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CREATING COHERENCE IN RESEARCH ARTICLES: NON-NATIVE RESEARCHERS AS WRITERS OF SCIENTIFIC ENGLISH

Master of Science thesis

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ABSTRACT

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This thesis focused on challenges faced by non-native researchers writing their scientific papers for publication in English. To publish in peer-reviewed international mainstream journals, researchers should be able to write in a genre-specific and persuasive manner. Academic writing requires explicit organization of texts, caution in making claims, signposting connections, and creating coherence and clarity in the text. The research article (RA) is a key genre of scientific publishing with a special communicative and rhetorical structure. The structure and language of the RA partly depend on the disciplinary knowledge-making practices and writing conventions applied in the field of research.

The subjects of this study were doctoral and post-doctoral researchers in Materials Science at Tampere University of Technology (TUT), all of them non-native speakers of English. The objective of the study was twofold: first, to explore the experiences, perceptions, attitudes, challenges, and wishes for further training of the researchers writing in English; second, to examine how they employed certain linguistic devices to present the results of their research. The study applied two methods to answer the research questions: an e-mailed questionnaire and a descriptive analysis of published sample RAs written by the subjects. Swales' Create-A-Research-Space (CARS) model for RA introductions and Hyland's model of interactive and interactional metadiscourse were used as investigative tools to study certain rhetorical and textual features.

On the whole, the TUT respondents showed a positive attitude to writing in English. Approximately half of them felt disadvantaged in writing RAs when compared to native speakers. The researchers considered "creating text flow and coherence to make my reasoning easy to understand" and "expressing my interpretation of the results with an appropriate degree of confidence" most challenging. Both skills involve the ability to write reader-friendly and professionally convincing text. Most sample RAs followed the 3-move rhetorical pattern of the CARS model. Most of the metadiscoursal items were interactive, which is characteristic of quantitative RAs in natural sciences and engineering. Overall, the writers employed a rather limited selection of metadiscoursal devices. Since proofreaders often pay attention only to obvious lexico-grammatical mistakes in scientific papers, an interactive system with early-stage consultation between writers and proofreaders can help to create persuasive and genre-specific argumentation. Discipline-based writing instruction and materials on textual and rhetorical organization beyond the sentence level could help writers to construct coherent texts.

TIIVISTELMÄ

TIINA OJAMO: Koherentin tekstin kirjoittaminen tutkimusartikkeleissa: Ei-natiivit tutkijat tieteellisen englannin kirjoittajina
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Avainsanat: tieteellinen kirjoittaminen, koherenssi, ei-natiivi tutkija, tutkimusartikkeli, CARS-malli, metadiskurssi

Tämä diplomityö tarkasteli ei-natiivien tutkijoiden haasteita heidän kirjoittaessaan englanninkielisiä julkaistaviksi tarkoitettuja tieteellisiä artikkeleita. Tutkimusartikkeli on tärkein tieteellisen julkaisemisen väline, jolla on oma tyypillinen rakenteensa ja muotonsa. Tieteenharjoittajan on kirjoitettava tutkimusartikkelin genren mukaista, retorisesti vakuuttavaa englantia saadakseen tekstinsä hyväksytyksi arvostettuun kansainväliseen vertaisarviointia käyttävään julkaisuun. Tieteellinen kirjoittaminen edellyttää tekstin kokonaisrakenteen suunnittelua, huolellista argumentointia sekä lukijan huomioivaa selkeyttä. Tavoitteena on johdonmukainen, tieteenalan konventioita noudattava kokonaisuus.

Tutkimus kohdistui osaan Tampereen teknillisessä yliopistossa työskentelevistä Materiaaliopin laitoksen tutkijoista, joiden äidinkieli ei ole englanti. Diplomityöllä oli kaksi päätavoitetta. Tarkoitus oli ensiksi selvittää tutkijoiden englanniksi kirjoittamiseen liittyviä kokemuksia, asenteita ja haasteita sekä selvittää heidän toiveitaan englanniksi kirjoittamiseen liittyvästä tuesta. Menetelmänä oli verkkokyselylomake. Toinen päätavoite liittyi tutkimusartikkelien kieleen. Kohderyhmältä saatujen julkaistujen artikkelien tiettyjä retorisia ja tekstuaalisia piirteitä tarkasteltiin John Swalesin CARS-mallin ja Ken Hylandin metadiskurssiluokituksen näkökulmasta.

Kyselyyn vastanneet suhtautuivat pääasiassa myönteisesti englanniksi kirjoittamiseen. Noin puolet heistä tunsi olevansa tutkimusartikkeleita laatiessaan huonommassa asemassa kuin äidinkielellään kirjoittavat. Vaikeinta tutkijoiden mielestä oli kirjoittaa koherenttia tekstiä, jonka avulla esittää ja tulkita omat tutkimustulokset vakuuttavasti.

Tutkimusartikkelien enemmistö sisälsi CARS-mallin tyypillisiä retorisia siirtoja ja askelia. Suurin osa identifioidusta metadiskurssista oli interaktiivista, mikä on ominaista teknis-luonnontieteellisen alan kvantitatiivisia menetelmiä käyttävien alojen teksteille. Metadiskurssi rajoittui muutamiin vakioilmaisuihin, joita kirjoittajat toistivat artikkelien eri osissa. Yleensä kielentarkastajat puuttuvat vain selviin kieliopillisiin ja sanaston virheisiin. Tästä syystä tieteellistä kirjoittamista voisi parantaa ”varhaisen tuen malli”, joka mahdollistaisi tutkijan ja kieliasiantuntijan yhteistyön jo ennen pintapuolista oikolukuvaihetta. Jo tutkimusartikkelien sisältöä suunniteltaessa kannattaa ottaa huomioon sana- ja lausetasoa syvemmällä olevat tekstipiirteet ja genrekohtaiset retoriset keinot. Kirjoit-

tamisen opetusmateriaalit ja -menetelmät voisivat perehdyttää alkuvaiheessa olevat kirjoittajat oman diskurssiyhteisönsä kielellisiin konventioihin.

PREFACE

This thesis for the Master's degree in Technology was prepared within the Study Programme of Materials Engineering at Tampere University of Technology. It explores some of the challenges of writing academic English faced by non-native researchers in Materials Science.

I would like to thank the Department of Materials Science and Professor Erkki Levänen, the examiner of this thesis, for the opportunity to study a subject that I find extremely interesting and definitely relevant for researchers who wish to become literate professionals in their discourse communities.

My two encouraging supervisors inspired me throughout the writing process. I am immensely grateful to Timo Lepistö from TUT Language Centre for his insight, expertise, and patience. He has taught me a lot about scientific writing. I also greatly value the friendly and helpful attitude of Saara Heinonen, my supervisor from the Department of Materials Science.

I also want to thank the researchers who completed and returned the questionnaire and gave their permission to examine the language of their research articles.

My sincere thanks go to Ghida, who shared her humor and thought-provoking outlook on life during our most enjoyable walks around Lake Suolijärvi.

Finally, I am extremely grateful to my family for their support and encouragement. I thank my dear husband Aapo for reminding me of the most worthwhile things in life.

Tampere, August 2015

Tiina Ojamo

LIST OF ABBREVIATIONS

CARS model	Create-A-Research-Space model
EAP	English for Academic Purposes
ELF	English as a Lingua Franca
ERPP	English for Research Publication Purposes
ESP	English for Specific Purposes
L1	Native language
L2	Second language
NN	Non-Native
NNS	Non-Native Speaker of English
NS	Native Speaker of English
RA	Research Article
RAI	Research Article Introduction
TUT	Tampere University of Technology
SciELF	Scientific English as a Lingua Franca
WrELFA	Written Academic English as a Lingua Franca

1 INTRODUCTION

The theme of the present study is non-Anglophone academics' scientific writing for publication in English. Numerous studies [1-4] have discussed the dominance of English in science publication and its implications for non-native speaker (NNS) academic writers. Much research [5-15] in recent years has also focused on the difficulties and challenges of NNS academics trying to publish their articles in internationally refereed high-impact journals. Some of the researchers' problems result from insufficient training in academic writing. The rhetorical, stylistic and discourse features of NNS texts may differ significantly from the conventions of academic English. Belcher [2] investigated the submission history of a mainstream journal's accepted and rejected papers originating outside the English-speaking countries. According to her study, the reviewers criticized the "language use and style" more frequently than any other feature of the manuscripts.

Academic discourse is a social, cognitive, and rhetorical process. Disciplinary ideologies and epistemologies influence the interpretation and production of scientific writing [16]. Novice writers, as part of their discourse socialization, are expected to learn a set of "writing games" [17], i.e., rules to follow, in order to develop academic literacy. To succeed in academic writing, researchers must master the persuasive practices of their disciplines. This persuasion requires using the appropriate language to connect fresh academic texts with the existing disciplinary culture [18].

Applied linguists have investigated the informational, rhetorical and stylistic features of academic written English in order to both describe academic texts and develop language instruction for NNS writers. The discipline of English for Academic Purposes (EAP) and its subfield English for Research Publication Purposes (ERPP) have focused on the needs of researchers and postgraduate students who need to publish [19]. If NNS academic writers have problems with vocabulary or syntax, proofreaders generally correct them. EAP is, however, mainly interested in the deeper level of the textual organization and style of academic texts. Writing persuasive and coherent academic prose relates to the rhetorical and textual level beyond the sentence [20]. Two EAP approaches have significantly contributed to the study of academic writing: genre analysis and the study of metadiscourse, commonly defined as "discourse about discourse".

Genre analysis classifies texts according to their key linguistic and rhetorical features. John Swales' [21, 22] Create-A-Research-Space (CARS) model analyses the structure of research article (RA) introductions. Several studies have applied the CARS framework to studying either disciplinary variation [23-29] or cross-cultural differences [30, 31] in the rhetorical organization of RA introductory sections. As an alternative, Ken

Hyland's [32] interpersonal model of metadiscourse emphasizes the socio-rhetorical context of academic writing. When academics write up their research, they also convey their stance not only to the content of their text but also to their readers. Metadiscourse markers help them write more coherent and reader-friendly research papers. Academics can also show their disciplinary awareness by means of metadiscoursal linguistic devices. In the past twenty-five years, a number of studies [33-49] have dealt with the use of metadiscoursal features in different genres of academic discourse.

Ventola and Mauranen [20] explored Finnish academics' writing for publication in English. They analyzed some of the difficulties faced by Finns writing their research papers and also examined language revisers' corrections of their texts. Most studies on Finnish academic writers belong to the field of contrastive rhetoric [33, 34, 50-52], and compare NNS and NS (native speaker) writers' texts. Wilson's [53] study examined the linguistic preferences and attitudes of senior research staff at the University of Jyväskylä. At present, Mauranen's group of researchers is compiling two corpora: one of both published and unpublished, unedited academic texts in English, most of which were written by NNS authors (WrELFA), and the other of unedited RAs written by multilingual academics (SciELF). By showing frequencies of rhetorical features, corpus-driven studies provide information on disciplinary practices and cultural preferences in academic writing [54].

Few studies have, however, examined the experiences, attitudes and writing problems of Finnish academics writing up and publishing empirical research in the "hard" sciences. It may be challenging for researchers in the natural sciences and engineering to write fluent and coherent academic prose, especially in the introduction and discussion sections of RAs, which writers generally consider the most demanding parts of scientific papers [22, 49, 62]. To complement the current large corpus-based studies, there is also a need for qualitative, small-scale investigations. A "local" corpus research [55] can provide an insight into how researchers in a particular discipline write, and what they think about their writing in English.

The subjects of the present study are NNS doctoral and post-doctoral researchers in Materials Science at Tampere University of Technology (TUT). The thesis has two main objectives: first, to explore the researchers' experiences, attitudes, challenges and wishes for further language training; second, to investigate how and to what extent certain linguistic features occur in their writing. The study combines two methods to answer the research questions: an e-mailed, 20-item questionnaire and a descriptive analysis of published sample RAs written by the subjects. The studied rhetorical and textual devices are analyzed drawing on John Swales' CARS model and Ken Hyland's model of academic metadiscourse.

This study will provide useful information for both the Department of Materials Science and the Language Centre. It is essential that the researchers of Materials Science partic-

ipate in international knowledge production and dissemination. Successful publishing, however, requires sufficiently developed writing skills. Awareness of the relevant linguistic features will help the researchers to write more fluent and coherent texts. The results of this thesis has implications for writing instruction targeted to researchers in the hard fields of science. Because academic writers are not a monolithic group [2], the degree of disciplinary specificity affects the design of courses and materials. Researchers writing RAs profit from instruction that provides them with discipline-specific skills to recognize and employ the appropriate rhetorical structures and conventions.

2 SCIENTIFIC WRITING FOR PUBLICATION

Hyland and Salager-Meyer [18] list the basic functions of academic writing: first, to persuade the academic community and construct knowledge; second, to legitimize the authority of science; and, third, to support the established hierarchical system, which accords the writers recognition and reward through publication. It is difficult for a researcher to pursue his career successfully unless he publishes. Publications ensure his promotion, tenure or grants to finance his research. Scientists who publish frequently are also likely to achieve important positions within their field. Scientific texts, however, do not only describe reality or introduce new knowledge but also provide colloquy between the members of a community and an important tool for disciplinary knowledge construction. To become prolific publishers, academic writers must master the writing practices of their discipline. Persuading the readers, i.e., the other members of their disciplinary community, involves making rhetorical choices appropriate to the context.

In today's academia, English is the language of scientific writing for publication. It has been estimated that 80 % of the world's scientific writing is in English [21], or that two thirds of scientific papers are published in English [56]. In 1997, John Swales in his article "English as *Tyrannosaurus rex*" called English "a powerful carnivore gobbling up the other denizens of the academic linguistic grazing grounds" [57, p. 374]. In recent years, attitudes toward the use of English in academic publishing have varied among the researchers in the field of English for Academic Purposes (EAP) and its branch, English for Research Publication Purposes (ERRP). Various empirical studies have examined the international publication practices of multilingual researchers, i.e., of those who are not native speakers of English. Some [13, 59, 60] have presented English as a valuable lingua franca, which enables knowledge dissemination, international communication and scientific co-operation. Others [1-3, 10-15, 60-64] have focused on the several problems and challenges of non-native academics, who publish their research in English-medium, peer-reviewed journals.

The challenges of non-native scientists are not limited to linguistic difficulties. Different cultures, disciplinary practices and rhetorical styles affect the features of academic writing [66]. The concept of *disciplinary culture* refers to the research paradigms, values and writing conventions that influence language use and writing [18]. Research methodologists apply Thomas Kuhn's [67] concept of *paradigm* to refer to the ontological and epistemological beliefs that underlie any approaches to inquiry. The two basic paradigms are quantitative and qualitative research. Because research paradigms influence academic discourse and its rhetorical conventions, there are differences in the rhetorical

conventions in which empirical research is presented. Academic disciplines are traditionally defined as either “hard” or “soft” based on the type of knowledge they produce. Bernstein [68] distinguishes between disciplines with “hierarchical knowledge structures” and “horizontal knowledge structures”. According to this distinction, hard disciplines with hierarchical knowledge structures consider scientific knowledge cumulative, value-free and based on empirical experiments. They also postulate explicit, universally shared criteria for the verification of fresh research findings. The soft disciplines with horizontal knowledge structures regard knowledge as reiterative, contextual and based on argumentation rather than verification according to a commonly approved set of criteria.

The studies of Swales [22], Li [69] and Li and Flowerdew [70] have shown that it may rather be stylistic differences than linguistic problems that affect the quality of multilingual writers’ texts. Swales [22] also points out that the NNS writer’s failure to describe a gap in the previous research is often more of a cultural issue than a linguistic problem. Tardy [71] discusses the difficulties of multilingual students in expressing stance, when they are presenting their knowledge claims. Often the NNS writer’s reluctance to persuade his readers is due to cultural values and literary practices. He may, e.g., not feel comfortable about making “overt attempts to boast”, which is the standard way to persuade in English-based disciplinary communities. Mauranen [35] compared texts written by Anglo-American and Finnish academics. The former favored “marketing-type rhetorical strategies”, whereas the latter appeared as “the poetic type”. While the native writers of English guided their reader explicitly, the Finnish scholars were implicit and laconic, concentrating on the propositional content of the text. The scope of the present study does not include a thorough discussion of cultural differences in academic rhetoric, which could, no doubt, offer interesting examples of linguistic transference.

