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Scaffolding Scientific Writing through Disciplinary Instruction

WSA-EC Forum

6 November 2014

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Communication Skill

- Communication skill is one of the competency domains gaining prominence in the 21st century.
- In today's Internet age, students are faced with torrents of information of various genres.
- Science teaching still focuses primarily on content knowledge building.
- Students need to be exposed to various genres so that they are able to read and write in various genres.
- Four major genres in science discipline:
 - Description
 - Argument
 - Explanation
 - Report



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Descriptive Scientific Article

- This study focuses on descriptive scientific articles (description).
- The descriptive scientific article genre is often encountered, especially in textbooks.
- This genre has the communicative purpose of informing readers of scientific phenomena or ideas.

Metals and Non-metals

The metals are on the left side of the Periodic Table, while the non-metals are on the right side of the Table. From left to right in every period, the elements change from metal to non-metal (Table 11.6).

Group	I	II	III	IV	V	VI	VII	O
Symbol	Na	Mg	Al	Si	P	S	Cl	Ar
Name	sodium	magnesium	aluminium	silicon	phosphorus	sulfur	chlorine	argon
Properties	metallic			metalloid	non-metallic			

Table 11.6 The change from metal to non-metal across Period 3

The dividing line between metals and non-metals runs diagonally through the Periodic Table (see Figure 11.2). Elements which are close to this dividing line are metalloids, and have some properties of metals and non-metals.

Changes in a Group

The atomic (or proton) number increases down a group. The properties of elements also change down a group as a result. The changes are usually gradual and are small at the sides of the Periodic Table (e.g. in Group I and VII), but are greater in the middle of the Table (e.g. the transition elements).

As the atomic number increases, the number of electrons also increases. Since only a certain number of electrons can fit into each shell, the number of shells also increases down the group. This means that the valence electrons are further away from the nucleus, and become less attracted to it — think of this in terms of two magnets attracting each other; the further the magnets are from each other, the weaker the attraction. This gives rise to the changes in properties down the group.

Mystery Clue

Is praseodymium a metal or a non-metal? Explain based on its location in the Periodic Table.

Description

Theory
Workbook
• Exercise 11.2

Skills Practice

- Iodine is in the same group as chlorine. Predict the charge of an iodide ion. [*predicting*]
- An element has a proton number of 5.
 - What is its electron arrangement?
 - Which (i) period, and (ii) group of the Periodic Table is the element in?
 - Is the element a metal, a non-metal or a metalloid?
 - What is the formula of its oxide?
 [*inferring*]
- Magnesium and barium are in the same group.
 - State two features of both elements that you would expect to be the same.
 - State two features of both elements that you would expect to be different.
 [*comparing*]

11.4 What is the Periodic Table Used for?

The Periodic Table organises the facts about each element and this allows us to predict the properties of elements from knowledge of other elements in the same group. Here are two examples.





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THEORETICAL FRAMEWORK



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Frameworks

- Disciplinary literacy
- Systemic Functional Linguistics
- English for Specific Purposes



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Disciplinary Literacy

- Disciplinary literacy is the ability to use the **specialized language, representations, and practices** of a discipline to navigate across the discipline.
- Disciplinary literacy can be conceived as (Moje, 2007):
 - Teaching cognitive literacy processes
 - Teaching epistemological processes of the disciplines
 - **Teaching linguistic processes of the disciplines**
 - Teaching linguistic and discursive navigation across cultural boundaries



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Teaching Linguistic Processes

- Teaching the language of the discipline
 - Vocabulary
 - Multiple and multimodal representation (e.g., graphs, tables, equations)
- Teaching the features of texts
 - Linguistic features
 - Organizational structure



Systemic Functional Linguistics

- Systemic functional linguistics (Halliday, 1994)
 - An approach to linguistics that considers language as a social semiotic system
 - Language as a systems that serve particular functions
- SFL in science discipline:
 - Special features of scientific writing (Fang, 2005):
 - **High informational or lexical density**
 - **Authoritativeness**
 - Abstraction
 - Technicality



