematic diagrams.

6.2.2.3 Comparison of VTMs and VTM Patterns

6.2.2.3.1 Comparison of VTMs

Tables 6.20-6.21 show that among the 4 VTMs identified in the CH, TH, and NS corpus, the most dominant one is *Announcing Results* (*AR*), accounting for 45.2%, 54.8% and 37% of all VTMs in the CH, TH, and NS corpus, respectively. The similarity among the three corpora was that *AR* and *D* were placed in the top two, while *EP* and *DAS* were found at the bottom in terms of their total occurrence in each corpus. This means both *AR* and *D* had higher occurrence than *EP* and *DAS*. In addition, it also indicated that visuals in the R&D section in EERAs mainly displayed functions of epistemology and argument since they were employed to report results and findings and to provide accounts and interpretation for them.

Table 6.20 The occurrence of VTMs in the R&D section in the three corpora

VTM	CH (RA=12)		TH (RA=12)		NS (RA=12)		Whole corpus (RA=36)	
	Occurrence	%	Occurrence	%	Occurrence	%	Occurrence	%
1 Announcing results (AR)	70	45.2	52	54.8	51	37	173	44.6
2 Discussion (D)	45	29	22	23.2	59	42.8	126	32.5
3 Establishing presumptions (EP)	27	17.4	11	11.6	25	18.1	63	16.2
4 Displaying apparatus or site (DAS)	13	8.4	10	10.5	3	2.1	26	6.7
Total	155	100	95	100	138	100	388	100

In addition, noticeable variations were revealed. First, the total number of VTMs was quite different, with 155 in the CH, 95 in the TH, and 138 in the NS. One reason for the variation in total amount was the theme and scope of the study and the EERA length. The numbers indicated Chinese researchers' stronger tendency to employ visuals. It coincided with the results of the preliminary needs analysis conducted at the beginning of the research: 97% of the participants thought visuals are necessary, because they regarded them as a means to establish presumption, construct concepts, serve as evidences, create new knowledge, and participate in discussion. Second, Chinese and Thai EE researchers tended more to adopt visuals when reporting the results than NS researchers, which could be seen from Table 6.20 that the top VTM was *AR* in the CH and TH corpora and *D* in the NS corpus.

NS writers paid more attention to explaining and interpreting the obtained results by providing more detailed causes since 42.8% of the 138 VTMs are identified as VTM *D*. The finding that 11 RAs in the CH demonstrating VTM *D* indicated that most of the Chinese EE writers employed visuals to assist commenting on and offering probable reasons for the results.

Table 6.21 The number of RAs in which each VTM occurs in the R&D section in the three corpora

VTM	CH (RA=12)		TH (RA=12)		NS (RA=12)		Whole corpus (RA=36)	
	No. of RAs	%	No. of RAs	%	No. of RAs	%	No. of RAs	%
1 Announcing results (AR)	12	100	12	100	12	100	36	100
2 Discussion (D)	11	91.7	8	66.7	12	100	31	86.1
3 Establishing presumptions (EP)	8	66.7	6	50	9	75	23	63.9
4 Displaying apparatus or site (DAS)	7	58.3	8	66.7	3	25	18	50

The condition of VTMs *EP* and *DAS* was interpreted as more of a similarity rather than a difference. The occurrence of VTM *EP* was 27, 11 and 25, ranking the third VTM in the three corpora. The occurrence of VTM *DAS* was 13, 10 and

3, ranking the fourth VTM in the three corpora. Table 6.21 shows that *DAS* in the NS corpus was the only VTM with its occurrence less than half of EERAs

6.2.2.3.2 Comparison of VTM Patterns

While the VTM analysis above is the way to see the overall occurrence and distribution of all VTMs in the R&D section in their respective corpus. The VTM pattern, on the other hand, is the method that could reveal the condition of communicative purposes or rhetorical functions of each visual.

As analyzed in Section 3.6.3.2.2.2, the nine VTM patterns were 1) *AR*, 2) *AR+D*, 3) *D*, 4) *DAS*, 5) *EP*, 6) *EP+AR*, 7) *EP+AR+D*, 8) *EP+D*, and 9) *DAS+EP*. Tables 6.22-6.23 show the summary of all nine VTM patterns represented in each visual in the three corpora. Every visual was assigned to one of the nine VTM patterns.

The variations were obvious in the top three most frequent VTM patterns among the three corpora. In the CH, there were 24 visuals that demonstrate the VTM pattern *AR+D*, accounting for 27% of all the visuals. However, *AR+D* ranked the second and the third VTM pattern in the TH and NS, respectively. This indicated that Chinese researchers tended to use visuals for both reporting results and providing interpretation. However, they also used visuals solely for result announcement. In their EERAs, they might engage the visuals in both the VTM patterns *AR+D* and *AR*. In the TH, the most frequently adopted VTM pattern was *AR*, indicating that rather than endowing visuals with two VTMs, Thai researchers had the tendency to only report their results through visuals. Forty-five point eight percent of all the visuals in the TH corpus demonstrated this trend. In addition, *AR+D* and *DAS* were the second and third most employed VTM patterns that the Thai researchers adopted to refer to their visuals. However, the number of *AR+D* and *DAS* was much less than, or less than half of the top VTM pattern *AR*, suggesting their strong tendency of applying visuals to support result announcement. Situations in the NS corpus demonstrated a different picture. The VTM pattern that most frequently occurred was *D*, implying that NS researchers tended to initiate discussion when referring to the visuals, even though VTM patterns *D*, *AR*, *AR+D* demonstrated no huge disparity in terms of occurrence.

Table 6.22 The occurrence of the VTM patterns in the R&D section in the three corpora

VTM pattern	CH (Visual=89)		TH (Visual=72)		NS (Visual=68)		Visual=229	
	Occurrence	%	Occurrence	%	Occurrence	%	Total	%
1 AR	23	25.9	33	45.8	15	22.1	71	31
2 AR+D	24	27	13	18	12	17.7	49	21.4
3 D	7	7.9	6	8.3	17	25	30	13.1
4 DAS	10	11.3	10	13.9	4	5.9	24	10.5
5 EP	4	4.5	7	9.7	5	7.4	16	7
6 EP+AR	8	9	1	1.4	4	5.9	13	5.7
7 EP+D	8	9	1	1.4	3	4.4	12	5.2
8 EP+AR+D	4	4.5	0	0	8	11.8	12	5.2
9 DAS+EP	1	1.1	1	1.4	0	0	2	0.9
Total	89	100	72	100	68	100	229	100
No. of RAs	12		12		12		36	

Table 6.23 The number of RAs in which each VTM pattern occurs in the R&D section in the three corpora

	VTM pattern	CH (Visual=89)		TH (Visual=72)		NS (Visual=68)		Visual=229	
		No. of RAs	%	No. of RAs	%	No. of RAs	%	Total	%
1	AR	11	91.7	10	83.3	6	50	27	75
2	AR+D	9	75	8	66.7	8	66.7	23	63.9
3	D	4	33.3	6	50	7	58.3	14	38.9
4	DAS	6	50	4	33.3	4	33.3	18	50
5	EP	2	16.7	2	16.7	3	25	9	25
6	EP+AR	7	58.3	1	8.3	3	25	11	30.6
7	EP+D	5	41.7	2	16.7	3	25	9	25
8	EP+AR+D	3	25	2	16.7	5	41.7	8	22.2
9	DAS+EP	1	8.3	1	8.3	0	0	2	5.6

The moves, steps, move-step structure of the Results & Discussion section in EERAs in the CH, TH, and NS corpora indicated the disciplinary features of this section. In this section, three moves and twelve steps were identified for constructing a move-step structure of the EERA R&D section. All the three moves were categorized as obligatory. The variations among the three groups were mainly demonstrated by steps within each move. For instance, *Step 1.4 Justifying procedures or methodology* was considered as obligatory in the CH and NS, while it was optional in the TH. Move cycles *2-3.1* and *1.4-2-3.1* occurred most frequently, which demonstrated similarity rather than variation among the three corpora. The obvious difference in terms of move cycle across the three corpora was the total number of move cycles identified and the number of occurrence of certain move cycles. The probable reasons for Chinese researchers employing more move cycles attributed to the research purposes, scope, and methodology. For example, the methodology they adopted consisted of more than one procedures, and each procedure yielded different results that influenced the following procedure. Thus, these different procedures might be identified as different move cycles.

VTM analysis revealed that EE researchers depended on visuals very much based on the large number of visuals they employed in their EERAs. Line graph was the top dominant visual in this discipline. Ontological, argumentative, and epistemological functions (Moghaddasi et al., 2019) were the three functions assigned to visuals in the R&D section of the EERAs. Four VTMs adapted from Moghaddasi et al., (2019) were identified. VTM *Announcing Results* (AR) was the most prevalent VTM among the three corpora since visuals in the R&D section mainly helped construct new knowledge. VTM *Discussion* (D) was also prevalent in the NS corpus, suggesting that NS writers in the EE discipline tended to employ visuals for the demonstration of not only new knowledge but also persuasive arguments for their claim. However, this kind of balance was not apparent in the CH and TH.

Apart from VTM analysis, VTM patterns were also analyzed to explore the rhetorical function of each visual. The results showed that there were nine VTM patterns in the whole corpus. Moreover, the Chinese, Thai, and NS researchers showed different tendency in applying visuals for achieving different or multiple communicative purposes. The Chinese researchers in this study preferred visuals to be engaged in only announcing results and both announcing results and providing interpretation since the VTM patterns *AR* and *AR+D* were the most popular ones. The Thai researchers had the obvious tendency to involve visuals for result announcement based on the fact that the occurrence of the VTM pattern *AR* was the most dominant one. NS researchers, to some degree, sought a balance among the VTM patterns *AR*, *AR+D*, and *D*, even though they showed that *D* is the most favorable VTM pattern. Compared with the other VTM patterns, NS would like the visuals to be involved in interpretation support.

6.3 Summary

This chapter presented the results and discussion from the analyses of the moves, steps, move-step structure, and VTMs of the R&D section in accordance to the three move-step frameworks (Kanoksilapatham 2005, 2015; Maswana et al., 2015) and the VTM framework (Moghaddassi et al., 2019). Three moves and twelve steps were found in the EERA R&D section. The variations existed in the employment of the moves, steps in the newly proposed move-step structure among the EERAs composed by Chinese, Thai, and Native English speaking writers. VTM analysis revealed that visuals tended more to participate in epistemological and argumentative functions in this section.

CHAPTER 7

RESULTS AND DISCUSSION
OF THE CONCLUSION SECTION

This chapter presents the results and discussion from the analysis of the move-step structure of EERAs in the Chinese, Thai, and NS corpora. Since visuals are totally absent in this section, visual-textual move analysis is not conducted. First, the move-step framework for the Conclusion section and the general move-step trend are provided. Second, the overall results of the moves and the steps in the whole corpus are discussed. Thirdly, description of each move and step and their examples are presented. Lastly, the comparisons of the moves, steps, move patterns and move cycle among the three corpora are provided with discussion of the findings.

7.1 Overview of the Conclusion Section

The analysis of the Conclusion of the whole corpus led to a modified and revised model of the move-step framework for this section. Tables 7.1-7.2 show the previously and newly proposed move-step model for the Conclusion section, respectively. Instead of arranging all the steps under the Move "*Stating research conclusion*", the researcher revised them into three moves. *Move 1 Summarizing the study* could be realized by three steps, i.e., *1.1 Restating purposes*, *1.2 Restating methods*, and *1.3 Summarizing findings*. *Indicating significance* and *Suggesting further research* were recognized as *Move 2* and *Move 3*, respectively. Different from the selected referential frameworks, i.e., Kanoksilapatham (2005, 2015) and Maswana et al. (2015), the present study analyzed the Conclusion section as a separate section since all of the EERAs in the CH, TH, and NS corpora contained the stand-alone Conclusion section, despite their small distinctions in headings: "Conclusion", "Conclusions", and "Summary". The EERAs with the heading of "Conclusions" were CH2, CH4, CH8, and CH12 in the CH corpus; TH4, TH5, TH7, TH9, TH10, and TH12 in the TH corpus; NS1, NS4, NS5, NS8, and

NS9 in the NS corpus. The heading of "Summary" was used in CH9, NS2, and NS3. Hence, "Conclusion" and "Conclusions", serving as headings for respective 18 and 15 EERAs in the whole corpus, were the popular headings for EE researchers to title their last section.

Table 7.1 The probable move-step framework proposed previously for the EERA Conclusion section

Move	Step
1. Stating research conclusions	1.1 Stating methodology (purposes, RQs, procedures)
	1.2 Restating research findings
	1.3 Indicating research significance
	1.4 Suggesting further research
	1.5 Stating research conclusions

Table 7.2 The revised framework for the EERA Conclusion section

Section (N=36)	Move and Step	%	Status
Conclusion	**1. Summarizing the study**	100	Obl
	1.1 Restating purposes	77.9	Con
	1.2 Restating methods	58.3	Con
	1.3 Summarizing findings	97.2	Obl
	2. Indicating significance	50	Con
	3. Suggesting further research	5.6	Opt

Note: Obl: obligatory; Con: conventional; Opt: optional

What's more, the categorization of the Conclusion section into three moves in the present study was in agreement with Yang and Allison (2003) and Ye (2019). Yang and Allison's (2003) framework for the Conclusion section comprised three moves: *Move 1 Summarizing the study*, *Move 2 Evaluating the study* and *Move 3 Deductions from the research*, while the three moves in Ye (2019) were *Move 10 Reviewing the present study*, *Move 11 Evaluating the present study*, and *Move 12 Promoting future research*. Comparing these two previous studies with the present study, the similarity was that the first moves of the three studies all were the most frequently present move in the Conclusion section, however with different frequency statuses. To be specific, *Move 1 Summarizing the study* in Yang and Allison (2003) occurred in 18 out of 20 RAs in Applied Linguistics; *Move 10 Reviewing the present study* occurred in 100% of the Energy Engineering RAs in Ye (2019), categorized as obligatory (categorizations of move and step status: obligatory, quasi-obligatory, and optional). In the present study, *Move 1 Summarizing the study* also had the highest occurrence among all the three moves.