In Finnish universities, particularly in natural sciences and engineering, publishing in English is fairly normative. For example, in the academic year 2011-2012, only 10 % of publications were national, and a mere 4 % of those were published in Finnish [72]. Researchers in natural sciences generally produce co-authored articles, which are typically published in conference proceedings. They appear in a standardized format, which follows codified writing conventions and includes its own symbol systems. When scientists write up their research, they are expected to follow certain commonly approved, discipline-based practices and rhetorical style. To succeed, writers must develop a “disciplinary awareness” [37]. As members of a disciplinary community, they construct and interpret academic arguments according to the appropriate conventions in their own field. Mauranen [35] refers to Finnish economists, but the following argument could also apply to Finnish researchers in Materials Science:

> There is no reason in principle . . . for Finnish economists to try to change their rhetorical strategies. However, in practice, the Finnish culture is a minority culture, and the Anglo-American culture dominates in the academic world. Aware

> ness of these intercultural rhetorical differences is therefore particularly useful for Finnish writers, if they want to make informed choices about whether and when to conform to the expectations of the target audience. [35, p.18]

Nowadays, the native versus non-native dichotomy is becoming a secondary issue, and successful academic publishing is seen to follow from the scientists' expertise and their academic seniority [23, 73]. Consequently, Swales [23] suggests rejecting the traditional distinction between NS and NNS writers. Instead, he prefers differentiating between experienced senior and less experienced junior researchers. In many cases, the non-native expert senior academic is a fluent writer, who masters the "rhetorical patterns [that] are inextricably related to the purposes of [his] discipline" [37, p.56]. However, in order to be a productive publisher, he must become academically literate in a foreign language. Several studies [2, 22, 64, 65] on multilingual academics participating in global academic communities through article and research publication have emphasized the need for instructional support for these writers. Explicit or implicit teaching of academic writing skills ought to be based on disciplinary enculturation. Writing courses traditionally focus on teaching scientists to present their research in coherent and reader-friendly English. Instructors could also aim at developing non-native scientists' awareness of the characteristic disciplinary practices and genres of academic writing.

3 RESEARCH ARTICLE AS A GENRE

Scientific writers are expected to write genre-specific and coherent text. To succeed in that, they should master the appropriate rhetorical and interactive features and conventions characteristic of their own research community [23, 74]. According to Swales [22, p. 93], a *genre* "comprises a class of communicative events, the members of which share some set of communicative purposes". Thus genre membership is based on a mutual communicative purpose. Genres differ from each other in several respects. They may have different rhetorical purposes, or they may apply different modes and media. Genres may also have different universal or language-specific features. In many research-based discourse communities, the research article (RA) is the key genre. Swales defines the RA as follows:

> a written text . . . , 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. It is to appear or has appeared in a research journal or, less typically, in an edited book-length collection of papers. [22, pp. 177-8]

The RA is generally the result of a multiphase process. A manuscript may be drafted several times and receive various comments from its coauthors, reviewers and editors before it is published. [22, 23]. The standard RA is also closely related to all the other research genres, as Figure 1 illustrates.

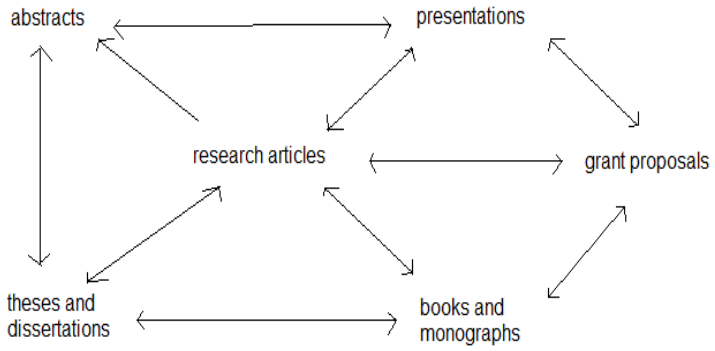

Figure 1. *The RA and other research-process genres [22, p. 177]*

In most cases, RAs are preceded by an abstract. After publication, the abstract of the RA may appear in an abstracting journal. Readers will thus be able to look for the original RA. Conference presentations and RAs are also connected. A presentation may be a version of an unpublished paper, or it may cover a published RA. Published RAs increase the chances for research grants, and research grants allow scientists to publish new RAs. Books and monographs are often based on previously published articles. New articles, on the other hand, may originate from books. Sections of theses and dissertations may earlier have existed as RAs, whereas sections of dissertations are frequently published as RAs.

Swales [23] points out that the RA is a dynamic genre, which is constantly undergoing slow evolution. Obviously e-journals and other electronic publications have had a huge influence on its development. Scientists writing RAs, and also those who teach academic writing, keep up with the evolving disciplinary practices by reading current and authentic discipline-specific texts. There is, e.g., clear disciplinary variation in the structural patterns of RAs. While many empirical RAs follow the Introduction-Method-Results-Discussion (IMRD) pattern, this structure is not necessarily the standard option for organizing research papers. Results indicate that nowadays, at least in a number of applied sciences, the most frequently used structural pattern is Introduction, Literature Review, Methods, Results and Discussion, Conclusion [29].

According to research [67, 75, 76], the introduction and discussion of an RA are for non-native writers of English the most challenging sections to write, because they require the writer to make essential rhetorical moves in order to place his research within the disciplinary context. In the introduction, the writer is supposed to “establish a research niche” [22]. He is, in other words, expected to present and discuss the arguments and results of others in the field and point out either inconsistencies or gaps in previous research. As Swales [23] states, introductions are sections in which the writer has the opportunity to present his “early positive evaluations, early justifications, and early clarifications” to persuade the reader to pursue further. Similarly, in the discussion section, the scientist should write coherent and persuasive prose to report and describe the results of his research. This is definitely more demanding than, e.g., presenting information in the methods section by using tables and figures. On the whole, writers who publish successfully do not just let their results “speak for themselves”. The discussion section offers them an opportunity to defend their findings and promote the value of their own contributions. A number of studies [6, 22, 35, 67, 68, 77] have shown that problems with the above sections are not necessarily due to linguistic problems. Swales [23] discusses the increase of “boosterism” in scientific writing, which may pose challenges for junior researchers, particularly for non-native writers. The accepted conventions of the English-based academic discourse community may appear alien to researchers who are not accustomed to seeing their readers as “consumers” or “customers”.

3.1 Textual coherence through rhetorical structure and meta-discourse

It is difficult to define coherence. It is a lot easier to spot the difference between a coherent and a non-coherent text. Exact, unambiguous and detailed instructions on how to achieve coherence in various writing genres may not even exist. The term is used widely, but it is under-theorized even in the EAP literature [78]. According to Hyland [79], academic writing involves primarily "explicit organization of texts, caution in making claims and signposting connections". All this requires taking responsibility for the overall coherence of the text. The reader should be able to follow how the separate ideas presented in the text develop and how they relate to each other; i.e., he should detect the coherence the writer was aiming at [76]. In EAP research, coherence and cohesion are frequently seen as connected; therefore, they are often discussed under the same title. Cohesion functions like coherence at a "local level" [80]. According to Williams and Bizup [81], cohesion, in the case of pairs of sentences, resembles pieces fitting together in a jigsaw puzzle. Coherence, on the other hand, is the result of all the sentences fitting together in a text similarly to the picture on the box containing the jigsaw puzzle.

Cohesive devices, such as conjunctions, can create coherence in texts. By signaling logical relations, they signpost connections and thus guide the reader. On the other hand, frequent use of cohesive devices does not automatically result in more coherence [82]. For example, when a text follows a conventional pattern of organization, it is unnecessary to employ any extra linguistic markers to ensure its correct interpretation. As Heuboeck [83] points out, the unity of any text is not situated on a semantic but on a pragmatic level. Texts communicate to text users, i.e., the other members of discourse communities. Schematized structures imposed by genres are an essential part of the texts' communicative purpose.

It could be argued that coherence is not basically, or not just, a characteristic of well-written texts. In successful communication, it is rather the readers who cohere with writers, when they understand their texts. [84, 85]. Hoey [86] observes that when one is reading a text, he is simultaneously formulating hypotheses about how the text will develop. The reader generally brings to texts his own background knowledge of the topic, his expectations and also his previous knowledge of how similar texts are typically structured. He may recognize familiar text patterns and rhetorical features. Based on this shared knowledge, writers may guide their readers by applying conventionalized structures and discoursal devices. All in all, coherence refers to the unity and continuity of discourse.

Numerous genre-based studies have analyzed the organization of rhetorical structures in the different sections of RAs. Move analysis is one of the theories applied to describe RA structure. It is possible to interpret texts by identifying distinct rhetorical units that

are conventionally applied to perform coherent communicative functions [23]. Most move-analysis research has focused on RA introductions [24, 25, 27, 28, 30-32, 87], whereas some studies have examined the methods [88] and results [89] sections as well as the discussions and conclusions [90]. Move analysis was first developed by John Swales [22], who based his description and analysis on a study of Research Article Introductions (RAI). According to Swales' approach, RAs are hierarchically organized texts. Consequently, introductions typically consist of certain moves and either obligatory or optional steps within the moves. Swales' three-part Create-A-Research-Space (CARS) model appears to describe a typical structure of English-written introductions in several disciplines.

Research on academic writing has also investigated the interpersonal character of texts. Studies [33-50] have focused on how persuasion is created in different genres. Academic writing involves constructing an authorial self and building a relationship with the reader. "Positioning" [33] in research writing refers to adopting a point of view related to both the text and the reader. If the text is coherent, a reader can follow the writer's argument. A coherent text is thus reader-friendly. Writing up their research for publication, scientists need to appear as disciplinary insiders. Such competence is based on successful writer-reader dialogue. Ken Hyland and his colleagues [19, 33, 37, 39, 40, 43] have published a number of studies on interaction in research writing. Their concept *metadiscourse* refers to the ways in which a writer or a speaker guides his reader or listener by using discoursal features and text commentary. There are several different definitions and classifications of metadiscourse. Ädel [42] discusses the broad and narrow approaches to research on metadiscourse. According to the broad approach [33, 56], metadiscourse refers to both linguistic devices applied to organize text and the features employed to communicate authorial attitudes (i.e., interpersonal functions). The narrow approach [46], in contrast, restricts metadiscourse to only those linguistic features that are used to organize text.

The present thesis will neither focus on the different definitions of metadiscourse nor make a choice between the broad and the narrow approach. It will present and discuss examples and findings within both approaches. The identification and analysis of the rhetorical features in the sample RAs of this study is, however, based on Hyland's [33] interpersonal model of metadiscourse. As Ädel [42] observes, the narrow approach "restricts the concept of metadiscourse too severely", because it leaves out the writer-reader interaction. After all, every instance of metadiscourse can be understood as interpersonal, since it includes the reader's knowledge, textual experiences and processing of texts [39]. Furthermore, since Hyland's model has been applied in several studies of metadiscourse, employing his classification will allow comparison of findings and results from previous research.

The following sections present the two investigative tools applied to studying rhetorical organization and coherence in the studied RAs. The RA introductions are examined using John Swales' CARS model. Both the introduction and "post method" sections (i.e., results, discussion, conclusion) are analyzed employing Ken Hyland's interpersonal model of discourse.

3.2 Swales' Create-A-Research-Space model for RA Introductions

As John Swales [22] states, "introductions are known to be troublesome". Starting an RA is generally considerably more challenging than writing the following sections. Writing the first paragraphs of an article involves making a number of important choices. The writer must decide, e.g., how much and what kind of background information to provide or what rhetorical style to apply. The challenge is significant, particularly since first impressions obviously matter. Swales describes the requirement of the writer by referring to "ecological competition" for research space:

> The need to re-establish in the eyes of the discourse community the significance of the research field itself; the need to 'situate' the actual research in terms of that significance; and the need to show how this niche in the wider ecosystem will be occupied and defended [22, p. 142].

The introductory section of RAs has interested researchers of academic writing especially since the publication of Swales' CARS model. The original 1990 and its revised 2004 version of the CARS model are based on genre analysis. The model was originally designed as a descriptive tool, which could also be used to organize text particularly in academic research papers. Swales constructed his model based on his analysis of a sample of 158 RAIs in English from various disciplines, including physics, medicine and social sciences.

According to Swales' model, a typical RAI consists of three moves: (1) establishing a territory, (2) establishing a niche and (3) presenting the present work. Each of these moves is divided into a number of obligatory or optional steps. Swales [23, p.228] defines a "move" as "a discoursal or rhetorical unit that performs a coherent communicative function in a written or spoken discourse". Sometimes it occurs in the form of a grammatical unit, such as a sentence, utterance or paragraph. It can, however, appear in various linguistic forms. A move is a functional rather than a formal unit. Each move contains a number of steps, which help the writer to achieve his rhetorical aims. The steps occur in varying combinations, thus creating the function of the move [22].

Several studies have used the CARS model to investigate RAIs in different academic fields and also in different languages. Some of the analyses have concentrated on identifying the rhetorical structure of specific disciplines [e.g., 24, 87]; others have analyzed either interdisciplinary [25] or intradisciplinary [27] differences between RAIs. For ex-

ample, Loi [91] based her study on contrastive analysis. The present study examines the realization of moves and steps in RAIs written in English by NNS researchers in Materials Science at TUT.

In spite of the various modifications proposed, the 1990 CARS version of move structure is still widely applied. The changes suggested to the original model concern mainly the steps within the moves. Loi [91] and Del Saz Rubio [28] employed a combination of the two versions. The present study follows Renu et al. [30] and analyzes the structural organization of the sample RAIs using the more comprehensive 2004 model with the addition of Step 1 "claiming centrality" in Move 1, adopted from the original 1990 model. Table 1 introduces the applied framework.

Table 1. Framework for the study of rhetorical moves and steps in RA introductions [22, 23]

Move 1	**Establishing a territory** (citation required) via
o Step 1	Claiming centrality
o Step 2	Topic generalizations of increasing specificity
Move 2	**Establishing a niche** (citation possible) via
o Step 1A	Indicating a gap
o Step 1B	Adding to what is known
o Step 2	Presenting positive justification
Move 3	**Presenting the present work** (citation optional) via
o Step 1:	Announcing the research descriptively and/or purposively
o Step 2:	Presenting hypotheses, research questions or assumptions
o Step 3:	Definitional clarifications
o Step 4	Summarizing methods
o Step 5	Announcing principal outcomes (*PISF)
o Step 6	Stating the value of the present research (*PISF)
o Step 7	Outlining the structure of the paper (*PISF)

*Probable in some fields (PISF)

Move 1 has two realizations. Step 1.1 (Claiming centrality) refers to "appeals to the discourse community, whereby members are asked to accept that the research to be reported is part of a lively, significant or well-established area" [22]. Emphasizing the importance of the current topic or referring to the dynamic research area of the study are typical ways of expressing centrality claims. Often the claim consists of only one sentence. Step 1.2 (Topic generalizations of increasing specificity) usually occurs as either statements about knowledge or practice in a particular field or as statements about phenomena related to the research. These may include references to previous studies and also reasons and background for further progress in research. Previous literature is frequently reviewed in all three moves of an RA, even though citation is obligatory only in Move 1. [22]

Move 2 (Indicating a gap) is like a “mini-critique” [92]. Its purpose is to link previous and current research. Gap signaling is the standard means to point to a need of progress within the discipline. By applying Steps 2.1A and 2.1B, writers typically refer to a gap in previous research by emphasizing the absence of studies on a particular subject. Step 2.2 (Presenting positive justification) may underline the insufficiency of research so far and express the need for further research, either in order to attend to problems in the real world or simply to add to the knowledge in a particular field [22].

