Scaffolding Scientific Writing through Disciplinary Literacy Instruction

Gde Buana Sandila, PUTRA

National Institute of Education

Nanyang Technological University, Singapore

Sihua Ken, OH

CHIJ St. Joseph's Convent, Singapore

Kok-Sing, TANG

National Institute of Education

Nanyang Technological University, Singapore

Abstract

One of the competency domains gaining prominence in the 21st century is communication skills. In Singapore, emphasis has been given to develop students' communication skills in all subjects. Despite a curriculum emphasis on communication skill, scientific communication skill such as scientific writing skill receives little attention and is often neglected in Science classrooms. This research study explored and examined how scientific writing was taught in a Chemistry classroom over the course of two weeks in a Secondary Three class. Informed by a disciplinary literacy approach of explicitly teaching the language and genre processes of the discipline, a series of lessons on the topic of the Atmosphere and the Environment was designed to scaffold the writing of the scientific article. The series of lessons incorporated a range of literacy activities such as reading, discussing, and writing. Student-generated articles were analyzed through genre analysis to examine their resemblance to conventional scientific report articles. Teacher's pedagogical strategies were analyzed sequentially. The current findings suggest that explicit teaching, coupled with proper scaffolding, results in student- generated articles that resemble conventional scientific articles. These findings imply that students at Secondary level are able to acquire the set of skills necessary to communicate in a Science community through literacy instructional scaffolding in the genre of scientific report articles.

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Introduction

One of the competency domains gaining prominence in the 21st century is communication skill. In Singapore, emphasis has been given to develop students' communication skill in all subjects with the launch of Whole School Approach to Effective Communication program by the English Language Institute of Singapore. Despite an increasing attention has been given to develop communication skill, the teaching of such skill is often neglected especially in Science classroom.

In today's age of Internet, students are bombarded with torrents of information. In the context of Science classroom, students may have to access and retrieve scientific information for their learning and for that they have to read scientific writings or texts. Scientific texts are often underestimated and thought to be the same as any other texts except for its content. However, studies suggest that the discipline of Science has its own peculiar language, linguistic features, and practices (Fang, 2005; Lemke, 1990; Wellington & Osborne, 2001) which lead to some difficulties in reading scientific texts.

To be able to navigate in the discipline of Science, students have to be disciplinarily literate – literate in Science. Disciplinary literacy is the ability to use the specialized language, representations, and practices of a discipline to navigate across the discipline. To be disciplinarily literate, students have to learn the linguistic processes of the discipline (Moje, 2007). Thus, they need to be exposed to and taught explicitly to understand and even produce disciplinary texts. Having understanding of how texts in the discipline constructed will enable students to make sense scientific writings they access.

Descriptive writing is one of the written genres that students often encounter when learning Science. Students may encounter this genre in Science textbooks, science-related

newspaper or magazine articles, and the internet every day but the teaching of it is often neglected. This study, therefore, attempts to address the gap in current teaching practices by introducing explicit disciplinary literacy instruction, focusing on building students' descriptive writing skill in secondary school Science. This study aims to examine students' ability to write descriptive scientific texts, though with scaffolds.

Theoretical and Analytical Framework

This study is informed by a disciplinary literacy approach that views teaching linguistic processes of the discipline as a central aspect (Moje, 2007). This approach suggests that the linguistic features of texts of a particular discipline can and should be made explicit to students in the classroom so that students are more familiar with the texts they face in the discipline. The lesson series enacted by the teacher in this study was designed with this approach in mind. Students were briefly informed and shown the linguistic features of scientific articles. The genre analyses of student-generated articles were done using two lenses, namely Systemic Functional Linguistics and English for Specific Purposes.

Systemic Functional Linguistics

Halliday's (1994) systemic functional linguistics (SFL) has gained traction in the area of disciplinary literacy due to its precision in clarifying how disciplinary learning is dependent on language. The basic goal of a functional linguistic model of language and learning is that it provides student with "access to, and control of, the written texts of mainstream education, for example, a persuasive essay, a laboratory, report, or a critical review of an artwork of literary text"(Coffin, 2006, pp. 413–414). According to Coffin (2006, p. 414), functional linguistics seeks to "bring consciousness (both for teachers and students) the way in which such texts are linguistically structured and shaped and the way in which

writers draw on grammar and lexis (i.e., vocabulary) to create different communicative effects".