Table 7.3 The number of EERAs in which each move or step occurs in the whole corpus

	Move/Step	No. of RAs in which the move or step occurs (RA=36)	%	Status
Move	**1. Summarizing the study**	36	100	Obl
	2. Indicating significance	18	50	Con
	3. Suggesting further research	2	5.6	Opt
Step	1.3 Summarizing findings	35	97.2	Obl
	1.1 Restating purposes	28	77.8	Con
	1.2 Restating methods	21	58.3	Con

Table 7.4 The total occurrence of all the moves and steps in the whole corpus

	Move/Step	Occurrence (RA=36)	%
Move	**1. Summarizing the study**	46	28.6
	2. Indicating significance	18	11.2
	3. Suggesting further research	2	1.2
Step	1.3 Summarizing findings	41	25.5
	1.1 Restating purposes	30	18.6
	1.2 Restating methods	24	14.9
Total		161	100

Tables 7.3-7.4 show the summary of the number of EERAs in which each move or step occurs and the total occurrence of each move and step in the whole corpus.

Firstly, it could be observed from Table 7.3 that there are one obligatory, i.e., *Move 1 Summarizing the study*, one conventional, i.e., *Move 2 Indicating significance*, and one optional move, i.e., *Move 3 Suggesting further research*. *Move 1* occurred in 100% of the EERAs in the whole corpus, indicating that the EE researchers were obliged to employ this move. Interestingly, *Move 2 indicating significance* occurred in 18 EERAs, only half of the corpus, implying that this move was not prevalent in the conventional category. *Move 3 Suggesting further research*, which occurred only in two EERAs, is of the least concern. Secondly, as for steps in the Conclusion, all of them are under *Move 1*. *Step 1.3* occurred in 35 EERAs of the whole corpus, suggesting its obligatory status. *Steps 1.1* and *1.2* are conventional because they occurred in 28 and 21 EERAs, respectively. The statuses of these three steps suggest EE researchers' obvious tendency in employing *Steps 1.3* and *1.1* over *Step 1.2*. Moreover, although being within the same conventional category, *Step 1.1* was found to be more popular than *Step 1.2*. Table 7.4 showing the total occurrence of the moves and steps implies similar results: *Move 1* and *Step 1.3* occurred the most; *Step 1.2*, *Step 1.1* and *Move 2* were in the second rank of being employed, and *Move 3* was in the last rank.

The results above showed a different picture from Yang and Allison (2003), which is shown in Table 7.5, in the second and third moves. EERAs in the present study focused much more on stressing the overall results obtained from the study; while *Step 2.1 Indicating significance/advantage* and *Step 2.3 evaluating methodology* under *Move 2 Evaluating the Study* in Yang and Allison (2003) occurred far less than *Move 1 Summarizing the study*. However, the similar move and step in the present study occurred in more than half of the whole corpus. *Step 3.1 Recommending further research* within *Move 3 Deduction from the research* in Yang and Allison (2003), occurred more often than that of the present study. *Step 3.2 Drawing pedagogic implication* did not exist in the current Conclusion framework. The distinctions observed could result from the disciplinary characteristics that RAs in Applied Linguistics should provide assistance in language teaching and learning, while EERAs tended more to focus on the applicability of the proposed model or design. Hence, the methods of designing the proposed model, its usefulness and advantages were claimed. The only similarity between Yang and Allison (2003) and the present study was found in *Move 1*, the most prevalent move in both studies.

Compared with Ye (2019), which is shown in Table 7.6, the Conclusion section of the two studies demonstrated more similarities in statistics of the similar or same moves and steps. For example, *M10S2 Summarizing results* in Ye (2019) was the counterpart of *Move 1* in the present study in the Conclusion, with 99% and 100% RA occurrence. Thus, they were recognized as an extremely necessary step or move for the Conclusion section. Other than the move mentioned above, *M10S1 Briefing purposes and methods* in Ye (2019) occurring in 96% of the corpus was found to correspond to a combination of *Step 1.1* and *Step 1.2* in the present study that occurred in 77.8% and 58.3% of the whole corpus, demonstrating their similarly important roles in this section since they were both categorized in the secondary rank of status: quasi-obligatory (Ye, 2019) and conventional in the present study. Similarly, *M11S1 Stating the significance or new findings* in Ye (2019) occurring in 68% of the corpus and *Move 2 Indicating significance* in the present study appearing in 50% of the whole corpus showed not only a similar percentage but also the same secondary status. The same picture was detected for the last move. That is, both of the moves: *M12 Promoting future research* in Ye (2019) and *Move 3 Suggesting further research* in the present study, were identified as optional. It was found that *Move 3 Suggesting further research* in the Conclusion section and *Step 3.6 Suggesting further research* in the R&D section occurred the least among all of the moves and steps in both of the two sections. The probable reasons of the low occurrence were explained by Informant B:

> *"It is not common for us to suggest a direction of future research, I think it might attribute to the fast development of the electronic engineering technique and devices. After we designed a model and had it simulated and validated, the paper came out, and it would go through several months for review until it is finally published. Newer technology, model or design might appear very soon. Therefore, we tend less to predict the further direction of the research being reported. Moreover, we incline to*

be concise and brief in our conclusion, mainly summarizing the objective and what we have found from our study."

Table 7.5 Moves and steps and their frequency in 13 Conclusion sections (Yang & Allison, 2003, p. 379)

Moves	Steps	Total[a]	Average occurrence per section
(C) Move 1-Summarizing the study		18	1.38
(C) Move 2-Evaluating the study	Indicating significance/advantage	6	0.46
	Indicating limitations	7	0.54
	Evaluating methodology	1	0.08
(C) Move 3-Deduction from the research	Recommending further research	7	0.54
	Drawing pedagogical implication	14	1.1

a The number of Moves or Step in the data

Table 7.6 Distribution of rhetorical moves and steps (N=74) (Ye, 2019, p. 55)

	Moves and Steps	Frequency	Percentage	Status
Conclusion				
M10	Reviewing the present study	74	100%	Obligatory
M10S1	Briefing purposes and methods	71	96%	Quasi-obligatory
M10S2	Summarizing results	73	99%	Quasi-obligatory
M10S3	Exemplifying results	66	89%	Quasi-obligatory
M11	Evaluating the present study	74	100%	Obligatory
M11S1	Stating the significance or new insights	50	68%	Quasi-obligatory
M11S2	Suggesting application of the results	27	36%	Optional
M12	Promoting future research	10	14%	Optional
M12S1	Stating a practical need for further study	6	8%	Optional
M12S2	Indicating the potential value of further study	5	7%	Optional

7.2 Description of Moves and Steps

Move 1: Summarizing the study is the move that provides an overview of the present study by briefing its purposes, design, research methodology, research procedure, and the main findings. Evaluating the findings of the study being reported is also included in this move. This move is realized by three steps: *Step 1.1 Restating purposes*, *Step 1.2 Restating methods*, and *Step 1.3 Summarizing findings*.

Step 1.1: Restating purposes is the step that objectives of the study being reported are briefly described. Most EE researchers provide a general description in this step of their proposed model and design. Usually, the verbs such as "*present*", "*investigate*" and the nouns such as "*research*", "*study*", and "*paper*" were the signals for this step and it is usually located at the very beginning of the Conclusion section, serving as an opening remark of the section. Examples 1 and 2 demonstrate the function of *Step 1.1*.

(1) *A twelve-port MIMO antenna system for multi-mode 4G/5G smartphone applications has been presented and investigated in this paper.* (CH5)

(2) *This research present a measurement and modeling of DTTV–SFN propagation to find the delay characteristics, path loss and related parameters with the relationship between different transmitted stations and delay time in guard interval which is ranging from 0 to 270 μs.* (T12)

Step 1.2: Restating methods is the step where authors depict the details related to their methods, including apparatuses, procedures, and theories that support their research activities. Examples 3 and 4 illustrate *Step 1.2*.

(3) *Modifications for adapting a BM to feed a planar array were presented both in theory and design for passive 2D beam switching.* (NS8)

(4) *The superiority of this method is that the cutters on the cutterhead of the TBM and the components assembled safely are used as the measuring electrodes, which are automatically electrically connected to the stratum through the TBM entity, and the data are automatically collected along with the rotation of the cutterhead, by which the geological detection results are displayed in real time.* (CH4)

Step 1.3: Summarizing findings gives a summary of the results or the findings of the study and the evaluation of these results or findings. Examples 5 and 6 demonstrate the function of this step.

(5) *The 200 μm size of the fabricated tower shaped waveguide gave a promising result in terms of light confinement when compared with different sizes of waveguide.* (TH2)

(6) *It achieves high sensitivity from its FMCW signal processing approach with 100% duty cycle, 0.58W average transmit power, 41 dB of antenna gain low-loss high-isolation quasioptical duplexing, and a low-noise receiver.* (NS7)

Move 2: Indicating significance is the second move of the Conclusion section identified in the three corpora. EE is a discipline that largely involves model designing, fabrication, testing or measure, and validation. Thus, the significance of these models usually finds its way in applying the models or the designs in practice. Examples 7 and 8 are the illustrations of this step.

(7) *Such a flexible hybrid integration approach would be able to provide an economic solution for adding sensing functions according to specific packaging requirements in terms of function and form factor without obviously increasing the cost.* (CH6)

(8) *Potential applications of this work include inspection of diffractive surfaces for quality control, future multidimensional optical data storage schemes, and coherent free space optical communication.* (NS2)

Move 3: Suggesting further research is the move where the authors indicate further research based on the present research. The further research could be generated from the limitation of the study such as the unconsidered factors, untouched methodology, or the idea of extending the scope of the present study to a different area. Examples 9 and 10 are the illustrations of *Move 3*.

(9) *The further research on the detection mechanism, inversion interpretation, and increase of effective observation data are urgently needed, as well as the site verification.* (CH4)

(10) *The <u>future</u> work of research will focus on the measurement in other area and improve the evaluation method of the DTTV–SFN propagation. This will made the proposed model more reliable.* (TH12)

7.3 Comparison of Move-Step Structures

7.3.1 Moves and Steps

Tables 7.7-7.9 show a summary of the comparison among the three corpora in terms of the moves and steps of the Conclusion section. The number of RAs in which each move and step occurred was presented in Table 7.7. Two moves and one step identified as similarities were *Move 1 Summarizing the study*, *Step 1.3 Summarizing findings*, and *Move 3 Suggesting further research*. Specifically, *Move 1 Summarizing the study* occurred in all of the EERAs in the CH, TH and NS corpora, showing a total agreement of adopting this move. *Step 1.3 Summarizing findings* demonstrated the same picture as *Move 1* since 100% of the EERAs in the CH and NS corpora, and 91.7% of the TH corpus were identified to have employed this step. Last, *Move 3 Suggesting further research* was not prevalent at all in all of the three corpora, with the occurrence of 1, 1, and 0 in the CH, TH and NS corpus, respectively.

Table 7.7 The number of EERAs in which move or step occurs in the CH, TH and NS

Move/Step	CH (RA=12)		TH (RA=12)		NS (RA=12)	
	No. of RAs	%	No. of RAs	%	No. of RAs	%
1. Summarizing the study	12	100	12	100	12	100
1.1 Restating purposes	11	91.7	12	100	5	41.7
1.2 Restating methods	10	83.3	8	66.7	3	25
1.3 Summarizing findings	12	100	11	91.7	12	100
2. Indicating significance	5	41.7	5	41.7	8	66.7
3. Suggesting further research	1	8.3	1	8.3	0	0

Table 7.8 The similarities and differences of obligatory, conventional and optional moves and steps among the CH, TH and NS

Move/Step	CH	TH	NS
Obligatory (≥80%)	**1. Summarizing the study** 1.1 Restating purposes 1.2 Restating methods 1.3 Summarizing findings	**1. Summarizing the study** 1.1 Restating purposes 1.3 Summarizing findings	**1. Summarizing the study** 1.3 Summarizing findings
Conventional (50%-79%)		1.2 Restating methods	1.1 Restating purposes **2. Indicating significance**
Optional (<50%)	**2. Indicating significance** **3. Suggesting further research**	**2. Indicating significance** **3. Suggesting further research**	1.2 Restating methods **3. Suggesting further research**

Table 7.9 The occurrence of all the move and step in the CH, TH and NS

Move/Step	CH (RA=12)		TH (RA=12)		NS (RA=12)		Whole corpus	
	Occurrence	%	Occurrence	%	Occurrence	%	Occurrence	%
1. Summarizing the study	16	26.7	13	25	17	34.7	46	28.6
1.1 Restating purposes	12	20	12	23.1	6	12.2	30	18.6
1.2 Restating methods	11	18.3	9	17.3	4	8.2	24	14.9
1.3 Summarizing findings	15	25	12	23.1	14	28.5	41	25.5
2. Indicating significance	5	8.3	5	9.6	8	16.3	18	11.2
3. Suggesting further research	1	1.7	1	1.9	0	0	2	1.2
Total	60	100	52	100	49	100	161	100

The variations among the three corpora were *Step 1.1 Restating purposes*, *Step 1.2 Restating methods* and *Move 2 Indicating significance*. *Step 1.1* occurred in 11, 12 and 5 EERAs, accounting for 91.7%, 100% and 41.7% of the CH, TH and NS corpus, respectively. *Step 1.2* were found to occur in 10, 8, and 3 EERAs in the CH, TH and NS corpus. These two steps occurred much less in the NS than those of the CH and TH, while *Move 2* had the reversed condition in which it occurred in 8 EERAs in the NS while only 5 in both of the CH and TH. Table 7.8, generated from Table 7.7, shows the move and step status of the three corpora. As can be seen from Table 7.8, first, in the CH corpus, *Move 1* and all of its three steps are in the obligatory category, while *Move 2* and *Move 3* are both optional. It was also noticeable that there were no conventional moves and steps in this corpus. Second, in the TH corpus, the distribution of the moves and steps into status categorization was almost the same as that in the CH, except for *Step 1.2 Restating methods* which is placed in the conventional category. This indicated that Chinese and Thai EE researchers were more alike in composing the last section of their EERAs. They showed their clear preference of *Move 1* over *Move 2* and *Move 3*, which corroborated with the information given by Informant A that when Chinese EE researchers write the conclusion section, they tended more to be focused on summing up what they had proposed, how they had obtained their findings, and most importantly, the general results they had gained. The NS corpus, with three different moves in the three different categories of status, showed variations when compared with the CH and the TH. There were one move and one step in each of the obligatory, conventional, and optional categories. NS writers took *Move 1* and *Step 1.3* as the most important, *Move 2* and *Step 1.1* the second most employed, and *Step 1.2* and *Move 3* to achieve the least important communicative purposes. Interestingly, NS EE researchers did not usually restate the methods while summarizing their study, but they tend to indicate the usefulness and applicability of the proposed model, which was usually not a concern of the Chinese and Thai researchers.