Moves 1 and 2 both focus on the significance of the topic and the field of research. The writer lists previous studies and points out insufficient research. Move 3, however, in “occupying the niche” [22], concentrates on the particular study it is reporting. Swales [23] presents seven possible steps, of which he considers obligatory only the first. Step 3.1 (Announcing the research descriptively and/or purposively) is also a natural choice to start presenting the work. The other six steps are either optional or “probable in some fields [PISF], but unlikely in others”. The following three steps, 3.2 (Presenting hypotheses, research questions or assumptions), 3.3 (Giving definitional clarifications) or 3.4 (Summarizing methods) offer writers further opportunities to attract the readers to their work. Whether writers employ these options generally depends on their field of research and its disciplinary conventions. For example, most of the RAIs in Anthony’s [24] study of articles in software engineering applied Step 3.5 (Announcing principal outcomes) and added a step, which he called “evaluation of research”, resembling Step 3.6 (Stating the value of the present research). In an engineering context, it is only natural to emphasize the applicability of the achieved result. Moreover, the occurrence of Step 3.7 (Outlining the structure of the paper) seems to depend on the discipline of the study. In fact, it is far more unlikely to occur, if the RAs are expected to follow the IMRD-type sectional organization [23].

3.3 Hyland’s interpersonal model of metadiscourse

According to Hyland [33], the term *metadiscourse* refers to the linguistic devices with which the writer or speaker, employing discoursal features and text commentary, guides the reader’s or listener’s perception of a text. The essential feature is the writer’s conscious engagement with the reader:

> Metadiscourse reveals the writer’s awareness of the reader and his or her need for elaboration, clarification, guidance and interaction. In expressing an awareness of the text, the writer also makes the reader aware of it, and this only happens when he or she has a clear-oriented reason for doing so. [33, p.17]

Metadiscourse involves the writer's references to himself, the reader or the text. Metadiscoursal studies are an important part of genre analysis, since they may show how language choices express the different purposes of writers, the assumptions they make about their readers and the various dimensions of writer-reader interaction [33, 34]. According to Hyland and Tse [39], the following are the three key principles of metadiscourse:

1. Metadiscourse is distinct from propositional aspects of discourse.

2. The term *metadiscourse* refers to those aspects of the text that embody writer-reader interactions.

3. Metadiscourse distinguishes relations that are external to the text from those that are internal.

Studies on metadiscourse frequently distinguish between metadiscourse and propositional content in texts [34, 93]. It is, however, not always easy or even possible to distinguish between content and non-content. In order to define metadiscourse, it is necessary to accept that both propositional and metadiscoursal elements occur simultaneously in texts. Thus a strict distinction between the propositional and metadiscoursal parts in texts is too rigid and regards metadiscourse merely as "glue" holding the crucial parts of the text together. In reality, metadiscourse constitutes an important part of the meaning itself. When it organizes coherent reader-friendly text and relates it to a given context, it also communicates meaning. [39]

All metadiscourse is interpersonal. The writer of a text is not writing to himself without, at least to some extent, considering his audience. In scientific writing, the writer obviously needs to consider the target audience's knowledge of the topic as well as their previous textual experiences. Hyland [33, 37, 40, 43, 47] prefers not to distinguish between the "textual" and "interpersonal" functions of metadiscourse, for in writing, textual and interpersonal elements often overlap in various ways. Conjunctions, modal or comment adjuncts provide an example of such overlap. They are typically used to relate a stretch of discourse to the preceding text. At the same time, they may also express the writer's idea of the logical relationship between the concepts or matters discussed. In sum, instead of only gluing the text together, they "extend, elaborate, or enhance propositional meanings" [39]. The following examples (a-g) illustrate the interpersonal nature of metadiscourse and the difference between text-internal and text-external relations [39]. In (a), (b) and (c), the textually functioning elements are also interpersonal.

(a) The author accepted the shortcomings of the study due to the fact that it was a non-random sample. Nevertheless the study did highlight that ageism is not confined to western countries alone.

(b) A parametric estimation technique using global optimization is introduced for the output space partition. But first we discuss the optimization technology in the next section.

(c) Undoubtedly, there are limitations to the findings of this thesis.

The third key feature of metadiscourse is the distinction between "internal" and "external" reference. The different uses of sequencing devices illustrate the distinction. They can either connect successive steps in discourse to organize the argument (internal) or connect activities and processes of the world outside that are referred to (external). Of the following examples, (d) represents internal reference and thus expresses a metadiscoursal (internal) function, whereas (e) expresses a relation between processes in the world outside (external).

(d) Firstly, the importance of complete images in compression is described in section one. Secondly, predictors used for lossless image coding are introduced. Thirdly, the results and analysis are used to show the performance of the proposed compression.

(e) For the boric acid indicator, firstly, 5g of boric acid crystals was dissolved in 200ml of warm distilled water, then, 40 ml of methyl red indicator [0.02 per cent (w/v) in 60 per centethanol] and . . . .

There is an analogy between the internal/external distinction and the distinction between *de re* and *de dicto* modality in modal logic. Linguistic items refer either to the reality expressed by propositions or to the propositions themselves. Sometimes a text may be interpreted to refer either to the writer's opinion or to the external circumstances. In the following examples, however, it is fairly easy to recognize internal metadiscoursal (f) and external (g) reference:

(f) The diverse insect fauna reported from the reedbeds in Mai Po suggests that the reedbeds could potentially be an important habitat for a wide variety of animal taxa.

(g) This statement obviously exploits the Maxim of Quantity at the expense of the Maxim of Quality because the salesperson could have simply said: 'This company is also very famous in Taiwan.'

The role of metadiscoursal features in fluent and coherent texts is indisputable. Ifantidou [41] tested the intuitions of a group of 75 non-native students of English language and literature about two versions of the same text. One of them (**Text A**) was an extract from Ken Hyland's [40] article "Persuasion and context: The pragmatics of academic

metadiscourse". From the other (**Text B**), a shorter version of the same text, all the 21 metadiscoursal items had been removed. The students were asked to select the extract that they considered more coherent and effective in communicating its message. The key question was "Which of the following texts would an academic reader prefer?"

TEXT A:

> **Turning to** variations in the use of person markers, the suppression of personal agency **is** often **considered to be** a means of concealing the constructedness of accounts. **However, the data revealed that** astrophysics articles contained the highest frequency of person markers and that there was a large intra-discipline variability in its use. This **suggests that** a writer's use of first person to intrude into an argument **may** be an area where a degree of freedom to manipulate conventions is permitted, allowing authors to mix 'private intentions' with socially recognized communicative purposes (Bhatia, 1993).
>
> **It is worth noting that** in all four disciplines this explicit intrusion often co-occurs with verbs conveying reasons or possibility, and **largely** performs text-internal functions. **Thus** writers **tend to** intervene to help organize the argument or to justify decisions or interpretations. **Most commonly** the author **appears to** signal text frames, introduce research activities or indicate their attitude to methods or findings.
>
> **Thus** the first person is **mainly** used to construct the text and present decisions, rarely is it used to question the object studied, which is **taken to be** independent of personal perception. **So** while the use of first person **appears to be** variable in how writers decide to indicate intellectual activities, references to real-world phenomena are **generally** impersonal.
>
> **To summarize this discussion**, the use of metadiscourse in these texts **appears to reflect** an intimate connection between discourse particles and the social organization of disciplinary communities.

TEXT B:

> On variations in the use of person markers, the suppression of personal agency is often a means of concealing the constructedness of accounts. Astrophysics articles contained the highest frequency of person markers and there was a large intra-discipline variability in its use. A writer's use of first person to intrude into an argument is an area where a degree of freedom to manipulate conventions is permitted, allowing authors to mix 'private intentions' with socially recognized communicative purposes.
>
> In all four disciplines this explicit intrusion often co-occurs with verbs conveying reasons or possibility, and performs text-internal functions. Writers intervene to help organize the argument or to justify decisions or interpretations. The author signals text frames, introduces research activities or indicates their attitude to methods or findings.
>
> The first person is used to construct the text and present decisions, rarely is it used to question the object studied, which is independent of personal perception.

> While the use of first person is variable in how writers decide to indicate intellectual activities, references to real-world phenomena are impersonal.
>
> The use of metadiscourse in these texts reflects an intimate connection between discourse particles and the social organization of disciplinary communities.

The subjects in Ifantidou's study preferred the "+ metadiscourse" text from both the writer's and reader's standpoint. It appeared to them more effective and reader-friendly.

It is difficult to identify and analyze metadiscoursal features without any classification or framework. Hyland's [33] taxonomy of metadiscourse in academic texts has been applied in a number of recent studies [48, 49, 5]. According to Hyland's [33] classification, metadiscoursal linguistic devices may be placed in two categories: *interactive resources*, which guide the reader through the text (e.g., in addition, furthermore, but, however, thus, finally, as noted above, according to X, in other words, namely, that is, for example); and *interactional resources*, which involve the reader in the text (e.g., might, may, perhaps, possible, probably, in fact, definitely, unfortunately, surprisingly, I agree, it is clear that, you can see that, I, we, my). Interactive features organize discourse, anticipate the reader's knowledge and reflect the writer's aim to guide the reader's interpretation of the text [47]. Interactional features, on the other hand, involve the author's focusing on both the propositional information and the reader. The following subsections introduce Hyland's model of the two basic categories of interpersonal academic metadiscourse, which are used to analyze the sample RAs in the present study.

3.3.1 Interactive metadiscourse

Through interactive devices the writer can structure his discourse and guide the reader's reactions. The writer in a way constrains the reader's interpretation of the text [47]. It is not possible to identify metadiscourse by merely linguistic criteria. It is an open class, which accepts new items depending on the writer's purpose. As a functional category of language, metadiscourse can appear as different linguistic units, sometimes through a combination of items. For example, it may occur as the use of parentheses, appear in the form of whole clauses, or consist of sequences of several sentences. Table 2 presents Hyland's five main types of interactive metadiscourse. The detailed distinctions in meaning within the main categories were suggested by Cao and Hu [49]. The key categories have their own basic functions in organizing text into coherent discourse.

Table 2. A model of interactive metadiscourse for academic texts [33, 49]

CATEGORY Interactive	FUNCTION Help to guide the reader through the text
Transitions	**Express relations between main clauses**
additive	(in addition, furthermore, moreover)
comparative	(similarly)
contrastive	(however, in contrast)
inferential	(thus, therefore, as a result)
Frame markers	**Refer to discourse acts, sequences or stages**
sequencers	(first, second, finally)
topicalizers	(with regard to, concerning, turning to)
discourse-labels	(in brief, in sum, thus far)
announcers	(aim to, will, I seek to)
Endophorics	**Refer to information in other parts of the text**
linear references	(in this paper, the next section, as noted earlier)
non-linear references	(see Table 1, in Fig. 2, as demonstrated in Excerpt 3)
Evidentials	**Refer to information from other texts**
integral citations	(according to X, as Y argued, in Z's study)
non-integral citations	(". . .", X, 2015, . . . previous research [1, 2, 3])
Code glosses	**Elaborate propositional meaning**
exemplifiers	(for example, for instance, e.g.)
reformulators	(in other words, that is, i.e.)

Transitions help the reader to understand connections between preceding and subsequent parts in sentences. They generate textual cohesion by creating logical links between propositions. Transitions are most frequently conjunctions and may refer to either additive (in addition, furthermore), comparative (similarly, in comparison), contrastive (however, in contrast), or inferential (thus, therefore) steps in the discourse [39, 49]. To be regarded as metadiscourse, conjunctions must refer to transitions in the argument (a) rather than link events or describe processes (b) in the external world [47]:

(a) The next question I want to examine is the durability of superhydrophobic antibacterial coatings.

(b) In the next phase, the water droplet rolls on the superhydrophobic surface and removes dust and dirt particles.

Frame markers organize text. They may refer to text boundaries, announce and sequence elements of text structure and also indicate topic shifts. Frame markers may appear as sequencers (first, second, finally), topicalizers (with regard to, concerning), discourse-labels (thus far, in brief) or announcers (aim to, will).

Endophoric markers add material to text. Linear references (the next section, in this paper) function as previews, reviews, or overviews in the unfolding text. Non-linear references (see Table 1, in Fig. 2) refer to additional material, such as tables or figures [49]. Both types of reference can effectively be used as signposts. Their function is to make sure that the reader understands what the writer means by his text. In addition, endophoric markers help the writer to avoid repetition.

Evidentials occur as citations, which are important elements of persuasion in academic writing, as they help to provide justification for arguments. They give the writer an opportunity to present his knowledge of the field's literature and in that way prove that he values his particular disciplinary research tradition. Evidentials are thus rhetorically important. They not only show readers that the writer has read a lot but also his evaluation of others' work to justify his own perceptions [40, 47]. In integral citations (according to X, in Y's study), the cited source is integrated into the text. Non-integral citations exclude the cited source (". . .", (X, 2015)) [49]. The use of evidential markers in academic writing can indicate one's membership of a particular disciplinary community [33].

Code glosses can be either exemplifiers (for example, e.g.) or reformulators (in other words, i.e.). In constructing arguments, exemplifiers provide examples, whereas reformulators restate the information using other words or expressions. The use of code glosses in RAs can elaborate on meaning and thus help readers to grasp propositional information [37].

3.3.2 Interactional metadiscourse

Interactional resources focus on both participants of the interaction. They involve the reader by revealing the writer's attitude and commitment to both the propositional information and his audience. Interactional devices thus help the writer to control the level of personality in a text. By using metadiscourse, he aims at establishing an appropriate relationship to his data, his argument and the readers. The writer may use interactional linguistic devices to persuade his audience by presenting his personal interpretations as consistent with the norms of the disciplinary community. [39, 47] Table 3 shows the main types of interactional resources.

Table 3. A model of interactional metadiscourse for academic texts [33]

CATEGORY **Interactional**	FUNCTION **Involve the reader in the text**
Hedges (might, perhaps, possibly)	**Withhold commitment and open dialogue**
Boosters (in fact, obviously**)**	**Emphasize certainty or close dialogue**
Attitude markers (unfortunately, surprisingly **)**	**Express writer's attitude to proposition**
Self mention (I, we, my, our)	**Explicit reference to author(s)**
Engagement markers ***Reader pronouns*** (you(r), we, us) ***Directives*** (consider, note) ***Questions*** ***Shared knowledge*** ***Personal asides***	**Explicitly build relationship with reader**

Hyland's [40] description of interactional metadiscourse is based on the ideas of authorial stance and reader engagement. *Stance* refers to the writer's textual voice or his community-recognized personality. When expressing stance, the writer presents himself and conveys his judgments, opinions and commitments to the audience. *Engagement*, on the other hand, refers to the ways in which the writer connects with his readers, guides them to follow his argument, focuses their attention, considers their uncertainties and involves them in the discourse. Figure 2 summarizes the options of realizing stance and engagement.

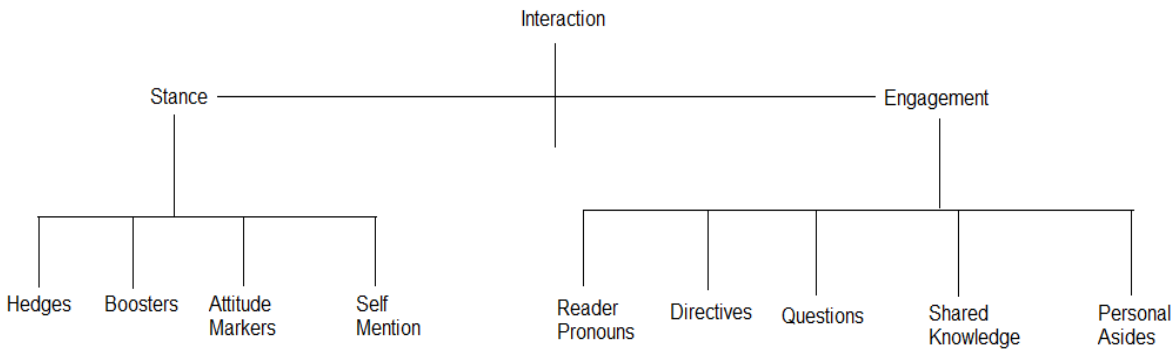

Figure 2. *Key resources of interactional metadiscourse [40]*

Hedges mark the writer's reluctance to present propositional information categorically**.** Hedging words, such as "possible", "might" and "perhaps" indicate the writer's decision to withhold his complete commitment to a proposition. He presents his information as more of an opinion than a fact. In research articles, all statements are evaluated and interpreted through disciplinary assumptions; therefore, writers must be careful in presenting propositional information categorically. It is risky to make claims, since it may lead to contradicting existing literature and challenging the research of potential readers.