SFL has been widely used to study the discourse in various areas. Through SFL, several studies in linguistic features of academic language learning (e.g.,Schleppegrell, Achugar, & Oteíza, 2004; Schleppegrell & Achugar, 2003) reveal that the language used in academia, both written and oral, is different from everyday language in terms of (a) the informational density, (b) the level of abstraction of concepts, (c) the technicality of concept presentation, (d) the type of voice that dominates, (e) the use of multiple semiotic systems, and (f) the structural conventions. Fang (2005) specifically studied the language used in the science discipline and described four special features of scientific writing which are (a) the high informational or lexical density, (b) the high level of abstraction achieved by mainly nominalization, (c) the frequent use of technical vocabulary, and (d) the use authoritative and objective tone. These special linguistic features of scientific writing will be the central of our analysis of student-generated articles. How these features aid the analysis will be elaborated in the methodology section.

English for Specific Purposes

Genre analysis through SFL tends to focus on the linguistic features of texts rather than the organization structure. In English for Specific Purposes (ESP) branch of study, there is a focus on analyzing the organizational structure of texts - analyzing how a text is organized to achieve its communicative purpose. The organizational structure of texts highlights the cognitive aspects of language organization (Bhatia, 1993). Texts in a particular genre tend to be consistent in the way the components are organized, and this suggests that specialist writers have preferred ways of communicating intention effectively in a particular genre.

A text performs specific rhetorical actions or moves in a certain sequence to achieve its communicative purpose. Analysis of move sequence or structure was pioneered by Swales (1981) through his work on the Creating a Research Space (CARS) model. Through analyzing a corpus of introduction section of research articles, Swales established a four-move structure which consists of (1) establishing the research field, (2) summarizing previous research, (3) preparing for present research, and (4) introducing the present research. These salient moves mark the genre of introduction of section of research articles. This means that any text that has such move structure is likely to be an introduction section of a research article. This concept of a particular move-structure marking a particular genre will be used to aid analysis of student-generated articles, which will be elaborated in methodology section.

Methodology

Research Context

The data for this study are taken from a design-based research situated at a Secondary Three Chemistry classroom of an all-girls school in Singapore. In this research, we designed a lesson series on the topic of Atmosphere with the classroom teacher. One of the literacy objectives of the lesson series was to develop students' ability to write scientific article. In the lesson series, students were tasked to do a simple research and writing as a warm-up, then briefly taught the linguistic features of scientific article through modelling, and given scaffoldings to help them write the articles in the forms of a set of readings, worksheets, and grading rubrics. The 28 students were grouped into 7 groups of 4 and each group was assigned a topic to write about. Students were given time to read, discuss, and write as a group. Most groups used online Google Docs as a tool for collaborative writing. Addition to the scientific articles, students were required to transform their articles into presentation.

Most students chose to do presentation using Microsoft Power Point. At the end of the lesson series, 7 scientific articles were collected and analyzed.

Each reading set consisted of 4 articles of the same topic, obtained from various sources, ranging from National Geographic articles to undergraduate level scientific articles published in university websites. The worksheet was adapted from Literacy Design Collaborative's template tasks (Crawford, Galiatsos, & Lewis, 2011). Each group was provided with a role-play scenario in which students need to write an article as environmental chemists to educate secondary school chemistry students about an environmental issue. Four scaffolding questions were given to help students know what information they need to look out for: a) What is <phenomenon>? b) How does it come about? c) What are some of the consequences? d) How can we minimize the consequences? Grading rubrics given to students contained the points that the teacher was looking out for, as well as the structures that students can follow in their writings.

Analytical Method

The data sources used in this paper included videos of classroom observations and student-generated writings. Videos of classroom observations were analyzed sequentially to examine how the explicit teaching of scientific writing was carried out in the Chemistry classroom. Student-generated writings were analyzed to see how closely their writings resemble typical scientific articles. We used SFL perspective (Fang, 2005; Halliday & Martin, 1994) to analyze the linguistic features present in student-generated writings such as lexical density and authoritativeness, and genre analysis (Bhatia, 1993; Swales, 1981, 1990) to analyze the move structure in students' scientific articles and compare it with an established move structure found in typical descriptive scientific articles. The analysis provided an insight into how well students wrote scientific articles.

