Disciplinary Literacy Strategies in Physics Teaching

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Scope of Presentation

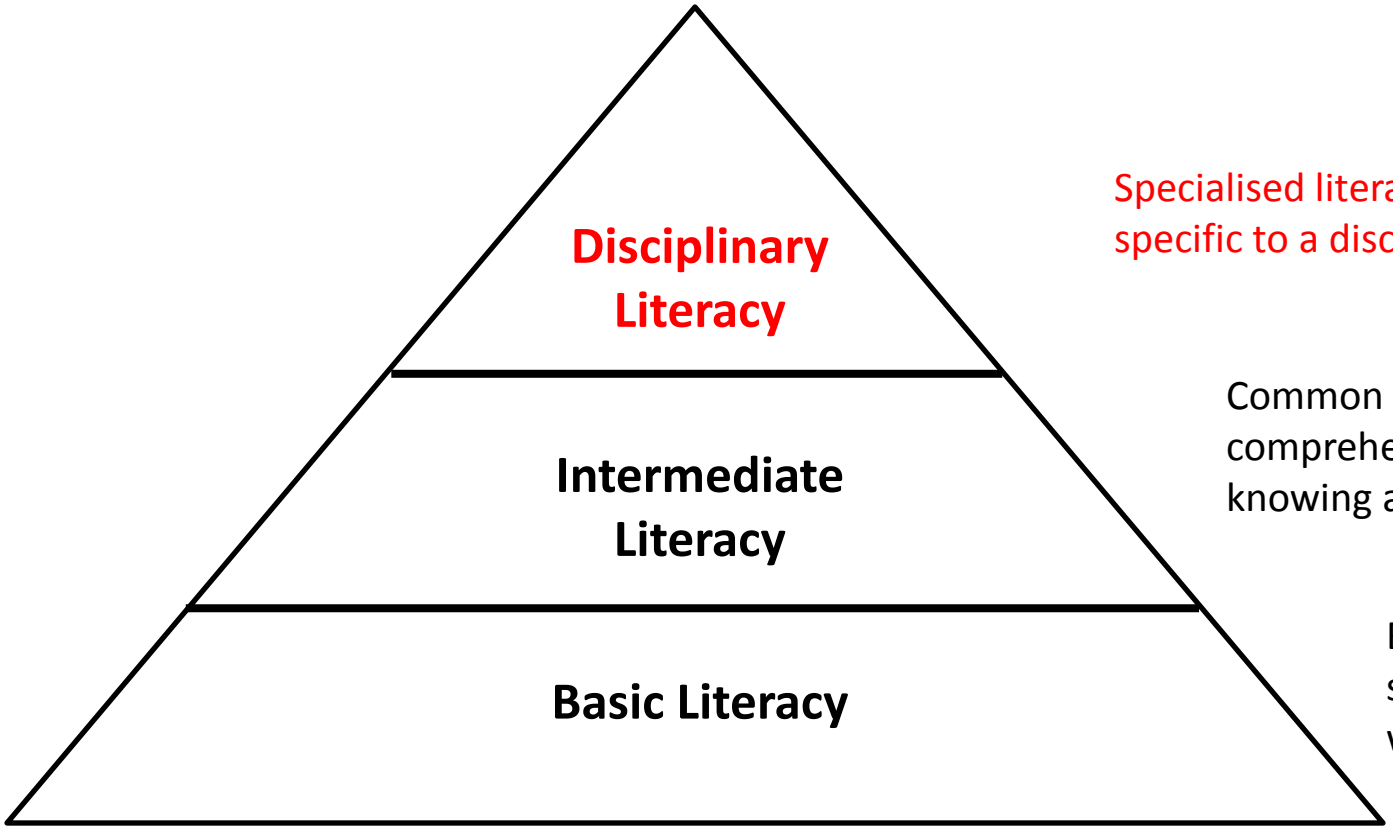
- What is disciplinary literacy (DL)?
- Why DL?
- Research in DL
- Teacher's perspective of DL
- Examples of DL strategies

What is Disciplinary Literacy?