Boosters express certainty and convey the force of propositions. They appear as words like "clearly", "obviously" and "demonstrate", which allow writers to express their certainty in what they say. Boosters signal the writer's involvement with the topic and his solidarity with the audience. They emphasize shared information, group membership and engagement with the readers.

Attitude markers show the writer's appraisal of propositional information. They convey, e.g., surprise, obligation, and agreement. According to Hyland, attitude markers indicate the writer's affective, rather than epistemic, attitude to propositions. Attitude may be expressed by using subordination, comparatives, progressive particles, punctuation and text location. Most explicit signals are, however, attitude verbs (agree, prefer), sentence adverbs (unfortunately, hopefully) and adjectives (appropriate, remarkable).

Self mentions imply the extent of the writer's presence through his use of first person pronouns or possessives. Presenting a discoursal self is a key element of the writing process [94]. Writers always project an impression of themselves and also their relation to their arguments, discipline and readers. This equals consciously adopting a stance and a disciplinary-related authorial identity [40].

Engagement markers have two main purposes: first, to meet the reader's expectations of inclusion; second, to rhetorically position the audience by guiding them to particular interpretations. Writers can involve the readers in their writing by employing one or more of the following elements: reader pronouns, directives, questions, appeals to shared knowledge or personal asides.

Reader pronouns (h) are perhaps the most explicit way to involve readers in a discourse. By employing the pronouns "you" and "your", the writer can acknowledge the reader's presence. Inclusive "we", "us", "our", and "ours" are the most commonly used engagement devices in academic writing. They signal membership by referring to both the writer and the reader as participants in a discourse, sharing common understanding and goals.

(h) Part of what <u>you</u> are doing in writing a paper is getting <u>your</u> readers onside, not just getting down a list of facts, ...

Directives (i) ask the reader to perform an action or to see things in a way determined by the writer. They are signalled mainly by imperatives (consider, note); modals addressed to the reader (must, should, ought to) and by predicative adjectives expressing the writer's opinion of necessity or importance (It is important to understand . . .).

(i) See Lambert and Jones (1997) for a full discussion of this point.

Questions (j) aim at involving the reader in a dialogue. Their purpose is to arouse the reader's interest and encourage him to investigate an issue with the writer as his interactive partner. Often the questions are rhetorical, presenting the writer's opinion in the form of an interrogative.

(j) Why does the capacitance behave this way? To understand we first notice that . . . .

By referring to *shared knowledge* (k), writers wish to remind the readers of the boundaries of disciplinary discourse. The writer, in a way, aims to share with the reader a conception of what can be accepted. Often these signals of solidarity explicitly ask the readers to identify with the writer's views.

(k) This tendency obviously reflects the preponderance of brand-image advertising in fashion merchandising.

According to Hyland [40], *personal asides* (l) allow writers to address their readers by interrupting the argument and commenting on what has been said. Personal asides can be considered a reader-oriented strategy. By turning to the reader in the middle of an argument, the writer at the same time starts an interpersonal dialogue.

(l) What sort of rigidity a designator is endowed with seems to be determined by convention (this, by the way, is exactly the target of Wittgensteinian critiques of Kripke's essentialism).

Comparisons in previous studies [19] show that there is considerable disciplinary variation in the use of interactional features in academic texts. At least some of the features of stance and engagement are less likely to occur in the hard fields of science and engineering.

4 SUBJECTS, DATA AND METHODS

This section describes the subjects, data collection, and methods of data analysis employed in the present study. Two methods were applied to answer the research questions: an e-mailed questionnaire and descriptive text analysis. The study had two aims: first, to explore the experiences, perceptions, attitudes and challenges of the researchers writing in English for publication purposes; and, second, to examine how the researchers applied certain rhetorical and metadiscoursal features in their texts. The approach in the study was primarily qualitative. Simple descriptive statistics was used for two purposes: first, to report the results of the questionnaire and, second, to indicate the frequencies of the identified and classified linguistic items in the analyzed RA samples. A study with a limited number of subjects and a small corpus does not necessarily profit from computer-aided data analysis. In larger corpus-based studies, specific linguistic items are searched automatically. When computational identification is applied, it is, however, sometimes difficult to "reduce noise" in the search results [38]. Therefore, even corpus-driven studies generally employ manual identification of linguistic units in order to ensure their correct interpretation [48, 50, 56]. The present study relies on careful context-specific identification of linguistic items.

4.1 Subjects in the study

The subjects of the present study were doctoral and post-doctoral researchers in Materials Science at TUT. All the 14 researchers were non-native speakers of English. The writer corpus was small, which undoubtedly had its drawbacks. It is obvious that the results of a limited and localized study cannot be generalized. Recent research has, however, emphasized the significance of using small corpora in EAP studies [95]. Large corpora may be preferable in determining, e.g., the frequencies of particular expressions in order to generalize the findings. The analysis of a small corpus can, however, give a deeper insight into individual writers' strategies and also offer a point of departure for teaching them the necessary language skills [56].

4.2 Questionnaire

A questionnaire was designed to survey the experiences and opinions of the researchers in Materials Science. The 20-item questionnaire (Appendix 1) was developed drawing on literature [96, 97] and inspired by similar studies [11, 12, 15, 16]. The questions in the form were in English. The open-ended items could, however, be answered either in English or in Finnish. A cover letter (Appendix 2) was attached to describe the study

and request the recipients' cooperation in completing the form. The questionnaire was piloted among three doctoral students from related fields. After minor revision, it was e-mailed to 15 researchers in October 2014.

The questionnaire included, first, questions about the subjects' professional and language background and, second, items related to their self-perceived skills of English as well as their writing experience and strategies. The third part of the questionnaire consisted of statements and questions concerning the respondents' attitudes to writing in English and also their challenges in writing for publication. In addition, questions concerning the researchers' opinions on and wishes for language courses at TUT Language Centre were presented.

The items in the questionnaire represented various types of response format [96, 97]. The closed questions were in the form of a numerical rating scale, a semantic differential format, multiple choice formats, such as a nominal single answer or a nominal multiple answer. The open-ended questions were either numerical or non-numerical. Three questions (10, 11, 18) included a non-committal response "I don't know". Four questions (9, 13, 15, 16) asked to specify the answer. Question 20 allowed the respondents to "add any thoughts regarding the subject".

4.3 Research Article samples

The text corpus of the present study consisted of 11 empirical co-authored research articles in Materials Science published between 2012 and 2014 (Appendix 3). The respondents gave their permission to study the language of the articles, which they had originally written for conferences or international journals. The RAs covered topics related to metals and ceramics. Four of the originally suggested texts were left out on the basis of their structure. One of them was a discussion section from a PhD thesis; the others were short extracts of reports on empirical tests. Three of the selected RAs followed the standard IMRD (introduction, methods and materials, results, discussion) pattern. The majority, however, employed the structure I-E-[RD], in which the merged section RD was preceded by "Experimental". Most of the RAs were structured as conference papers. Four RAs had been published in journals. One of the articles (11) was entitled "Manuscript", began with an introduction and ended with a conclusion, while the materials, methods, results and discussion sections were combined under "The Body of the Article". In the following, the studied RAs (Table 4) are referred to by their number.

Table 4. The TUT research articles analyzed in the study

1.	Improving the Properties of Plasma and HVOF Sprayed Alumina Coatings by Chromia Addition
2.	Bacterial growth on a superhydrophobic surface containing silver nanoparticles
3.	Influence of powder composition and manufacturing method on electrical and chromium barrier properties of atmospheric plasma sprayed spinel coatings prepared from $MnCo_2O_4$ and Mn_2CoO_4 + Co powders on Crofer 22 APU interconnectors
4.	Influence of microstructure on temperature-induced ageing mechanisms of different solar absorber coatings
5.	Influence of the powder morphology and plasma spray process parameters on the structure and properties of Al_2O_3 based plasma sprayed coatings
6.	Photocatalytically active titanium dioxide nanopowders: Synthesis, photoactivity and magnetic separation
7.	Geometrical model to evaluate the lower boundary of nanoparticle size in ceramic/metal nanocomposites produced by thermolysis
8.	Surface deformation of steels in impact-abrasion: The effect of sample angle and test duration
9.	Characterization of the effects of embedded quartz layer on wear rates in abrasive wear
10.	High-speed wear testing of selected ceramics in abrasive slurry
11.	Use of thermal imaging in characterization of ceramic fiber structures.

The present study examined the introduction and post-method (results, discussion, conclusion) sections of the sample RAs. The corpus consisted of 26 062 words with nearly three-quarters of them occurring in the post-method parts. The introductions contained 468 words on average. Some of the RAs had probably undergone editing by a proof-reader, at least with respect to lexico-grammatical mistakes. The purpose of this study was not to discuss the remaining surface level lexical and grammatical problems.

The investigation focused on the introductions and post method parts of the RAs, since they are generally considered the most difficult sections to write. Both native and non-native writers regard RA introductions a challenge. The beginning of an article affects the readers' decision to either interrupt or continue reading. Through introductions, writers project themselves and justify their research by pointing to possible gaps in the

literature. Also the post method sections are considered particularly demanding: the writers are expected to present their findings, explain the reasoning behind their knowledge claims and point out the connections between their findings and conclusions [49, 62].

John Swales' [22, 23] move analysis was applied to examine the rhetorical organization of text in the sample RA Introductions. The analysis of metadiscourse in the RA introductions and post-method sections followed Ken Hyland's [33] model of interpersonal discourse. Section 6 presents the identified, classified and interpreted moves and steps in the introductions and the metadiscoursal features in both the introductions and post method sections.

5 RESULTS OF THE QUESTIONNAIRE

The following subsections present the results of the questionnaire completed and returned by 14 researchers in Materials Science at TUT, a response rate of 93.3 %. The informants consisted of doctoral students (78.6 %), postdoctoral researchers (14.3 %), and one project researcher. All respondents were native speakers of Finnish, who had received most of their pre-doctoral education in Finland. Their experience outside Finland amounted to spending short periods abroad. The longest stays were 4 years in Russia, 18 months in France, and 12 months in either Sweden or Germany. They all had studied English for about 10 years in comprehensive and upper secondary school. One had received only 4 years of English instruction.

In the following, some of the researchers' responses to questions concerning their English writing experience, self-perceived skills, writing strategies, attitudes and language training preferences will be compared to findings in similar studies.

5.1 English writing experience, skills and strategies

All the respondents had experience in writing conference abstracts and had published research articles in English. The majority (57.1 %) had written their Master's thesis in English. Fewer had preferred English in their Doctoral (28.6 %) and Bachelor's (7.1 %) theses. In addition, 42.9 % had prepared grant proposals, and 28.6 % had produced professional writing in English.

The informants assessed their competence in English on a scale from "poor" to "excellent" according to four dimensions: listening, speaking, reading and writing. Table 5 shows that the researchers regarded themselves better than "poor" in all dimensions.

Table 5. Self-rated language skills of the TUT respondents

	Excellent	Very Good	Good	Limited	Poor
Listening	**35.7%**	**42.8%**	**21.5%**	—	—
Speaking	**14.3%**	**14.3%**	**57.1%**	**14.3%**	—
Reading	**57.1%**	**28.6%**	**14.3%**	—	—
Writing	**14.3%**	**21.4%**	**50%**	**14.3%**	—

All respondents rated their competence in listening between "good" and "excellent". The same applied to their reports on reading. As many as 57.1% considered their English reading skill excellent. When asked about speaking and writing skills, the ratings scattered more. The majority (57.1 %) rated their speaking skills "good", while 14.3 % of the respondents chose to describe themselves either "excellent" or "limited". The researchers gave divided ratings on their writing skill: whilst 71.4% regarded their writing in English as "good" or "very good", only 14.3 % chose the option "excellent" or "limited". All except one respondent preferred writing their scientific papers in English. The majority (85.7 %) preferred to write even the first drafts in English.

5.2 Attitudes to writing Research Articles in English

The researchers were fairly unanimous in agreeing with the statement *English as the single common language makes international co-operation and scientific communication possible.* The majority (71.4 %) chose "strongly agree". Half of them agreed with the statement *When writing research articles in English I feel disadvantaged when compared to native speakers*, whereas 35.7 % "disagreed" and 14.2 % "disagreed strongly".

The question *What are your personal reasons for writing in English your articles to be published?* suggested seven potential motives. All checked the option "Writing in English will advance my professional promotion". The majority (71.4 %) chose also "I wish to get cited more frequently" and "Writing in English will develop my writing ability". Half of the respondents checked "I am used to writing my articles in English". Only one researcher opted for "I like challenges".

The respondents were allowed to provide additional comments, either in English or in Finnish, on any of the issues in the questionnaire. Some expressed their opinions mainly by offering their reasons for preferring either English or Finnish in writing their papers:

> "Technical vocabulary is mostly in english."
>
> "Written in English, the article has an exponentially wider audience; there are only a few people who are both interested in the subject and know Finnish language. The terminology is mostly in English anyway, and it would be difficult to come up with a good Finnish counterpart. It is also almost a question of habit."
>
> "Because it is basically impossible to get noticed internationally if the scientific papers are published only in finnish. Secondly, there is a very limited number of professional journals published in my native language suitable for the studied field."
>
> "There are no possibility to write them in other language than English."

”On helpompi saada sanottua asiansa haluamillaan painotuksilla ja sävyillä suomeksi verrattuna englanniksi kirjoittamiseen.”

”Suurin osa lehdistä, joilla on jonkinlaista merkityksellisyyttä tieteenalamme kentällä vaativat englanninkielisiä käsikirjoituksia. Niinpä tuo "prefer" on vähän, että joo. . . Vaikka haluaisimmekin ehkä kirjoittaa suomeksi höpötyksiämme, on se turhaa.”

“I could perhaps write more fluent articles in Finnish, but as majority of the prospective readers do not understand it, I favor English.

5.3 Challenges in writing Research Articles in English

The question *How difficult do you find writing in English compared to writing in your native language?* divided opinions. The most frequent option (42.9 %) was “slightly difficult”. Nearly as many (35.7 %) considered writing “moderately” or “very difficult”. On the other hand, 14.3 % found writing in English “not at all difficult” and 7.1 % “extremely difficult”.

The respondents could choose three items at most on a list of five reasons for their possible difficulties in English scientific writing. As Figure 3 illustrates, the most frequent choices were “Linguistic reasons” or “My scientific writing experience so far”.

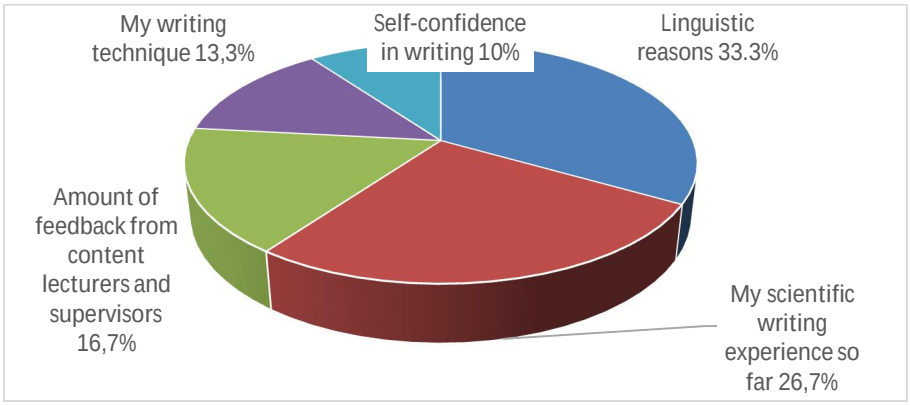

Figure 3. *Reasons for difficulties in writing scientific English according to the TUT respondents*

The researchers were also asked to rate suggested challenges in writing RAs on a five-point scale ranging from 1 (min) to 5 (max). The list of ranked difficulties in Table 6 indicates the major problems perceived by the respondents:

Table 6. Ranked (1 min – 5 max) difficulties of the TUT respondents in writing RAs in English

Creating text flow and coherence to make my reasoning easy to understand	**3.50**
Expressing my interpretation of the results with the appropriate degree of confidence	**3.50**
Expressing my ideas in correct grammar	**3.21**
Applying the general academic vocabulary	**2.86**
Applying the academic style and specific terminology in my field	**2.50**
Linking together the different ideas, paragraphs, and the sections of the article	**2.43**
Reviewing the literature	**2.14**

It appears that the researchers considered writing fluent and coherent, grammatically correct English most challenging. Confidence in reporting and interpreting research findings is based on appropriate persuasive practices in academic writing. The concepts "reasoning", "interpretation" and "confidence" all refer to the communicative function of writing. Research writing is necessarily social engagement, and it involves negotiating with others as well as making decisions about the effects we are having on our readers [33].

