The languages and literacies of the STEAM content areas

Katherine Doyle

ABSTRACT

This article primarily addresses the STEAM (Science, Technology, Engineering, Arts, and Mathematics) content areas (Maeda, 2013) and, in particular, their languages and lexicogrammatical systems. Science is used as the prime example because the literacy demands of this discipline somewhat overlap with those of the others even though the lexical demands differ. The language of science demonstrates how language works in specific content areas. However, prior to the languages and literacies discussion, this paper indicates related specifications from the Australian Curriculum (ACARA, 2018) and notes Australian government positions on STEM (Science, Technology, Engineering and Mathematics) education (Australian Government, 2015). The Arts, as a mode of creative investigation, representation and expression, are then outlined as a pivotal resource to the STEM content areas. Finally, some ideas for the development of school STEAM language and literacy are provided as springboards for practical classroom activities.

The Australian Curriculum contains two overarching aspects: general capabilities and cross-curriculum priorities (ACARA, 2018). The general capabilities focus on critical and creative thinking, personal and social capabilities, ethical understanding, and intercultural understanding while the cross-curriculum priorities focus on issues of sustainability and cultural perspectives thus fostering ethical and moral societal values (ACARA, 2018). These issues and values link directly to STEAM content pedagogies and learning.

Over recent years, the Australian Government has promoted the vitality of STEM education in relation to Australia’s future. For example, the National STEM School Education Strategy, 2016 – 2026, for Australian schools reports on the educational goals for STEM (Australian Government, 2015). Senator Birmingham’s (2016) announcement that STEM disciplines are aspects of the government’s $1.1 billion National Innovation and Science Agenda aimed at boosting STEM competencies in students and teachers, the National Innovation and Science Agenda (Australian Government, 2016) coupled with the Ideas Boom, through which, according to the then Prime Minister, Malcolm Turnbull (Australian Government, 2016), young Australians will be equipped with the skills required for success in the 21st century. His emphasis was repeatedly on innovation. Furthermore, the Office of the Chief Scientist (2014) stated a primary objective that ‘Australian education, formal and informal, will prepare a skilled and dynamic STEM workforce, and lay the foundations for lifelong STEM literacy in the community’ (p. 24). These initiatives and schemes require ‘thought on the best ways of implementing STEM education in schools’ (Doyle, 2017, p. 24). Two proposals in this article are:

1. the inclusion of art within the realm of STEM, thus creating STEAM as an interrelated and collaborative content community for solving problems; and
2. a focus on the language, the lexicogrammatical structures of each discipline, and literacies of STEAM.

Questions have arisen related to the inclusion of Arts with STEM. This inclusion is not new and, in fact, extends back to the early beginnings of human communication and problem-solving. For example, ancient indigenous peoples not only communicated through Arts, their investigations of
creation, but used the Arts as a way of making sense of and creating the technologies of their time (Lawlor, 1991). Ancient Egyptians’ and ancient Greeks’ technological, scientific, engineering and mathematical advances as portrayed in and through their Arts abound (Pope, 2012; Pope & Todonai, 2015). The Arts are evidenced throughout history as a mechanism and voice of STEM. The article draws attention to the Arts as a visual grammar of expression and representational multimodal device for and of STEAM. Art possesses its own language, grammar and literacy and understanding how to use art language provides a dynamic resource to represent STEAM concepts and designs visually.

The Arts introduce artistic or creative processes into the STEM content areas for the purpose of solving problems (Bequette & Bequette, 2012). Furthermore, they tap into the creative mind bringing forth creative and divergent thinking to fuse with ‘design thinking’ prevalent in engineering. Harris and de Bruin (2017) argue:

the most significant pedagogical developments in twenty-first century learning may not be just the continued specialisation of skills and knowledge, but ... learning and teaching in ways that fuse arts, sciences, mathematics, and humanities domains through contemporary real-world curricula that enhances learning potentials, creative possibilities and adaptive growth-mindsets in learners (p. 3).