7.3.2 Move Patterns

Table 7.10 shows the beginning and the ending move of the Conclusion section of all EERAs in the three corpora. On the one hand, it could be seen that all EERAs in the three corpora adopted *Move 1 Summarizing the study* as the beginning move. However, within *Move 1*, *Step 1.1 Restating purposes* was the most frequently employed in the CH and TH, while it was *Step 1.3 Summarizing findings* in the NS corpus that was used in 6 EERAs, half portion of the corpus, for opening the Conclusion section. Different preference of the employment of steps within *Move 1* was revealed.

On the other hand, Table 7.10 shows a noticeable variation of adopting the ending moves. All of the three moves could be employed by these EE researchers. Specifically, *Move 1 Summarizing the study* served as the ending move in 6, 8, and 4

EERAs in the CH, TH, and NS corpus respectively, whereas the number of *Move 2 Indicating significance* serving as the ending move in the CH, TH and NS were 5, 3, and 8. *Move 3 Suggesting further research*, because of its low occurrence, was identified in only 1, 1, and 0 EERA in the three corpora. These variations revealed that the ending move could be more flexible. From the step level, *Step 1.3* was the most prevalent ending move in the CH and TH since 6 and 8 EERAs in the corresponding corpus were ended with this step, demonstrating a similarity between the two corpora. However, in the NS corpus, it was still *Move 2* which was popular functioning as the ending move. What's more, the researcher of the present study identified in the NS corpus that 3 EERAs (NS1, NS4, NS12) employed only one step, *Step 1.3*, for describing the whole conclusion section, which to a certain extent explained the degree of the importance of the major findings of the research topic in this section.

To sum up, *Step 1.1* and *Step 1.3* were the popular beginning and ending moves in both of the CH and TH corpora, while *Step 1.3* and *Move 2* were most frequently employed as beginning and ending moves in the NS corpus, demonstrating different preferences and emphases from the three writer groups in constructing their conclusion section.

Table 7.10 The beginning move/step and ending move/step of the Conclusion section

CH		TH		NS	
CH1	1.1-...-2	TH1	1.1-...-1.3	NS1	1.3-...-1.3
CH2	1.1-...-2	TH2	1.1-...-1.3	NS2	1.2-...-2
CH3	1.1-...-1.3	TH3	1.1-...-1.3	NS3	1.1-...-2
CH4	1.1-...-3	TH4	1.1-...-1.3	NS4	1.3-...-1.3
CH5	1.1-...-1.3	TH5	1.1-...-1.3	NS5	1.1-...-2
CH6	1.1-...-2	TH6	1.1-...-2	NS6	1.3-...-2
CH7	1.1-...-1.3	TH7	1.1-...-2	NS7	1.1-...-2
CH8	1.2 -...-1.3	TH8	1.1-...-2	NS8	1.2-...-1.3
CH9	1.1-...-1.3	TH9	1.1-...-1.3	NS9	1.1-...-2
CH10	1.1-...-2	TH10	1.1-...-1.3	NS10	1.3-...-2
CH11	1.1-...-2	TH11	1.1-...-1.3	NS11	1.3-...-2
CH12	1.1-...-1.3	TH12	1.1-...-3	NS12	1.3-...-1.3

7.3.3 Move Cycles

The Conclusion section is more of a linear rather than a cyclical section due to its requirement of conciseness. Therefore, as can be seen from Table 7.11, move cycles did not frequently occur in the whole corpus. The number of the identified move cycles was eight. Among them, the first four move cycles occurred more frequently. They were: move cycles *1-2*, *1.1-1.2-1.3*, *1.1-1.3*, and *1.2-1.3*. The last four move cycles: *1.1-1.3-1.2-1.3*, *1-3*, *1.1-1.2*, and *1-2-3* barely occurred in the whole corpus. It could be seen from these cycles that the sequences of arranging moves and steps were from *Move 1* to *Move 2* to *Move 3*. The top move cycle *1 Summarizing the study -2 Indicating significance* occurred in 17 EERAs and the same number of occurrence was identified, which indicated each move cycle only occurred in one EERA once. Move cycle *1-2* was the most prevalent pattern in terms of move level in the Conclusion section. The prevalent cyclical patterns at the step level were *1.1 Restating purposes-1.2 Restating methods-1.3 Summarizing findings* and *1.1 Restating purposes -1.3 Summarizing findings*, with respective occurrence in 15 and 11 EERAs, and respective total occurrence of 15 and 12. Move cycle *1.2 Restating methods -1.3 Summarizing findings* was the least frequently occuring one among the top four move cycles. In addition, the identification of Move cycle *1.1-1.3-1.2-1.3* illustrated that *Step 1.3* had the higher possibility of recurrence.

Table 7.11 Summary of move cycles in the Conclusion section in the whole corpus

	Move cycle	No. of RAs	%		Move cycle	Occurrence	%
1	1-2	17	51.5	1	1-2	17	31.5
2	1.1-1.2-1.3	15	45.5	2	1.1-1.2-1.3	15	27.8
3	1.1-1.3	11	33.3	3	1.1-1.3	12	22.2
4	1.2-1.3	5	15.2	4	1.2-1.3	5	9.3
5	1.1-1.3-1.2-1.3	2	6.1	5	1.1-1.3-1.2-1.3	2	3.7
6	1-3	1	3	6	1-3	1	1.9
7	1.1-1.2	1	3	7	1.1-1.2	1	1.9
8	1-2-3	1	3	8	1-2-3	1	1.9
					Total	**54**	**100**

The comparison in terms of the move cycles among the three corpora is shown in Tables 7.12-7.13. Both of the similarities and variations were observed. First, similarities rather than variations were identified between the CH and the TH corpora since all of the identified move cycles, whether more or less frequent, were found similar statistically. Second, the similarities observed from the comparison of the three corpora were the less occurring move cycles: *1.1-1.3*, *1.2-1.3*, *1.1-1.3-1.2-1.3*, *1-3*, *1.1-1.2*, and *1-2-3*. Among them, *1.1-1.3*, *1.2-1.3* were more commonly adopted, the other four were rare in all of the three corpora. Another obvious similarity is move cycle *1-2*, which occurred in 5 and 4 EERAs in the CH and TH, and appeared in 8 EERAs in the NS corpus, demonstrating that the three groups of writers' similar tendency in employing *Move 2* after *Move 1*. Third, the only variation among the three corpora was move cycles *1.1-1.2-1.3*. According to Tables 7.12-7.13, it had the occurrence in 8 and 6 EERAs in the CH and TH corpus, respectively, but only occurred in 1 EERA in the NS corpus. The noticeable discrepancy indicated that Chinese and Thai EE researchers intended more to not only summarize their studies, but also summarize them in the way by synthesizing all of the three steps: stating the purposes, describing the main methods, and revealing main findings of their study. NS researchers, on the other hand, tended much less to employ all of the three steps under *Move 1* for their Conclusions.

For explanations of these results, Informants A and B provided their valuable information. Informant A, when taking the interview questions concerning the move cycles identified in the Conclusion section, firstly confirmed that the move cycles did not appear as recurring cycles that were common in other sections such as the Results and Discussion. In other words, it was more of a linear section. Moreover, it was also confirmed by Informant A that *Move 1* and its steps were the most important in constructing a Conclusion section. Other moves or steps were less common due to the brief and concise nature of this section. Informant B also stressed that they tended more to only summarize their study, and the implications or the significance of the study could be mentioned concisely but it was not a necessary move in the Conclusion. Besides, Informant B mentioned that she was glad to be informed of the three different employing strategies of the three different writer groups, which provided her with more options for constructing their Conclusion section.

Table 7.12 The number of EERAs in which move cycles occur in the CH, TH and NS

Move cycle	CH (RA=12)		TH (RA=12)		NS (RA=12)	
	No. of RAs	%	No. of RAs	%	No. of RAs	%
1-2	5	41.7	4	33.3	8	66.7
1.1-1.2-1.3	8	66.7	6	50	1	8.3
1.1-1.3	3	25	5	41.7	3	25
1.2-1.3	2	16.7	1	8.3	2	16.7
1.1-1.3-1.2-1.3	1	8.3	1	8.3	0	0
1-3	1	8.3	0	0	0	0
1-2-3	0	0	1	8.3	0	0
1.1-1.2	0	0	1	8.3	0	0

Table 7.13 The occurrence of move cycles in the CH, TH and NS

Move cycle	CH		TH		NS		Whole corpus	
	Occurrence	%	Occurrence	%	Occurrence	%	Occurrence	%
1-2	5	23.8	4	21.1	8	57.1	17	31.5
1.1-1.2-1.3	8	38.1	6	31.6	1	7.1	15	27.8
1.1-1.3	4	19.1	5	26.3	3	21.4	12	22.2
1.2-1.3	2	9.5	1	5.3	2	14.3	5	9.3
1.1-1.3-1.2-1.3	1	4.8	1	5.3	0	0	2	3.7
1-3	1	4.8	0	0	0	0	1	1.9
1-2-3	0	0	1	5.3	0	0	1	1.9
1.1-1.2	0	0	1	5.3	0	0	1	1.9
Total	**21**	**100**	**19**	**100**	**14**	**100**	**54**	**100**

There are three moves and three steps identified in the Conclusion section. The CH and TH have several similarities. There were differences between the CH, TH, and NS. To be more explicit, when starting their Conclusion section, the Chinese and Thai EE researchers in this study are prone to first revisiting their research purposes. They were shown to have provided a thorough summary of the study being reported. The NS authors, on the other hand, concentrated more on summarizing the findings, with revisiting research purposes being employed less frequently. Furthermore, the

Chinese and Thai authors emphasized *Move 1* and all of its steps, whereas NS writers emphasized *Step 1.3*.

7.4 Summary

This chapter provided the results and discussion yielded from move-step analysis of the Conclusion section of the three corpora. First, the move-step framework of the Conclusion section generated from the pilot coding based on the three referential frameworks (Kanoksilapatham 2005, 2015; Maswana et al., 2015) was modified and revised. Second, the results obtained from the analysis based on the revised move-step framework showed the overall employment of the moves and steps in the whole corpus and demonstrated the description of each move and step. Furthermore, the results and discussion regarding to the comparison of the move patterns and move cycles were provided at the end of this chapter.

CHAPTER 8

CONCLUSION

In this chapter, the main findings which are the answers to the four research questions are presented in the first section. It is followed by the presentation of the theoretical and pedagogical implications in the second section. Finally, limitations and suggestions for further research are discussed to finish this current study.

8.1 Summary of Main Findings

8.1.1 Move-Step Structure

The present study aimed to address four research questions. The first two research questions were concerned with the moves, steps, and their structures of the EERAs written by Chinese, Thai, and NS writers. Therefore, the summary of the findings regarding move-step structure is organized in accordance to the two research questions.

8.1.1.1 Research Question 1

RQ 1. What are the moves, steps and move-step structures of the Introduction, Methods, Results and Discussion, and Conclusion of Electronic Engineering RAs (EERAs) written by Chinese (CH), Thai (TH), and native English speakers (NS), respectively?

In answering RQ 1, the researcher of the present study firstly searched for the appropriate referential frameworks, i.e., Kanoksilapatham (2005, 2015) and Maswana et al. (2015), for move-step analysis. Thereafter, the researcher invited a disciplinary expert to participate in a pilot coding based on 15% of EERAs of the whole corpus for the purposes of not solely obtaining a general framework for the EERAs, but more importantly, of making the researcher herself and the invited expert become acquainted with the structural organization of the EERAs, so that they would be better prepared for the inter-rater reliability check. The move-step analysis was conducted on all of the four sections, starting from the Results and Discussion, to the Methods, the

Introduction, and the Conclusion. The order of the analyses of each section was determined by the four research questions that needed to be addressed in the present study. To be specific, the Results and Discussion section in the pilot study was the first section for analysis since its results could provide initial answers to all of the four research questions that would enable to move the researcher on to analysis of the other sections with confidence.

The analysis of the move-step structure of each section yielded a proposed move-step framework of 12 moves for EERA, which is shown in Table 8.1. From this Table, 3 moves were identified for each section with different number of steps within each move. Specifically, 3 moves and 9 steps, and 3 moves and 10 steps were revealed in the Introduction and the Methods section, respectively; 3 moves and 12 steps were identified in the Results and Discussion section; whereas the Conclusion section was confirmed to contain 3 moves and 3 steps. In addition, the status categorization of each move and step in the whole corpus (CH+TH+NS) was unveiled. Firstly, in the Introduction section, *Move 1 Announcing the importance of the field*, *Move 2 Preparing for the present study*, *Move 3 Introducing the present study*, *Step 1.1 Claiming centrality*, *Step 1.2 Making topic generalizations*, and *Step 2.1 Reviewing previous research* in the Introduction section were obligatory. Three steps were identified as conventional, and four were optional. Secondly, in the Methods section, there were only one move and one step, *Move 5 Describing experimental procedure* and *Step 5.2 Detailing procedure* were obligatory. Conventional moves and steps were prevalent in this section in the whole corpus, which include *Move 4 Introducing materials/instruments* and *Move 6 Demonstrating data or design analysis*, *Steps 4.2 Specifying materials/instruments*, *5.1 Indicating principles, theories or previous studies*, and *6.2 Detailing analysis*. The remaining 5 steps, *Steps 4.1 Specifying time/location*, *4.3 Justifying materials/ instruments*, *6.1 Indicating analysis procedure*, *6.3 Referring to theories and previous research*, and *6.4 Suggesting implication* were recognized as optional. Thirdly, the Results and Discussion section was found to comprise 3 moves and 1 step that were obligatory: *Moves 7 Preparatory information*, *8 Reporting results*, *9 Commenting on results*, and *Step 9.1 Interpreting results*. *Steps 7.4 Justifying procedures or methodology*, *7.5 Summarizing procedures*, and *9.4 Summarizing results* were conventional, while the other 8 steps were identified optional. Finally, in the Conclusion section, *Move 10 Summarizing the study* and *Step 10.3 Summarizing findings* were the obligatory move and step, while *Move 11 Indicating significance*, *Steps 10.1 Restating purposes* and *10.2 Restating methods* received conventional status. *Move 12 Suggesting further research* was revealed as an optional move.