Linguistic Features

Fang (2005) described four special features of scientific writings: high informational density, abstraction, technicality, and authoritativeness. These four features distinguish scientific writings from texts from other discipline.

Informational density refers to the packing of information within a text. Informational density can be measured by an index called lexical density. Lexical density can be measured in two ways: (a) as the number of lexical items or content words per non-embedded clauses (Halliday, 1994),or (b) as percentage of content words over total running words (Eggins, 1994). Content words include nouns, the main part of the verb, adjectives and some adverbs; non-content words include prepositions, conjunctions, auxiliary verbs, determiners, pronouns, and some adverbs. A clause minimally consists of a subject (as expressed by noun phrase) and a predicate (as expressed by verb phrase). Figure 1 below exemplifies how lexical density is analyzed in a text. In Figure 1 there are 38 content words, 6 clauses, and a total of 71 words. This results in a lexical density of 6.3 content words per clause or 53.5%.

Ozone layer is a **belt** of **naturally occurring ozone gas** that **sits fifteen** to **thirty kilometres** above **Earth.** // Its **purpose** is to **shield Earth** away from **harmful ultraviolet B radiation emitted** by the **Sun**. // **Ozone** is also a **highly reactive molecule**. // It **contains three oxygen atoms**. // It is **continually** being **formed** and **broken** down in **stratosphere**. // **Stratosphere** is the **second major layer** of the Earth's **atmosphere**.

Figure 1. An excerpt from student-generated article Ozone 1. Clause boundaries are marked with //. Content words are in bold.

In the discipline of science, information is typically presented accurately and objectively as well as is in assertive tone (Schleppegrell, 2002), resulting in the feature of authoritativeness. Typically, texts are written without first person references, reference to mental processes, direct quotes and vagueness (Chafe, 1982). Informal and interactive

language, while intended to engage readers, is rarely found as it lessens the degree of objectivity and impersonality. In analyzing student-generated articles, the number of instances of informality is counted. For example, "*if your parents must use the car, ask them to avoid it...* " (an excerpt from student-generated article Ozone 2) has two instances of informality as underlined. Both instances attempt to interact with readers by including readers in the text (as denoted by "*your parents*") and using imperative clause (as denoted by" *ask them...*").

Abstraction is a feature that removes immediate lived experiences to build truths (Christie, 2002) which typically achieved by means of nominalization. Nominalization turns processes (as expressed by verbs and adjectives) into participants (as expressed by nouns). Technicality is another related feature. Scientific articles cannot be written in everyday language as accurate and precise use of words is essential to capture scientific concepts and ideas. These two features may be reflected in informational density of texts. Both features tend to have extended noun phrases that increase the number of content words, hence lexical density.

Move Structures

The genre of the student-generated articles is descriptive scientific article. Typically the communicative purpose of such genre is to inform readers certain scientific phenomena, concepts, or ideas. One distinguishing trait that differentiate descriptive scientific article from scientific research article is that descriptive scientific article rarely reports original and new experience or concepts. Thus, the move structure of descriptive scientific writing is more akin to that of academic essay than to that of scientific research. Writing guides for writing scientific essays at undergraduate level or high school level (e.g., Cresent Public Schools, n.d.; Monash Univeristy, 2007) are sufficient to describe the move structures in descriptive

scientific article as they share similar communicative purpose and trait. The move structure of such genre can be generalized, simplified, and described as illustrated in Table 1. Figure 2 exemplifies how the analysis is done.