5.4 Writing courses at TUT Language Centre

The last three items of the questionnaire concerned instruction and training in research writing. Half of the respondents had attended the course English for Engineers, which for many was included in their MSc studies at TUT. Fewer than that (42.9 %) had completed Scientific Writing. Only 7.1% reported that they had either completed or were attending Academic Writing or Research Writing.

When asked whether they felt that the TUT English writing courses had improved their scientific writing skills, the opinions diverged: 28.6 % answered "yes, a lot" and 35.7 % "a little". Only one researcher checked "not at all". "I don't know" was chosen by 28.6 % of the subjects. Considering the number of courses the respondents had attended, the answers were perhaps not very informative. None of them had experience of Thesis Writing and Writing Clinic, and both Academic Writing in English and Research Writing were checked only by 7.1 % each.

The participants were asked to choose between different types of support to help them to improve their English scientific writing skills. From the 10 alternatives they were allowed to check four at most that they agreed with. The answers to *What type of support would help you improve your English scientific writing?* express the training preferences of the respondents (Table 7):

Table 7. The TUT respondents' training preferences for English scientific writing

Consulting native English-speaking colleagues within my field	**71.4%**
Comments from proofreaders	**64.3%**
Peer-based writing support	**50%**
Constructive feedback from the content lecturers and supervisors in my academic field	**42.9%**
Teaching of the general formal features and conventions of academic writing	**35.7%**
One-to-one writing tutorials	**28.6%**
Group work and practical workshops on scientific writing	**28.6%**
Explicit training in writing research articles for publishing purposes	**21.4%**
Comments from editors and peer reviewers	**14.3%**
Computer-based interactive courses	**7.1%**

The findings from the questionnaire are, in the main, consistent with the results obtained by Duszak and Lewkowicz [5], Uzuner, [6], Perez-Llantada et al. [10], Ferguson et al., [11], Olsson and Sheridan [12] and Gea-Valor et al. [15]. The NNS academics in the above studies reported linguistic difficulties as their major challenge in writing and publishing in English. The perceived difficulties were related to achieving the appropriate degree of assertiveness in making claims and discussing findings.

As in the case of TUT writers, also in the above studies the researchers' attitudes to the dominance of English in scientific publication tended to be ambivalent. On the one hand, they regarded English as a useful lingua franca for scientific communication and knowledge dissemination; on the other, some of them saw themselves as linguistically disadvantaged compared to NS academics. On the whole, academics in the hard field of technology and science appeared more likely to have a positive attitude to writing in English. As a rule, communicating the results to an international audience was the main reason for writing RAs in English. Respondents also emphasized the connection between their own career promotion and publishing in English.

The training preferences of TUT researchers were partly in line with findings in previous research. Interestingly, while Spanish scholars in Economy, Psychology and Sociology [15] appreciated “Computer-based interactive help”, the TUT respondents ranked computer-based courses last on the list.

6 MOVES AND METADISCOURSE IN STUDIED MATERIAL

One of the aims of this thesis was to examine how the studied TUT RAs employed both particular rhetorical devices to organize text and certain metadiscoursal features. Section 6.1 presents the results of a move analysis of the investigated RA introductions based on Swales' [22, 23] CARS model, and section 6.2 focuses on the applied metadiscoursal devices in both the introduction and post-method sections of the sample RAs. The identification and classification of the metadiscoursal features followed Ken Hyland's [33, 39] interpersonal model.

6.1 Moves and Steps in Research Article Introductions

Analysis of the RAIs began with identifying and labeling the moves and steps in each introduction. As Swales [22] states, the identification of moves and thus the setting of move boundaries "is based on a mixed set of criteria". According to him, identification is, in part, possible by intuition, which is based on how we understand different text types and genres. Sometimes lexico-grammatical features show the type of a move. For example, negative or quasi-negative elements may signal gap indications [23]. Technical words, phrase types, summary statements, tense, aspect and voice may reveal move and step boundaries [86]. In the following, the main results of identification will be compared with findings in earlier studies in three different disciplines. Samraj [25] examined RAIs in Wildlife Behavior (WB), Kanoksilapatham [85] analyzed Civil Engineering (CE) and Renu et al. [30] focused on Forestry research RAIs. The above studies were chosen for reference, because they examined academic writing practices in disciplines closer to Materials Science than a number of recent studies in the soft fields [27, 28, 31, 32].

The longest RAI in the studied TUT corpus contained 938, the shortest 224 words. The average number of words was 468. Table 8 shows the identified move sequences and move units.

Table 8. Identifed move sequences in the studied TUT RA introductions

RA	Number of words	Move sequences M 1 M2 M3	Number of moves
RA 1	484	1-2-1-2-3	5
RA 2	228	1-3	2
RA 3	800	1-2-1-2-1-2-3	7
RA 4	938	1-2-1-2-1-2-1-2-3	9
RA 5	423	1-3	2
RA 6	436	1-2-1-2-3	5
RA 7	358	1-3-2-1-3	5
RA 8	427	1-2-1-2-1-2-3	7
RA 9	537	1-2-1-3-2-3	6
RA 10	291	1-2-1-3	4
RA 11	224	1-2-3	3

M 1: Establishing a territory
M 2: Establishing a niche
M 3: Presenting the present work

The results of applying Swales' move analysis indicate that most of the studied TUT RAIs employed the three main moves of the CARS model. The findings of move sequences corroborate the results in earlier studies [30, 85]. For example, the RAIs did not necessarily follow the 1-2-3 sequence. The section always opened with Move 1 and most typically continued with Move 2, except in RAI 7, which opened with a 1-3-2 sequence, and RAIs 2 and 5, which both consisted of one 1-3 sequence. All the other RAIs contained cyclic patterning (e.g., 1-2-1-2-1-2-3; 1-2-1-3-2-3). The 1-2 sequence occurred most frequently, and Move 3 functioned as the closing move in each RAI. Move 1 recurred in all, except in RAIs 2, 5 and 11. Move 2 recurred in six RAIs. The average number of move units was 5. The longest cycle, 9 units, appeared, as expected, in the longest RAI 4. Table 9 indicates the frequencies of the individual steps.

Table 9. Step frequencies in the studied TUT RA introductions

Move 1	**Establishing a territory**
o Step 1	Claiming centrality **100%**
o Step 2	Topic generalizations of increasing specificity **100%**
Move 2	**Establishing a niche**
o Step 1A	Indicating a gap **72.7%**
o Step 1B	Adding to what is known **0%**
o Step 2	Presenting positive justification **45.5%**
Move 3	**Occupying the niche**
o Step 1:	Announcing the research descriptively and/or purposively **63.6%**
o Step 2:	Presenting hypotheses, research questions or assumptions **27.3%**
o Step 3:	Definitional clarifications **9.1%**
o Step 4	Summarizing methods **45.5%**
o Step 5	Announcing principal outcomes **27.3%**
o Step 6	Stating the value of the present research **45.5%**
o Step 7	Outlining the structure of the paper **9.1%**

Previous studies [e.g., 30, 88] have classified each step in a RAI either as "obligatory", "quasi-obligatory" or "optional", depending on how frequently it occurs. A step is considered "obligatory" if it occurs in all the investigated texts, and "quasi-obligatory" if it occurs in 51% to 99% of the texts. A step that appears in half or fewer than 50% of the texts is considered "optional". In the present study, it is not possible to draw any firm conclusions about the obligatory character of steps due to the limited number of text samples. It seems, however, that the authors of the studied RAIs considered essential the first two steps of Move 1, "Claiming centrality" and "Topic generalizations of increasing specificity". Similarly, Steps 2.1, "Indicating a gap", and 3.1, "Announcing the research descriptively and/or purposively", could be classified as "quasi-obligatory". The remaining two steps in Move 2 and the various alternatives in Move 3 would thus appear "optional".

The following subsections present the Swalesian moves and steps identified in the RAIs and also indicate some of the criteria for step recognition. The examples of step types occurred in the studied texts.

6.1.1 Move 1: Establishing a territory

Both step types representing Move 1 occurred in each TUT RAI. In contrast, only half of the WB and Forestry, and less than 50% of the CE RAIs employed Step 1.1 (Claiming centrality). In the case of Step 1.2 (Topic generalizations), they were similar to TUT RAIs: it occurred in 100% of WB and Forestry and in 96.7% of CE RAIs.

Step 1.1 Claiming centrality

In centrality claims (Examples 1-3), evaluative adjectives and adverbs generally refer to the significance of the field or investigation (widely, the most used). The simple present or present perfect tense is preferred. Activity verbs, such as “used” or “studied” are typical. [30, 85]

(1) Solar thermal collectors are an environmentally friendly and non-polluting way to gather energy. (RA 4: 462)

(2) Alumina is a widely studied and utilized material in thermally sprayed coatings. (RA 1: 488)

(3) Alumina (Al_2O_3) is one of the most used ceramic materials in thermal spraying because of its good wear resistance and low price. (RA 5: 1)

Step 1.2 Topic generalization of increasing specificity

Topic generalizations (Examples 4-6) are generally in non-past tenses (simple present, present perfect). Nouns tend to be technical and concrete (semiconductor photocatalysis, solar thermal collectors) rather than abstract as in Step 1.1. Lexical items referring to research as well as adjectives expressing significance (extensive research, a clear difference, significantly) occur frequently. [30, 85]

(4) After that, the semiconductor photocatalysis has been under extensive research as a possible way to purify water, air and surfaces from organic and inorganic impurities [2-4]. (RA 6: 1)

(5) It has been observed [1] that there is a clear difference in the wear behavior of WC-Co hard metals and wear resistant steels when abraded with granite or quartz. (RA 9: 174)

(6) The efficiency of the solar thermal collectors has been developed significantly and thus the operation and stagnation temperatures of absorber coatings have increased. (RA 4: 462)

6.1.2 Move 2: Establishing a niche

Most of the TUT (72.7%) and CE (71.7%) RAIs employed Step 2.1A (Indicating a gap). In both Forestry and WB texts, the same step occurred in all but one RAI. The Forestry and WB RAIs were similar to the TUT results in that nearly half the RAIs contained Step 2.2 (Presenting positive justification). Step 2.1.B (Adding to what is known) was identified in none of the RAIs discussed.

Step 2.1A Indicating a gap

The non-past tenses (simple present, perfect) are typical of gap indication (Examples 7-9). Step 2.1A points to the limitations of data, methods and results in previous studies. The use of negatives, such as “no”, “not” or expressions “few studies”, “little research” or “limited information”, indicates that there is a gap in the present knowledge and that further research is necessary [85].

(7) Also some other oxides, like TiO_2 and Fe_2O_3, have been studied for a α-phase stabilization by Lin et al. [Ref 5] and by Ilavsky et al., but no outstanding improvements have been achieved. (RA 1: 488)

(8) To the best of our knowledge, no earlier studies compare photocatalytic activities of the low-temperature and liquid flame spray produced TiO_2 powders. (RA 6: 2)

(9) However, the impeller-tumbler method is not standardized and the parameters vary. (RA 8: 94)

Step 2.2 Presenting positive justification

Presenting justification (Examples 10-12) for the study typically employs the present tense. Positive adjectives and adverbs as well as modal auxiliaries “can” and “may” occur frequently. Their purpose is to convey the idea of the benefits of the study. [30]

(10) Knowledge of the behavior of the abrasive media under crushing can lead to more precise expected lifetime estimations and thus minimizing the number of unnecessary down-times caused by early failures or replacement of still unctioning parts. (RA 9: 174)

(11) Only accurate simulation can give directions for reliably tailoring material properties to best suit the final application. (RA 10: 2)

(12) The better understanding of the wear mechanisms makes the material selection easier for impact-abrasion environment. (RA 8: 94)

6.1.3 Move 3: Presenting the present work

At least one of the steps in Move 3 occurred in all the discussed RAIs, including the corpus of the present study. The RAIs contained instances of all the seven steps proposed by Swales [23]. All the Forestry and WB RAIs, 78.3 % of the CE and 63.6% of the TUT RAIs employed Step 3.1 (Announcing the research purposively or descriptive-

ly). Nearly half (45.5%) the TUT corpus used Steps 3.4 (Stating the value of the present research) and 3.6 (Summarizing methods). Fewer (27.3%) RAIs contained Steps 3.2, (Presenting hypotheses, questions, and assumptions) and 3.5 (Announcing principal outcomes) (27.3%). Steps 3.3 (Definitional clarifications) and 3.7 (Outlining the structure of the paper) were each used by one writer.

Step 3.1 Announcing the research descriptively and/or purposively

Step 3.1 appears to be the most common choice to start presenting the work (Examples 13-15). The description of the research typically begins with a noun phrase, such as "the aim/purpose of this/the present study". In many examples, a reporting verb is employed, e.g., "this paper presents" or "we evaluate". Both past and present tenses occur. The simple present is usually more frequent, when the writer wishes to describe the study. The past tense, as in Example (14) below, is common when the writer announces the purpose of the study. [30]

(13) In present study we evaluate nanocomposites synthesized by thermolysis. (RA 7: 24)

(14) The aim of this study was to improve the properties of APS and HVOF sprayed alumina coatings by the means of chromia addition. (RA 1: 488)

(15) This paper presents a geometric tool to predict the lower boundary of obtained nanoparticle size in ceramic/metal nanocomposites. (RA 7: 24)

Step 3.2 Presenting hypotheses, questions and assumptions

Half the Forestry RAIs employed Step 3.2 (Examples 16 and 17), whereas hypotheses occurred in only 27.3% of the TUT corpus. Similarly, only a minority (33.3%) of WB RAIs presented a hypothesis or an assumption. Example (17) should probably be interpreted as follows: "we hypothesized that by increasing the α-content of the coatings by chromia addition, the wear and corrosion resistance of the coatings could be improved".

(16) We suggest, based on the results and literature data, that the second phase nanoparticle formation and growth during sintering is controlled by the matrix particle size. (RA 7: 25)

(17) The hypothesis was to increase the α-content of the coatings by chromia addition and by extension to improve the wear and corrosion resistance of the coatings. (RA 1: 488)

Step 3.3 Definitional clarifications

Only one TUT RAI employed Step 3.3 in order to explain a term (Example 18). According to earlier studies [25, 30, 85], definitional clarifications are not common in Move 3. A definition is generally in either the simple past or simple present tense.

(18) When a water droplet rolls on a superhydrophobic surface, it removes dust and dirt particles and the surface is cleaned. This property is known as self-cleaning effect or 'lotus effect'. (RA 2: 2)

Step 3.4 Summarizing methods

Step 3.4 (Examples 19 and 20) appeared in the CE (66.7%), Forestry (50%) and TUT RAIs (45%). The step did not occur in the WB RAIs. Procedural verbs (e.g., sprayed, synthesized) are characteristic of the step. The passive structure is typical, as in the following examples:

(19) In this study, three different A/S alumina based powders were sprayed with plasma torch and two CCD (charge-coupled-device) based diagnostic systems were used for online monitoring of the plasma process. (RA 5: 1)

(20) In this study, titanium dioxide powders were synthesized by two different synthesis methods: firstly, at a relative low temperature (50°C) as a function of acidity, and secondly, using liquid flame spray method. (RA 6: 2)

Step 3.5 Announcing principal outcomes

Announcing outcomes or findings (Examples 21-23) was most common in the CE RAIs (45%). Only 27.3% of the TUT RAIs, 25% of the WB and none of the Forestry RAIs employed Step 3.5. Outcomes of the study often occur in the passive or expressions using personal pronouns. Simple present tense sentences often employ verbs, such as "observe", "notice", "see", and nouns such as "study" and "paper" [30].