English for Specific Purposes

- Teaching English language to meet specific professional need.
E.g., teaching scientific English, business English.
 - Typically at university or professional level
- Genre study in English for Specific Purposes
 - Analyzing texts in a particular fields for their structures
 - Teaching organizational structure of genre

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



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METHODOLOGY



Lesson Design

- Rationale
 - Promoting disciplinary literacy / communication skill
- Deliverables
 - Scientific article (written communication)
 - Presentation (oral communication)



Lesson Design

- Self-directed learning lessons series
 - Topic: Atmosphere (Air)
- In-class mini research on 'Haze in Singapore'
- Writing tips
 - Describing the writing tips
 - Modelling the writing
- Scaffoldings
 - Reading resources
 - Worksheet (adapted from Literacy Design Collaborative's)
 - Grading rubric



Lesson Design

Lesson Series Structure

No	Activity	Period
1	Teacher opening the topic by going through sub-topic of clean air	1
2	Teacher instructing students to do research on haze in Singapore	1
3	Students reading, discussing, and writing down their research findings	2
4	Some students presenting their research findings	2
5	Teacher teaching students how to write scientific article	2
6	Teacher instructing students to read articles at home	2
7	Teacher reminding reviewing the previous lesson	3
8	Students discussing, writing their scientific reports and preparing presentations	3 & 4
9	Students presenting their articles	5, 6, 7 & 8
10	Teacher giving feedback	8



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Teaching Linguistic Features

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?

- Emphases:
 - To write clearly and concisely
 - To be organized by using headings
 - To use appropriate language
 - To use scientific terms and conventions
 - To include reference
- Teacher is teaching ways to write that lead to having linguistic features of scientific writing rather than the features



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Scaffolding Resources

- Reading set
 - Four articles per set
 - Various sources
 - Science article for kids
 - National Geographic article
 - Government agency produced article
 - Undergraduate-level chemistry article
- Worksheet
 - Role-play instruction
 - Questions
- Grading rubric
 - Article structure



Worksheet

You are a group of environmental chemists from the National Environment Agency and tasked to educate secondary school chemistry students about acid rain. Do some research and write down a short scientific article and a presentation for your task. Your article and presentation should at least answer these questions:

- What is acid rain?
- How does it come about?
- What are some of the consequences?
- How can we minimise the consequences?

Include appropriate diagram(s) and/or chemical equation(s) in your article and presentation.



Thinking Box

Write down relevant information that you find from your readings / research in the boxes below to help you organise your thoughts.

What is acid rain?

How does it come about?

Role-play instruction:

- Setting the writer's role
- Setting the audience

Guiding questions:

- Helping students to look out for appropriate information
- Scaffolding for their articles

Writing space:

- Helping students to organize their information



Grading Rubric

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



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ANALYSES



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Informational Density

- Informational or lexical density
 - The number of content word per clause
 - The percentage of content word over the total word
-

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.

- 71 words; 38 content words; 6 clauses
- 6.3 content word per clause or 53.5% content word



Authoritativeness

- Authoritativeness
 - Using impersonal tone
 - Projecting objectivity
- Non-authoritativeness
 - Using personal tone
 - Informality and interactivity
 - Reference to first person, mental processes

-
- 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, **ask them** to avoid using it...