Table 1
Move Structure of Descriptive Scientific Article

Stage	Move Structure		
Introduction	Move 1	:	Introducing the topic of the article
	Move 2	:	Giving necessary background information for the article
Body	Move 3	:	Introducing a scientific idea, concept, or phenomenon
	Move 4	:	Elaborating the idea, concept, or phenomenon
Conclusion	Move 5	:	Summarising key points
	Move 6	:	Stating the conclusion
Reference	Move 7	:	Citing references

Move 1 is identified by locating the keyword that encompasses and drive the flow of the article. For example in Figure 2, there is a mention of "there is certainly global warming" which introduces to reader that the article is about global warming. Move 2 is identified when relevant background information such as definition and examples is presented. In Figure 2, the definition of global warming is stated and elaborated to give readers enough information to be able to follow the subsequent information. Move 3 is typically identified by identifying the topic sentence of the body paragraph. Move 4 is identified when sentences after the topic sentence answer the 'so what?, 'how? 'or 'why?'. In Figure 2, Move 4 answers how humans contribute to global warming (Move 3). Move 5 is identified by looking at repetition of key points in the body paragraphs. The penultimate Move 6 concludes the article by stating the main idea of the article, or the moral of the article. In Figure 2, there is re-statement of global warming currently happening and that humans have to make choices. The ultimate Move 7 is simply citing the references used in writing the article.

Move 1

Doomsday is approaching.

Well, we don't know for sure, but there is certainly global warming, which all the more confirms this statement. What is global warming? It is the slow and steady rise in the overall temperature of the earth's atmosphere mainly due to the greenhouse effect caused by increased levels of carbon dioxide, CFCs, and other pollutants. Move 2

What are the causes of Global Warming? Move 3

Human beings have caused the greenhouse effect, by increasing the carbon dioxide (CO_2) concentration in the atmosphere by about 30%. This increase in CO_2 concentration contributes to global warming by increasing temperatures. This is because heat energy from the earth, or infrared radiation, is trapped by CO_2 molecules. Thus heat energy is retained in the earth's atmosphere by CO_2 gas, causing a rise in temperature of the earth. Move 4

Conclusion Move 5

In conclusion, global warming is a serious matter. We have to take really quick action on this matter, or our whole planet will be in danger. Humans can lose homes, food and possibly even their lives due to extreme climate changes. We should implement measures such as the three 'R's and find new ways to produce electricity. Whether doomsday comes or not, the consequences of global warming are very real and are happening presently. The ultimate choice on whether to act on this problem lies with us. Move 6

Figure 2. An excerpt from student-generated article Global Warming 2

Validity

The validity of the resemblance of student-generated articles to typical scientific articles may be questioned. Students could have lifted sentences or even paragraphs from their sets of readings or internet. The claim may be valid but the act of lifting is still a step towards mastery of scientific writing for students.

Undeniably, a case of lifting might occur; however, students still need to adjust the language of the articles that they have come across to the level of that of secondary school chemistry students, as the assignment specified. They need to transform technical words and scientific ideas in their readings to something that they understand and are able to convey to their fellow chemistry students. In addition, students need to look out for information that is relevant for their articles. They have to think and decide which information to include and discard in order to craft a clear and concise scientific article. In terms of organization, students have to organize the filtered information into a more coherent article. Overall, the student-generated articles, even if there are some cases of lifting, are still original works of the students.

Findings and Analyses

Teaching Scientific Article Writing

Prior to giving out the writing assignment to students, the teacher gave a few pointers that students need to know to be able to write a good scientific article and then highlighted how each point was realized in an sample article.

Speaker	Utterances
Teacher	So what are some of the writing tips? Number 1. When I start to write an article, I must make sure that it is **clear and concise**... make sure your ideas are **well organized**...you should **know your audience**..., and **adjust your language accordingly**. Okay? **Use headings to organize your article systematically**...**use scientific or technical terms**, you must **understand the word that you use,**.... use **other scientific convention** such as **chemical equations**, or **tables** to help you **present your article more scientifically**.... **use passive voice whenever possible** to create **objectivity**...**use appropriate tenses,**.... including the **references** towards the end of your article, alright?

Figure 3. An excerpt of teacher's classroom teaching

Shown in Figure 3, there are a few things that the teacher emphasized: 1) to write clearly and concisely, 2) to be organized by using headings, 3) to use appropriate language, 4) to use scientific terms and conventions, 5) to include references. The teaching of linguistic features is not explicitly taught here. The teaching of linguistic features may not be seen practical as knowing informational density, authoritativeness, technicality, and abstraction may do little in helping students to write. Instead, teacher taught ways to write that lead to having linguistic features of scientific writing. To achieve concise writings, students need to pack their ideas which leads to lexically denser article. Using appropriate language such as passive voice helps in creating authoritative tone in their articles as students can distance themselves from readers. Technicality and abstraction will be achieved when students use scientific terms and conventions in their articles, and also when they write concisely.