(21) It was observed in this study that the embedment of quartz mainly decreased the wear rate in specimens but it also increased the wear rates in low-hardness specimens. (RA 9: 175)

(22) We have noticed that a randomly oriented fibrous structure heats faster in certain areas when hot air flows through it. This takes place due to local differences in the air permeability that in this case is mostly controlled by the wall thickness and bulk density of the sample. (RA 11: 1)

(23) As a result we see a linear relationship between matrix particle size and the size of synthesized nanoparticles in sintered samples. (RA 7: 25)

Step 3.6 Stating the value of the present research

Step 3.6 (Examples 24-26) occurred in 45% of the TUT corpus, which is slightly more than in the Forestry (30%) and CE RAIs (38.3%). Modals (can, may, will), adjectives (important), adverbs (reliably) and verbs (understand, benefit, support) are commonly used to express the worth of the study [30].

(24) It is important to understand ageing phenomena as a basis for the further development of the absorber coatings to be used at higher operating temperatures. (RA 4: 463)

(25) This observation can benefit and support the selection of materials for example in mining and rock excavation, particularly in cases where the handling of both quartz and granite exists. (RA 9: 175)

(26) Only accurate simulation can give directions for reliably tailoring material properties to best suit the final application. Understanding wear mechanisms is the key connection between material properties and the environmental conditions. (RA 10: 2)

Step 3.7 Outlining the structure of the paper

Step 3.7 (Outlining the structure of the paper) did not appear in the TUT and Forestry corpus but occurred in 28.3% of CE and 17% of WB RAIs. The absence of Step 3.7 in most RAIs is not surprising. Swales [23] observes that the occurrence of the outlining step seems to depend on the conventions in the discipline. If there is an established IMRD-like sectional arrangement, a structural outline is not strictly necessary.

Comparison between the findings in the RAIs of TUT Materials Science and those in Wildlife Behavior, Civil Engineering and Forestry showed that the texts were similar in their use of some rhetorical steps. The variation in the organizational structure of the RAIs could, among other things, be due to differences in corpus size or, most probably, to disciplinary conventions. According to previous studies [25, 30], cross-disciplinary variation may occur, e.g., in gap indication and hypothesis postulation. The TUT RAIs were similar to those of the WB and Forestry in their frequent use of Step 1.2 (Topic generalizations). Moreover, Step 2.1A (Indicating a gap) appeared in most TUT, WB and Forestry RAIs. When it comes to stating hypotheses, the TUT researchers resem-

bled the WB and CE writers, who preferred to apply Step 3.1 (Announcing the research descriptively or purposively) to present their study.

6.2 Metadiscourse in studied material

This study of metadiscoursal features in TUT RAs focused on the introduction and post-method sections. To start with, metadiscoursal items in the text corpus were identified, analyzed and classified. The limited size of the corpus allowed manual coding of items. Manual identification and coding of linguistic features may also be justified by the nature of metadiscourse, which is, in essence, highly contextual. A linguistic item may, e.g., be either propositional or metadiscoursal depending on its context [37, 41, 49].

First, individual items were identified on the basis of a taxonomy of interpersonal discourse [33, 49]. Next, occurrences of metadiscourse were classified as either interactive or interactional. Examples of the two main types of metadiscoursal features were further divided into ten functional subcategories based on Hyland's framework of metadiscourse in academic writing (see Section 3.3). The following, mainly qualitative analysis of metadiscoursal features, applied some simple descriptive statistics. Frequencies of the classified instances of metadiscourse were counted. In addition, results were normalized per 10 000 words to allow comparison with findings in previous studies.

The following interpretation of the identified features is based on findings in previous research. Hyland [37] analyzed 28 research articles in four disciplines: Microbiology, Marketing, Astrophysics and Applied Linguistics. Hyland [47] and Hyland and Tse [39] investigated the use and distribution of metadiscoursal features in a corpus of 240 dissertations by L2 postgraduate students, who spoke Cantonese as their first language. The corpus consisted of 20 Master's theses and 20 doctoral dissertations from six academic disciplines: Electronic Engineering, Computer Science, Business Studies, Biology, Applied Linguistics, and Public Administration. Furthermore, Hyland [40, 43] examined an RA corpus of 240 published papers from eight disciplines, comparing the rhetorical practice in Mechanical engineering, Electrical, Engineering, Marketing, Philosophy, Sociology, Applied Linguistics, Physics, and Microbiology. A more recent study by Cao and Hu [49] analyzed interactive metadiscourse in 120 research articles in Applied Linguistics, Education, and Psychology.

Analysis of the TUT RA corpus indicated that, on the whole, the writers employed a rather limited selection of metadiscoursal devices. In addition, the analyzed sections contained substantially more interactive (77.4%) than interactional forms (Table 10). Most (77.9%) of the metadiscoursal features occurred in post-method sections, which was expected for two reasons in particular. First, the introductions contained only 24.6% of the total count of words in the corpus; second, post-method sections typically

require more complicated, discipline- and paradigm-specific patterns of metadiscourse [49].

Table 10. Metadiscourse in the studied TUT RA corpus (26 062 words)

Category	No. of items	Items per 10 000 words	%
Interactive	543	241.9	77.4
Interactional	159	70.9	22.6
Total	**702**	**312.8**	**100**

Table 11 shows that evidentials, endophorics and code glosses occurred most frequently, followed by transitions and hedges. The writers employed hedges more than the other interactional subcategories.

Table 11. Metadiscoursal subcategories identified in studied TUT RAs (26 062 words)

Subcategory	No of items
Evidentials	201
Endophorics	145
Code glosses	113
Transitions	66
Hedges	61
Self mentions	36
Frame markers	18
Engagement markers	15
Boosters	11
Attitude markers	9
Total	**675**

The following subsections present the results, some examples and observations of the frequencies of interactive and interactional metadiscoursal items.

6.2.1 Interactive devices

Tables 12 and 13 list the ranked interactive metadiscoursal items employed in the studied material. The findings are partly in line with those in previous studies. The TUT RAs applied relatively frequently some of the features typical of quantitative research.

Table 12. Interactive metadiscourse identified in the TUT RAs

Category	No of items	Items per 10 000 words	% of total metadiscourse
Evidentials	201	89.7	28.6
Endophorics	145	64.7	20.7
Code glosses	113	50.4	16.1
Transitions	66	29.5	9.4
Frame markers	18	7.6	2.6
Total	**543**	**241.9**	**77.4**

Table 13. Subcategories of interactive metadiscourse identified in the TUT RAs

Identified subcategories	No. of items	% of interactive metadisc.
EVIDENTIALS		
integral citations	55	10.1
non-integral citations	146	26.9
ENDOPHORICS		
linear references	51	9.4
non-linear references	94	17.3
CODE GLOSSES		
exemplifiers	21	3.9
reformulators	92	16.9
TRANSITIONS		
additive	19	3.5
comparative	1	0.2
contrastive	34	6.3
inferential	12	2.2
FRAME MARKERS		
sequencers	17	3.1
topicalizers	-	0.0
discourse-labels	-	0.0
announcers	1	0.2

Writers in the pure and applied hard sciences generally employ more evidentials and endophorics than those in the soft fields [39]. There is also paradigmatic and disciplinary variation in the use of code glosses. While elaboration through code glosses is typical of all academic writing, the rhetorical choices vary in different fields [43]. Reformulators are typically preferred in the natural sciences. As regards the use of transitions and frame markers, the findings in TUT RAs differ from those in several previous studies [37, 47, 49]. For example, in Cao and Hu's [49] comparative study of interactive

discourse in RAs, quantitative research papers used significantly more transitions and frame markers than qualitative RAs.

The remaining part of this subsection describes in detail identified metadiscoursal categories and gives examples from the studied RAs.

Evidentials

Both two subtypes of evidential markers, integral (Example 28) and non-integral (Example 29) citations, appeared in the RAs. The majority were, however, of the non-integral type.

(28) Yang et al. (Ref 3) have studied the effect of chromia addition to APS coatings. (RA 1: 488)

(29) The reduction of greenhouse gasses is the main advantage of utilizing solar energy [1]. (RA 4: 462)

The use of evidential markers in academic writing indicates membership of a particular disciplinary community. It provides support for the writer's argument and gives him a frame within which he can present his claims. The RAs examined in this study presented the writers' knowledge of the field's literature through a relatively high use of citations. Most of the identified evidentials (73%) occurred in introductions, which is logical considering the section's basic function: the writer typically refers to the dynamic research area of his own study and quotes previous studies. Moreover, gap indication requires pointing out insufficient research [22, 23].

Endophorics

The corpus material contained more examples of non-linear (Example 30) than linear (Example 31) type endophorics. References to figures and tables occurred most frequently.

(30) Seven materials were tested with two different test combinations, which are presented in Table 1. (RA 9: 175)

(31) In the present study, the S355 with ferritic-perlitic microstructure had the highest hardening depth and relative hardness increase, ... (RA 8: 101)

Previous research [39, 47, 49] has indicated that students in the hard disciplines employ more endophorics than those in soft fields. Writers in engineering tend to rely on multimodal scientific argumentation. Quantitative RAs, as a rule, refer to tables, figures and photographs to present various statistics.

Code glosses

Most of the identified code glosses were reformulators (Example 32), of which parentheses (92%) occurred most frequently. The second type of code gloss, exemplification (Example 33), was in most cases signaled by using either "for example", "such as" or "e.g.".

(32) It is excavated from metamorphic rock (quartzite) and may also contain some levels of feldspar (below 5wt%). (RA 9: 175)

(33) Impeller-tumblers have been used, for example, to test the impact-abrasion wear resistance of various steels [2-6] and wearfacing welding alloys [7]. (RA 8: 94)

The findings are in line with the results from Hyland's [43] investigation of exemplifying and reformulating in academic discourse. Almost two-thirds of the reformulators he coded in 240 published RAs from eight disciplines occurred in science and engineering papers. Furthermore, the employed reformulators typically occurred as syntactically separate from the rest of the sentence, generally indicated by parentheses. In the same analysis of the two basic types of code gloss, three-quarters of exemplifiers were expressed by using "for example", "such as" or "e.g.". Exemplification in the hard sciences typically presents a particular instance as a representative of a general category of events or phenomena.

Transitions

Following the studies by Hyland [47], Cao and Hu [49] and Mur Dueñas [98], only transitional markers functioning as inter-sentential devices were identified as metadiscoursal features in the present study. "In addition" was the most frequently used additive transition marker (Example 34). For the most part, the RAs preferred the contrasting type (Example 35), which accounted for 51.5% of all transitions. The marker "however" expressed contrast most frequently. The corpus contained only a few inferential transitions (Example 36); "thus" occurred most commonly.

(34) In addition, the surface roughness and microhardness results were almost similar for both 60° and 90° angles. (RA 8: 99)

(35) However, evidence of any oxide layers inherent to tribochemistry was not found. (RA 10: 5)

(36) Thus, for low-hardness specimens (< 400HV), the quartz running-in increased the wear rates in the actual wear tests. (RA 9: 178)

In quantitative RAs (35), contrastive transitions often signal a difference between empirical results and initial expectations or alternative hypotheses. Inferential transitions (36), on the other hand, imply cause-effect relations in knowledge claims or conclusions [49].

Frequent use of transitions is important in academic argument. In Hyland's study [47] of postgraduate dissertations from six fields, transitions ranked first in the interactive category and represented over a fifth of all metadiscourse. The TUT writers used fairly few transitional connectives to make their text more fluent and explicit. As a rule, they did not clearly indicate what the text was aiming at in order to prepare the reader for what was coming. The texts did not orient the reader in retrospect either. Lack of explicit guidance generally makes reading more challenging. In addition to potential disciplinary influence, one possible reason for the scarcity of transitions in the studied RAs may relate to culture. In studies [21, 35, 38] discussing the distinction between "writer-responsible" and "reader-responsible" [99] writing cultures, Finnish academic discourse has been recognized as "reader-responsible".

Frame markers

With the exception of one single occurrence of the announcer "aim to", the few frame markers found in the studied RAs were sequencers (Example 37). "On the other hand" was employed most frequently.

(37) On the other hand, severe wear mode for silicon nitride is yet to be found with this specific wear testing method. (RA 10: 6)

Quantitative studies commonly apply sequencers, e.g., to list research results or limitations, topicalizers to mark topic shifts, discourse-labels to refer to the stage of the unfolding discourse, and announcers to outline the goals of discourse. A judicious use of frame markers creates coherent and writer-responsible texts. By leaving out frame markers, the writer leaves his readers more or less on their own. It is possible that their absence in the TUT RAs was, to some extent, due to disciplinary context. Hyland [93] points out that texts for specialist audiences may contain fewer textual devices. The target readers will in most cases be able to follow the argumentation without explicit guidance.

To sum up, in their use of interactive metadiscourse, the TUT RAs seemed to follow, at least partly, conventions characteristic of the hard sciences. Similarly to most quantitative studies, they employed evidentials to express their sources, endophorics (especially non-linear references) to refer to different parts of the text and code glosses (particularly reformulators) to explain and elaborate the propositional content. On the other hand, the

low density of transitions and frame markers sets them apart from several RAs and dissertations analyzed in previous studies [40, 47, 49]. This difference does not necessarily arise from the "epistemologies underlying the qualitative and quantitative research paradigms" or the "different knowledge-knower structures prevailing in the discipline" [49]. It is also possible to look for an explanation in the Finnish "reader-responsible" writing culture.

6.2.2 Interactional devices

The findings of interactional devices, illustrated in Table 13, were in line with Hyland's [40] results. His study of 240 RAs from both soft and hard research fields revealed clear disciplinary distributions in the occurrence of interactional metadiscourse. The soft fields in his study contained the highest proportion of stance and engagement. RAs in Philosophy, Marketing, Sociology and Applied Linguistics used some 75% more interactional features than engineering and science papers. Furthermore, stance markers were about five times more common than engagement features, and hedges were the most frequent feature to express stance. In the studied TUT RAs, the number of interactional instances was small compared to the total number of identified metadiscourse. Out of the 132 interactional devices only 15 were engagement markers. Moreover, hedges made 46.2 % of all the stance markers. There was, however, a difference in the relative frequency of self mentions. In Hyland's study they ranked lowest among the interactional subcategories. He explains the result by referring to the empiricist ideology in sciences, which tends to downplay the personal role of the author and emphasize the research activities and findings. In comparison, the Materials Science RAs in this study appeared to employ self mentions more than boosters and attitude markers. However, the result is perhaps not generalizable, since all the instances of self mention occurred in only three RAs.

Table 14. Interactional metadiscourse identified in the studied TUT RAs

Subcategory	No of items	Items per 10 000 words	% of total metadiscourse
Hedges	61	27.2	8.7
Self mentions	36	16.1	5.1
Engagement markers	15	5.8	2.1
Boosters	11	4.9	1.6
Attitude markers	9	4.0	1.3
Total	**132**	**70.9**	**22.6**

The latter part of this section describes the identified interactional features and presents some examples of stance and engagement found in the studied RAs.

Hedges

Hedges dominated the interactional category. The use of modals (might, may) (Example 38), "seem(s) to" and "it is possible, probable that" (Example 39) expressed the writers' aim to withhold their commitment to a claim. The fairly low density of hedges compared to interactive subcategories in the analyzed RAs is presumably a discipline-related feature. The main function of hedges is to distinguish fact from opinion and give the writer an opportunity to evaluate his own findings [47]. The hard sciences, however, tend to trust the results of quantitative methods and thus base their arguments on them. The softening effect of hedges may appear unnecessary, if the statistics and hard data seem clearly to answer the research questions.