Table 8.1 The proposed complete move-step structure of EERA in the present study

Section (RA=36)	Move and Step	%	Status
Introduction	1. Announcing the importance of the field	100	Obl
	1.1 Claiming centrality	86.1	Obl
	1.2 Making topic generalization	86.1	Obl
	2. Preparing for the present study	83.3	Obl
	2.1 Reviewing previous research	83.3	Obl
	2.2 Stating limitations of previous research	61.1	Con
	2.3 Indicating a gap	13.9	Opt
	3. Introducing the present study	100	Obl
	3.1 Stating purposes	77.8	Con
	3.2 Summarizing methods	66.7	Con
	3.3 Presenting findings	27.8	Opt
	3.4 Indicating significance	11.1	Opt
	3.5 Outlining article structure	30.6	Opt
Methods	4. Introducing materials/instruments	66.7	Con
	4.1 Specifying time/location	11.1	Opt
	4.2 Specifying materials/instruments	63.9	Con
	4.3 Justifying materials/instruments	25	Opt
	5. Describing experimental procedure/design	97.2	Obl
	5.1 Indicating principles, theories or previous studies	69.4	Con
	5.2 Detailing procedure	80.6	Obl
	6. Demonstrating data or design analysis	58.3	Con
	6.1 Indicating analysis procedure	5.6	Opt
	6.2 Detailing analysis	52.8	Con
	6.3 Referring to theories and previous research	5.6	Opt
	6.4 Suggesting implication	5.6	Opt

Table 8.1 The proposed complete move-step structure of EERA in the present study (Continued)

Section (RA=36)	Move and Step	%	Status
Results and Discussion	**7. Preparatory information**	91.7	Obl
	7.1 Introducing the section	5.6	Opt
	7.2 Specifying equipment or site	5.6	Opt
	7.3 Explaining principles	19.4	Opt
	7.4 Justifying procedures or methodology	72.2	Con
	7.5 Summarizing procedures	58.3	Con
	7.6 Defining terms	2.8	Opt
	8. Reporting results	100	Obl
	9. Commenting on results	100	Obl
	9.1 Interpreting results	100	Obl
	9.2 Comparing results	16.7	Opt
	9.3 Relating to theories and previous studies	11.1	Opt
	9.4 Summarizing results	50	Con
	9.5 Indicating research implications	8.3	Opt
	9.6 Suggesting further research	2.8	Opt
Conclusion	**10. Summarizing the study**	100	Obl
	10.1 Restating purposes	77.9	Con
	10.2 Restating methods	58.3	Con
	10.3 Summarizing findings	97.2	Obl
	11. Indicating significance	50	Con
	12. Suggesting further research	5.6	Opt

Note: Obl: obligatory; Con: conventional; Opt: optional

8.1.1.2 Research Question 2

RQ 2. What are the variations of the moves, steps, and move-step structures of the Introduction, Methods, Results and Discussion, and Conclusion of EERAs among these three groups?

To address the second Research Question, the comparisons of the moves, steps and their structures were carried out by examining two quantitative parameters, the frequency of occurrence and the number of EERAs in which the moves and steps occurred. The main findings were summarized in Table 7.2. The moves and steps with "*" were the main variations found among the three corpora. Specifically, in the Introduction section, the variations identified among the three corpora lied in one move and fours steps. *Move 2 Preparing for the present study*, *Steps 1.1 Claiming centrality*, *2.1 Reviewing previous research*, and *3.1 Stating purposes* were considered as obligatory in the CH and TH corpora, while they were recognized as conventional in the NS corpus. *Step 3.3 Presenting findings* were conventional in the CH, while it was optional in the TH and NS corpora. The findings revealed that Chinese and Thai EE researchers were similar in composing their Introductions. The obligatory column shows that these two groups of writers tended to employ the same moves and steps that outnumbered those used by the Native English Speaking writers, illustrating Chinese and Thai writers' tendency to produce a more comprehensive Introduction that comprised more communicative purposes. On the contrary, Native English speaking writers adopted fewer moves and steps in their Introductions which can imply that they concentrated on fewer communicative purposes in supporting their Introduction.

In the Methods section, the variations among the three corpora were one move and three steps. *Move 4 Introducing materials/instruments* and *Step 4.2 Specifying materials/instruments* were detected to be obligatory in the CH corpus, conventional in the TH, optional in the NS corpus. *Step 5.1 Indicating principles, theories or previous studies* was conventional in the CH and NS, while it was obligatory in the TH. *Step 5.2 Detailing procedure* was conventional in the CH and TH, while it was obligatory in the NS. The findings showed that *Move 4* and *Step 4.2* were flexible. Chinese writers saw them as the most necessary for them to include in the Methods section. Thai researchers viewed them as moderately important; NS writers regarded them with less important roles than *Moves 5 Describing experimental procedure* and *6 Demonstrating data or design analysis*. *Steps 5.1* and *5.2* demonstrated slight variations among the three corpora. They were in the conventional category in the CH, implying that Chinese writers treated them as two equally moderately important strategies, and adopting either one of them, not both of them, was the choice that Chinese researchers made. *Step 5.1* with higher frequency than *Step 5.2* in the TH corpus illustrated that the Thai researchers were more interested in *Step 5.1 Indicating principles, theories or* *previous studies* than *Step 5.2 Detailing procedure*, while the situation in the NS of the two steps was reversed to the TH corpus, showing the NS writers' strong tendency of employing *Step 5.2* when constructing their Methods.

The Results and Discussion section was found to have demonstrated more similarities than variations. All of the moves and steps were found in the same status categories except for 2 steps, *Steps 7.4 Justifying procedures or methodology* and *9.4 Summarizing results*, which showed variations among the three corpora. *Step 7.4* was obligatory in the CH and NS but conventional in the TH. This step was the most favored one within *Move 7 Preparatory information* in all of the three corpora, with other remaining in the optional category. The Chinese and NS writers in this study exhibited a stronger tendency to open their R&D section by notifying their readers the experimental procedure and methodology than the Thai writers. *Step 9.4* being optional in the CH but conventional in the TH and NS showed that Thai and NS writers had the tendency to conclude what they had found at the end of the R&D section. However, the tendency of the employment of this step of Chinese writers was not at all apparent.

In the Conclusion section, similarities were mainly found between the CH and TH. Variations were found mainly between the CH and TH, and the NS. To be specific, *Move 11 Indicating significance* was optional in the CH and TH, but it was conventional in the NS. *Step 10.1 Restating purposes* was obligatory in the CH and TH, while it was conventional in the NS. This indicated that Chinese and Thai researchers, when opening their Conclusion sections, inclined to firstly revisit the objectives of their research. They considered the last section, the Conclusion section, should have the main purpose of summarizing the study in a comprehensive way. Other communicative purposes such as indicating the significance and suggesting further research were not totally necessarily included. This was also a confirmation made by one of the expert informants. NS writers, however, focused more on summarizing the findings, and revisiting purposes was less frequently adopted. Compared with the CH and TH, *Move 11* was more prevalent in the NS, stressing that the value of the research was another important parameter in the Conclusion section. *Step 10.2 Restating methods*, demonstrated the most noticeable variation among the three corpora since it was regarded as obligatory in the CH, conventional in the TH, and optional in the NS. Its flexibility could make the conclusion in the CH a more comprehensive one, and it could also occur less frequently in the TH or did not show up in the NS. To sum up, Chinese and Thai writers concentrated more on *Move 10* and its steps, while NS writers focused more on both *Move 10* (especially *Step 10.3*) and *Move 11* in their Conclusions.

The analysis of move cycles indicated that that the R&D section was a highly cycled section, while the Methods section was less cycled. The other two sections, the Introduction and the Conclusion sections were more linear. In addition, the main move cycles identified in each section included: *1.1 Claiming centrality -1.2 Making topic generalizations*; *2.1 Reviewing previous research -2.2 Stating limitations of previous research* in the Introduction section; *4.2 Specifying materials/instruments -5.2 Detailing procedure*, *5.2 Detailing procedure -6.2 Detailing analysis* in the Methods section; *7.4 - Justifying procedures or methodology-8 Reporting results -9.1 Interpreting results*, *8 Reporting results -9.1 Interpreting results* in the R&D section; *10-11 Summarizing the study-Indicating significance*, and *10.1 Restating purposes-10.2 Restating methods-10.3 Summarizing findings* in the Conclusion section. The employment of the main move cycles mentioned above was found to exhibit no great variations among the three corpora.

Table 8.2 The comparison of the move-step structures of the EERAs in the CH, TH, and NS

Section	Status	CH	TH	NS
Introduction	Obligatory (≥80%)	**1. Announcing the importance of the field** 1.1 Claiming centrality* 1.2 Making topic generalizations **2. Preparing for the present study*** 2.1 Reviewing previous research* **3. Introducing the present study** 3.1 Stating purposes* 3.2 Summarizing methods	**1. Announcing the importance of the field** 1.1 Claiming centrality* 1.2 Making topic generalizations **2. Preparing for the present study*** 2.1 Reviewing previous research* **3. Introducing the present study** 3.1 Stating purposes*	**1. Announcing the importance of the field** 1.2 Making topic generalizations **3. Introducing the present study**
	Conventional (50%-79%)	2.2 Stating limitations of previous research 3.3 Presenting findings*	2.2 Stating limitations of previous research 3.2 Summarizing methods	1.1 Claiming centrality* **2. Preparing for the present study*** 2.1 Reviewing previous research* 2.2 Stating limitations of previous research 3.1 Stating purposes* 3.2 Summarizing methods
	Optional (<50%)	2.3 Indicating a gap 3.4 Indicating significance 3.5 Outlining article structure	2.3 Indicating a gap 3.3 Presenting findings* 3.4 Indicating significance 3.5 Outlining article structure	2.3 Indicating a gap 3.3 Presenting findings* 3.4 Indicating significance 3.5 Outlining article structure
Methods	Obligatory (≥80%)	**4. Introducing materials/instruments*** 4.2 Specifying materials/instruments* **5. Describing experimental procedure**	**5. Describing experimental procedure** 5.1 Indicating principles, theories or previous studies*	**5. Describing experimental procedure** 5.2 Detailing procedure*

Table 8.2 The comparison of the move-step structures of the EERAs in the CH, TH, and NS (Continued)

Section	Status	CH	TH	NS
Methods	Conventional (50%-79%)	5.1 Indicating principles, theories or previous studies* 5.2 Detailing procedure* **6. Demonstrating data or design analysis** 6.2 Detailing analysis	**4. Introducing materials/instruments*** 4.2 Specifying materials/instruments* 5.2 Detailing procedure* **6. Demonstrating data or design analysis** 6.2 Detailing analysis	5.1 Indicating principles, theories or previous studies* **6. Demonstrating data or design analysis** 6.2 Detailing analysis
	Optional (<50%)	4.1 Specifying time/location 4.3 Justifying materials/instruments 6.1 Indicating analysis procedure 6.3 Referring to theories and previous research 6.4 Suggesting implication	4.1 Specifying time/location 4.3 Justifying materials/instruments 6.1 Indicating analysis procedure 6.3 Referring to theories and previous research 6.4 Suggesting implication	**4. Introducing materials/instruments*** 4.1 Specifying time/location 4.2 Specifying materials/instruments* 4.3 Justifying materials/instruments 6.1 Indicating analysis procedure 6.3 Referring to theories and previous research 6.4 Suggesting implication
Results and Discussion Section	Obligatory (≥80%)	**7. Preparatory information** 7.4 Justifying procedures or methodology* **8. Reporting results** **9. Commenting on results** 9.1 Interpreting results	**7. Preparatory information** **8. Reporting results** **9. Commenting on results** 9.1 Interpreting results	**7. Preparatory information** 7.4 Justifying procedures or methodology* **8. Reporting results** **9. Commenting on results** 9.1 Interpreting results
	Conventional (50%-79%)		7.4 Justifying procedures or methodology* 9.4 Summarizing results*	9.4 Summarizing results*

Table 8.2 The comparison of the move-step structures of the EERAs in the CH, TH, and NS (Continued)

Section	Status	CH	TH	NS
Results and Discussion Section	Optional (<50%)	7.1 Introducing the section 7.2 Specifying equipment or environment 7.3 Explaining principles 7.5 Summarizing procedures 7.6 Defining terms 9.2 Comparing results 9.3 Relating theories and previous studies 9.4 Summarizing results* 9.5 Indicating research implications 9.6 Suggesting further research	7.1 Introducing the section 7.2 Specifying equipment or environment 7.3 Explaining principles 7.5 Summarizing procedures 7.6 Defining terms 9.2 Comparing results 9.3 Relating theories and previous studies 9.5 Indicating research implications 9.6 Suggesting further research	7.1 Introducing the section 7.2 Specifying equipment or environment 7.3 Explaining principles 7.5 Summarizing procedures 7.6 Defining terms 9.2 Comparing results 9.3 Relating theories and previous studies 9.5 Indicating research implications 9.6 Suggesting further research
Conclusion	Obligatory (≥80%)	**10. Summarizing the study** 10.1 Restating purposes* 10.2 Restating methods* 10.3 Summarizing findings	**10. Summarizing the study** 10.1 Restating purposes* 10.3 Summarizing findings	**10. Summarizing the study** 10.3 Summarizing findings
	Conventional (50%-79%)		10.2 Restating methods*	10.1 Restating purposes* **11. Indicating significance**
	Optional (<50%)	**11. Indicating significance*** **12. Suggesting further research**	**11. Indicating significance*** **12. Suggesting further research**	10.2 Restating methods* **12. Suggesting further research**

Note: The asterisk “*” represents variation

8.1.2 Visual-Textual Move

8.1.2.1 Research Question 3

RQ 3. What are the visual-textual moves (VTMs) in EERAs written by Chinese (CH), Thai (TH), and native English speakers (NS), respectively?