The teaching of move structure in this segment is minimal. Students were merely instructed to organize their articles and to include references. However, the teaching of the move structure was done by giving students scaffolds in their worksheets and grading rubric. The grading rubric presented students with the structures that they need to follow which can be simplified to that in Table 1 (see Appendix 1 for more details). The worksheet contained four questions that presented students a more detailed structured of the Body stage. The effect of this scaffold may be observed when student-generated articles are analyzed.

Student-Generated Scientific Article

Seven student-generated articles were collected and analyzed. These articles were written in groups of four and each group was assigned a topic to write. These articles were analyzed for their linguistic features and move structures.

Linguistic Features

Seven student-generated articles were analyzed for their linguistic features as described in Fang (2005). The analyses focus on authoritativeness and lexical density. The results of analyses of the special features of scientific writings are presented in Table 2.

Table 2
Linguistic Features of Student-Generated Scientific Article

No	Article	Non-authoritativeness	Lexical Density (content words/clause)	Lexical Density (%)
1	Ozone 1	0	7.2	48.3
2	Acid Rain 1	1	7.8	52.3
3	Global Warming 1	12	7.4	53.5
4	Air Pollution	7	8.0	55.9
5	Acid Rain 2	10	5.3	46.6
6	Global Warming 2	10	8.7	52.8
7	Ozone 2	17	7.2	48.8
Average		8.1	7.4	51.2

In terms of authoritativeness, only two groups of students (Ozone 1 and Acid Rain 1) managed to reflect this feature in their articles, indicated by the absence of non-authoritative instances. The other five groups show a degree of non-authoritativeness. This result may suggest that students may not be aware of an important aspect of science communication that is objectivity. This could also imply that students lack the exposure to scientific writings and hence they did not know of a more objective way of writing an article.

However, upon a closer look, the degree of non-authoritativeness arises not because of first person references, reference to mental processes, direct quotes and vagueness but because of their attempts to engage readers. Figure 4 shows a list of examples of instances of non-authoritativeness.

Triangulating this result with the analysis of classroom videos, it is likely that the attempts to engage with readers are due to the fact that students have to present their articles at the end of the lesson series. In presentation discourse, audience is present

- How can we minimise the consequences?
- Do you know what the causes of air pollution are?
- Through industrialization and commercialization, we have dramatically increased the…
- As individuals, we can help prevent acid rain by conserving energy.
- If your parents must use the car, as them to avoid using it…

Figure 4. Examples of non-authoritativeness in attempts to engage readers.

within the same space as presenter and they can interact with each other. Hence, presenters may be required to engage the audience in their presentations. It is possible that when students were writing the scientific articles, they were writing in preparation for their presentations, using the articles as speech guides. Thus, a degree of interactivity is observed in student-generated articles.

Although authoritativeness is an important feature of scientific writing, Fang (2005) reported that there is a growing trend of using informal and interactive language in science textbooks to engage readers and capture their interest. The use of such language, however, is dangerous and students need to be careful. Schleppegrell (2004) argued that if the informal and interactive language is not carefully juxtaposed with the more authoritative and objective language of science, incoherent registers can arise. This may result in distortion of the genre as the article loses its objectivity and readers having difficulty to comprehend the articles.

In terms of lexical density, on average students write articles with density of 7.4 content words per clause or 51.2% of the whole text. According to Halliday (1994) in everyday speech, there are 2-3 content words per clause while in written language, the number increases to 4-6 content words per clause. The number can become considerably higher in scientific writings, sometimes as high as 10 – 13 content words per clause. Comparing the results to Halliday's (1994) findings, student-generated articles are lexically denser than spoken language, and slightly than typical written language. Though the lexical

density is not very high (10-13 word per clause) as suggested, having 7.4 content words per clause suggests that students are able to condense ideas and concepts just like typical scientific writings. In addition, the average of lexical density of 51.2% is higher than typical writings. Ure (1971) suggests lexical density of greater than 40% is considered high and implies complex writing. Thus, the relatively high lexical density in student-generated articles suggests that students were able to produce complex, informationally dense articles that are signature of written texts in the science discipline.