(38) These results findings may find potential use in separation of powders from the solutions. (RA 6: 5)

(39) This is probably due to differences in the film growth of tin oxide . . . and silicon oxide . . . . (RA 4: 466]

Self mentions

All the instances of self mention were in the form of "we" and "our" (Examples 42 and 43), which is natural, since all the articles were co-authored. Probably the authors of the three RAs that employed self mention had consciously chosen to present their own "voice". Traditionally, self mention is more frequent in the soft fields. Presenting a discoursal self [92] is an effective way for a researcher to promote himself and his contributions. In Hyland's [47] study, PhD writers used this device significantly more often than Master's degree students. It seems that more advanced writers are more likely to display their personal perspective and emphasize their contribution to the field.

(42) At the beginning we would like to point out that some basic principles are the same as used for ceramic crystal structures. (RA 7: 25)

(43) We investigated how these solar absorbers behave at prolonged high-temperature exposure. (RA 4: 463)

Engagement markers

Most (71.4%) of the identified engagement markers were reader pronouns (Example 40). A few directives occurred. "It is important to understand . . ." (Example 41). No instances of appeals to shared knowledge, questions or personal asides were found. In

Hyland's study [40], directives were the only engagement feature that appeared more frequently in science and engineering papers. They have, however, a different function in soft and hard disciplines. In the former, they direct readers to a reference, in the latter, directives are used to save space in short articles.

(40) Also this model gives us only the lower boundary of the obtainable particle size. (RA 7: 27)

(41) It should be noted that in the tests the force at which the abrasive particles hit the sample surface does not change in the course of the test. (RA 8: 101)

Boosters

Most of the identified boosters (Examples 44 and 45) occurred in the same RA. "It is clear that" was used most frequently.

(44) The clear advantage is that dense microstructure can be produced without the separate post heat treatment processes and hence, the Cr-rich oxide layer is not formed as discussed in the introduction. (RA 3: 17250)

(45) It is most likely that the melted Co particles were evenly distributed in the gaps and oxidized or mixed with the Mn_2CoO_4 spinel phase . . . (RA 3: 17250)

According to Hyland [40] both boosters and hedges express the writer's response to potential viewpoints of readers. By using boosters, the writer can emphasize his certainty in what he says and also acknowledge disciplinary norms. Most of the studied RAs did not rely on boosters to signal group membership and engagement with the reader. This may be due to their disciplinary reliance on empirical demonstration and quantitative methods, which do not require additional "boosting" to persuade the audience.

Attitude markers

The few instances of attitude markers (Examples 46 and 47) were most frequently expressed with the adverb "surprisingly".

(46) Overall, the results of the corrosion exposure tests seem to be surprisingly good and APS coatings succeeded better than TG coatings, as expected. (RA 1: 492)

(47) There were surprisingly small differences between the wear surfaces in the center of the samples tested at 60° and 90° angles. (RA 8: 99)

Attitude markers generally express the writer's affective, rather than epistemic, attitude to propositions. They can convey his surprise, agreement or frustration. In natural sciences and engineering, persuading readers is traditionally not based on a need to build up a relationship with readers [40, 47]. The studied Materials Science RAs seemed to

focus on reporting the research practices and findings without emphasizing the researchers' own attitudes to propositions.

In brief, the TUT RAs followed the disciplinary practice of their field in applying significantly fewer interactional than interactive metadiscoursal features. The somewhat higher frequency of hedges compared to other interactional subcategories is in accordance with results of previous studies. The low density of engagement markers, boosters and attitude markers is, according to research [40], characteristic of natural sciences. As in the case of interactive metadiscourse, it is tempting to speculate on the potential effect of cultural rhetorical strategies. As Mauranen [35] points out, the Finnish writer is known to "make minimal inscriptions on paper, leaving plenty of scope for the reader's interpretations" [35].

7 DISCUSSION

The topic of the present thesis was NNS researchers' scientific writing in English. The study had two objectives: first, to explore the English scientific writing experiences and preferences of TUT researchers in Materials Science; second, to investigate certain features of rhetorical organization and metadiscourse in their published RAs. The hypothesis was that the NNS subjects in the study might find it challenging to write fluent and coherent academic prose in English. Moreover, it was assumed that the genre-based devices of linguistic persuasion are closely connected with the researchers' own disciplinary culture. In research writing it is important to organize the writing as a coherent text. Coherence is inevitably dependent on the rhetorical context: texts are located in settings that determine their use and meaning. Scientific writing is not solely propositional and impersonal. Rather, argumentation and presenting claims involve linguistic elements that readers recognize as persuasive. [37] Thus in order to write coherent RAs the researchers need to know the rhetorical practices in their own field.

The study used two methods to answer the research questions. The e-mailed questionnaire gathered information on the researchers' writing experiences, perceived challenges and language training wishes. Descriptive analysis of their published RAs employed Swales' CARS model to study the rhetorical organization in the introductions and Hyland's framework of academic discourse to examine the use of metadiscoursal features in the introductions and post-method sections.

Close to three-thirds of the TUT respondents were ready to define English as the single common language of international scientific communication. Communicating their results to an international audience was the researchers' main reason for writing RAs in English. They also recognized the connection between their own career promotion and publishing in English. The issue of perceived linguistic disadvantage divided opinions. Approximately half the respondents admitted that they felt disadvantaged in writing RAs when compared to native speakers; the others disagreed, a few even "strongly". Most of the subjects considered writing in English "slightly difficult".

The TUT researchers reported linguistic difficulties as a major challenge in writing and publishing in English. A Spanish academic expressed the difficulty perceived by one of the TUT respondents: "Sometimes you want to convey nuances but you don't know how to do it" [10]. The results of the present study were fairly consistent with the findings of a number of previous studies [5, 6, 10-12, 15]. Non-native writers, regardless of their native language, have the same problem: how to be appropriately assertive and

persuasive in making claims and discussing research findings? The following subsections discuss, first, the influence of disciplinary conventions on the rhetorical organization and use of metadiscourse in RAs and, second, the implications of the connection between disciplinary cultures and language demands for teaching scientific writing in English.

7.1 Research paradigms and disciplinary conventions

According to several studies on rhetorical organization in RAs [25, 27, 28, 30, 87], some of the variation in RA move structures appears to be due to differences in disciplinary conventions. In RA introductions, such variation may show, e.g., in the occurrence of gap indication, hypothesis postulation or presenting the outline of the article. Previous research [37-40, 43, 47, 48] has also found differences between hard and soft disciplines in the use of both interactive and interactional metadiscourse. Cao and Hu [49] compared interactive metadiscourse in the post method sections of qualitative and quantitative RAs in different disciplines. They found significant cross-disciplinary differences in the use of metadiscoursal features, which they attributed to the differing nature of the two research paradigms.

Hyland [101] points out that languages are closely connected with the epistemological frameworks of disciplines. Thus "disciplinary culture" in the academic context refers not only to variation between the research methods and type of data produced but also to differences in language demands and practices [14]. Materials Science as a specific field of science and engineering is a hard-applied discipline. For natural scientists and engineers knowledge is based on cumulative steps. Fresh scientific problems are discussed in an established context. Consequently, readers are familiar with the earlier studies in the field. The audience can thus be expected to recognize the significance of a researcher's contribution. Writers can, therefore, use standardized language in reporting their findings. The shared context ensures that their claims are correctly interpreted. [100]

The corpus in the present study consisted of 11 co-authored empirical RAs, which were reports on research based on experimental data. The structure of the RAs was fairly predictable due to their experimental orientation. Gnutzmann and Rabe [14] suggest that a high degree of genre rigidity sets lower language demands on NNS writers. The stiff format of a research article gives the writers less freedom to improvise. Their readers do not even expect them to write creatively. The TUT RAs had structures which Hyland [101] describes as "more highly standardized and less discursive, drawing on semiotic resources which are graphical, numerical and mathematical rather than simply textual". It would therefore seem that the burden of the NNS writer is not extremely heavy in the case of researchers in Materials Science. The vocabulary used in the field is fairly lim-

ited, and the writers can find most of the language they need in previously published articles.

The findings in the above studies on rhetorical structure suggest that disciplinary conventions affect the choice of step options. Both two steps of Move 1 in the CARS model, "Claiming centrality" and "Topic generalizations", were easily identified in every TUT RA. The writers were explicit in claiming centrality and giving increasingly specific generalizations of their topic. Discussion of previous research in the form of a literature review occurred mostly in Moves 1 and 2, even though it can, in principle, be presented in all three moves throughout the introduction [23]. Gap indication in Move 2 was identified in all but two RAs. The lack of the essential "niche-establishing" step may have various explanations. The most obvious reason may be the writers' ignorance of the need to explicitly establish a niche. Samraj [25] compared RAs in Conservation Biology (CB) and Wildlife Behavior (WB). The former resembles Materials Science in being an applied and interdisciplinary field. It is also a young field compared to WB. Centrality claims in Move 1 were frequent and thorough in CB RAs, whereas gap indication occurred less frequently than in WB. Moreover, in both CB and TUT RAs, when gaps were indicated, they concerned the "real world" rather than the world of research. Hirano [31] discusses reasons for avoiding gap indication. Solidarity to the research community may in some contexts prevent researchers from establishing their niche. Move 3 is probably mostly influenced by disciplinary preferences. Most of the studied RAs preferred to announce the purpose of their research at the beginning of the last move, but none of them offered an outline of their paper. Swales [23] observes that in fields with established standardized RA formats there is less need to "roadmap" the structure of the article.

Also metadiscourse is influenced by disciplinary differences. The knowledge-knower structure in the discipline may explain some of the features. Bernstein [68] compares hierarchical and horizontal knowledge structures. Hierarchical knowledge-horizontal knower structures are characteristic of natural sciences, in which explanations are based on observable experience and precise measurement. According to several studies [e.g., 33, 37, 39, 40, 47], metadiscourse is generally less frequent in hard than soft fields of science. Interactive devices, however, occur more often than interactional markers in natural science RAs. Three-quarters of all metadiscourse in the studied material consisted of interactive features. Table 15 compares the findings of Polly and Tse's [39] study of metadiscourse in postgraduate dissertations and the results of the present study. The comparison is only approximate and suggestive, because the studied corpora belong to different genres of academic writing and differ in size. It is, however, possible to make some tentative conclusions about the most obvious differences between hard and soft disciplines.

Table 15. Interactive metadiscourse (per 10 000 words) in Hyland and Tse's [39] study of postgraduate dissertations by discipline and the TUT RA corpus.

Category	Applied Linguistics	Business Studies	Electronic Engineering	Biology	Mat. Science (TUT)
Interactive					
Transitions	95.1	89.1	76.9	86.6	29.5
Frame markers	25.5	25.3	24.7	22.5	7.6
Endophorics	22.0	19.6	43.1	23.0	64.7
Evidentials	82.2	60.7	20.1	99.5	89.7
Code glosses	41.1	30.0	30.7	36.0	50.4
Total	**265.9**	**224.7**	**195.5**	**267.6**	**241.9**

On the basis of the total number of interactive features employed, there seem to be no significant differences between the TUT corpus and the two hard disciplines of Electronic Engineering and Biology. A closer examination of the individual categories reveals that the total amount of TUT RA metadiscourse consisted, for the most part, of two features. Evidentials and endophorics had the highest frequencies. Hyland [37] refers to writers' need to locate and justify their contributions through a high use of overt intertextuality. Evidentials enable researchers in the hard fields to build on previous research and place their claims within a structured schema of knowledge. It is important for writers to acknowledge those who originally "owned the ideas" [39]. Writers in the hard disciplines, especially in engineering, also tend to rely on endophorics to persuade their readers. Endophorics were primarily used to refer to tables, figures and photographs in the TUT corpus. Code glosses (exemplification and reformulation) ranked third in the TUT interactive metadiscourse. As Hyland [43, 281] observes, exemplification in the knowledge-oriented disciplines can "carry considerable empirical authority", "tie examples to the writer's data" and "reinforce the reader's acceptance of the evidential weight of the interpretation". Reformulation is also typical of science and engineering because of a need to "reconstrue experience in a technical way" [43].

In general, transitions and frame markers are characteristic of academic writing. Frame markers occurred frequently in Hyland's corpus of Master's theses, and especially Doctoral dissertations [39, 47]. It is possible to hypothesize reasons for the fairly low frequencies of transitions and particularly frame markers in the TUT RAs. The writers may not have recognized their function in creating coherent, logical and reader-friendly discourse. Furthermore, the TUT researchers relied on a narrow range of connectives functioning as transitions. According to Noble [56], the lack of connectives may indicate

either that there is a problem in the writing, or that the writers employ other methods to link ideas, such as topical or lexical connections. It can be reasoned that the low frequency of frame markers revealed that the writers were either consciously avoiding them, or that they were careful not to overuse them. It is also possible that they did not know how to use them, or as in the case of transitions, were applying other text organizing devices. TUT researchers' avoidance of frame markers can also serve as an example of writing to disciplinary insiders. Hyland [95, 190] observes that texts for specialist audiences employ fewer textual devices, because the readers understand the content from the lexical relations. Dahl [38] made similar observations in her study, which included RAs in Medicine. The writers used a highly structured IMRD format in their writing, and, as a result, the readers received no extra guidance to orient themselves within the text, because they were expected to know where to look for and how to interpret the research data.

The two types of interactional features, stance and engagement, are important in both supporting a writer's argument and signaling a disciplinary context. Their use may either follow more general rhetorical practices or indicate writers' idiosyncrasies. Table 15 compares the frequencies of interactional features (normalized per 1000 words) in the RAs in two hard fields, two "softer" fields and the studied TUT RAs.

Table 16. Stance and engagement features by discipline (per 1000 words) in Hyland's study [40, modified] and TUT RAs.

Category	Philosophy	Sociology	Microbiology	Mechanical Engineering	Materials Science (TUT)
Interactional					
Stance	**42.8**	**31.1**	**23.8**	**19.8**	**4.5**
Hedges	18.5	14.7	13.6	8.2	2.3
Self mentions	5.7	4.3	3.4	1.0	1.4
Boosters	9.7	5.1	3.9	5.0	0.5
Attitude markers	8.9	7.0	2.9	5.6	0.3
Engagement	**16.3**	**5.1**	**1.6**	**2.8**	**1.6**
Reader ref.	11.0	2.3	0.1	0.5	1.2
Directives	2.6	1.6	1.3	2.0	0.4
Questions	1.4	0.7	0.1	0.1	0.0
Shared knowledge	1.0	0.4	0.1	0.3	0.0
Personal Asides	0.2	0.2	0.0	0.0	0.0
Total	**59.1**	**36.2**	**25.4**	**22.6**	**6.1**

On the whole, the more discursive disciplines of Philosophy and Sociology contained significantly more stance items than the hard field disciplines. Hedges were the most frequent in all the disciplines. They are generally employed considerably more in the soft disciplines, possibly in order to make the writers' claims even more tentative [43]. Self-mention is also a more frequently used device in the soft field. In hard disciplines, writers appear to minimize their presence instead of presenting their own "voice". The research practices and accurate presentation of data are essential, whereas the individual researcher prefers to remain in the background. In the TUT RAs, self-mentions occurred in only three papers, which strongly questions the generalizability of the result. Boosters and attitude markers are not typical of science texts. TUT RAs differed in the use of engagement markers from the other hard disciplines in Table 15. Reader pronouns are usually more common in soft discipline papers to create solidarity and to link writer and reader. Unlike in the TUT RAs, directives are more typical than reader pronouns in science and engineering papers. Hyland [43] suggests that they function as space savers making articles shorter. From a number of previous studies and the data presented above, it is possible to infer that there are marked linguistic differences between disciplines in their use of rhetorical organization and metadiscoursal devices. Thus, disciplinary culture should not be ignored in teaching scientific English.