Visual-textual moves (VTMs) were identified in the Methods and the Results and Discussion (R&D) section by adopting Moghaddasi et al. (2019) as the analysis framework. By inheriting three VTMs from Moghaddasi et al. (2019) and generating one new VTM, the four VTMs existing in both of the Methods and the R&D sections were *Establishing presumptions* (EP), *Announcing results* (AR), *Discussion* (D), and a new VTM *Displaying apparatus or site* (DAS) specifically identified for the first time in this current study. Different VTMs demonstrate different rhetorical functions of visuals. The three functions, *ontology*, *argument*, and *epistemology*, were inherited from Moghaddasi et al. (2019), too. The VTMs *EP* and *DAS* suggest the visual's ontological function; VTM *D* indicates the argumentative function of the visuals; and VTM *AR* implies the epistemological function of the visuals.

VTM pattern was the parameter that could reveal each visual's rhetorical function or multifunction since visuals tended to be pointed at by VTMs more than once. Nine VTM patterns were found in both of the Methods and the R&D section. The identified VTM patterns in the Methods section were: 1) *EP*, 2) *AR*, 3) *AR+D*, 4) *EP+AR,* 5) *DAS*, 6) *EP+DAS,* 7) *EP+D,* 8) *EP+AR+D,* and 9) *D*. VTM pattern *EP* was the most prevalent, accounting for 31.5% of the corpus. *AR+D* and *AR* were the second and the third popular VTM patterns with respective occurrence of 19.4% and 18.4% of all the visuals in the whole corpus. This indicated that the visuals in the Methods section played mainly the ontological role alone, while the combination of epistemological and argumentative functions or the argumentative function alone of the visuals was also prevalent in this section. The VTM patterns that were prevalent in the R&D section were: 1) *AR*; 2) *AR+D*; 3) *D*; 4) *DAS*; 5) *EP*; 6) *EP+AR*; 7) *EP+AR+D*; 8) *EP+D*; and 9) *DAS+EP*. Among them, *AR*; *AR+D*; and *D* were the most popular ones, accounting for 66.5% of all of the visuals in the whole corpus, which illustrated that epistemological, argumentative and their combination were the main rhetorical functions that the visuals played in the R&D section.

8.1.2.2 Research Question 4

RQ 4. What are the variations in terms of the VTMs among these three groups?

The comparisons of VTMs and VTM patterns were carried out to reveal the variations among the three corpora. In the Methods section, first, the four VTMs *EP*, *AR*, *D* and *DAS* were compared quantitatively, and the findings showed that *EP* was the most dominant VTM in both of the CH and NS corpora, while it ranked the third in terms of the occurrence in the TH corpus as shown in Table 5.22 in Chapter 5. The statistics from the table implied that Chinese and NS researchers employed visuals in the Methods section mainly to introduce certain notation or concept, and purpose and procedure of the experimental action. *AR*, *D*, and *DAS* were the less employed VTMs in both of the CH and NS corpora. In contrast, Thai researchers employed *AR* the most to associate with the visuals, but VTMs *EP* and *D* displayed no great discrepancies from *AR*. What's more, the VTM patterns in the Methods section showed the consistent results as the VTMs did. That is, VTM pattern *EP* was the most dominant one, and *AR* and *AR+D* occurred much less in the CH and NS. However, all of the three VTM patterns, *EP*, *AR*, and *AR+D*, were almost equally prevalent in the TH. The findings implied that Thai researchers applied the visuals to fulfill such three roles as participating in introducing procedures and methods, and reporting and discussing the results. On the contrary, Chinese and NS researchers were more inclined toward VTM and VTM pattern *EP*, focusing more on only the one function, ontological function, of the visuals. In other words, Chinese and NS were more similar in using visuals to perform ontological function, or to assist in informing their readers of their specific methods, while Thai researchers were found to be different from Chinese and NS researchers that apart from the ontological function that the visuals played, they also were used for reporting and commenting on the results of some experimental procedures.

In the R&D section, Table 6.21 in Chapter 6 suggests that Chinese, Thai, and NS writers demonstrated similarities in adopting VTMs *AR* and *D*, which were the top two prevalent VTMs in all of the three corpora. However, NS writers seemed to leaning toward VTM *D* more than the Chinese and Thai writers since the visuals in the NS corpus were discovered to be pointed at by both the VTMs *AR* and *D* in the similar amount. The findings of the VTM patterns showed that Chinese and NS researchers tended more to use the visuals in the R&D section to both report and interpret results, while Thai researchers mainly reported results through visuals.

8.2 Implications

8.2.1 Theoretical Implications

First and foremost, this study adds to the body of knowledge in the field of ESP genre research. The first and third Research Questions yield the types of moves, steps, move-step structures, and VTMs in RAs by the Chinese, Thai, and NS groups, respectively. The findings provide fresh insights into the move-step structures of RAs in general, and EERAs in particular. Second, the similarities and differences found in the second and fourth Research Questions add to the diversity of move-step structure and visual-textual knowledge of the RA genre on the one hand, and provide us with the chance to learn more acceptable and viable move structures and VTMs within the same field on the other. Last but not least, giving explanation for the discrepancies through the rigorous and in-depth contrastive investigation might provide insights on the underlying probable reasons for the variations in move-step patterns and VTMs, such as cultural background or language transmission. Finally, by contrasting and analyzing the structural patterns and visual-textual movements created by the three groups of writers, the current study adds to the contrastive rhetoric theory in genre analysis. Their rhetorical structural awareness and the influence of their L1 formed in their own social and academic environment on their L2 would be shown by the comparison and contrast findings.

8.2.2 Pedagogical Implications

The move-step structure and VTM analysis could, to a certain degree, provide especially non-native English speaking writers, ESP and EAP practitioners with writing or instructional insights in terms of the organizational structure and visual rhetoric knowledge. In other words, the findings of the present study would shed light on the teaching and learning in composing or constructing a RA for international publication. First, the answer to Research Question 1 yielded one move-step structure which contained 12 moves and 34 steps that could be applied to the composition of EERAs. For EE researchers, this newly proposed move-step structure could be helpful for preparing themselves to conform to the particular discourse community they want to be member of. Besides analyzing all of the 36 EERA as an entirety, the present study also compared and contrasted the move-step structure of EERAs written by the three writer groups, which offered an overall finding as well as three distinctive categorizations of the obligatory, conventional and optional moves and steps. However, in light of the three groups of writers being all successful in their international publications, we could not assume which one is better or worse than the other two groups. Thus, they are all of help and use for EE researchers in their writing. The findings from the comparisons of the employment of the moves and steps revealed three different organizations of the identified moves and step, which provided different writing conventions under different social contexts. EE researchers could learn from one, two, or all three of them to produce their own piece of writing that is fit for their social and academic setting and requirement of the targeted journal. For example, *Move 2 Preparing for the present study* was categorized as an obligatory move in the Chinese and Thai corpora, but it was a conventional in the NS corpus. Hence, EE researchers could make a choice whether to add it or not based on the social and academic convention of this discourse community, including the subject matter, methodology, and requirement of the journal.

Second, for ESP and EAP practitioners, the findings of the moves, steps, and their structures could provide certain assistance in designing an academic writing course and specific instruction materials. The questionnaire and interview in the preliminary needs analysis reveal that there were basically no academic writing courses existing in EE discipline in both undergraduate and graduate levels. Thus, the thought of launching an academic writing course for non-English majoring discipline could be gradually realized. There are already researchers who have conducted the genre-based teaching research. For example, Cai (2019) conducted research on Chinese undergraduates' ability of reading and writing research articles based on move identification and analysis. Results showed that not only the students' genre knowledge and academic literacy were enhanced, but also their ability of reading discipline-specific RAs as well as confidence in writing RAs were promoted. Therefore, ESP and EAP courses informed by findings from genre analysis are deemed as one of the recent trends in English language teaching.

Third, visual-textual move analysis, on the one hand, could enhance the awareness of ESP/EAP practitioners of the visuals since they incline to underestimate the important role that visuals play. The meaning and communicative purpose of the EERAs were achieved through the combined effort by textual language and visuals. This is a feature of RAs in science and engineering discipline. Therefore, when ESP and EAP practitioners have plans to conduct research on the similar genre, it is necessary for them to pay the same attention to the visuals as they pay to the textual language, or they could give more attention to the visuals than they used to. On the other hand, visual-textual move analysis could enhance ESP and EAP instructors' awareness of the relationship between the textual language and the visuals. The four VTMs identified in the present study showed three rhetorical functions of the visuals in EERAs. Specifically, the visuals in the Methods section were found to have the tendency of demonstrating ontological function by VTMs *EP* and *DAS*, showing a great consistency with the overall communicative purposes of this section. For another example, the visuals in the R&D section were mainly to help demonstrate the results and findings and build arguments for them, also indicating the visual's rhetorical functions-epistemological and argumentative functions were in agreement with the overall communicative function of this section. Therefore, ESP and EAP instructors could teach students how to integrate visuals into arguments effectively, i.e., arranging the visuals in appropriate places, letting them fit for the communicative function and purpose of each section. "Teachers need to ask themselves how the arrangement of the visual has been organized for maximum effect (Miller, 1998, p. 44)." This is a crucial skill for young researchers of disciplines that use visuals, not only to create authorial credibility, but also to learn, know and communicate in the discipline (Moghaddasi et al., 2019). In addition, ESP and EAP instructors could try to teach visual rhetoric to students in the higher levels by guiding them to analyze the visuals and the texts, as well as draw the connection between them. This, however, might be achieved through the joint effort of the ESP or EAP instructors and disciplinary specialists in the academic writing course design and implementation.

8.3 Limitations and Suggestions for Further Research

There are several limitation of the study. First, limitations existed in the data collection process. As mentioned in Chapter 1, several factors were left behind during data collection. These factors included: the total number of words of the EERAs, the impact factor and the quartile of the journals. These factors could have some impact on the analysis and the results of the study. They were not regarded as the criteria for the selection of the EERAs due to the settled criteria such as three writer groups as understudied groups, the larger database SCOPUS, and the latest data. However, these left-out factors should be seriously considered as criteria for the similar studies in the future.

Second, although the proposed frameworks of the move-step structure and VTM were based on previous studies (Kanoksilapatham, 2005; 2015; Maswana et al., 2015; Moghaddasi et al., 2019), there must have been some limitations on the labeling and descriptions of the moves, steps and VTMs since they were labeled and described in accordance with the researcher's own words and understanding.

Third, the VTM analysis, being an exploratory study on visuals' rhetorical functions through their associated textual language, might not be comprehensive enough since these VTMs were only one type of move that visuals initiated. The other type of move that visuals initiated, visual move (Moghaddasi et al., 2019), was not included in this study since visuals in the EE discipline were identified associated with textual language. However, there are still a few visuals that could be studied in the deeper level as visual moves in the corpus. Thus, this could be a consideration for the further study concerning visual rhetoric in the academic writing genre.

Last but not the least, it is also a limitation that the writers of the EERAs in the three corpora were not the interviewees of the preliminary and post interviews due to unavailability of these writers. This lack of voices from the actual writers on the moves, steps, move-step structures, VTMs, and VTM patterns might result in less complete and accurate understanding in the findings. Nevertheless, the researcher of the present study invited two disciplinary experts in compensation of this limitation. They provided their opinion on their RA writing issue nowadays and also helped to triangulate some of the results obtained from the analyses. This is of great help for the researcher of the present study to achieve better understanding, to remove doubts, and to confirm the assumptions towards the findings about the move-step structure and VTM.

The directions of further research on move-step structure and visual-textual move are as follows. Since Electronic Engineering is a large discipline which contains subdisciplines, it is suggested that a future study could explore in depth the two subject matters in these subdisciplines within the field of Electronic Engineering, with the aim of finding the subdisciplinary variations that could assist students in writing their subdiscipline-specific RAs. Moreover, future researchers could expand the scope of the current study to other engineering disciplines so as to build a connection among them, and finally make a generalization of move-step structure and VTM applicable to these engineering disciplines.

Except for the expansion of the research scope, the limitations of the present study also put forward some directions for further research. First, the data collection should consider more sources that the data come from. That is to say, the source of the data in one group should come from journals with similar impact factors or quartiles. The comparative or contrastive analysis of two or more than two groups should also keep their grouped data at the same or similar level so that the results and findings of the study could be more valid and reliable. Second, the labels and descriptions of each move and step could be assisted by ESP or EAP instructors so that they could teach their students with confidence in their RA writing class. With their help, the labeling and descriptions could be more refined and comprehensible to the EE researchers and students. Third, VTM analysis would suggest more and deeper investigations on the visual rhetoric in the EE or other disciplines. VTM analysis in this study is just an initial and exploratory piece of research on the visuals' rhetorical function through their related textual language. From VTM analysis, the visuals' functions of contributing to the communicative purposes of EERAs could be understood. However, visual moves, which were mentioned in the limitations, were not the target of the present study but could be an aim to be realized in the future study. Finally, it is also suggested by the last limitation that it is ideal to interview the actual writers of the RAs for their opinion on the subject matters. This could be taken into serious consideration if they are readily available in the further study.

8.4 Summary

This chapter concluded the present study by firstly presenting the main findings of the four research questions. Theoretical and pedagogical implications were summarized in the second section. Finally, Limitations and suggestions for further research were concluded in the last section.

REFERENCES

Adel, S. M. R., & Ghorbani Moghadam, R. (2015). A comparison of moves in conclusion sections of research articles in psychology, Persian literature and applied linguistics. *Teaching English Language*, *9*(2), 167-191.

Al-Khasawneh, F. M. (2017). A genre analysis of research article abstracts written by native and non-native speakers of English. *Journal of Applied Linguistics and Language Research*, *4*(1), 1-13.

Amirian, Z., Kassaian, Z. and Tavakoli, M. (2008). Genre analysis: An investigation of the discussion sections of applied linguistics research articles. *Asian ESP Journal*, *4*(1), 39-63.

Amnuai, W., & Wannaruk, A. (2013a). Investigating move structure of English applied linguistics research article discussions published in international and Thai Journals. *English Language Teaching*, *6*(2), 1-13.

Amnuai, W., & Wannaruk, A. (2013b). An analysis of moves in introductions in international and Thai journal research articles. *PASAA*, *45*, 61-90.