Having the special linguistic features of scientific writings does not warrant the good and coherent writings. These findings on surface level linguistic features do not provide adequate information whether the intended communicative purpose is accomplished. Analyzing the articles for its move structure may provide a better insight to students' ability to write scientific article.

Move Structures

The analysis is applied to all seven student-generated articles. The analysis is only done to identify the presence of the moves in student-generated articles. Since there can be multiple ideas in the body stage, if there is only one occurrence of Move 3 or 4 over many ideas, Move 3 or 4 may be labelled absent. This is so because it shows inconsistency and it may be possible that it is a fluke and students may not have grasped the skill to organize their article. Percentage of how much each move occupies the text will not be done as the aim of the analysis is to examine students' ability to organize their articles as a result of the scaffolds given. The results of the analysis are tabulated in Table 3.

Comparing student-generated articles to the move structure of descriptive scientific

Table 3
Move Structure of Student-Generated Articles

Move	Ozone	Acid Rain	Global	Air	Acid Rain	Global	Ozone

	1	1	Warming 1	Pollution	2	Warming 2	2
Move 1	Absent	Present	Present	Present	Absent	Present	Present
Move 2	Present	Present	Present	Present	Present	Present	Present
Move 3	Present	Present	Absent*	Present	Present	Present	Absent*
Move 4	Present	Present	Present	Present	Present	Present	Present
Move 5	Absent	Absent	Present	Absent	Absent	Present	Absent
Move 6	Absent	Absent	Present	Absent	Absent	Present	Absent
Move 7	Absent	Absent	Present	Absent	Absent	Absent	Absent

Absent* denotes inconsistency - mostly absent

article, it is found that most groups left out the conclusion and reference stages of the article. The leaving out of both the conclusion and reference stages is interesting to note. This may imply that students do not see the importance of both stages or students merely follow the tasks written in the worksheet. The communicative purpose of descriptive scientific articles is similar to news reports - to inform readers of phenomena or ideas. Students, thus, may have adopted the genre of news reports, which typically leaves out conclusion and reference, instead due to their lack of awareness of the scientific writing genre and their familiarity to the news reports which share similar communicative purpose. The second possibility is more likely. Students may have simply followed the instructions in the worksheet to at least answer the questions given: 1) What is <phenomenon>? 2) How does it come about? 3) What are some of the consequences? 4) How can we minimize the consequences? Students may have seen the objective of this activity to merely answer the questions given. However, the leaving out of both moves might have less impact in the achievement of the communicative purpose of the genre – to inform readers a scientific phenomenon or idea. Thus, these two moves, although they are common in scientific writing, may not be obligatory moves.

The inconsistency of Move 3 in some of the articles can be explained by their use of headings. The use of headings is common in scientific writing to help writers to organize their thoughts systematically and to ease locating information for readers. In student-generated articles, some headings are treated as part of paragraphs rather than as information organization marker. Therefore, they may not see the need to introduce the idea again as they may think it is sufficient to have Move 3 in the heading.

Despite missing several moves, students were able to produce articles that resemble typical scientific articles, in terms of linguistic features and move structures with the help of scaffolds in the reading or preparation stage. We, however, do not claim that students did not have the ability to produce such text prior to the teaching or scaffolds. We argue that students become more conscious in writing texts in a manner that is more typical in the genre. For comparison, students' scientific articles prior to the teaching of scientific writing lacked the organizational structure that is salient in scientific article (see Appendix 2 for example). Students mostly wrote in point forms and the only consistent move present was Move 4 across all articles.

Discussion

In this study, it was found that generally students were able to produce articles that resemble typical scientific articles, in terms of linguistic features and move structures. There are a few areas that still need some improvements: authoritativeness and organization of moves. Although some moves were left out by majority of student groups, the intended communicative purpose is largely achieved by the presence of the more essential first 4 moves that carry the bulk of information and ideas. Thus, we argue that the scaffolds in the forms of writing tips, worksheet, and grading rubric seem to have positive impact on

students' writings, enabling them to be able to produce articles that resemble typical scientific articles more consciously.