The Arts provide alternate approaches to solving problems and brings more opportunities for collaborative processes within ‘transdisciplinary’ spaces (Guyotte, Sochacka, Costantino, Walther, & Kellam, 2015). Ultimately, the STEM content areas can be described as problem-solving areas. Employing art as a representative resource as well as a means to engage in the problem-solving process provides an ‘aesthetic nature’ to discover and represent solutions (Bequette & Bequette, 2012; Hogan & Down, 2015; Macda, 2013; McAuliffe, 2016). Quigley and Herro (2016) contend that the ‘transdisciplinary nature’ of STEAM promotes ‘non-linear problem-solving’ and open-endedness in creative thinking (p. 414). McAuliffe (2016) argues that while convergent thinking evaluates and synthesises creative thought, divergent thinking produces solutions. The Arts provide a space for divergent thinking allowing solutions to be represented through such means as graphics, models, software, diagrams, and other means of visual imagery such as composite photography, paintings, animation, or video imagery. An example of the power of artistic representation is reported by Sochacka, Guyotte, and Walther (2016). They found that Arts-Engineering students who had difficulty in articulating their process of solving, reasons for their methods and thinking as well as their ultimate solution were able to express and represent their thinking after ‘questioning and dialogue during the artists critique’. (p. 43). This led to students digging deeper as they developed ‘an awareness of their personal and shared processes of creation and (making) sense of the complex relationships between people, artefacts, and the natural world’ (p. 43). The Arts in STEM content areas are both a means of problem-solving and a means to represent solutions. In other words, the Arts provide a visual language by which to express the concepts and design of Science, Technology, Engineering and Mathematics.

The language systems and literacies of STEAM

This article uses the terminology types of texts or text types rather than genres to indicate texts which have the same social purpose within a culture or content area and share ‘the same obligatory and optional structural elements’ (Butt, Fahey, Feez, Spinks & Yallop, 2006, p. 99). In thinking about communicating within the STEAM content areas, I concur that language is a socially-constructed, meaning-making system (Bernstein, 2000; Halliday, 1978; Halliday & Matthiessen, 2004 &) and thus STEAM literacies are also perceived in this way. Therefore, literacy in STEAM becomes the ability to operate effectively within the integrated, socially-constructed, dynamic meaning-making systematic processes of the content areas by having the capability to:

1. attain the content knowledges and skills,
2. to use Science, Technology, Engineering, Art and Mathematics and
3. to operate according to the social practices of each discipline (Doyle, 2017).
Learning the languages of STEAM is the enabler for these capabilities. Studies by Seah, Clarke, and Hart (2011, 2013, 2015, 2016) and Xu and Clarke (2012) and reported by Hand (2017) have demonstrated the crucial role language plays in students’ grasp of instruction and ability to express their learning. These studies found that both primary and middle school students had difficulty both with understanding instructional Science language and communicating their learning. However, in these studies, students were not taught the grammatical conventions and codes of the content area language prior to collecting data for analysis. Examples of where students have been taught lexicogrammatical components and structures of content area language are reported in Doyle’s studies (2011, 2006). Although these studies were conducted with younger students, they provide examples of what can be achieved when students are taught explicitly about the languages, text types, and structures of STEAM content areas. Functional grammar techniques, top-level structuring (see below in ‘classroom activity’ section) as well as related technical vocabulary were used in explicit and implicit pedagogies. It was found that even from a young age, children began to use the language of Science in their explanations, reports, and other Science and technological designs and representations. The outcomes also demonstrated that they could represent their instructional learning in a variety of ways.

The complex nature of STEAM languages is evident in a number of characteristics which exhibit themselves through the predominant argumentative structure of the language of Science. These include, for example, explanation, reporting, conjecture, challenge, reasoning and justification. In other words, individual text types which in turn have their own grammatical structuring, form the language resources enabling the creation of meaning in each content area. Furthermore, each area has its own specialised vocabulary or technical and symbolic language. Digital technologies also require travelling between real and virtual worlds and the capacity to discriminate between the two (Doyle, 2017).