Angot-Pellissier, R. (2015). The relation between logic, set theory and topos theory as it is used by Alain Badiou. In A. Koslow, & A. Buchsbaum (Eds.), *The Road to Universal Logic. Studies in Universal Logic*. Birkhäuser. https://doi.org/10.1007/978-3-319-15368-1_7

Atkinson, D. (1996). The philosophical transactions of the Royal Society of London, 1675–1975: A sociohistorical discourse analysis. *Language in Society, 25,* 333–371.

Bakhtin, M. M. (2000). The problem of speech genres. In D. Duff (Ed.), *Modern Genre Theory* (pp. 82-97). Longman.

Basturkmen, H. (2009). Commenting on results in published research articles and masters dissertations in Language Teaching. *Journal of English for Academic purposes*, *8*(4), 241-251.

Basturkmen, H. (2012). A genre-based investigation of discussion sections of research articles in Dentistry and disciplinary variation. *Journal of English for Academic Purposes*, *11*, 134-144.

Bateman, J. A. (2014). *Text and Image: A Critical Introduction to the Visual/Verbal Divide.* Routledge.

Bazerman, C. (1988). *Shaping Written Knowledge: The Genre and Activity of the Experimental Article in Science*. University of Wisconsin Press.

Berkenkotter, C., & Huckin, T. N. (2016). *Genre Knowledge in Disciplinary Communication: Cognition, Culture, Power*. Routledge.

Bhatia, V. K. (1993). *Analysing Genre: Language Use in Professional Settings*. Longman.

Bhatia, V. K. (2002). Applied genre analysis: A multi-perspective model. *Ibérica: Revista de la Asociación Europea de Lenguas para fines específicos (AELFE)*, (4), 3-19.

Bhatia, V. K. (2006). Analyzing genre: Some conceptual issues. In M. Hewings (Ed.), *Academic Writing in Context: Implications and Applications* (pp. 79-92). Continuum.

Biber, D. (2006). *University Language: A Corpus-Based Study of Spoken and Written Registers*. John Benjamin.

Biber, D., Connor, U., & Upton, T. (2007). *Discourse on the Move: Using Corpus Analysis to Describe Discourse Structure*. John Benjamins Publishing.

Blommaert, J. (2010). *The Sociolinguistics of Globalization*. Cambridge University Press.

Brett, P. (1994). A genre analysis of the results section of sociology articles. *English for Specific Purposes, 13*(1), 47-59.

Bruce, I. (2008). Cognitive genre structures in Methods sections of research articles: A corpus study. *Journal of English for Academic Purposes*, *7*(1), 38-54.

Bruce, I. (2009). Results sections in sociology and organic chemistry articles: A genre analysis. *English for Specific Purposes*, *28*, 105-124.

Burrough-Boenisch, J. (2003). Shapers of published non-native speaker research articles. *Journal of Second Language Writing*, *12*, 223 - 243.

Cai, J. (2018). International research article writing and publishing: A compulsory course for Chinese graduate students. *Academic Degrees & Graduate Education*, *4*. 10-15. https://doi.org/10.16750/j.adge.2018.04.002

Canagarajah, A. S. (2002). *Critical Academic Writing and Multilingual Students.* University of Michigan Press.

Carson, J. G. (1992). Becoming biliterate: First language influences. *Journal of Second Language Writing*, *1*(1), 37-60.

Chang, C.-F., & Kuo, C.-H. (2011). A corpus-based approach to online materials development for writing research articles. *English for Specific Purposes, 30*, 222-234.

Charles, C., & Ventola, E. (2002). A multi-semiotic genre: The conference slide show. In E. Ventola, C. Shalom, & S. Thompson (Eds.), *The Language of Conferencing* (pp. 169-210). Peter Lang.

Cho, D. W. (2009). Science journal paper writing in an EFL context: The case of Korea. *English for Specific Purposes, 28*, 230–239.

Cho, S. (2004). Challenges of entering discourse communities through publishing in English: Perspectives of nonnative-speaking doctoral students in the United States of America. *Journal of Language, Identity and Education, 3*(1), 47-72.

Christie, F. (1991). Genres as social processes. In *Working with Genre: Papers from the 1989 LERN Conference* (pp. 73-88). Common Ground.

Coe, R., Lingard, L., & Teslenko, T. (Eds.). (2002). *The Rhetoric and Ideology of Genre.* Hampton Press.

Connor, U. (1996). *Contrastive Rhetoric: Cross-Cultural Aspects of Second-Language Writing*. Cambridge University Press.

Connor, U. (2002). New directions in contrastive rhetoric. *TESOL Quarterly*, *36*(4), 493-510.

Connor, U. (2004). Intercultural rhetoric research: Beyond texts. *Journal of English for Academic Purposes*, *3*(4), 291-304.

Connor, U., Davis, K., & de Rycker, T. (1995). Correctness and clarity in applying for overseas jobs: A cross-cultural analysis of U.S. and Flemish applications. *Text*, *15*(4), 457-475

Connor, U., Nagelhout, E., & Rozycki, W. (Eds.). (2008). *Contrastive Rhetoric: Reaching to Intercultural Rhetoric* (Vol. 169). John Benjamins Publishing.

Cotos, E., Huffman, S., & Link, S. (2017). A move/step model for methods sections: Demonstrating rigour and credibility. *English for Specific Purposes*, *46*, 90-106.

Devitt, A. J. (2004). *Writing Genres*. SIU Press.

Dias, P., Freedman, A., Medway, P., & Pare, A. (1999). *Worlds Apart: Acting and Writing in Academic and Workplace Contexts.* Lawrence Erlbaum.

Du, J. (2020). *Non-native English-speaking Engineers' Writing at the Workplace*. Springer.

Dubois, B. L. (1980). The use of slides in biomedical speeches. *The ESP Journal*, 1(1), 45-50.

Dudley-Evans, T. (1994). Genre analysis: an approach to text analysis for ESP. In M. E. Coulthard (Ed.), *Advances in Written Text Analysis* (pp. 219–228). Routledge.

Dudley-Evans, T., & St John, M. J. (1998). *Development in ESP: A Multidisciplinary Approach*. Cambridge University Press.

Eggington, W. G. (1987). Written academic discourse in Korean: Implications for effective communication. *Writing across Languages: Analysis of L2 Text*, 153-168.

ElMalik, A. T., & Nesi, H. (2008). Publishing research in a second language: The case of Sudanese contributors to international medical journals. *Journal of English for Academic Purposes, 7*, 87-96.

Fairclough, N. (1992). *Discourse and Social Change* (Vol. 10). Polity Press.

Fairclough, N. (2001). Critical discourse analysis as a method in social scientific research. *Methods of Critical Discourse Analysis*, *5*(11), 121-138.

Feez, S. (2001). Heritage and innovation in second language education. In A. M. Johns (Ed.), *Genre in the Classroom* (pp. 47-68). Lawrence Erlbaum.

Feng, H. (2008). A genre-based study of research grant proposals in China. *Pragmatics and beyond New Series*, 169, 63.

Flowerdew, J. (1999a). Writing for scholarly publication in English: The case of Hong Kong. *Journal of Second Language Writing*, *8*, 123-145.

Flowerdew, J. (1999b). Problems in writing for scholarly publication in English: The case of Hong Kong. *Journal of Second Language Writing*, *8*, 243-264.

Flowerdew, J. (2001). Attitudes of Journal Editors to Non-Native Speaker Contributions. *TESOL Quarterly*, *35* (1), 121-150.

Flowerdew, J. (2004). The argument for using English specialized corpora to understand academic and professional langauge. In U.Conner & T. A. Uption (Eds.), *Discourse in the Professions: Perspectives from Corpus Linguistics* (pp. 11-23). John Benjamins.

Flowerdew, L. (2000). Using a genre-based framework to teach organizational structure in academic writing. *ELT Journal*, *54*(4), 369-378.

Freedman, A., & Adam, C. (2000). Write where you are: Situating learning to write in university and workplace settings. In P. Dias, & A. Pare (Eds.), *Transitions: Writing in Academic and Workplace Settings* (pp. 31-60). Hampton Press.

Freedman, A., & Medway, P. (1994). *Genre in the New Rhetoric*. Taylor & Francis.

Ghazanfari, M., Mohtasham, N. H., & Amirsheibani, M. (2016). Genre analysis of Nursing and ELT academic written discourse. *Journal of Language Teaching and Research*, *7*(5), 973-978.

Gibbs, W. (1995). Trends in scientific communication: Lost science in the third world. *Scientific American*, August, 76-83.

Graves, H. (2014). The rhetoric of (interdisciplinary) science: Visuals and the construction of facts in Nanotechnology. *Poroi*, *10*(2), 12 https://doi.org/10.13008/2151-2957.1207.

Graves, H., Moghaddasi, S., & Hashim, A. (2014). "Let G = (V, E) be a graph": Turning the abstract into the tangible in introductions in mathematics research articles. *English for Specific Purposes*, *36*, 1-11.

Gross, A. G. (2007). Darwin's diagram: Scientific visions and scientific visuals. In K. S. Fleckenstein, S. Hum, & L. T. Calendrillo (Eds.), *Ways of Seeing, Ways of Speaking* (pp. 52-80). Parlor Press.

Gross, A. G., & Harmon, J. E. (2014). *Science from Sight to Insight: How Scientists Illustrate Meaning*. University of Chicago Press.

Halliday, M. A. K. (1985/1994). *An Introduction to Functional Grammar*. Edward Arnold.

Hemais, B. J. W. (2014). Word and image in academic writing: A study of verbal and visual meanings in marketing articles. *ESP Today*, *2*(2), 113-133.

Hinds, J. (1983). Contrastive rhetoric: Japanese and English. *Text-Interdisciplinary Journal for the Study of Discourse*, *3*(2), 183-196.

Hinds, J. (1990). Inductive, deductive, quasi-inductive: Expository writing in Japanese, Korean, Chinese, and Thai. In U. Connor, & A. M. Johns (Eds.), *Coherence in Writing: Research and Pedagogical Perspectives*, (pp. 87-109). TESOL.

Hirano, E. (2009). Research article introductions in English for specific purposes: A comparison between Brazilian Portuguese and English. *English for Specific Purposes*, 28, 240-250.

Hoffmann, C. (2000). The spread of English and the growth of multilingualism with English in Europe. In J. Cenoz & U. Jessner (Eds.), *English in Europe: the Acquisition of a Third Language* (pp. 1-21). Multilingual Matters.

Hofstede, G. (1984). *Culture's Consequences: International Differences in Work-Related Values* (Vol. 5). Sage.

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.

Hopkins, A., & Dudley-Evans, T. (1988). A genre-based investigation of the discussion sections in articles and dissertations. *English for Specific Purposes*, *7*, 113-121.

Huang, J. C. (2010). Publishing and learning writing for publication in English: Perspectives of NNS PhD students in science. *Journal of English for Academic Purposes*, 9, 33-44.

Huckin, T. N. (1987). *Surprise Value in Scientific Discourse*. Paper delivered at CCCC Conference, Atlanta, Georgia, March, 1987.

Hull, J. G., Lehn, D. A., & Tedlie, J. C. (1991). A general approach to testing multifaceted personality constructs. *Journal of Personality and Social Psychology*, *61*(6), 932.

Hyland, K. (1998). *Hedging in Scientific Research Articles*. John Benjamins Publishing Company.

Hyland, K. (2004). *Genre and Second Language Writing*. University of Michigan Press.

Hyland, K. (2006). *English for Academic Purposes*. Routledge.

Hyland, K. (2007). English for professional academic purposes: Writing for scholarly publication. In D. Belcher (Ed.), *English for Specific Purposes in Theory and Practice* (pp. 17-38). University of Michigan Press.

Hyland, K. (2008). Genre and academic writing in the disciplines. *Language Teaching*, *41*(4), 543-562.

Hyland, K., & Tse, P. (2012). 'She has received many honours': Identity construction in article bio statements. *Journal of English for Academic Purposes*, *11*, 155-165.

Hyon, S. (1996). Genre in three traditions: Implications for ESL. *TESOL Quarterly*, *30* (4), 693-722.

Jenkins, J. (2012). English as a Lingua Franca from the classroom to the classroom. *ELT Journal*, *66*(4), 486-494.

Jenkins, J. (2015). Repositioning English and multilingualism in English as a Lingua Franca. *Englishes in Practice*, *2*(3), 49-85.

Jenkins, J., Baker, W., & Dewey, M. (Eds.). (2017). *The Routledge Handbook of English as a Lingua Franca*. Routledge.

Johns, A. M. (1997). *Text, Role and Context: Developing Academic Literacies.* Cambridge University Press.

Johns, A. M. (1998). The visual and the verbal: A case study in macroeconomics. *English for Specific Purposes*, *17*(2), 183-197.

Johns, A. M. (2013). The history of English for specific purposes research. In B. Paltridge, & S. Starfield (Eds.), *The Handbook of English for Specific Purposes* (pp. 5-30). Wiley-Blackwell.

Johns, A. M., Bawarshi, A., Coe, R. M., Hyland, K., Paltridge, B., Reiff, M. J., & Tardy, C. (2006). Crossing the boundaries of genre studies: Commentaries by experts. *Journal of Second Language Writing*, *15*, 234-249.

Joyce, H. (1992). *Workplace Texts in the Language Classroom*. New South Wales Adult Migrant English Service.

Kanoksilapatham, B. (2003). *A corpus-based investigation of scientific research articles: Linking move analysis with multidimentional analysis*. Doctoral Dissertation, Georgetown University, Washington, DC.

Kanoksilapatham, B. (2005). Rhetorical structure of biochemistry research articles. *English for Specific Purposes*, *24*(3), 269-292.

Kanoksilapatham, B. (2007). Writing scientific research articles in Thai and English: Similarities and differences. *Silpakorn University International Journal, 7*, 172-203.

Kanoksilapatham, B. (2012). Research article structure of research article introductions in three engineering subdisciplines. *IEEE Transactions on Professional Communication*, *55*(4), 294-309.

Kanoksilapatham, B. (2015). Distinguishing textual features characterizing structural variation in research articles across three engineering sub-discipline corpora. *English for Specific Purposes, 37*, 74-86.