The analyses in this study are restricted to mainly surface level linguistic features and move structure. These analyses may be sufficient but there are still many aspects of scientific writing that can be explored for example the semiotic features of scientific articles. The discipline of science is not only realized and represented by words but also by images, graphs, tables, symbols, and equations. There is definitely a need to look at how students create and integrate non-word representations in their articles. However, those are beyond our current scope and that calls for further research.

Limitation

This study is limited largely by time factor. Pre-teaching writing activity to assess students' ability to write scientific articles was not able to be conducted in a same manner as the final writing task. Due to time constraint, students were only given 20 minutes to research and write their articles for pre-teaching writing activity. It could be possible that if students are given more time, they can produce articles that are beyond point forms. The lack of fair comparison between the pre- and post-teaching articles limit the richness of data and hence the scope of analysis.

Implication

There are a few implications from this study. First, students were able to grasp some communication skill in writing descriptive scientific articles, as reflected by the resemblance in linguistic features and move structures, through the use of scaffolding. This shows the positive impact of disciplinary literacy teaching and such teaching can and should be done in the science classroom. It may not only be in the form of descriptive scientific writing genre but also in other genres that are prominent in science discipline such as scientific

argumentation or explanation. Second, student-generated writings reveal that students are not exposed enough to and unfamiliar with typical scientific writing. With the torrent of information in the internet age, it is essential to expose students to various type writings including scientific writings so that they are able to differentiate the many types of writing and filter out information appropriately. This consequently calls for a curriculum that infuses disciplinary literacy practices in science classroom to enable students to be familiar and proficient in navigating the discipline of science.

Conclusion

This study has shown the exploration of the teaching of scientific writing in science classroom. The findings show that students were able to produce articles that resemble typical scientific articles, in terms of linguistic features and move structures, more consciously with the help of scaffolds. This study reveals that students may not be exposed enough to scientific texts as they seemed to be unable to recognize fully the typical structure and feature of scientific texts. This calls for a possible curriculum that infuses disciplinary literacy practices in science classroom to enable students to be familiar and proficient in navigating the discipline of science.

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References

Bhatia, V. K. (1993). Analysing Genre: language use in professional settings.

Chafe, W. L. (1982). Integration and Involvement in Speaking, Writing, and Oral Literature. In D. Tannen (Ed.), Spoken and Written Language: Exploring Orality and Literacy. Norwood, N.J: ABLEX Pub. Corp.

Christie, F. (2002). The development of abstraction in adolescence in subject English. InM. J. Schleppegrell & MC Colombi (Eds.), Developing advanced literacy in first and second languages: Meaning with power (pp. 45-66). Mahwah, NJ: Erlbaum.

Coffin, C. (2006). Historical discourse: The language of time, cause and evaluation. Continuum.

Crawford, M., Galiatsos, S., & Lewis, A. C. (2011). The 1.0 Guidebook to LDC: Linking Secondary Core Content to the Common Core State Standards. Retrieved October 23, 2013, from http://www.literacydesigncollaborative.org/

Cresent Public Schools. (n.d.). Science Essay Evaluation Rubric. Retrieved March 12, 2014, from http://crescentok.com/staff/jaskew/WebBased/essayeval.htm

Eggins, S. (1994). An introduction to systemic functional grammar. London: Pinter.

Fang, Z. (2005). Scientific literacy: A systemic functional linguistics perspective. Science Education, 89(2), 335–347. doi:10.1002/sce.20050

Halliday, M. A. K. (1994). Functional grammar. London: Edward Arnold.

Halliday, M. A. K., & Martin, J. R. (1994). Writing science: Literacy and discursive power (Vol. 8). CRC Press.

Lemke, J. L. (1990). Talking Science: Language, Learning, and Values. Ablex Publishing Corporation.

Moje, E. B. (2007). Chapter 1 Developing Socially Just Subject-Matter Instruction: A Review of the Literature on Disciplinary Literacy Teaching. Review of Research in Education, 31(1), 1–44. doi:10.3102/0091732X07300046001

Monash Univeristy. (2007). Writing in Science. Retrieved March 12, 2014, from http://www.monash.edu.au/lls/llonline/writing/science/6.xml?accessible=true

Schleppegrell, M. J. (2002). Linguistic features of the language of schooling. Linguistics and Education, 12(4), 431–459.