- **Disciplinary literacy** is the **ability** to use the specialised language and representations of a discipline to construct knowledge and participate effectively in the discipline.
- **Disciplinary literacy teaching** is the "**pedagogical practices** for teaching content alongside the linguistic, cognitive, and cultural text-based practices and processes associated with a discipline".[1]
- **The goal of disciplinary literacy teaching** is to "build secondary students' academic content knowledge and their reading, writing, and thinking skills **at the same time**". [2]

1. Moje, E.B. (2007). Developing Socially Just Subject-Matter Instruction: A Review of the Literature on Disciplinary Literacy Teaching. *Review of Research in Education,* 31, 1-44.
2. McConachie, S., Hall, M., Resnick, L., Raci, A., Bill, V, Bintz, J., Taylor, J., (2006). Task, Text, and Talk: Literacy for All Subjects, *Educational Leadership*, 64, 8-14.

A Framework of Disciplinary Literacy



Specialised literacy skills specific to a discipline

Common text structure, comprehension strategies, knowing author's purpose

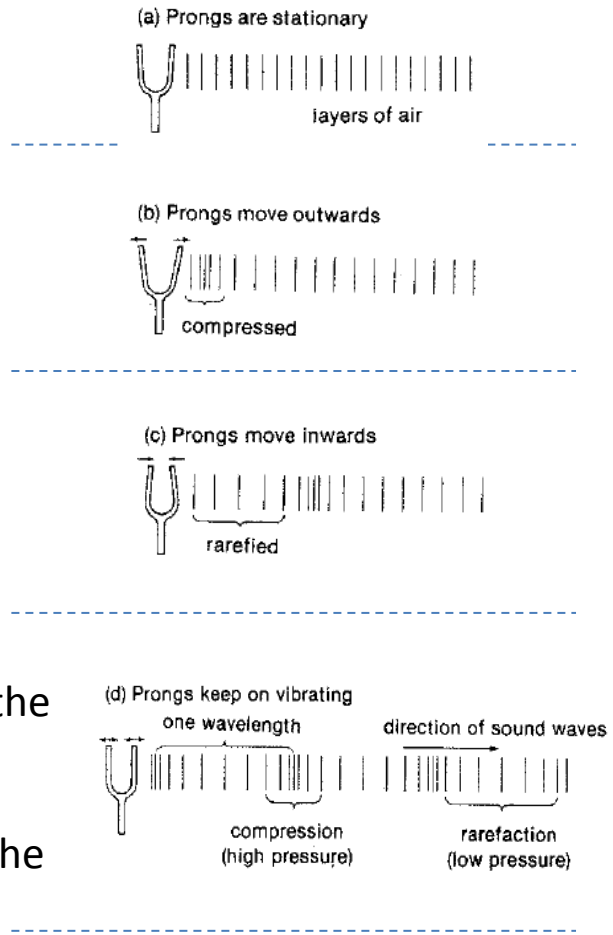
Basic punctuation, spelling, grammar, word recognition

Shanahan, T., & Shanahan, C. (2008). Teaching disciplinary literacy to adolescents: Rethinking content-area literacy. *Harvard Educational Review,* 78(1), 40-59.

Example of DL skill

How does sound propagate through the air to our ear?

- Sound can travel through air <u>because</u> it contains **molecules**.
- Consider a tuning fork.
- <u>When</u> the arms of the tuning fork move outwards
- they compress the air molecules next to them.
- <u>Because</u> the air molecules are compressed
- this creates a **compression** region.
- <u>When</u> the arms move inwards,
- they create a vacuum for the air molecules next to them to spread out.
- <u>Because</u> the air molecules spread out,
- this creates a **rarefaction** region.
- <u>As</u> the tuning fork continues to vibrate,
- a **series of compression and rarefaction** moves away from the tuning fork.
- <u>When</u> this **compression and rarefaction** reaches our ear,
- it causes our eardrum to vibrate at the same **frequency** as the tuning fork.
- <u>Therefore</u>, this is how we can hear the sound traveling through the air to our ear.



Why teach Disciplinary Literacy in Science?