Kaplan, R. B. (1966). Cultural thought patterns in inter-cultural education. *Language Learning*: *A Journal of Applied Linguistics*, *16*, 1-20.

Khamkhien, A. (2015). Textual organisation and linguistic features in applied linguistics research articles: Moving from Introduction to Methods. *International E-Journal of Advances in Social Sciences*, *1*(2), 111-122.

Kirkpatrick, A. (2017). The development of English as a lingua franca in ASEAN. In J. Jenkins, W. Baker, & M. Dewey (Eds.), *The Routledge Handbook of English as a Lingua Franca* (pp. 138-150). Routledge.

Knorr-Cetina, K. D. (1981). *The Manufacture of Knowledge*. Pergamon.

Kostelnick, C. (2007). The visual rhetoric of data displays: The conundrum of clarity. *IEEE Transactions on Professional Communication*, *50*(4), 280-294.

Kress, G. R., & van Leeuwen, T. (1996). *Reading Images: The Grammar of Visual Design*. Psychology Press.

Kress, G. R., & van Leeuwen, T. (2001). *Multimodal Discourse: The Modes and Media of Contemporary Communication*. Arnold.

Kwan, B. S. C. (2006). The schematic structure of literature reviews in doctoral theses of applied linguistics, *English for Specific Purposes*, *25*(1), 30-35.

Kwan, B. S. C. (2017). A cross-paradigm macro-structure analysis of research articles in Information Systems. *English for Specific Purposes*, *45*, 14-30.

Leki, I. (1997). Cross-talk: ESL issues and contrastive rhetoric. *Writing in Multicultural Settings*, 234-244.

Lemke, J. L. (1998). Multiplying meaning: Visual and verbal semiotics in scientific text. In J. R. Martin, & R. Veel (Eds.), *Reading Science: Critical and Functional Perspectives on Discourses of Science* (pp. 87-113). Routledge.

Lemke, J. L. (2003). Mathematics in the middle: Measure, picture, gesture, sign, and word. *Educational Perspectives on Mathematics as Semiosis: From Thinking to Interpreting to Knowing*, *1*, 215-234.

Lemke, J. L. (2005). Multimedia genres and traversals. *Folia Linguistica*, *39* (1-2), 45-56.

Lester, J. D., & Lester, Jr, J. D. (2006). *Writing Research Papers in the Social Sciences*. Pearson/Longman.

Li, L., & Ge, G. (2009). Genre analysis: Structural and linguistic evolution of the English-medium medical research article (1985–2004). *English for Specific Purposes, 28*, 93-104.

Lim, J. M. H. (2006). Method sections of management research articles: A pedagogically motivated qualitative study. *English for Specific Purposes*, *25*, 282-309.

Lim, J. M. H. (2008a). Analysing recommendations for future research: An investigation into a hybrid sub-genre. In R. Wilkinson, & V. Zegers (Eds.), *Realizing Content and Language Integration in Higher Education* (pp. 131-154). Maastricht University.

Lim, J. M. H. (2008b). Indicating significance of current research: Pedagogical implications of a genre analysis for dissertation writing. *The Open Applied Linguistics Journal*, 1, 46-55.

Lim, J. M. H. (2009). Rhetorical categories and linguistic mechanisms in describing research conditions: A comparative genre-based investigation into researchers' choices in education and applied linguistics. *The Open Applied Linguistics Journal*, *2*, 1-19.

Lim, J. M. H. (2010). Commenting on research results in applied linguistics and education: A comparative genre-based investigation. *Journal of English for Academic Purposes*, *9*(4), 280-294.

Lim, J. M. H. (2012). How do writers establish research niches? A genre-based investigation into management researchers' rhetorical steps and linguistic mechanisms. *Journal of English for Academic Purposes*, *11*(3), 229-245.

Lim, J. M. H. (2017). Writing descriptions of experimental procedures in language education: Implications for the teaching of English for academic purposes. *English for Specific Purposes*, *47*, 61-80.

Lin, L. (2020). *Perspectives on the Introductory Phase of Empirical Research Articles: A Study of Rhetorical Structure and Citation Use*. Springer

Lin, L., & Evans, S. (2012). Structural patterns in empirical research articles: A cross-disciplinary study. *English for Specific Purposes*, *31*, 150-160.

Liu, M. H., & Liu, S. S. (2014) Processes, challenges and coping strategies of academic English writings by graduate EFL learners. *Journal of PLA University of Foreign Languages*, *37*(4)， 23-31.

Loi, C. K. (2010). Research article introductions in Chinese and English: A comparative genre-based study. *Journal of English for Academic Purposes*, *9*, 267-279.

Lu, X., & Deng, J. (2019). With the rapid development: A contrastive analysis of lexical bundles in dissertation abstracts by Chinese and L1 English doctoral students. *Journal of English for Academic Purposes*, *39*, 21-36.

Lynch, M., & Woolgar, S. (1990). *Representation in Scientific Practice*. MIT Press.

Martin, J. R. (1989). *Factual Writing: Exploring and Challenging Social Reality*. Oxford University Press.

Martin, J. R. (1992). *English Text: System and Structure*. John Benjamins.

Martin, J. R. (1997). Analysing genre: Functional parameters. In C. Frances, & J. R. Martin (Eds.), *Genre and Institutions: Social Process in the Workplace and School* (pp. 3-39). Cassell.

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). Deakin University Press.

Martín, P. M. (2003). A genre analysis of English and Spanish research paper abstracts in experimental social sciences. *English for Specific Purposes*, *22*, 25-43.

Marusˇic´, M., & Marusˇic´, A. (2001). Good editorial practice: Editors as educators. *Croatian Medical Journal, 42*, 113-120.

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*, 1-11.

Mat Hussin, N. I. S., & Nimehchisalem, V. (2018). Organisation and move structure in the results and discussion chapter in Malaysian undergraduates' final-year projects. *Pertanika Journal of Social Sciences & Humanities*, *26*(4).

Mauranen, A. (1993). *Cultural Differences in Academic Rhetoric*. Peter Lang.

Mauranen, A. (2012). *Exploring ELF: Academic English Shaped by Non-Native Speakers*. Cambridge University Press.

Miller, C. R. (1984). Genre as social action. *Quarterly Journal of Speech*, *70*, 151-167.

Miller, C. R. (1994). Rhetorical community: The cultural basis of genre. In A. Freedman, & P. Medway (Eds.), *Genre and the New Rhetoric* (pp. 67-78). Taylor & Francis.

Miller, T. (1998). Visual persuasion: A comparison of visuals in academic texts and the popular press. *English for Specific Purposes*, *17*(1), 29-46. https://doi. org/10.1016/S0889-4906(97)00029-X.

Moghaddasi, S., & Graves, H. A. (2017). "Since Hadwiger's conjection… is still open": Establishing a niche for research in discrete mathematics research article introductions. *English for Specific Purposes*, *45*, 69-85.

Moghaddasi, S., Graves, H. A., Graves, R., & Gutierrez, X. (2019). "See Figure 1": Visual moves in discrete mathematics research articles. *English for Specific Purposes*, *56*, 50-67.

Morell, T. (2015). International conference paper presentations: A multimodal analysis to determine effectiveness. *English for Specific Purposes*, *37*, 137-150. https://doi.org/10.1016/j.esp.2014.10.002.

Moreno, A. I. (2008). The importance of comparable corpora in cross-cultural studies. In U. Connor, E. Nagelhout & W. Rozycki (Eds.), *Contrastive Rhetoric: Reaching to Intercultural Rhetoric* (pp. 25-41). John Benjamins.

Myers, G. (1990). *Writing Biology: Texts in the Social Construction of Scientific Knowledge*. University of Wisconsin Press.

Najar Vazifehdan, S., & Amjadiparvar, A. (2016). A generic analysis of the conclusion section of research articles in the field of sociology: a comparative study. *Journal of Language and Translation*, *6*(2), 63-77.

Nelson, G. L., & Carson, J. G. (1998). ESL students' perceptions of effectiveness in peer response groups. *Journal of Second Language Writing*, *7*(2), 113-131.

Noorizadeh-Honami, L., & Chalak, A. (2018). Comparative analysis of Architecture research article abstracts written by native and non-native authors: A cross-linguistic, cross-cultural study. *Theory and Practice in Language Studies*, *8*(3), 325-330.

Nwogu, K. N. (1997). The medical research paper: Structure and functions. *English for Specific Purposes, 16*, 119-138.

O'Halloran, K. L. (2005). *Mathematical Discourse: Language, Symbolism and Visual Images*. Continuum.

O'Halloran, K. L. (2010). The semantic hyperspace: Accumulating mathematical knowledge across semiotic resources and modalities. In F. Christie, & K. Maton (Eds.), *Disciplinarity: Functional Linguistic and Sociological Perspectives* (pp. 217-236). Continuum.

Ozturk, I. (2007). The textual organization of research article introductions in applied linguistics: Variability within a single discipline. *English for Specific Purposes*, *26*, 25-38.

Pak, C. S., & Acevedo, R. (2008). Spanish-language newspaper editorials from Mexico, Spain, and the US. In U. Connor, E. Nagelhout, & W. Rozycki (Eds.), *Contrastive Rhetoric: Reaching to Intercultural Rhetoric* (pp.123–145). John Benjamins Publishing.

Pare, A. (2000). Writing as a way into social work: Genre sets, genre systems, and distributed cognition. In P. Dias, & A. Pare (Eds.), *Transitions: Writing in Academic and Workplace Settings* (pp. 145–166). Hampton Press.

Peacock, M. (2002). Communicative moves in the discussion section of research articles. *System*, *30*(4), 479-497.

Peacock, M. (2011). The structure of the methods section in research articles across eight disciplines. *Asian ESP Journal, 7*(2), 99-124.

Peng, J. (1987). Organizational features in chemical engineering research articles. *ELR Journal*, *1*, 79-116.

Pennycook, A. (1997). Vulgar pragmatism, critical pragmatism, and EAP. *English for Specific Purposes*, *16*(4), 253-269.

Pennycook, A. (2001). *Critical Applied Linguistics: A Critical Introduction*. Routledge.

Phothongsunan, S. (2016). Thai university academics' challenges of writing for publication in English. *Theory and Practice in Language Studies*, *6*(4), 681-685.

Posteguillo, S. (1999). The schematic structure of computer science research articles. *English for Specific Purposes*, *18*, 139-160.

Pramoolsook, I., Li, Q., & Wang, S. (2015). The methods sections in management and marketing research articles: Rhetorical variations between two sub-disciplines of business. *International E-Journal of Advances in Social Sciences*, *1*(2), 294-300.

Rhekhalilit, K., & Lerdpaisalwong, S. (2019). The increasing role of English in Thai academic publications. *Manusya: Journal of Humanities*, *22*(3), 335-357.

Roth, W.-M., Pzzer-Ardenghi, L., & Young Han, J. (2005). *Critical Graphicacy: Understanding Visual Presentation Practices in School Science*. Springer.

Rowley-Jolivet, E. (2002). Visual discourse in scientific conference papers A genre-based study. *English for Specific Purposes*, *21*(1), 19-40. https://doi.org/10.1016/S0889-4906(00)00024-7

Rowley-Jolivet, E. (2004). Different visions, different visuals: A social semiotic analysis of field-specific visual composition in scientific conference presentations. *Visual Communication*, *3*(2), 145-175. https://doi.org/10.1177/147035704043038

Salager-Meyer, F. (1994). Hedges and textual communicative function in medical English written discourse. *English for Specific Purposes*, *13*(2), 149-170.

Scollon, R. (1997). Contrastive rhetoric, contrastive poetics, or perhaps something else? *TESOL Quarterly, 31,* 352–363.

Seidlhofer, B. (2013). *Understanding English as a Lingua Franca-Oxford Applied Linguistics*. Oxford University Press.

Sheldon, E. (2011). Rhetorical differences in research article introductions written by English L1 and L2 and Castilian Spanish L1 writers. *Journal of English for Academic Purposes*, *10*, 238-251

Sherman, T. (2017). ELF and the EU/wider Europe. In J. Jenkins, W. Baker, & M.Dewey (Eds.), *The Routledge Handbook of English as a Lingua Franca* (pp. 115-125). Routledge.

Smagorinsky, P. (2008). The method section as conceptual epicenter in constructing social science research reports. *Written Communication*, *25*(3), 389-411. http://dx.doi.org/10.1177/0741088308317815

Soodmand Afshar, H., Doosti, M., & Movassagh, H. (2018). A comparative study of generic structure of applied linguistics and chemistry research articles: The case of Discussions. *Research in Applied Linguistics*, *9*(1), 28-56.

Spack, R. (1997). The rhetorical construction of multilingual students. *TESOL Quarterly*, *31*(4), 765-774.

Stoller, F. L., & Robinson, M. S. (2013). Chemistry journal articles: An interdisciplinary approach to move analysis with pedagogical aims. *English for Specific Purposes*, *32*, 45-57

Suárez, L., & Moreno, A. (2008). The rhetorical structure of academic book review of literature: An English–Spanish cross-linguistic approach. In U. Connor, E. Nagelhout, & W. Rozycki (Eds.), *Contrastive Rhetoric. Reaching to Intercultural Rhetoric* (pp. 147-167). John Benjamins Publishing.

Swales, J. M. (1981). *Aspects of Article Introductions.* The University of Aston.

Swales, J. M. (1990). *Genre Analysis: English in Academic and Research Settings.* Cambridge University Press.

Swales, J. M. (2004). *Research Genres: Explorations and Applications*. Cambridge University Press.

Swales, J. M. (2019). The futures of EAP genre studies: A personal viewpoint. *Journal of English for Academic Purposes*, *38*, 75-82.

Swales, J. M., & Feak, C. B. (2003). *English in Today's Research World: A Writing Guide*. The University of Michigan Press.

Tanko, G. (2017). Literary research article abstracts: An analysis of rhetorical moves and their linguistic realizations. *Journal of English for Academic Purposes*, *27*, 42-55.

Tardy, C. M., & Swales, J. M. (2014). Genre analysis. In K. P. Schneider, & A. Barron (Eds.), *Pragmatics of Discourse* (pp. 165-187). De Gureyter Mouton.