Schleppegrell, M. J. (2004). The language of schooling: A functional linguistics perspective. Routledge.

Schleppegrell, M. J., & Achugar, M. (2003). Learning language and learning history: A functional linguistics approach. TESOL Journal, 12(2), 21–27.

Schleppegrell, M. J., Achugar, M., & Oteíza, T. (2004). The Grammar of History: Enhancing Content-Based Instruction Through a Functional Focus on Language. Tesol Quarterly, 38(1), 67–93.

Swales, J. (1981). Aspects of article introductions. Language Studies Unit, University of Aston in Birmingham.

Swales, J. (1990). Genre analysis: English in academic and research settings. Cambridge University Press.

Ure, J. (1971). Lexical density and register differentiation. Applications of Linguistics, 443–452.

Wellington, J., & Osborne, J. (2001). Language and Literacy in Science Education. Buckingham: Open University Press.

Appendix 1: Grading rubric

	Science Article Evaluation Rubric	**Topic:**		
Group Name:		**Assignment Grade:**		
Category	**Scoring Criteria**	**Points**	**Student Evaluation**	**Teacher Evaluation**
Introduction (1 paragraph) *15 points*	There is a clear purpose and direction or theme of the article. *(The theme is clear and it foreshadows readers to the rest of the points of the article.)*	**5**		
	Background information is provided to illustrate the importance of the article topic. *(Examples include descriptions of key terms and restatement of complicated concepts.)*	**10**		
Report of Article (body paragraphs) *35 points*	All curriculum concepts for the topic are included. *(It covers the necessary information for the topic / answers the questions given)*	**15**		
	Ideas are presented systematically and logically. *(Paragraphs flow smoothly. Headings ,if used, are used appropriately)*	**10**		
	Information in the article is presented in the student's own words, not merely "cut and pasted" from other sources. *(Other people's ideas are not acceptable in the article – that is Plagiarism!)*	**10**		
Conclusion (1 paragraph) *20 points*	Student's thoughts presented in the article are summarized. *(Emphasize the point of the article.)*	**10**		
	The most important points are restated. *(Include information the reader should remember)*	**5**		
	No new information is introduced in the conclusion. *(The conclusion summarizes information. It does not introduce it!)*	**5**		
Language *30 points*	The article is written in appropriate language and conventions. *(There is a use of appropriate technical terms, equations, or tables. Difficult technical terms are explained.)*	**15**		
	There are no "first person" statements in the article. *(It is understood the thoughts are yours, so words like "I" and "My" are unnecessary.)*	**5**		
	There are no spelling errors or visible corrections. *(Proof-reading is required - even with spellcheck.)*	**5**		
	There are no obvious grammar or punctuation errors. *(Such as "their - there" and "to - too - two")*	**5**		
Score	**Total Points**	**100**		

Adapted from Crescent Public Schools' Science Essay Evaluation Rubric

Appendix 2: An example of student's pre-teaching scientific article

▷ sulphur dioxide, nitrogen dioxide, ozone, carbon monoxide and particulate matter called PM10

▷ PM2.5 are 'fine' particles less than 2.5 micrometers in diameter. These particles, approximately $\frac{1}{30}$ the average width of a human hair, can lodge deeply into the lungs

▷ PM 2.5 allow harmful particles to be carried into the internal organs which may cause a wide range of illnesses. People with heart or respiratory diseases, the elderly, pregnant women and children are highly susceptible

▷ PM Lee Hsien Loong said on Thurs, 20 June '13, the haze from fires in Indonesia blanket SG could persist 4 wks or longer, until the dry season ends in Sumatra

▷ Illegal burning of forests and other land on Indonesia's Sumatra island to clear space for palm oil plantations is a chronic problem during the June to September dry season

▷ how to minimise its health impact?

cover your nose and mouth with a mask when you go out. Also, remember to drink more water than usual to flush out any toxins absorbed through the skin and lungs.

▷ it is not safe to exercise outdoors.