Teaching technical writing in multilingual contexts: A meta-analysis

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Abstract: Teachers of technical and professional writing in Science, Engineering and Technology (SET) Programmes need to understand the particular needs and social contexts of students for whom English is not a first language. The focus of this paper is on technical writing, and the paper presents the findings from four broad areas surveyed in a meta-analysis of research articles on curricular, teaching, learning and assessment practices for university-level English technical communication in multilingual contexts. Communication lecturers in the SET professions are faced with decisions regarding the kind of language forms, topics and purposes to address when teaching, developing materials, or designing assessment tasks for a multilingual technical communication class. It is hoped that this meta-analysis will provide communication lecturers, who work within SET fields, with information for effective and inclusive practice.

Introduction

There are a number of empirical studies in the field of technical writing, and these are available to inform the programmes and practices of communication lecturers. Extensive Internet searches using a variety of databases captured approximately 60 research-based studies on teaching writing to students for whom English is not a first language (hereafter ESL students). Selection criteria for inclusion in the data base required the article to be empirically based and to deal with ESL students' strengths and difficulties in acquiring specific aspects of technical writing. The studies included in the meta-analysis fall into four broad areas of interest: studies that are concerned with the lexico-grammatical level of writing, studies that focus on textual organisation, genre studies, and studies that focus on technical writing as a social practice. The focus of this paper is on the implications of the meta-analysis findings for the teaching of technical writing to ESL students; the full report covers a wider range of issues (Winberg, van der Geest, Lehman & Nduna, 2005).

A brief overview of the characteristics of standard technical writing

The characteristics of technical writing have largely been identified through corpus linguistic studies that reveal how expert writers use passives, nomalisations, lexical bundles, syntactic frames (such as titles and sub-titles), as well as the vocabulary frequency and appropriate word and sentence usage in particular disciplines (Bazerman & Paradis, 1991). Standard technical report writing is strongly structured in terms of introduction, methods section, and solution (or versions of this) (Bazerman & Prior, 2004). Within this organising framework, generalisations must be supported, and the writer must move logically to subtopics, maintain relevance within a topic, and create logical links between sub-topics (Berkenkotter & Huckin, 1995). Standard technical writing is economical and to the point; writers tend to use short sentences, and organise paragraphs thematically (Duin & Hansen, 1996). The reader expects a balance between the writer's own input and the use of other sources. The expert technical writer is expected to achieve an acceptable level of originality, and must scrupulously avoid plagiarism (Ornatowski, 1992). Technical manuals have little contextual and overview information, and are direct and task focused. Thatcher (1999) found that when English first

language (L1) technical writers revised and edited ESL texts, they consistently re-worked concrete and particular patterns into more abstract and universal patterns, and changed accumulative into analytical logic structures.

In academic SET contexts, five basic technical writing genres are identified: experimental/ laboratory reports, design reports, summary papers, case studies, and research papers (Braine, 1995). Each of the identified genres has common features: an abstract, an introduction, a theoretical section, a procedures section that includes methods, apparatus and materials, a results section, a discussion of the results, a conclusion, and sometimes recommendations. The order and the emphasis of these elements depend on the discipline. Some disciplines require very little in the way of contextual information and narrative linking text, preferring tables, lists, diagrams, and other schematic forms of representation. Other disciplines require more background information and more narrative linkages. There is usually a prescribed format for the different forms of technical writing. For example, engineering literature reviews are characterised by the critical appraisal of sources, a tendency not to quote verbatim, and the inclusion of a few, focused citations (Selzer, 1983).

Authentic technical writing tends to be more innovative than prescriptive tools and templates allow, and expert writers will modify standardised forms. Levis and Levis (2003), for example, find a great variety in the application of the introduction-method-results-analysis-discussion formula in professional technical reporting. There is usually a high level of participation and collaboration in terms of text production, as well as the provision of feedback on others' texts in workplaces (Pogner, 2003).

Research findings: The characteristics of ESL technical writing

ESL technical writers do not constitute a homogenous group. Writers have different levels of English proficiency and different levels of experience with scientific, academic, professional and technical writing. Some are novice writers, others are experienced technical writers in English or in their home languages. Some ESL speakers are more proficient at oral communication, while others experience difficulties with face-to-face communication.

Lexicon and grammar

ESL writers experience greater or lesser difficulties at the lexico-grammatical level, dependent on their levels of English proficiency and experience in the technical context in which they are learning to write (Munilla & Cox, 1998; Yeo, 2001). Difficulties noted by researchers at the level of vocabulary include general editing and an inappropriate mix of standard and technical English. Leki's (2003) Chinese-speaking student nurses experienced particular difficulty with semi-technical (rather than technical) language, while Tichenor's (1994) ESL students experienced difficulties with 'sub-technical' vocabulary and with acronyms and abbreviations in particular.