One part of STEAM languages acquisition is knowing how text types are structured or logically connected at the grammatical level (Halliday & Matthiessen, 2004). Logical connectives are indicative of certain text structures such as cause/effect, compare/contrast, problem/solution and description (Bartlett, 1979; Korner, McInnes, & Rose, 2007). This list is not exhaustive but indicates the four structures that Bartlett (1979) refers to as top-level structures. Bartlett, Liyang, Jones, Penridge and McKay (2001) described top-level structuring as a procedure that allows ‘hierarchal organisation of content in order to achieve memory, comprehension and expression outcomes’ (p. 67). This organisation is applied to ‘both encoding and retrieval features of learning’ allowing strategic readers, listeners or reviewers to gauge main ideas, form opinions and conduct critical or inferential analysis on essential content and to produce coherent texts. Studies such as those by Bartlett (2003) and Doyle (2006, 2011) demonstrate significant changes in students’ Science and Mathematics literacy skills as a result of learning top-level structuring of texts. Table 1 provides examples of text types, text structures of STEAM, and examples of logical connectives which indicate the structure of the text. To the left of the shaded area, multimodal representation of STEAM genre examples and specific language skills required to negotiate STEAM learning are listed. These lists provide language considerations applicable across all text types so are not meant to connect directly to the adjacent columns. The lists in this table are by no means exhaustive but are indicative of types of texts, language and grammatical structures encountered in STEAM disciplines and the consequent language requirements.

‘Learning to use language as representational tools also means learning the grammatical and structural features’ (Seah et al., 2014. p. 969). Halliday (1978) and more recently Hand (2016, 2017) endorse immersion in language in order to become fully literate in specific languages. In particular, they referred to the language of Science on which we shall focus as the exemplar of STEAM languages.

The language of Science comprises ‘both mathematical symbols and cultural language (e.g., English, French ...)’ (Yore, 2004, p. 72). Halliday (1998) adds that the language of Science is the ‘systemic resource for creating meaning’ through which natural phenomena can be described and explained.
Table 1. **STEAM text type language and structure examples** (adapted from Doyle, 2011)

<table>
<thead>
<tr>
<th>STEAM text types</th>
<th>Possible text structures examples</th>
<th>Logical connective and clues to text structure examples</th>
<th>(some) Multimodal representations of STEAM genres</th>
<th>Language considerations across STEAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysing</td>
<td>description; cause/effect; problem/solution; Compare/Contrast</td>
<td>(Description) and, additionally, for example, furthermore, such as, as well as. (Problem/solution) so, therefore, the solution to, the answer … to fix this, you could …. (Cause/effect) as a result, so, because, since, caused, this is why, if/then. (Compare/contrast) but, instead, alike, the same as, different</td>
<td>Diagrams, Drawings, Physical artefacts, Digital design, Video graphics, Video interactive devices, Photographic design, Architectural Design, Coding, 3D models</td>
<td>Technical/specialised vocabulary, Process (verbal) types: action, linking; abstract relations; mental/thinking, Active/passive voice, Tense: past, present, future, Participant types: generalised or specific, Clause extensions: enhancement; elaboration; extension, Nominalisation, Connectives/conjunctions, Taxonomic Reports, Multimodality, Non-linearity, Interactivity</td>
</tr>
<tr>
<td>Argumentation*</td>
<td>Cause/effect; Problem/solution</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Explanation*</td>
<td>Cause/effect</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compare/Contrast*</td>
<td>Compare/Contrast</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generalisation</td>
<td>Description</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Hypothesising</td>
<td>Description</td>
<td></td>
<td></td>
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<tr>
<td>Identifying variables</td>
<td>Description/comparison</td>
<td></td>
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<tr>
<td>Investigation</td>
<td>Problem/solution</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inventing</td>
<td>Problem/solution</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Justification</td>
<td>Cause/effect; Problem/solution</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interpreting data</td>
<td>Description</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Making inferences</td>
<td>Description</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Making links *</td>
<td>Cause/effect; Problem/solution</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Making predictions</td>
<td>Description</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Measurement</td>
<td>Description, Comparing</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Observation</td>
<td>Cause/effect, Comparing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procedure*</td>
<td>Description</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reasoning*</td>
<td>Cause/effect</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reporting</td>
<td>Description</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summarising</td>
<td>Description</td>
<td></td>
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</tr>
</tbody>
</table>
Halliday (2004) outlines seven grammatical difficulties in scientific language:

