Paper Title Impact of Explicit Disciplinary Literacy Instruction on Students' Written Scientific Explanations

Author(s) Gde Buana Sandila Putra, National Institute of Education - Nanyang Technological University; Kok-Sing Tang, National Institute of Education - Nanyang Technological University

Session Title Creating Science and Literacy Connections

Session Type Poster Presentation

Presentation Date 4/17/2015

Presentation Location Chicago, Illinois

Descriptors Instructional Design/Development, Literacy, Writing

Methodology Mixed Method

Unit Division C - Learning and Instruction

Impact of Explicit Disciplinary Literacy Instruction on Students' Written Scientific Explanations

Abstract

This paper reports on a finding from a design-based research aimed to help secondary school chemistry students develop scientific explanation writing skill. A lesson series on the topic of Chemical Bonding was specially designed to explicitly teach the three-part structure often found in the genre of scientific explanation. The lesson series was observed and students' worksheets and test papers were collected and analyzed as informed by genre analysis. It was found that most students could write well-structured scientific explanations related to Chemical Bonding but only a fraction of them could re-contextualize their knowledge of a scientific explanation genre to other topics. From the findings, the strengths and limitations of a highly domain-specific disciplinary literacy instruction will be further discussed.

Introduction

In the current context of falling literacy standards in all content areas, there is growing attention toward the importance of disciplinary literacy in the United States and other developed countries. Disciplinary literacy is the ability to use the specialized language, representations, and practices of a discipline to navigate across the discipline. Moje (2007) reviewed that disciplinary literacy can offer socially just subject-matter pedagogy. By equipping students with the right skills to navigate in a particular discipline, disciplinary literacy pedagogy allows students to have access to the knowledge of the discipline and participate in the discipline, providing equal learning opportunities for everyone.

The discipline of science is one of the most challenging disciplines to learn. Not only do students need to learn the content knowledge of science but also its peculiar language, linguistic features and practices (Fang, 2005; Lemke, 1990; Wellington & Osborne, 2001).

Due to the nature of science discipline that focuses on logical explanations of natural phenomena, one of the most prominent linguistic practices in the science discipline is the need of structuring of sentences in a logical manner (Halliday & Martin, 1994).Thus, as also suggested by various researches (e.g., Moje et al., 1997; Osborne & Patterson, 2011), scientific explanation is a crucial genre that students need to learn in order to be able to participate in the science discipline.

The genre of scientific explanation is central to the science discipline but the teaching about it is rarely the focus in science classroom. This study, therefore, attempts to address this gap in current teaching practices by introducing explicit disciplinary literacy instruction, focusing on developing students' written scientific explanations, and aims to examine the impact of explicit disciplinary literacy instruction on students' written explanations. This is important in developing effective disciplinary literacy instruction and consequently helping students acquire the skills to navigate in the science discipline.

Theoretical and Analytical Framework

Our study is framed within a disciplinary literacy approach that views teaching linguistic processes of the discipline as a central aspect in socially just subject-matter pedagogy (Moje, 2007). This approach argues that the linguistic features of texts of a particular discipline can and should be made explicit to students with teachers' guidance so that students are more familiar with the texts they face in the discipline. This approach is theoretically supported by two branches of study, namely Systemic Functional Linguistics (SFL) (Halliday & Matthiessen, 2004) and English for Specific Purposes (ESP) (Swales, 1990).

Both SFL and ESP believe that the organization of language within a culture is influenced by social purpose and context. In this sense, each discipline, thus, has its own unique way in organizing language and has various genres which are dependent on the

communicative purposes. The teaching of language organization and genre in the discipline, therefore, becomes a crucial classroom teaching practice to allow students to recognize and be familiar with the unique language used in the discipline, and subsequently acquire the skills to navigate in the discipline.

Specifically for written language, Swales (1990) and Bhatia (1993) analyzed copious writing samples that served a common communicative purpose in a specific context (e.g., research) and generate a move structure that governed the organization of the text. Based on researches on the genre of scientific explanation (e.g., Osborne & Patterson, 2011; Unsworth, 2001), we generate a three-part move structure called the PRO (Principle-Reason-Outcome) structure. This structure consists of three moves: (1) stating the Principle, (2) inferring the Reason, and (3) stating the Outcome. This PRO structure becomes the basis of the teaching of the scientific explanation genre and our analysis, in which we compare students' written scientific explanations to this move structure.

Methodology

The data for this study are taken from a designed-based research in a Secondary Three (Grade 9) Chemistry classroom. In this research, we designed a lesson series on the topic of Chemical Bonding with the classroom teacher. One of the literacy objectives of the lesson series was to develop students' ability to construct scientific explanations. As such, the classroom teacher explicitly taught students how to write a scientific explanation using the PRO structure and writing scaffolds. Students were then required to write scientific explanations throughout the lesson series with the writing scaffolds gradually removed. At the end of the term, five explanation questions were inserted to the term test paper to test students' ability to write scientific explanations.