7.2 Implications for teaching scientific English

"The rhetorical and stylistic features of NNS texts may differ a lot from the conventions of Anglo-American academic writing style" and "when NNS scientists write RAs in English they feel disadvantaged when compared to native speakers" are arguments whose accuracy is often taken for granted. At least in some disciplines the need to aim at native-level fluency is, however, not such a strict requirement any more. This change is at least partly due to the fact that most academics, editors and reviewers in the field are themselves NNS writers. Mauranen [102] sees this development as positive: giving up the native-like standards in academic discourse will enable global scientific discourse. The purpose of writing RAs is, after all, not to appear as an NS researcher but to share knowledge.

Gnutzmann and Rabe [14] interviewed German researchers from four disciplines in order to find out how disciplinary cultures are connected with language demands in scientific writing. Their findings revealed a clear difference between texts in empirical sciences and those in the soft field of humanities. The rigid conventional format and style of, e.g., Mechanical Engineering makes writing and publishing easier than it is in discursive disciplines, such as History. "Language re-use", i.e., using sentence templates, is practical also in Materials Science, where RAs are mainly reports on conducted experiments. Working and writing in teams, which is the prevalent mode in the discipline, may also decrease the perceived difficulty in writing.

The sample RAs in the present thesis compared well with those of previous research. Most RAIs followed the rhetorical pattern of the CARS model. Furthermore, the TUT researchers were even more active in their use of the two interactive types of metadiscourse, evidentials and endophorics, than many previously studied writers in engineering and natural sciences. However, the low frequencies of transitions and frame markers were not in line with most earlier findings. Maybe the researchers felt that they were "writing around figures and diagrams" to convey the reader "facts, facts and facts" [14], and therefore considered metadiscoursal resources superfluous decorations. It is also possible that the TUT writers did not consider transitions and frame markers necessary, since their readers can usually follow the text without explicit guidance. Another explanation may be provided by the nature of Finnish academic discourse, which has been characterized as "reader-responsible". Ventola and Mauranen [21] discuss the Finnish writers' use of connectors, a category which includes the transitions and frame markers of Hyland's classification. In their study, the Finnish academics not only used fewer connectors than English-speaking writers but also seemed to favor the same lexical items throughout their texts. Such simplification strategy, however, ignores the Anglo-American tradition of writing, which expects more of the writer's presence in the text. A more engaged writer signals a friendly attitude to the reader and creates coherence by relating ideas to one another [33].

The argument that there are disciplinary differences in academic writing has been the thread of the present thesis. Those differences concern knowledge structures, research methods and the data produced. Obviously disciplinary cultures also affect the writing modes and genres applied. Furthermore, the same genre label may refer to different texts in different disciplines [103]. According to the genre-based approach to language learning [22], writers must learn to create texts that employ the conventions of their disciplinary field. The CARS model is widely used as a pedagogical tool. Preferably not employed as a mechanical template, it makes writers aware of the commonly used rhetorical organization of RAIs in English. Teaching the CARS model should, in any case, take into account the characteristic conventions and patterns used in different disciplines and subdisciplines. Similarly, the extent and quality of metadiscourse varies between disciplines. Employing metadiscourse in the ways accepted within one's discipline helps the researchers to create reader-friendly RAs. However creative scientific writers wish to be, at least so far, they have been encouraged to conform to the approved discursive practices of their own field [19]. Teachers of academic writing may have to ignore their personal stylistic and rhetorical conventions, which are typically employed in the field of humanities [21].

Teaching metadiscourse in scientific writing, or in any writing, is a challenge. The following four difficulties do not make an exhaustive list. First, as Hyland states, metadiscourse "is an umbrella term for the range of devices writers use to explicitly organize their texts, engage readers, and signal their attitudes to both their material and their au-

dience". *Umbrella term* refers to the main characteristic of metadiscourse: it can appear in various surface linguistic forms. Identifying a stretch of discourse as metadiscourse is always based on the context. The first problem is closely connected to the second difficulty: since metadiscourse is not a fixed but rather an open category of expressions, metadiscoursal devices are not easy to explain and define to those who would like to employ them. Third, it is often difficult, if not impossible, to add or "glue" metadiscourse on a nearly finished RA. The fourth challenge has a bearing on the current thesis: since metadiscourse is a "fuzzy term" [37], and since no exact description of it can be found in previous studies, it is particularly difficult for an NN reader and writer to be absolutely certain of her metadiscoursal interpretations.

There are no strict rules on the ideal amount and quality of metadiscourse in RAs. Finnish writers, who represent a "reader-responsible" culture, sometimes avoid high levels of metadiscourse in their texts, because they find the Anglo-American way of guiding the reader intrusive and patronizing [35]. The RA samples in the present study contained fairly low frequencies of two important categories of interactive metadiscourse, transitions and frame markers. According to research [36], skilled writers typically use metadiscourse more frequently and apply a wider range of markers than less successful writers. The challenge in teaching scientific writing to researchers lies, however, not only in turning them more "writer-responsible" by making them add extra linguistic devices into their RAs. Optimal use of metadiscourse involves clear and critical reading, thinking and writing. Scientific writers must present the propositional content of their texts logically and coherently. Instead of mechanically applying lists of metadiscoursal devices to make their text seem fluent and attractive, they should pay attention to exactly what kind of knowledge and beliefs they wish to convey to their readers. They must thus become familiar with the general use of particular devices as well as their shades of meaning, which may differ from those of translations into their native language. Instruction and materials on the use of metadiscourse should, therefore, not only focus on linguistic forms and word lists per se but also encourage researchers to see their texts more as active interaction and engagement with their readers than as products in the format of an RA.

Hyland [20] argues that there is a need for change in the EAP units in universities. He also thinks that language specialists' relatively low standing is due to their image as merely supporters to departments. The role of EAP should involve more than providing general exercises to repair researchers' language skills. The marginalized position of language teaching is related to a tradition of seeing "text" above "practice". This text-centered approach may lead to regarding EAP merely as a separate remedial measure. By contrast, a participant-oriented attitude would necessarily be linked to disciplinary knowledge. In designing writing instruction and materials, researchers' own experiences of academic writing and wishes for further training could offer a rewarding starting point. In the field of EAP, opinions differ on whether EAP writing instructors or content

course professors should teach students and researchers the essential disciplinary discursive practices. Hyland [104] considers teaching specific disciplinary literacy skills a task of EAP teachers. In addition, he argues against the belief that writers could cope with mastering "a set of rules which can be transferred across fields". Writing instruction would consequently profit from having EAP specialists work closely together with subject specialists in different disciplines.

The concept of disciplinary culture is not a homogeneous notion, and various sub-fields frequently follow their own writing conventions. Offering the same writing courses to all researchers adopts the "single literacy" view [20]. In discussing the question of whether to offer doctoral students disciplinary or non-disciplinary writing courses, Swales [23] refers to a successful tripartite approach of an EAP program, which offered, first, the same common core basic courses to all groups, second, disciplinary-specific team-taught courses, and, third, "writing clubs" for peer-based writing support. Peer-based support ranked third in the studied TUT researchers' preferences for training in scientific writing. As members of a disciplinary writing group, researchers of, e.g., Materials Science would share the structural and rhetorical writing strategies of their own field. Making claims, advancing arguments and positioning themselves in their texts to a group of peers in the same discipline would be more useful, interesting and challenging than presenting their writing to a heterogeneous group of writers. Aitchison and Lee [105] observe that eventually members of such groups develop a set of specialized language skills to analyze and describe texts and in that way become themselves resources for learning.

A combination of the TUT researchers' top training preferences, "Consulting native English-speaking colleagues within my field" and "Comments from proofreaders", could, at best, amount to specialists who have a good command of English and the ability to orient to the knowledge content of the discipline. Such expert editors or "professional academic literacy brokers" [65] could act as mentors, who actively participate in preparing RAs for publication [6]. Cooperation between NNS writers and such language specialists might help writers with their most difficult aspects of RA writing: "creating text flow and coherence to make my reasoning easy to understand" and "expressing my interpretation of the results with the appropriate degree of confidence".

8 CONCLUSION

The present thesis, which focused on NNS researchers' scientific writing in English, had two objectives. First, it explored the writing experiences and preferences of 14 researchers in Materials Science at TUT through a questionnaire. Second, it examined the use of certain resources of rhetorical organization and metadiscourse in their published RAs. The analysis employed Swales' CARS model and Hyland's taxonomy of metadiscourse in academic texts to study the introductions and post method sections of 11 sample RAs.

In general, the TUT respondents felt that it was natural to write up their research in English. However, approximately half of them admitted feeling disadvantaged in writing RAs when compared to native speakers. The researchers considered creating text flow and coherence as well as making claims with an appropriate degree of confidence the most difficult parts of writing RAs. Their primary wishes for language support included consulting NS colleagues in their own field and receiving comments from proofreaders.

Most of the studied RAs followed Swales' 3-move rhetorical pattern in introductions. Some of the step choices were characteristic of disciplines in engineering and natural sciences. When it comes to findings of metadiscourse, the results were, in general, consistent with those of previous research. According to the approved practice in their discipline, the TUT writers employed metadiscourse, especially interactional resources, relatively sparingly. Adherence to disciplinary conventions could not unequivocally explain all the features. The low frequencies of two interactive subtypes, transitions and frame markers, were a special characteristic of the sample RAs. Employing those two markers would help to create coherent, persuasive discourse and logical text flow.

The basic limitation of the present study was its small writer corpus and number of text samples. Evidently the findings of a localized small-scale study cannot be generalized. Considering the main observation of disciplinary culture made in the thesis, it would be interesting to collect a larger corpus and compare RAs from different disciplines and subdisciplines. Questionnaires also have their limitations. The use of close-ended and predetermined questions may guide the respondents' reactions. Some of the challenges concerned the text analysis of the sample RAs. Identification of moves in the CARS model according to "a mixed set of criteria" [23] is not always a clear-cut procedure. Another difficulty arises from the nature of metadiscourse. It may appear in various linguistic surface forms, which often make its interpretation challenging. The identification of metadiscourse in the RAs of this study was based on NNS interpretation.

Despite its admitted limitations, this thesis has some implications for EAP writing pedagogy. Both the findings and previous literature point to the existence of disciplinary differences in writing RAs. Teaching academic writing should be based on the varying patterns of rhetorical organization and metadiscourse in different disciplines. Furthermore, this study revealed that there were two subcategories of interactive metadiscourse that the TUT researchers used less than expected. The implication, however, is not to start mechanically adding transitions and frame markers to the otherwise completed RAs. Creating coherent text involves joining both the propositional and interpersonal aspects into a whole. For this reason, both content and metadiscourse must be constructed together. There are two potential ways to meet this challenge. First, researchers could continue developing their rhetorical consciousness and disciplinary awareness of genre-specific conventions. Second, they could, at least at the beginning of their writing careers, work together with EAP specialists in order to create coherence in their RAs through textual organization beyond the sentence-level.

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APPENDIX A: COVER LETTER

Dear Participant,

As a part of the thesis for my Master' degree, I am conducting a survey on academic English writing. The objective of the survey is to investigate the writing experiences and strategies of postgraduate students and researchers in the Department of Materials Science at Tampere University of Technology (TUT).

The following questionnaire is designed to give information to both the Department of Materials Science and the Language Centre of TUT on researchers' perceptions, current needs and their wishes for further training in writing in English. Completing the questionnaire will require approximately 5-10 minutes of your time. You may give your answers to the open questions as well as your comments in either English or your native language. All information you provide will remain confidential.

If you would like a summary of the results of the study or have any questions on the survey, you may contact me

at tiina.ojamo@student.tut.fi or
at 040 7451248

Thank you for your assistance!

Sincerely,
Tiina Ojamo

APPENDIX B: QUESTIONNAIRE

Questionnaire

Survey on scientific English writing

1. Home country*

2. Other countries lived in /for how long?*

3. My native language*

4. Years of (comprehensive and upper secondary school) English instruction*

5. Field of study*

6. Position at university*

- ☐ Doctoral student
- ☐ Postdoctoral researcher
- ☐ Project researcher
- ☐ Other:

7. Writing experience in English *

Check all that apply

- ☐ Bachelor's thesis
- ☐ Master's thesis
- ☐ Doctoral thesis
- ☐ Grant proposals
- ☐ Conference abstracts
- ☐ Scientific papers/articles (published)
- ☐ Professional writing

8. How would you describe your competence in English?*

	Excellent	Very good	Good	Limited	Poor
Listening	○	○	○	○	○
Speaking	○	○	○	○	○
Reading	○	○	○	○	○
Writing	○	○	○	○	○

9. In which language do you prefer to write your scientific papers?*

- ○ My native language
- ○ English
- ○ Other

Please specify the reason(s) for your choice*

10. How do you feel about the following statement? "English as the single common language makes international co-operation and scientific communication possible."

- ○ Strongly agree
- ○ Agree
- ○ Disagree
- ○ Strongly disagree
- ○ I don't know

11. How do you feel about the following statement? "When writing research articles in English I feel disadvantaged when compared to native speakers."

- ○ Strongly agree
- ○ Agree
- ○ Disagree
- ○ Strongly disagree
- ○ I don't know

12. How difficult do you find writing in English compared to writing in your native language?*

- ○ Extremely
- ○ Very
- ○ Moderately
- ○ Slightly
- ○ Not at all

13. What are your personal reasons for writing your articles to be published in English?*
Choose the ones that you agree with

- [ ] I wish to get cited more frequently.
- [ ] I wish my research to reach an international audience.
- [ ] Writing in English will advance my professional promotion.
- [ ] I am used to writing my articles in English.
- [ ] Writing in English will develop my writing ability.
- [ ] I like challenges.
- [ ] I am expected to write in English.

Other
Please specify

14. Which of the following methods do you generally apply when you write your scientific papers?*

- ( ) I write my scientific papers in my native language and (when necessary) translate them into English.
- ( ) In the first version(s) of my scientific papers I use both my native language and English.
- ( ) I write my scientific papers in English.

15. Reasons for possible difficulties in scientific writing in English
Choose 3 at most that you agree with

- [ ] My scientific writing experience so far
- [ ] My writing technique
- [ ] Linguistic reasons
- [ ] Self-confidence in writing
- [ ] The amount of feedback received from content lecturers and supervisors

Other
Please specify

16. Which aspects of writing research articles do you find most difficult?
Please rank the following in a scale of one (min) to 5 (max)

	1	2	3	4	5
Linking together the different ideas, paragraphs and sections of the article	○	○	○	○	○
Creating text flow and coherence to make my reasoning easy to understand	○	○	○	○	○
Expressing my interpretation of the results with the appropriate degree of confidence	○	○	○	○	○
Reviewing the literature	○	○	○	○	○
Expressing my ideas in correct grammar	○	○	○	○	○
Applying the general academic writing vocabulary	○	○	○	○	○
Applying the academic style and specific terminology in my field	○	○	○	○	○

Other
Please specify

17. Which of the following courses (if any) have you completed or are you attending at TUT?

- [ ] English for Engineers
- [ ] Written Communication in English
- [ ] Scientific Writing
- [ ] Academic Writing in English
- [ ] Thesis Writing
- [ ] Research Writing
- [ ] Writing Clinic

18. Do you feel that the TUT English writing courses have improved your scientific writing skills?

- ( ) Yes, a lot
- ( ) A little
- ( ) Not much
- ( ) Not at all
- ( ) I don't know

19. What type of support would help you to improve your English scientific writing skills?
Choose 4 at most that you agree with

- [ ] Constructive feedback from the content lecturers and supervisors in my academic field
- [ ] Group work and practical workshops on scientific writing
- [ ] Peer-based writing support
- [ ] Teaching of the general formal features and conventions of academic writing
- [ ] Explicit training in writing research articles for publishing purposes
- [ ] One-to-one writing tutorials
- [ ] Consulting native English-speaking colleagues within my field
- [ ] Comments from proofreaders
- [ ] Comments from editors and peer reviewers about my writing
- [ ] Computer-based interactive courses

20. Please add any thoughts regarding the subject

APPENDIX C: TEXT SAMPLES

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[8] V. Ratia, I, Miettunen and V-T Kuokkala, Surface deformation of steels in impact-abrasion: The effect of sample angle and test duration, *Wear*, 301, 2013, pp. 94-101.

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