- **Interlocking definitions** – one part of a definition is dependent on knowing the meaning of another part of the definition e.g., ‘A circle is a plane curve with the special property that every point on it is at the same distance from a particular point called the centre …’ The words *circle* and *centre* are used to define each other through the conciliatory terms plane curve and distance under the assumption that these latter terms are already understood (p. 163).

- **Technical taxonomies** – ‘highly ordered constructions in which every term has a definite functional value’ (p. 164).

- **Special expressions** – the language of Science taking on the grammar likened to the language of mathematics. Halliday also refers to the language of Science creating its own meaning, such as, a table referring to a table of figures.

- **Syntactic ambiguity** – Halliday explains via the example: ‘Higher productivity means more supporting services’. He asks, ‘Is higher productivity brought about by more supporting services, or does it cause more supporting services to be provided?’ Halliday discusses the ambiguity between *cause and effect* that can occur in the language of Science (pp. 169–170).

- **Semantic discontinuity** – the language of Science often requires making inferences to work out the cause/effect relationships. Halliday (2004 gives the example: ‘... strong anti-pollution laws over the last twenty years have resulted in cleaner factories, cleaner countryside and an increase in the number of light-coloured pepper moths.’ He rewords this to make the actual meanings clearer: ‘over the last twenty years, [the governments have passed] strong laws to stop [people] polluting; so, the factories [have become] cleaner ...’ (p. 177). The message being conveyed ultimately leads to the pepper moths being also cleaner and therefore their numbers have increased. His point is that the reader needed to cope with ambiguities to reach the final outcome.

- **Lexical density** – the density of information within a text. Lexical density is measured by the number of technical items or content-specific vocabulary within a main clause of a grammatical structure such as a simple sentence or part of a complex sentence (Halliday, 2004; Halliday & Mattiessen, 2004). The example Halliday gives is: ‘The atomic nucleus absorbs and emits energy in quanta, or discrete units’ (p. 168). In this example containing two ranking or *main* clauses there are eight lexical items (underlined) which the reader needs to interpret.

- **Grammatical metaphor** – the restatement of texts in a summary or condensed form. For example, ‘Prolonged exposure will result in rapid deterioration of the item’ (p. 102). Halliday compared this statement with the following: ‘If the item is exposed for long, it will rapidly deteriorate’ (p. 102). He explains the difference between the two statements as the *power of the language*. The term ‘exposure’ expresses grammatical metaphor in the form of *nominalisation* which features prominently in the language of Science. Nominalisation is the device which enables processes (goings-on or verb-related parts of a sentence) and properties (adjectives) to be reworded as nouns. *Exposure* is the nominalised form of the process *is exposed*. ‘Nominalisation is the single most powerful resource for creating grammatical metaphor’ (Halliday, 1994, p. 352).