Textual organisation

ESL writers experience difficulty with applying a coherent organisational framework and there is often a failure to link across paragraphs (Newman-Nowicka, 2004). Davies (1997b) finds that unsuccessful ESL students introduce many new topics, use 'pseudo organisers' (headings or introductions that raise expectations that are not met), and maintain little coherence in the information flow. Introductions pose difficulties for ESL writers in terms of the appropriateness of introductory terminology, the amount of contextual information needed, topic identification and coherence, provision of overviews, and reader orientation. ESL writers' difficulties with the methods section of technical reports include: problem definition, referentiality and continuity. Davies' (1997a) engineering students experienced the most difficulty with confirming and referencing claims. In a study of technically orientated business letters, Knoy (2000) found that ESL engineers' experienced difficulties in expressing clear statements of purpose, succinct rationales, appropriate background information, proactively making suggestions, commending, inviting, explaining benefits, setting an itinerary, and coming to the point when making requests.

Disciplinary genres

Studies confirm that many ESL engineering students have the content knowledge and writing

skills to produce competent engineering reports; their main difficulties have to do with writing in the conventions of the genre, not fully understanding the requirements of an assignment, or becoming confused when taught to write in more than one genre simultaneously. For example, Silyn-Roberts (1997) found that all but the most able Mechanical Engineering students in her study were confused by learning to write in two genres: the technical report and the academic essay.

The literature review is a genre that causes considerable difficulty. Students have difficulty in managing multiple references and in integrating data from various sources. They therefore tend to 'plagiphrase' (Melles, 2005), that is plagiarise entire phrases as a compensatory strategy.

Social practice
Students' writing is likely to be influenced by the social hierarchies and politeness strategies of their home cultures (Newman-Nowicka, 2004). Japanese manuals, for example, have polite introductions, and avoid introductory summaries, which are seen as impolite or arrogant, preferring to present material which is then summarised at the end (Amant, 1999). Asian students' writing may seem circuitous, with delays in the introduction of purpose (Tichenor, 1994). Sentences are longer than those of US technical manuals, possibly because sentence length is associated with level of education and with the complexity of technical item. South American technical writing is characterised by the inclusion of historical and contextual information, concrete and particular patterning, and accumulative logic (Thatcher, 1999). Thatcher finds South American ESL writing close to oral 'high context' communication forms, collective and particular patterning in written communication, narrative and accumulative features of text, high power distance, collaboration and quality (Thatcher, 2000). In a project in which English L1 and English ESL students in different countries collaborated on a computer documentation project, Duin and Archee (1996) found that only 25% of the average e-mail content was task focused; 75% of all e-mail correspondence had to do with the contextual and background information required to enable partners to collaborate constructively.

Many ESL writers are inattentive to, or confused about, audience. When writing in English, ESL students experience a confused sense of audience. In a case study in Papua New Guinea, technical writers tended to show how much they had read, rather than communicate specific information (Moody, 1992). When technical writing instructors included the two main local pigeon languages, *Tok Pisin* or *Tok Ples*, in a broad communication strategy, the writers had a clearer sense of text purpose and audience, despite students' initial reluctance to use local languages. Engineering was perceived to 'belong' to English rather than to *Tok Pisin* or *Tok Ples*. In a study of Master's students' writing, Mexican students writing in English did not have a sense of purpose; writers focused on format and presentation, without taking into account their audience (Evia, 2004). For ESL writers, compliance gaining in different cultural contexts can involve a range of strategies which English L1 writers might find inappropriate or strange, such as: friendliness, promises, threats, and demonstrations of positive and negative outcomes (Warren, 2004).

There is a danger of stereotyping and over-simplifying cultural influences on writing. Many rhetorical differences, such as originality and hyper-codification, are informed by local usage while others, such as distance and procedures, tend to be based on personal choice, or adaptation for a specific audience. Studies do, however, emphasise that the concise, terse style of technical writing is often in conflict with the home cultures of many ESL writers (Williams & Pimental, 2010).

Implications for teaching, learning and assessment
Programmes that include input from ESL students at all levels tend to be more successful. ESL students who were consulted on their own technical writing needs recommended: a basic 'four skills' introductory course, materials to encourage deep thinking, coursework that is immediately applicable, a communication curriculum that is integrated with technical training, out-of-class opportunities to use English, electives suited to students' needs and levels, and more classes that are short in duration and have small numbers of students (Yoshida, 1998).