The data sources used in this paper included videos of classroom observations, students' worksheets, test papers, and test scores. We used genre analysis (Bhatia, 1993; Swales, 1990) to analyze the move structure in students' scientific explanations. Specifically, we developed a coding scheme based on the PRO structure to analyze the students' scientific explanations was compared. The analysis provided an insight into how well students wrote scientific explanations.

In this paper, we present a genre analysis of students' written scientific explanations of the five explanation questions inserted in their term test paper. The five questions comprised three questions related and two questions unrelated to Chemical Bonding. Students' written scientific explanations were analyzed and compared to the developed PRO model, and then tabulated.

Finding

Our key finding in this study is that after explicit disciplinary instruction on the genre of scientific explanation during the lesson series on the topic of Chemical Bonding, the majority of students were able to write scientific explanations that have the structure of typical scientific explanations, to answer questions related to Chemical bonding but only a fraction of them were able to re-contextualize the knowledge of a scientific explanation genre to other topics. We posit that a highly domain-specific disciplinary literacy instruction may impede the development of disciplinary literacy knowledge such as the genre of written scientific explanations.

Analysis

In the conference paper, analyses of the teaching of the PRO structure, development of students' written scientific explanations throughout the lesson series, and students'

performance of written scientific explanations in the term test will be presented. Due to space limitation, only the analyses of the teaching of the PRO structure and students' performance will be briefly discussed here.

Teaching of the PRO Structure

The following excerpt shows a typical instruction on how the classroom teacher introduced the PRO structure to the students in the observed classroom. The excerpt shows how the teacher introduced the PRO structure to students.

Excerpt 1

Speaker	Utterance
Teacher	Alright, so basically the three things we have mentioned will be the **principle**, the **reason**, and your **observation**, alright, known as the **PRO**.
	So basically **principle** is what you know **about the compound in terms of structure and bonding**. What do you know, alright?
	And when we talk about **reasons**, the **reasons** will be the things we see **on the micro level**, okay, are things that we see at the micro level, in terms of the **forces of attraction**, or in terms of the **free mobile ions**. Okay?
	And of course, the last one is actually the **observation**. So **observation** would be, stating, alright, what you observe about its **physical properties**.

In this excerpt, in terms of explaining the Principle, Reason, and Outcome (here she used the term Observation instead), the teacher contextualized the PRO structure specifically to the content of the topic. Specifically, she equaled the term Principle to something about structure and bonding, Reason to something on the microscopic level (e.g., forces of attraction and free mobile ions), and Outcome to something about physical properties. Although the pedagogical intention behind such contextualization could be good in terms of easing students' understanding, we argue that such an instruction impede the generalization of the PRO structure to be used in other topics as students only equal PRO structure to a

structure limited to explain phenomena related to Chemical Bonding. The analysis of students' performance in term test supports our argument.

Students' Performance in Term Test

Five questions were inserted to students' term test paper to assess how well they could explain each of the following:

a) Why does copper have a high melting point of 1036 ^{0}C?

b) Why is aluminum malleable and ductile?

c) Why is iron a good conductor of electricity?

d) Why does hot air rise?

e) Why do liquids take the shape of their containers but not solids?

The first three questions are related to Chemical Bonding while the last two are not.

Students' answers to those questions were analyzed for their structures (Bhatia, 1993; Swales, 1990). Figure 1 exemplifies how the analysis was done.

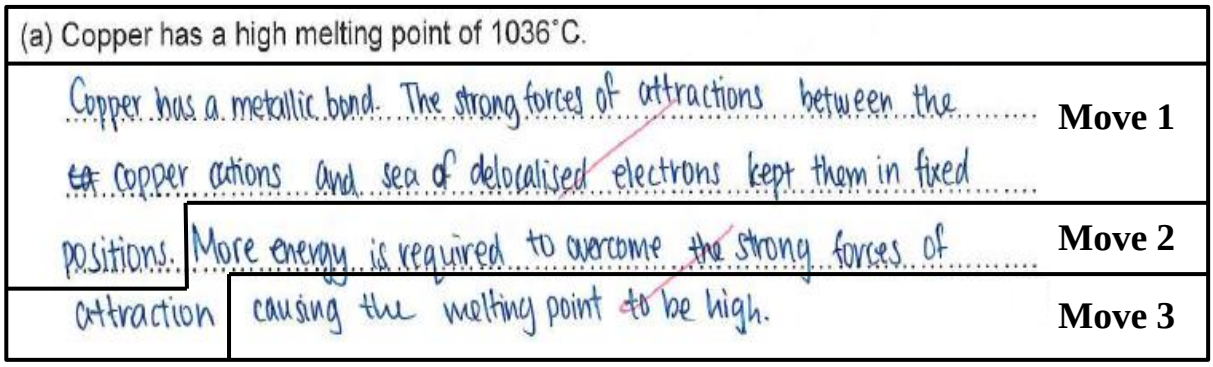

Figure 1. Move structure analysis of question (a)