Researchers in the field such as Hand (2017), Seah et al., (2014) ... ‘call for more effective instructional strategies to teach school Science language in order to address ‘the conceptual and representational challenges related to students’ appropriation and employment of the language of..."
school Science’ (2014, p. 971). Although this paper has focused on Science as an example of content area language requirements for full participatory capabilities, the call extends across all STEAM content areas. This paper has provided an extremely brief overview of STEAM languages and literacies and the final section of this article offers an even briefer idea of suggestions for classroom instructional activities focusing on STEAM languages acquisition. These ideas are meant only as a kickstart to the process of addressing STEAM languages in the classroom.

STEAM languages activities
Teaching the languages of each STEAM content area provides students with the lexicogrammatical resources vital to facilitate their capabilities to actively participate in STEAM both at the school level and throughout life. This means students can operate within each discipline because they understand how the language works as well as use each as a language in its own right (Figure 2).

<table>
<thead>
<tr>
<th>Science</th>
<th>the language of explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology</td>
<td>the language of enabling</td>
</tr>
<tr>
<td>Engineering</td>
<td>the language of design</td>
</tr>
<tr>
<td>Arts</td>
<td>the language of interpretation (creative thought and critical thinking) and expression</td>
</tr>
<tr>
<td>Mathematics</td>
<td>the language of the universe reality</td>
</tr>
</tbody>
</table>

Figure 2: STEAM as languages

The following activities offer suggestions for explicitly teaching how STEAM texts work grammatically, structurally and at word level. They are based on functional grammar (Halliday, 1994 & Halliday & Matthiessen 2004), and top-level structuring (Bartlett, 2003). The focus in the first two examples is on text book exemplars and taken from the Australian Curriculum samples (ACARA, 2018).

Example 1

<table>
<thead>
<tr>
<th>Text: Excerpt from ACARA (2018) Year 9 Science work sample:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical change, also called a chemical reaction, occurs when two substances react to form an entirely new substance. This product has a different set of properties from the reactants. For a chemical change to occur, the bonds of the reactants need to be broken, and then new bonds are formed between the atoms in the reaction to form new compounds. A chemical change can be either endothermic or exothermic – that is, it either takes in heat from the environment and converts it to chemical energy or transfers heat to the environment after converting chemical energy into heat energy. Chemical changes can be both natural and manmade. Natural chemical changes include photosynthesis, combustion and oxidation. Manmade chemical changes include saponification in wet chemical fire extinguishers, combustion in fireworks and engines, and batteries.</td>
</tr>
</tbody>
</table>

Logical connective understandings required to negotiate the initial text:
Examples of logical connections are shown below. Chemical change, also called a chemical reaction, occurs when two substances react to form an entirely new substance. This product has a different set of properties from the reactants. For a chemical change to occur, the bonds of the reactants need to be broken, and then new bonds are formed between the atoms in the reaction to form new compounds. A chemical change can be either endothermic or exothermic – that is, it either takes in heat from the environment and converts it to chemical energy or transfers heat to the environment after converting chemical energy into heat energy. Chemical changes can be both natural and manmade. Natural chemical changes include photosynthesis, combustion and oxidation. Manmade chemical changes include saponification in wet chemical fire extinguishers, combustion in fireworks and engines, and batteries.
Science vocab | Science concepts | Discourses of Science
---|---|---
Chemical reaction | Chemical reaction | Explanation
Substance | Bonds | Comparing/contrast
React | Compounds | Cause/effect
Reactants | Convert | 
Product | Transfer | 
Atoms | Natural/manmade | 
Compounds | | 
Endothermic/ exothermic | | 
Photosynthesis/ combustion/oxidation | | 
Saponification | | 

Text Structure: Compare/contrast
The important thing is that students choose a structure which, to them, best fits the text – either; List/description; Cause/effect; Compare/contrast; or Problem/solution.
Students can then take notes accordingly. If the student chooses a list/description then notes will be in the form of a list of important points. If the student chooses a structure such as compare/contrast, then the objects of comparison or contrast can be listed in two adjacent columns and notes taken accordingly e.g.,

<table>
<thead>
<tr>
<th>Natural chemical changes</th>
<th>Manmade chemical changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photosynthesis</td>
<td>Saponification in wet chemical fire extinguishers</td>
</tr>
<tr>
<td>Combustion</td>
<td>Combustion in fireworks and engines</td>
</tr>
<tr>
<td>Oxidation</td>
<td>Batteries</td>
</tr>
</tbody>
</table>

This process is Top-level structuring. Bartlett (2003) and Doyle (2006) demonstrated how knowing the text structures and taking notes accordingly improves students recall of facts and aids written, oral, and graphic representations of information.