Linguistic Features

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



Authoritativeness

- Average instances of non-authoritativeness: 8.1
 - No first person references, references to mental processes
 - All are interactive and informal instances
- Attempts to interact with readers
 - Possibly due to presentations after writing the articles
 - Writing in preparation for their presentations
 - Using the articles as speech guides
- However, interactivity is increasingly common in textbooks
 - Need to be careful so as not to distort the genre



Informational Density

- Student-generated articles: 7.4 content words per clause
- Spoken discourse: 2-3 content words per clause
- Written discourse: 4-6 content words per clause
- Scientific written discourse: can be as high as 10-13 content words per clause

-
- Student-generated articles: 51.2%
 - Ure (1971) suggests lexical density higher than 40% is considered high and implies complex writing



Informational Density

- Student-generated articles have slightly higher informational density than everyday written discourse.
- Student-generated articles are considerably complex.
- Students produced articles that are complex and dense in information – signature of written texts in science discipline



Move Structure

- Seven-move structure is generated based on typical descriptive scientific articles at high school and university levels, with a communicative purpose of informing readers of scientific phenomena or ideas

Move Structure of Descriptive Scientific Article

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Doomsday is approaching.

Move 1

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 (CO₂) concentration in the atmosphere by about 30% - this increase in CO₂

concentration contributes to global warming by increasing temperatures. This is because heat energy from the earth, or infrared radiation, is trapped by CO₂ molecules. Thus heat energy is retained in the earth's atmosphere by CO₂ 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



Move Structure

Move Structure of Student-Generated Articles

Move	Ozone 1	Acid Rain 1	Global Warming 1	Air Pollution	Acid Rain 2	Global Warming 2	Ozone 2
Move 1	∅	✓	✓	✓	∅	✓	✓
Move 2	✓	✓	✓	✓	✓	✓	✓
Move 3	✓	✓	∅*	✓	✓	✓	∅*
Move 4	✓	✓	✓	✓	✓	✓	✓
Move 5	∅	∅	✓	∅	∅	✓	∅
Move 6	∅	∅	✓	∅	∅	✓	∅
Move 7	∅	∅	✓	∅	∅	∅	∅

∅* denotes inconsistency - mostly absent



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Move Structure

- Most common missing moves:
 - Move 5: Summarizing key points
 - Move 6: Stating conclusion
 - Move 7: Citing references
- } Conclusion
- Students may view Conclusion and Reference sections unimportant
 - Students are not used to read or not familiar with articles with Conclusion and Reference sections
 - Students may regard scientific article genre the same as news genre
 - Students simply answered the 4 guiding questions



Move Structure

- Inconsistency of Move 3: introducing scientific idea
 - Due to the use of headings
 - Students regard headings as part of the prose rather than as organization markers
- Despite missing a few moves, students were generally able to convey the communicative purpose – informing readers of scientific phenomena such as acid rain
 - Students are more conscious in their organization of articles in a manner that is more typical in the genre
 - For comparison, prior to the explicit teaching of linguistic features and move structure, students mostly write in bullet points.



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- ▷ Sulphur dioxide, nitrogen dioxide, ~~the~~ 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 ~~to~~ 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, a haze from fires in Indonesia's blanket fog could persist 4 wks or longer, until the dry season ends in Sumatra
- ▷ legal 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 Sept outdoor dry season.
- ▷ How to minimize 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~~ safe to exercise outdoors.

Bullet points

Move 4:
Elaborating
scientific idea

Move 3:
Introducing
scientific ideas

Move 4:
Elaborating
scientific idea



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DISCUSSION



Findings

- With the supports given, students are more conscious and aware of the demands required of scientific articles.
- Students were able to convey the communicative purpose despite the missing moves.
- Students seem unfamiliar with the genre of scientific article as evidenced by the missing moves.



Implication

- Exposing students to various types of scientific texts
 - Curriculum that infuses disciplinary practices
 - Reading, writing, discussing, and doing like scientists
- Explicit disciplinary teaching on the genre of texts prominent in science discipline
 - Description
 - Argument
 - Explanation
 - Report



Limitation

- Time limitation
- Limited comparison with students' writing prior to the teaching



Further Work

- Linguistic features and move structures analyses alone may not be enough to assess students' proficiency.
 - Semiotic features / non-word representations analysis may be required.
 - How students utilize graphs, tables, equations, and images to complement their articles.



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Q & A

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