Tarone, E., Dwyer, S., Gillette, S., & Icke, V. (1981). On the use of the passive in two astrophysics journal papers. *The ESP Journal*, 1(2), 123-140.

Tencent Technology. (Ed.) (2020). Zoom has more than 200 million daily active users, 20 times more in three months. https://tech.qq.com/a/20200402/013930.htm

Tessuto, G. (2015). Generic structure and rhetorical moves in English-language empirical law research articles: Sites of interdisciplinary and interdiscursive cross-over. *English for Specific Purposes*, *37*, 13-26.

Thompson, S. (1994). Frameworks and contexts: A genre-based approach to analyzing lecture introductions. *English for Specific Purposes*, 13, 171-186.

Thongrin, S. (2018). Developing an instructional model to teach Thai research assistants to write English scientific research articles. *LEARN Journal: Language Education and Acquisition Research Network*, *11*(2), 21-65.

Tian, M. & Lu, G. (2016). Publish or perish: pressure faced by young scholars under ‘tenure-track’ contracts to publish in international journals, *Fudan Education Forum*, *14*(5), 14-20.

Vodovozov, V. (2010) *Introduction to Electronic Engineering*. Bookboon.com. https://bookboon.com/en/introduction-to-electronic-engineering-ebook

Wang, Q. H. (2012). How to play an international card in Chinese academic papers. *Guangming Daily*, 1(31).

Wang, Y. (2017). Chinese English as a lingua franca: an ideological inquiry. In J. Jenkins, W. Baker, & M. Dewey (Eds.), *The Routledge Handbook of English as a Lingua Franca* (pp. 151-164). Routledge.

Weissberg, R., & Buker, S. (1990). *Writing up Research: Experimental Research Report Writing for Students of English*. Prentice Hall Regents.

Williams, I. A. (1999). Results sections of medical research articles: Analysis of rhetorical categories for pedagogical purposes. *English for Specific Purposes, 18*(4), 347–366.

Wolfe, M. L. (2008). Different cultures, different discourses? In U. Connor, E. Nagelhout, & W. Rozycki (Eds.), *Contrastive Rhetoric: Reaching to Intercultural Rhetoric* (pp. 87-121). John Benjamins Publishing.

Wood, A. (2001). International scientific English: The language of research scientists around the world. In J. Flowerdew, & M. Peacock (Eds.), *Research Perspectives on English for Academic Purposes* (pp. 71-83). Cambridge University Press.

Wu, F., & Wang, X. (2018). Promotion and transcendence: An innovative approach to the international publication of Chinese journalism and communication, *Journal of Western*, *9*, 5-9. https://doi.org/10.16721/j.cnki.cn61-1487/c.2018.09.002

Xiao, G., & Chen, X. (2015). English academic writing difficulties of engineering students at the tertiary level in China. *World Transactions on Engineering and Technology Education, 13*, 259-263.

Xu, F. (2014). A review of studies on international publication of scholars from non-English speaking countries, *Foreign Language World*, *1*, 27-33.

Yang, L., & Cahill, D. (2008). The rhetorical organization of Chinese and American students' expository essays: A contrastive rhetorical study. *International Journal of English Studies*, *8*(2), 113-132.

Yang, L., Xu, M., & Li, C. (2019). Four-element MIMO antenna system for UWB applications. *Radioengineering*, *28*(1), 60-67.

Yang, R., & Allison, D. (2003). Research articles in applied linguistics: moving from results to conclusions. *English for Specific Purposes*, *22*, 365-385.

Yang, R., & Allison, D. (2004). Research articles in applied linguistics: Structures from a functional perspective. *English for Specific Purposes*, *23*, 264-279.

Yao, M. (Ed.) (2019). University ranking of electronic information engineering in Chinese universities in 2019. http://www.ccutu.com/222796.html.

Ye, Y. (2019). Macrostructures and rhetorical moves in energy engineering research articles written by Chinese expert writers. *Journal of English for Academic Purposes*, *38*, 48-61.

Yu, W. (2014) Main problems and solutions of English scientific paper writing for engineering doctoral students. *Foreign Language World*, *3*, 55-62.

Zamani, G., & Ebadi, S. (2016). Move analysis of the conclusion sections of research papers in Persian and English. *Cypriot Journal of Educational Sciences*, *11*(1), 9-20.

Zamel, V. (1997). Toward a model of transculturation. *TESOL Quarterly*, *31*(2), 341-352.

Zhang, B., Thuc, Q. B. T., & Pramoolsook, I. (2012). Moves and linguistic realizations: English research article abstracts by Vietnamese agricultural researchers. *The Asian ESP Journal, 8*(3), 126-149.

APPENDICES

APPENDIX A

An Online Questionnaire for Preliminary Needs Analysis on English RA Writing and International Publication

First of all, I would like to express my sincere gratitude to you all for taking this online questionnaire. This questionnaire is only collected for my dissertation research, thus your privacy will not be harmed and please feel safe and free to answer the questions according to your own situation.

Name ______________________ Title__________________ Age ____________

Email _________________________________ Profession ____________________

Major ____

1. Have you ever published papers in international journals?
   A. Yes
   B. No
2. How many papers have you published internationally?
   A. 1-3
   B. 4-6
   C. More than 7

3. How often do you write international RAs for publication?
   A. 1 piece every three months
   B. 1 piece every six months
   C. 1 piece every year
   D. other__________________
4. What is your opinion on publishing papers in international journals?
   A. Very important
   B. Important
   C. Not important.
5. The reason/reasons you publish internationally is/are______________________
   (Multiple options allowed).
   A. Graduation requirements.
   B. Promotion requirements.
   C. Research needs.
   D. Others________________________
6. The language you publish in international journal is_______________________
   A. English
   B. Chinese
   C. Others ________________________

7. What is your opinion on the difficulty in publishing internationally?
   A. Very difficult
   B. Difficult
   C. Neutral
   D. Not difficult
8. The difficulty/difficulties in publishing internationally lie/lies in____________ (Multiple options allowed)
   A. Contents
   B. Language
   C. Article structure
   D. Logic
   E. Other_____________________
9. The reason/reasons contributing to the difficulties in publishing internationally is/are_______. (Multiple options allowed)
   A. Less experience in writing articles for international publication.
   B. Less instruction on writing articles for international publication.
   C. Less knowledge in writing articles for international publication.
   D. Other________________

10. On the premise of publishing in international journals, how could you manage to overcome your difficulties in terms of research paper format, text structure and language? (Multiple options allowed)
    A. Appeal to professional personnel such as classmates, colleagues, teachers, or advisers
    B. Look for relative network resources
    C. Look for relative information in books.
    D. Other________________
11. How often do you search for international research paper model that you can refer to in terms of text format, structure and language?
    A. Never
    B. Seldom
    C. Often
12. Have you ever attended courses on English paper writing?
    A. Yes
    B. No
13. If the answer to item 11 is Yes, please write down the name of the courses:
    ____

14. Has your university, teacher or supervisor ever provided you with reference material regarding to English RA format, text structure and language?

    A. Yes

    B. No

15. If the answer to item 14 is Yes, which of the following category do they belong to? (Multiple options allowed)

    A. Reference material regarding to the format of English RA

    B. reference material regarding to the structure or language of English RA

    C. Reference book regarding to English RA writing guidance.

    D. the full-text model of English RA.

    E. Other________________________________

16. Do you usually use visual elements (tables, charts, graphs, figures, etc.) in your English RA for internationally publication?

    A. Yes

    B. No

17. Do you think it is necessary to include visual elements in your RAs?

    A. Yes.

    B. No

18. What's your opinion on the percentage of visual elements in Electronic Engineering RAs?

    A. About 30%

    B. About 50%

    C. About 70%

    D. Other______________________

19. Which of the following functions do you think visual elements mainly display in RAs? (Multiple options allowed)

    A. Establishing presumptions: preceding labeled definitions, help to construct specific concepts;

    B. Serving as evidence in the argument that the concept or object actually exist. Supporting argumentation

    C. Creating new knowledge.

D. Discussion.

E. Others ______________________

20. Do you know anything about the relation or interaction between the written words and visual elements in RAs?

A. Yes

B. No

21. Would you like to get more knowledge about visual elements and how they contribute to RAs' rhetoric?

A. Yes

B. No

APPENDIX B

附录B

An Interview Protocol for Preliminary Needs Analysis on RA Writing and International Publication

初步需求分析：关于英语研究论文写作与发表的访谈方案

First of all, I would like to express my sincere gratitude to you all for taking part in this interview, which is only a way of collecting information for my dissertation research. Thus, your privacy will not be harmed in any way. Please feel safe and free to answer the questions according to your own situation.

首先，我要对各位参与本次访谈表示衷心的感谢，这只是为我的论文研究收集资料的一种方式。因此，您的隐私不会受到任何损害，请您放心，根据自己的情况自由回答问题。

The interview aims to have a basic investigation on your comments and evaluation on the writing and publishing of research articles (RAs) for international journals. The results of the present interview serve as a preliminary step for my study on rhetorical structure and visual elements in Electronic Engineering international RAs. The findings of the present study might have pedagogical implications for learning and instructing journal article writing for international publication.

本次访谈的目的是对您对国际期刊论文写作和出版的评论和评价进行基本调查。本次访谈的结果为我研究电子工程研究论文中的修辞结构和视觉元素提供了初步的依据。本研究的结果可能对学习和指导国际研究论文发表**的写作具有教学意**义。

Contents:

内容：

The interview includes the following contents: a) your understanding on the RA writing; b) your comments on RA writing instruction; c) your difficulties in writing and publishing RA internationally.

访谈内容包括：a) **您**对研究论文写作的理解；b) **您**对研究论文写作教学的看法；c) **您在研究**论文写作和国际出版方面的困难

Warm-up questions:

热身问题：

1) What is your major and what do you think of this major?

1) **您的**专业是什么？您觉得这个专业怎么样？

Your perception on RAs.

您对研究论文的看法

2) Have you published articles in international journals? How many articles have you published? What are the journals' name? Can you say something about the journals?

2) **您在国**际期刊上发表过文章吗？您发表了多少篇文章？期刊的名字是什么？您能说说对这些期刊的看法吗？

3) Can you say something about publishing RAs in international journals? What are the process or steps you usually adopt for publication? Can you say something about the comments made by reviewers? What do you think of their comments?

3) **您能**谈谈在国际期刊上发表 RAs 吗？您通常采用什么流程或步骤出版？您能谈谈评论员的评论吗？您觉得他们的评论怎么样？

English writing issues

英语写作问题

1) What do you think of writing in English for international publication? Do you always write in English? Are you familiar with any English writing paradigm?

1) **您**对**用英**语写作国际论文**有什么想法？您**总是用英语写作吗？您熟悉英语写作模式吗？

2) Are you familiar with the structure or rhetorical organization of the RA? How many sections are usually included in the RAs in your field? Which section is the most challenging part for you to write, and in what way? Have you referred to any material or resources when you felt lost in organizing the text? What are the materials and resources?

2) **您熟悉研究**论文的结构或修辞结构吗？您所在领域的研究论文中通常包含多少章节？哪一章节对您来说是最具挑战性的？为什么**？当您在构建**论文时感到迷茫时，您有没有参考过任何材料或资源？这些材料和资源是什么？

3) Could you say something about the visual elements/visuals (e.g. figures, charts, graphs, etc.) in your RAs for international publication? What functions do you think they have in your RAs?

3) **您能**谈谈您的研究论文国际出版物中的视觉元素/视觉效果（如数字、图表、图表等）吗？您认为他们在您的研究中有什么功能？

APPENDIX C

附录C

A Post Interview Protocol
on the Composition of Electronic Engineering Research Articles
电子工程研究论文写作的后访谈方案

First of all, I would like to express my sincere gratitude to you all for taking part in this interview, which is only a way of collecting information and triangulating some of the results of my dissertation research. Thus, your privacy will not be harmed in any way. Please feel safe and free to answer the questions according to your own situation.

首先，我要对大家参加这次采访表示衷心的感谢，这次采访只是收集资料，对我的一些论文研究成果进行三角剖分的一种方式。因此，您的隐私不会受到任何损害。请根据自己的情况自由回答问题。

The interview aims to obtain information and possible explanation of the results of the present research, which could help the researcher clarify doubts, confirm and strengthen discussion. The findings of the present research might have pedagogical implications for learning and instructing journal article writing for international publication.

访谈的目的是获取信息和对本研究结果可能的解释，帮助研究者澄清疑问，确认和加强讨论。本研究的结果对学习和指导国际期刊论文写作有一定的教学意义。

1. Can you provide your opinion on RA move-step structure of the Introduction/ Methods/Results and Discussion/Conclusion section?

1. **您能否就引言/方法**/结果和讨论/结论部分的步骤结构提出您的看法？

2. Could you please explain why _____________ is more frequently adopted than__________ (Or could you please provide explanation that why __________ has a higher/highest occurrence between or among _____________?)
2. **您能解释**一下为什么______**被采**纳的频率比_______**被采**纳的频率高吗?（**您能解释**一下为什么______**在两**/**三**______**之**间出现的频率较高/**最高**吗？）

3. Could you please provide explanation why ______________ among these three writer groups?
3. **您能解释**一下在这三组**作者中**，为**什么**_____________？

4. What kind of visuals do you usually adopt in this section?
4. **在**这一部分您通常采用什么样的视觉元素？

5. What function do the visuals have to achieve the communicative purpose of this section as well as the whole RA?
5. 为了实现本节以及整个研究论文的交际目的，视觉元素有什么作用？

6. When you mention the visuals using the textual language in a RA, that is, visual-textual move, it helps contribute to the communicative purpose of the EERAs. Could you help provide your opinion on the interaction among visuals, visual-textual move and move-step structure?
6. **当你提到使用文本**语言的视觉元素时，即视觉语篇语步，它有助于实现电子工程**研究**论文**的交**际目的。你能否就视觉元素、视觉语篇语步和篇章语步结构之间的相互作用提出你的看法？

CURRICULUM VITAE

Sutong Gao, born in October, 1984, is currently a lecturer in School of Foreign Languages, Xi'an Shiyou University, Shaanxi, China. She obtained her Master of Arts of Linguistics and Applied Linguistics from Xi'an International Studies University in 2010. Her research interests include second language writing, genre analysis, and genre-based approach to teaching writing.