Linguistic resources required
- Nominalisation – reactants, reaction
- Process of chemical change – as indicated by ‘and then’
- The realisation of cause/effect relations
- The understanding of contrast

Example 2

Text: excerpt from ACARA (2018) Year 8 Mathematics work sample:
Please expand the expression to solve the equation: $9(d + 6) = 63$

Functionally speaking this question is worded as a demand or Logical connective understandings required to negotiate the initial text: –
Students need to understand – –
‘expand the expression’ links to …
‘equation’ links to …
Students need to understand the meanings of vocabulary, concepts and discourses which link to the expected task. The text of the equation and the task required is a ‘procedure’ in that there is a set process and order that must be followed to solve the problem.

Text structure: Ask students about the structure of the text. Even though it is a brief text, students need to become aware of text structures as this knowledge aids understanding of instructions in differing circumstances. Students can relate prior knowledge to new task instructions more easily.

Logical structure of the task – problem/solution
Key words (clue words) – to solve

Linguistic resources required
Ask open-ended questions about the mathematics vocab, concepts and discourses to determine students understanding of the terms, logical connections and process of solving the problem.

Visual Representation: Have students provide a visual representation to show their understanding of the task.

Example 3

Text: reprinted with permission from Professor Robert Pope, Science Art research centre, Australia.

The Stereoscopic Mind Nous by Robert Pope

This art is an example of visual representation of the Science concept of the stereoscopic mind. It links to the mathematical concept of infinity, to the artistic concept of 3 dimensional (3D) representations on a 2D plane surface. When viewed through stereoscopic glasses this image appears in 3D (see Doyle, 2016). Students can use stereoscopic glasses to investigate this representation which is an ‘end product’. Work backwards to investigate the initial question. List questions that this (or other) representations seek to represent. See artworks of others e.g., Salvador Dali, Roger Saunders (Australian Indigenous), Rod Bearcloud Berry (Native American).

Students draw on visual literacies to realise meanings through creative interpretations of spatial awareness, compositional elements e.g, angles, framing, as well as use of light, colour etc (see Kress & van Leeuwen, 2006).

Linguistic resources required
Language of description
Language of problem/solution
Example 4

Text: Use any text which requires investigating a problem from the local area. For example, a council report in the local newspaper drew attention to floating salvinia weed in the drainage system of a local suburban lake. Local students could investigate the environmental impact of this, the causes and effects of the problem, then design possible solutions. This type of problem requires drawing on all STEAM disciplines.

Extract from Tweed Link (February 1, 2018)

Council contractors will return to Vintage Lakes early next month to remove floating salvinia weed from the Western drainage scheme at Banora Point.

The harvester will collect floating weeds, the majority of which is Salvinia molesta, taking care not to shred the rooted Cabomba caroliniana as any disturbance speeds its spread.

The harvester also must avoid disturbing the beneficial species of waterlilies and water fern (red azolla). The waterlilies provide habitat for the threatened comb-crested jacana, which can be found in small numbers on and around the freshwater drain ...

Possible investigations

How could the weed problem be addressed?
What are the possible causes of the growth?
What are the most probable effects of this growth?
Address the environmental impact of such growths.
Provide reasons for your agreement/disagreement on a harvester being used by council to clean up the problem.