Lexicon and grammar
Decontextualised grammar instruction is not effective; the teaching of grammar, vocabulary, and

discourse structures needs to be located within contexts that make the writing activity meaningful to the writer. Topics should be meaningful to students and the technical context in which they are learning, and the course should meet students' specific learning and career needs. Appropriate contexts can be created by the use of problem-based learning. Rainey (1990) suggests that instructors should control problem-based learning to avoid potential 'bottlenecks'. For example, doing an authentic literature search is very time consuming; in order to focus on the language development task, students can be given specific, relevant readings.

Teaching at this level should enable ESL speakers to self-correct. According to Pogner (2003), the extensiveness of students' text revision indicates their level of membership within a technical writing community. When ESL students use on-line grammar correctors, such as Grammatik, in conjunction with compatible technical writing manuals (Conrad, 1996) they are more able to self-correct. Improvements that were noted when ESL writers used a combined approach included: correct spelling, intelligent use of the passive voice, appropriate variety in sentence length, and clear formatting of documents. Teachers need to choose textbooks and manuals that are sensitive to ESL technical writers' needs. Thrush (2001) for example, warns that simplified 'Plain English' may cause more problems than it solves in a technical context, and that the appropriate technical terms should be taught to ESL students.

Textual organisation
The application of formulaic technical writing models is not advised, but the analysis of such models by ESL students and teachers can raise awareness and socialise students into the disciplinary culture (Master, 1997). Report writing can be learned through an integrative approach, and the teaching of appropriate frameworks and techniques. Rainey (1990: 134) finds four factors to be particularly helpful: one-to-one conferencing (which can include formative assessment of students' work), the provision of 'meticulously detailed and clear instructions', multiple drafts, and peer assessment.

The different levels of textual organisation (global, textual, sentence) need to be understood within particular disciplinary or professional contexts, as there is likely to be considerable variation between disciplines. Communication lecturers should draw on a variety of approaches to teach sentence level cohesion, such as the given/new organising structure of Systemic Functional Linguistics (Knoy, 2000). The sentence level subject-verb-object word order should also be taught, together with authentic examples from the discipline or professional context (Stoller *et al*., 2005). In teaching global organisation strategies, instructors need to raise awareness of appropriate rhetorical structures, such as parallel structures, which aid coherence (Marshall, 1991). Teaching coherence at the paragraph level should be accompanied by information on the importance of focus, relevance, and limiting new (and possibly irrelevant) information (Hallet, 1997).

Disciplinary genres and cultures
Gender, class, and prior subject knowledge influences writing proficiency in disciplinary and professional genres. Prior experience with generic English writing is an advantage for ESL students enrolled in technical writing courses. Older students are more likely to be familiar with professional genres, rather than academic ones (Harvie *et al*., 1997; Parks & Maguire, 1999; Leki, 2003). Writing is easier to learn in a new genre (whether academic or professional) when there is an open, explicit approach.

Explicit teaching of the conventions of the genre is recommended. Explicit teaching of the literature review enables ESL students to integrate secondary sources, address particular audiences, manage the formal rhetorical structures of headings, format references, as well as integrate visual and graphic representation. Acculturation into technical genres is facilitated when more experienced mentors are available. Parks and Maguire (1999) found that four types of collaboration enabled Francophone nurses to appropriate genre-specific language: traditional (i.e. consultation with colleagues), committee (in which the broader group takes responsibility), 'incidental' (which, in a more focused study, Parks (2000) describes as both self-initiated and other-initiated, although the ESL nurses were more likely to interact with colleagues with whom they were linked in an official

or semi-official capacity), and 'covert' (which involved the use of an English L1 colleague's notes as a model). Over a 22-month period, Parks and Maguire (1999) noted an improvement in nurses' documentation procedures.

Social practices
Communication lecturers need to understand the appropriate audiences for technical communication and gear courses towards this (without losing the pedagogical importance of more generic technical writing in English). There is also a need to explore the potential of including local languages in technical courses for professional as well as pedagogical purposes (Moody, 1992; Qiuye, 2000). ESL instructors need to familiarise themselves with the dominant communication modes of their ESL students – such as the relative importance of contextual exemplification, acceptable levels of flexibility for dealing with a collective based culture, levels of flexibility in writing practices to accommodate preferred writing styles, and awareness of the role of writing in power relations. The instructor needs to be aware not only of culturally based rhetorical preferences, but also of the range of individual and local choices within the larger cultural frames. For example, the style of US and Chinese engineers' technical reports could be quite similar, but the letter-writing practices of US and Chinese engineers might be quite different.