- Skills are specific to science:
  - Scientific process skills
  - Skills are intertwined with content knowledge
- Academic & curriculum trend:
  - Research & arguments for disciplinary literacy teaching
  - Common Core Standards in USA
  - New South Wales curriculum reforms in Australia

Common Core State Standards in the U.S.

- U.S. education initiative to bring diverse state curricula into alignment
- Adopted by 45 states and to be implemented in 2015
- Standards include:
  - English Language Arts Standards
  - Mathematics Standards
  - Literacy in History/Social Studies, Science, and Technical Subjects Standards

From http://www.corestandards.org/

Common Core Standards for Science

Reading Standards for Literacy in Science and Technical Subjects 6–12

RST

Grades 6–8 students:	Grades 9–10 students:	Grades 11–12 students:
Key Ideas and Details		
1. Cite specific textual evidence to support analysis of science and technical texts.	1. Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.	1. Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
2. Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.	2. Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.	2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
3. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.	3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.	3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
Craft and Structure		
4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 6–8 texts and topics.*	4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 9–10 texts and topics.*	4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 11–12 texts and topics.*
5. Analyze the structure an author uses to organize a text, including how the major sections contribute to the whole and to an understanding of the topic.	5. Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., *force, friction, reaction force, energy*).	5. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.
6. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.	6. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.	6. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.
Integration of Knowledge and Ideas		
7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart,	7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information	7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in

Examples of standards in literacy/science for grade 11-12 students:

Reading:

- Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context
- Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas

Writing:

- Write informative/explanatory texts, including scientific procedures/ experiments, or technical processes

Representing:

- Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem

Research in Disciplinary Literacy

- **"Developing Disciplinary Literacy Pedagogy in the Sciences"** research project from July 2013 to June 2015
- Focusing on the role of literacy skills in improving science teaching & learning
- Research in two secondary schools:
  - Northbrooks Secondary
  - CHIJ (St. Joseph's Convent)

Research Aims

	Objectives	Phases
1	To observe and document current teaching practices in physics and chemistry in order to draw links with disciplinary literacy teaching.	**(1) Naturalistic** July 2013 – June 2014
2	To develop disciplinary literacy pedagogical strategies in collaboration with the teachers that cater to the specific context of the observed classroom.	**(2) Intervention** July 2014 – June 2015
3	To document student learning benefits from a disciplinary literacy teaching approach.	

Perspectives of DL

Previously

- Language is just a communication tool
- Not aware of how language can help in the teaching of Physics
- Not aware that Physics has a language of its own and that it can be taught

Currently

- More than just a communication tool but one that expresses Physics concepts concisely
- Does make a difference in the learning of Physics
- Physics has its own language (structure and vocabulary)

DL Strategies Employed

- Chosen based on students' language comfort zone and topics taught
- Topic: Thermal Physics
  - Compare and Contrast Table (Kinetic Model of Matter)
  - Scaffolding Explanation – Flow Chart (PVT Relationships)
  - Jigsaw Reciprocal Teaching and Notes Creation (Transfer of Thermal Energy & Temperature)

Compare & Contrast Table

Properties	Solid	Liquid	Gas
Volume & Shape			
Motion of particles			
Forces btw particles			
Distance btw particles			

Upon heating, changes to…	Solid	Liquid	Gas
KE of particles			
Distance btw particles			
Volume			
Density			

Compare & Contrast Table

- Students to fill up table as a group for one 2-periods lesson
- In the next 2-periods they are to do a **Gallery Walk**, while one member of the team defends the answer
- Rest of students to critic others' work

Compare & Contrast Table

- Cognitively demanding, linguistically undemanding task
- Reduce Teacher Talk & increase Student Talk
- Identify **Key Vocabulary**
- Explicit "unpacking" of different text types in science
  - Part of scaffolding before progress to cognitively demanding and linguistically demanding task

Scaffolding Explanation – Flow Chart

- Topic is Pressure In Gases
- LO – Students expected to explain how pressure of gas is related to its molecular motion
- Heavy in explanation. Use of Key Vocabulary is essential

Scaffolding Explanation – Flow Chart

Volume-Temperature relationship

A syringe contains a gas. The gas in the syringe is being heated. The piston is allowed to move so that the gas pressure is kept constant.