The lexicogrammatical requirements of comprehending such a problem necessitate negotiating scientific terms as well as compass directional understandings. The text itself provides a descriptive explanation on the issue. Taking one suggested investigation: Address the environmental impact of such growths — as an example — the student is required to realise what is meant by the terms ‘address’, ‘impact’ and, realise the ellipsis, that is, that ‘growths’ refers to the Salvinia molesta in this case, but can also refer to other growths such as blue-green algae.

Investigating such a problem could entail visiting the area in order to experience the environment first-hand, photograph data, observe animal/bird habitats, the wildlife, measure the extent of the problem, and so on.

In the classroom, related research, designing, discussions in collaborative teams could mirror ‘real-world’ investigations.

Logical connective understandings required to negotiate the initial text: -

Council contractors will return to Vintage Lakes early next month to remove floating salvinia weed from the Western Drainage Scheme at Banora Point.

The harvester will collect floating weeds, the majority of which is Salvinia molesta, taking care not to shred the rooted Cabomba caroliniana as any disturbance speeds its spread.

The harvester also must avoid disturbing the beneficial species of waterlilies and water fern (red azolla). The waterlilies provide habitat for the threatened comb-crested jacana, which can be found in small numbers on and around the freshwater drain ...

<table>
<thead>
<tr>
<th>Science Vocab</th>
<th>Discourses of STEAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salvinia molesta</td>
<td>Explanation</td>
</tr>
<tr>
<td>Cabomba caroliniana</td>
<td>Problem/solution</td>
</tr>
<tr>
<td>Red azolla</td>
<td>Cause/effect</td>
</tr>
<tr>
<td>Comb-crested jacana</td>
<td>Compare/contrast (e.g. wind conditions as possible cause)</td>
</tr>
</tbody>
</table>

Students need to understand the meanings of vocabulary, concepts and discourses which link to the expected task. They are required to know about the plant and bird species. They also need to research harvesters used in these operations. Part of the project could include design improvements or inventions.
Linguistic resources required

• Technical vocabulary negotiation
• Knowledge of appropriate text structure for representation of ideas e.g., cause/effect; problem/solution
• Knowledge of text types for representation of ideas e.g., report, analysis, procedure.
• Visual literacy – e.g., composition of photograph, camera angles, types of shots, etc to determine the best way of representing ideas and arguments.
• Grammatical considerations – e.g., nominalisation, nominal grouping, processes (verbal group) of relation and/or behaviour etc, conditional relations, causal relations, logical connectives.

Example 5

Text: Taxonomic representation (adapted from Korner et al., 2010, p. 62).

This text provides a simple diagrammatic representation of relationships and classifications. Students could provide a written report of the information given in this text. By highlighting the logical connections, nominal groups and relational processes, students are guided to realise the representational language and how it functions to express the idea or content. The written report would most likely be descriptive in nature and use relational process like has, have (compositional) and is (classification). The text structure would be that of procedural text explaining the relationships and classifications. Classification is a feature of Science texts and represented in taxonomies. Taxonomies also feature specialised or technical vocabulary which is built up in nominal groups in order to represent classification or sub-classification groups. The text is organised from whole to part.

Logical connective understandings required to negotiate the initial text:

- Students need to realise the meanings represented by the joining lines in the diagram. They can associate these with corresponding written or oral language e.g., then, because, and …

<table>
<thead>
<tr>
<th>Science vocab e.g.</th>
<th>Science concepts</th>
<th>Discourses of Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elasmobranchiomorphi</td>
<td>Classification</td>
<td>Procedure</td>
</tr>
<tr>
<td>cetacea</td>
<td></td>
<td>Explanation</td>
</tr>
<tr>
<td>etc</td>
<td></td>
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</tr>
</tbody>
</table>

Students need to understand the meanings of vocab, concepts and discourses which link to the expected task. The text of the equation and the task required is a ‘procedure’ in that there is a set process and order that must be followed to solve the problem.

Text structure:

- Procedural
- Explanation
- List/description

References


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