The importance of audience analysis in technical writing cannot be overestimated (Ward, 2009). Students need to be able to 'recast', that is, revise or rewrite their work in a more appropriate style for different audiences. The provision of models, inclusive technical writing instructional materials for ESL students, and clear explanation of assignments are important for helping students to understand the audiences of technical communication. The communicative theory of compliance gaining offers some suggestions for how technical writers can adapt texts to enhance user acceptance when communicating within and across cultures. Teachers need to understand how to combine rhetorical with compliance strategies for effective technical communication (Warren, 2004).

Many researchers comment on ESL students' 'fear' of writing and the concomitant need for instructors to ease apprehension and build a more positive attitude towards writing. Classroom practices that take into account, and affirm, the diversity of ESL writers facilitate students' acculturation into particular ways of writing. For example, in environments where there is tolerance of typical L2 errors, and acceptance of different politeness structures and strategies, ESL writers are able to write more effectively (Thrush, 1993). There is a need to build an inclusive classroom culture to facilitate learning. This can be done by setting collaborative writing tasks, following a supported writing process, providing useful feedback, including peer review and opportunities for revision. In order to accommodate ESL students, ESL instructors should: revise course objectives, consider classroom dynamics, discuss diversity, choose texts carefully (for level and inclusiveness), devise projects based on diversity, and recognize difference in students' writing styles (Scheffler, 1995). Four techniques are effective in building inclusive classroom cultures: one-on-one conferences (aimed at easing apprehension), clear and detailed instructions, feedback on successive drafts, and peer evaluation (Rainey, 1990). Thrush (1993) suggests a three-pronged approach: raising awareness in classrooms, providing information/resources and providing opportunities for practice. Studies confirm that it is important for teachers to build confidence and students' 'writer' identities through cooperative practices and the positive tone of teacher-student exchanges. It is, as Paré (2000) points out, not possible to teach technical writing outside of the context in which it operates.

Conclusion
The improvement of ESL students' textual organisation requires an authentic writing curriculum that involves collaboration between communication and discipline-based lecturers (Stoller *et al*., 2005). The lack of shared knowledge between communication and SET lecturers creates limitations for the teaching of technical writing by writing specialists in terms of vocabulary, semantic choices and conventions of the discourse (Davies, 1997a). The need to broaden the language educator's role into the specialist area is assisted by the use of authentic samples and models

of technical writing (Hallet, 1997). SET educators are often not qualified to meet ESL students' language needs. SET lecturers tend to focus their feedback on surface error correction. The implications of these findings include: sharing of responsibility, integration of language and discipline content, explicitness of expectations, sensitivity to language differences, and cross-cultural awareness. The integrated teaching of writing with disciplinary content is therefore recommended. Communication lecturers in ESP fields should be familiar with key concepts, understand discourse characteristics, and   processes, and be aware of disciplinary value systems, repertories and strategies (Carreon, 1996).

The recommendation is then that lecturers aim for: discipline specific writing courses, a focus on the experimental or laboratory report, explicit and meta-cognitive teaching of the genre conventions, de-emphasising the research report in science, engineering and technical contexts (Braine, 1995), providing clear and consistent guidelines for assignments and in feedback, providing handouts and explanations that break tasks into manageable 'chunks', ensuring that comments and marks correlate with each other and with explicit criteria for evaluation, and providing opportunities for repeating practice in new genres. Both explicit writing teaching is needed and what Pulko and Parikh (2002) call 'embedded' writing instruction in mainstream subjects.

Ideally, technical writing instruction should integrate English language development within programme focused, content instruction. The ESL student, and his/her future profession, might be better served by requiring students to write according to clear technical report writing principles, rather than including essay writing. Traditional academic writing assignments do not necessarily help ESL students with technical writing tasks. In their study, Stoller and colleagues (2005) identify the need for multidisciplinary collaboration in discipline-specific writing; in the project described there were two applied linguists, two Chemistry faculty members, one assessment expert, and one web consultant. Most researchers recommend the use of authentic (primary) materials (e.g. Leki, 2003; Yeo, 2001) and authentic tasks at the appropriate level (e.g. Braine, 1995; Levis & Levis, 2003) for undergraduate students.

The use of authentic materials and tasks raises cultural awareness (Koltay, 1999). Teachers need relevant texts, including textbooks and journals as sources of information and as resources for the teaching of technical writing to ESL students (Zielinska, 2003). The use of authentic tasks, set by content faculty, and peer feedback is useful and time saving. In graduate writing courses there is a need for collaboration between the technical writing instructor and the advisor. The ESP instructor should facilitate student and instructor explorations of terminology and writing conventions, task based approaches using authentic tasks and texts, self-assessment (in cases where the instructor has minimal knowledge of the discipline), and assistance from content experts (for syllabi, choices of tasks and texts, and so on) (Fuentes, 2000).