Gas is heated

[Text]

[Text]

Volume increases

Key Terms

Temperature	Bombard	Frequently	Outward net force	Equal
Average speed of molecules	Vigorously	Average force per collision	Gas pressure	Atmospheric pressure

the temperature of the air rises

the average speed of the air molecules increases

air molecules bombard inner wall more vigorously and more frequently

average force per collision between air molecules and wall increases

gas pressure increases resulting in an outward net force

piston moves outwards until gas pressure is equal to atmospheric pressure

volume increases

Scaffolding Explanation – Flow Chart

- Visual Organiser – Aid students to construct sentences by **sequencing** using appropriate **Key Vocabulary**
- Role modeling of mental process in crafting explanation (Teaching of DL)
- At the same time, build understanding and promote critical thinking of process
- ZPD while working in pairs

Jigsaw Reciprocal Teaching & Notes Creation

- 2 Chapters are learnt in tandem – Temperature & Transfer of Thermal Energy
- Heavy in facts and description hence Teacher Talk will be dry
- Jigsaw reading + Notes Creation
  - 4 groups of Home Group
  - Regroup into Expert Group to work on Expert Task
  - Return to Home Group to share knowledge
  - Complete Home Group Task as AFL

Jigsaw Reciprocal Teaching & Notes Creation

Expert 1 – Temperature

Learning Objectives:

- To explain how a physical property which varies with temperature may be used to define temperature scales
- To describe the process of calibration of a liquid-in-glass thermometer, including the need for fixed points such as the ice point and steam point

Instructions:

1) Read **Pg 144 to 150** of your textbook for 20 mins.
2) Look out for the following keywords while reading
   a. Temperature
   b. Heat
   c. Features of good thermometer
   d. Thermometric substance
   e. Temperature scale
   f. Calibrate
   g. Ice point
   h. Steam point
   I. Mercury-in-glass
   j. Thermocouple
3) After reading, take 40 mins to discuss and work with the other experts to complete the following tasks on the paper provided
   I. Compare the difference between temperature and heat
   II. State the features of a good thermometer. Explain the difference between the terms "responsive" and "sensitive"
   III. State the steps to construct a temperature scale.
   IV. Describe how a liquid-in-glass thermometer is calibrated
4) Transfer these into notes for the next lesson.

Expert 2 – Conduction

Learning Objectives:

- To state that thermal energy is transferred from a region of higher temperature to a region of lower temperature
- To describe how energy transfer occurs in solids at the molecular level

Instructions:

1) Read **Pg 168 to 171 and 177 to 178** of your textbook for 20 mins.
2) Look out for the following keywords while reading
   a. Thermal equilibrium
   b. Temperature
   c. Process of thermal energy transfer
   d. conduction
   e. free electron diffusion
   f. particle vibration
   g. conductors
   h. insulators
3) After reading, take 40 mins to discuss and work with the other experts to complete the following tasks on the paper provided
   I. Explain thermal equilibrium by providing a real-life example
   II. Describe in molecular terms how conduction in solids occur
   III. Compare the difference in conduction between metals and non-metals.
   IV. Which is a poorer conductor of heat, water or air? Explain your answer using Kinetic Model of Matter.
4) Transfer these into notes for the next lesson.

Jigsaw Reciprocal Teaching & Notes Creation

- **Word Bank** provided in task list to help students identify Key Vocabulary
- Build reading, writing & thinking skills
- Self directed learning
- ZPD

Summary

- **Disciplinary literacy** is the skills in using the language of the discipline to participate effectively in its unique practices. It is specific to the discipline and central to learning its knowledge
- **Disciplinary literacy teaching** is a more conscious awareness of emphasizing the language practices of the disciplinary, while teaching the content knowledge at the same time

Current & Future Research

1. What DL strategies are suitable in physics, chemistry and primary school science? (Reading-to-learn, writing-to-learn, talking-to-learn etc.)
2. What are the learning benefits from an explicit disciplinary literacy approach?
3. How to scale up DL strategies gleaned from current research project to benefit other science teachers in Singapore?

Thank you!

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