In figure 1, move 1 (stating the Principle) was identified by locating clauses that showed facts about the object in question i.e., copper metal, in this case, clauses that were about the structure and bonding of copper metal. Move 2 (inferring the Reason) was identified by locating clauses that were not 'obvious' facts and had to be inferred from the

principle, in this case, clauses that were about energy requirement. Move 3 (stating the Outcome) was identified simply by locating clauses that showed the phenomena and were similar, if not the same, to the question, in this case, clauses that were about high melting point.

The same method of move structure analysis was applied to questions (b), (c), (d), and (e). Students' written scientific explanations were then labeled as 'Having PRO' if all three moves were found, and 'Not Having PRO' if any of the moves was found missing. The analysis result was then tabulated in Table 1.

Table 1

Analysis of Students' Written Explanations

Question	Having PRO (%)	Not Having PRO (%)
(a)	81	19
(b)	41	59
(c)	70	30
(d)	22	78
(e)	56	44

Note. N=27

The high percentage of PRO structure found in (a) and (c) suggests that most students have understood the structure and applied their knowledge during the test. However, in (b), (d), and (e), only low to moderate percentage of PRO structure is found which may suggest otherwise.

Triangulating this result with the analysis of classroom videos, we posited that the high percentage in (a) and (c) is due to the highly contextualized disciplinary literacy instruction (see Excerpt 1). Students may have thought that the PRO structure taught in the lesson series is the structure of scientific explanation on Chemical Bonding and can only be applied to explain phenomena related to Chemical Bonding as the teacher equaled Principle to structure, Reason to microscopic level, and Outcome to physical properties.

Interestingly, although question (b) is related to Chemical Bonding while (e) is not, moderate percentage of PRO structure is found in students' answers to both questions. Upon closer analysis of the nature of the explanation required, although question (e) is unrelated to Chemical Bonding, the requirement for the explanation is similar to that for questions on Chemical Bonding. In question (e), the Principle is about the structure of liquids and solids; the Reason is about the ability of particle to move about (microscopic level); and Outcome is about the physical properties of liquids and solids. Students could have recognized the connection between question (e) and the contextualized PRO structure and thus applied it in the answer to question (e). The reason why only moderate percentage of PRO structure is found in questions (b) and (e) could be the lack of writing practice.

Low percentage of PRO structure found in students' answers to question (d) suggests that most students could not apply their knowledge of the PRO structure to an entirely new context. We posit that the highly contextualized instruction impedes students' application of the PRO structure to a new context. Students may have failed in generalizing and re-contextualizing the PRO structure, the structure of written scientific explanations.

Conclusion

Disciplinary literacy instruction shows a promise in a search toward a socially just pedagogy. Explicit disciplinary literacy instruction has its value in helping students acquire the skills to navigate in the discipline, in this case, understanding and applying the structure of written scientific explanation. However, a highly domain-specific form of explicit disciplinary literacy instruction proves to be a double-edged sword. It may ease understanding in a particular context but at the same time impede generalizability and re-contextualization. Overall, this paper provides insights into the impact of explicit disciplinary

instruction on students' written scientific explanations and offers a case for consideration in delivering effective disciplinary literacy instruction - socially just subject-matter instruction.

Reference

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

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

Halliday, M. A., & Matthiessen, C. M. (2004). An Introduction to Functional Grammar.

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

Moje, E. B., Peek-brown, D., Sutherland, L. M., Marx, R. W., Blumenfeld, P., & Krajcik, J. (1997). Explaining Explanations: Developing Scientific Literacy in Middle School Project-Based Science Reforms. In D. Strickland & D. E. Alvermann (Eds.), *Bridging the gap: Improving literacy learning for preadolescent and adolesecent learners in grades 4-12*. New York: Teachers College Press.

Osborne, J. F., & Patterson, A. (2011). Scientific argument and explanation: A necessary distinction? *Science Education*, *95*(4), 627–638. doi:10.1002/sce.20438

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

Unsworth, L. (2001). Evaluating the language of different types of explanations in junior high school science texts. *International Journal of Science Education*, *23*(6), 585–609. doi:10.1080/09500690010006473

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