In terms of developing technical writing competence there should be an awareness of how generic communication and technical communication are conceptualised and interrelated in the curriculum. General writing (such as note-taking or e-mail correspondence) is important in facili-tating problem solving tasks within technical writing contexts. In some cases a more pedagogi-sised version of a professional writing form is needed to facilitate students' learning. If this is the case, as in Leki's (2003) project, communication lecturers need to explain to the ESL student why, for example, they are required to write more formal Nursing Care Plans in the academic classroom than those required in the clinical context; and why the criteria for communication might be different in the academic and clinical contexts – as well as how and why the demands for accuracy in the academic context will enable ESL students to achieve the level of accuracy needed in clinical (and other) contexts.

A general-to-specific approach is recommended. The lecturer should provide ESL students with both generic principles of technical writing and authentic examples of texts. The relationship between the principles and how the authentic texts and models differ or are the same as more generic examples should be discussed. 'Top down' (organisation, problem-solution, advantage-disadvantage, cause-effect, compare-and-contrast) features, contextual features (audience, purpose) and lexical and grammatical features need to be taught. The selection of specific writing skills is important, as is the need to match curricula with needs.

Writing tools, templates, and models for the teaching of technical writing should not be rigidly applied. Once the student is familiar with a writing template or model, they should be introduced to variants, and guided in the adaptation of the format to the topic in hand. Teachers should use authentic examples of writing from models to show adaptation. The importance of pedagogies of collaboration and modelling of authentic texts is necessary in learning to write for specific purposes.

Teachers of technical writing need to take into account the socially embedded nature of writing in the workplace. Mapping the sub-cultures of an organisation, becoming aware of its communication practices, and consulting widely are strategies for novice writers to build their understanding of organisational cultures.

Issues for further research

Many of the issues for further research listed below were identified by the surveyed authors, but the authors of this paper identified several additional research gaps. Addressing these research gaps would be an important way of taking work on technical writing in multilingual contexts forward.

As many of the studies are small in scale and located within a single context, site or community there is a need for what Payne and Williams (2005) call '*moderatum* generalizations', which are modest, pragmatic generalisations that can bring 'a semblance of order and consistency' (Payne & Williams, 2005: 298) to research findings and ensure some dependability in their use by writing instructors. Confirming studies, in which the tools and approaches are tested in different sites and contexts with different communities (particularly different linguistic and cultural contexts) are necessary to support researchers' claims. There is also a need for more focused studies. Most of the studies treat technical writing as a broad concept. There were very few studies on specific aspects of technical writing in engineering or health sciences. Many of the studies of ESL technical writing were not directly in technical fields, but were in the fields of commerce and trade linked to technology development and transfer, so there is a need for more studies in 'hard' technical fields. There are practically no studies of ESL writing in other medical disciplines or health sciences. Most of the studies in the meta-analysis involved the technical writing practices of students, rather than professionals, and were located in higher education institutions rather than in places of work. Work-based studies were relatively rare, and tended to be confined to studies where there is traditionally movement between the educational institution and the workplace, such as teaching hospitals. Confirming studies in workplace technical writing, with a particular focus on achieving such literacy in context-dependent cultures are needed.

Many studies are practitioner based, and comprise reflections on practice. Such studies are particularly meaningful to the practitioner community, and we support these studies. What is needed, however, are more systematic approaches to practitioner research. For example, evaluations of technical writing programs are needed to support the claims made about the success of various programmes. Confirming studies, particularly with regard to recommendations for improvements to the programme and writing technologies would also be helpful to practitioners wanting to learn from research or to implement research-based findings. Most of the research surveyed was of relatively short duration (less than one year), with a few exceptions. Additional longitudinal case studies, or other forms of prolonged engagement with research participants in various technical disciplines and related professions, are important for the dependability of the research findings of the field.

Technical writing is a hybrid discipline, located at the intersection between Linguistics/Applied Linguistics and a variety of scientific, technical and professional fields. Investigation into the nature of this hybridity is required, in particular with regard to forms of interdisciplinary collaboration in the teaching of technical writing. When novice communication lecturers are located within different technical disciplines, the nature of such collaboration is particularly important. This would include further investigation into the role of Applied Linguists in technical writing contexts, and a clearer mapping of the spaces between the writing professionals and the professional writers.

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