

## Writing in the Different Disciplines

### Summary

*Each discipline differs from others in what counts as knowledge and the ways in which knowledge is created (Kamberelis, Gillis, & Leonard, 2014). This issue of the Digest begins by conceptualising the importance of writing in the disciplines. It then examines the disciplinary writing in the classroom through two lenses, looking at: one, how disciplinary experts (and learners) approach and produce written texts differently; and, two, how language use in each discipline differs from that in others as experts convey knowledge through the writing of texts in discipline-specific ways. Research on disciplinary writing generally falls into these two categories. The studies reviewed focus on both approaches' mutual goal of distilling instructional strategies that are effective in helping students learn subject content matter and in developing their disciplinary writing. Such discipline-specific strategies include the explicit teaching of technical vocabulary, using model texts, making thinking processes explicit, and engaging students in the work of professionals in the discipline. These instructional strategies necessitate more opportunities for pre-service and in-service teachers to develop their understanding of what constitutes writing in their respective disciplines, as well as the instructional practices that improve students' writing. The studies cited validate the benefits of professional development opportunities in the context of collaborative programmes. These studies emphasise exploring disciplinary distinctions in writing, identifying instructional practices that teach these distinctions, and importantly, validating the effectiveness of those strategies in the classroom.*

### Introduction

C. Shanahan and Shanahan (2014b) posited that there was a growing recognition that disciplinary distinctions exist beyond just content. One marked difference is in the way that knowledge is represented linguistically in the production and evaluation of writing in the different disciplines (Fang & Coatoam, 2013). For example, the conventions that writers follow for structuring arguments differ from discipline to discipline (Hyland, 2013). In science-based disciplines, knowledge is communicated by a process of accumulating the different components of an argument, following a set of strict rules (Paltridge, 2004). In history, however, arguments are produced interpretively, taking into account the strength of the evidence, the views of people in the past, the credibility of authors of texts, and the context of the argument in the time and place under consideration (De La Paz & Felton, 2010). Another writing-related difference between disciplines is the way that writers' attributes are conceptualised (Gimenez, 2012). For example, in

medicine, criticality requires good clinical reasoning, and understanding of evidence-based medicine and ethics, whereas in history it entails examining evidence as well as acknowledging ambiguity and the ideologies involved in a historical event (Jones, 2009). The implication of these disciplinary differences is that writing instruction should be customised to address the kinds of writing that represent the ways of thinking and communicating valued within each discipline (Draper, Broomhead, Jensen, Nokes, & Siebert, 2010).

### Writing interventions

The literature on writing intervention is extensive. Writing often contributes significantly to learning (Bangert-Drowns, Hurley, & Wilkinson, 2004). Meta-analyses by Gillespie and Graham (2014), Graham, McKeown, Kiuahara, and Harris (2012) and Graham and Perin (2007) indicated that strategy instruction, which involved the direct and explicit teaching of students to independently use strategies for planning, revising, and editing texts, had a significant effect on the quality of writing

across a diverse group of learners, including those with learning disabilities. Yet the findings from the research reviewed suggest that classroom literacy practices have not been adequate in preparing young people to write in the disciplines.

Studies demonstrated that the discursive practices of different disciplines appeared in texts and teacher talk in elementary school (Moje, 2010), in which students were increasingly exposed to information texts (C. Shanahan & Shanahan, 2014a). The *instructional* practices of elementary school writing, however, are not reflective of disciplinary writing (Cutler & Graham, 2008). In middle and high schools (Grades 6 to 12), the demands of texts are increasingly discipline-specific (Freebody & Muspratt, 2007), but research and policy studies reviewed by T. Shanahan and Shanahan (2012) indicated that students rarely received overt writing instruction, in either literacy or subject area classrooms beyond the seventh grade.

Each discipline holds particular ideas and beliefs about what constitutes knowledge (Kamberelis et al., 2014). These ideas, however, are rarely discussed or taught, and students' difficulties in producing discipline-specific texts can be masked as linguistic problems throughout their education (Lillis & Scott, 2007). The findings from a report by the US Department of Education (Rampey, Dion, & Donahue, 2009) indicated that 25% of American high school graduates lacked the skills to meet the demands of college writing courses, and, as a result, the industry spent billions of dollars on professional courses to improve their workers' writing.

In response to students' poor writing performance, academics (e.g., Goldman, 2012; McConachie & Petrosky, 2010; Moje, 2007; T. Shanahan & Shanahan, 2012) have called for an increased emphasis on disciplinary literacy with the aim of equipping students to approach literacy tasks with a greater sense of agency and an appropriate set of responses in order to meet the increasingly specialised demands of the disciplines as they progress through school.

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The previous issues of this Digest have cited a range of studies that suggest how students can better grasp the content of different subjects when they have mastery of the thinking and language practices that are specific to those subjects. This issue continues in the same vein with its focus on disciplinary writing. This review of approaches and instructional practices involving disciplinary writing covers a range of disciplines, from language arts and literature (e.g., Beattie, 2007; Faggella-Luby, Graner, Deshler, & Drew, 2012; Wilder, 2012), sciences (e.g., Stoller, Horn, Grabe, & Robinson, 2007), mathematics (e.g., Schleppegrell, 2007; Sinclair & Pimm, 2008), to humanities (e.g., Pytash & Morgan, 2014; Somerville & Creme, 2005). It also looks at a range of learners from elementary schools (e.g., Cervetti, Barber, Dorph, Pearson, & Goldschmidt, 2012; Metz, 2008; Monahan, 2013), secondary schools (e.g., Coffin, 2006; De La Paz et al., 2014; Pytash, Edmondson, & Tait, 2014), and tertiary institutions (e.g., Gimenez, 2012; Hunter & Tse, 2013).

## Approaches to disciplinary writing

Moje (2007), in her review of the literature on disciplinary literacy, identified four approaches to teaching disciplinary literacy: (a) cognitive literacy strategies; (b) linguistic and discursive navigation across cultural boundaries; (c) epistemological processes of the disciplines; and (d) linguistic processes of the disciplines. These approaches are described briefly below.

### Cognitive literacy strategies

Cognitive literacy strategies, such as Concept-Oriented Reading Instruction (Guthrie et al., 2004), focus on the role of the reader, emphasising his or her motivation in applying cognitive strategies to processing any text, whether rooted in the disciplines or found in everyday life. Thus, while such strategies have demonstrated positive effects on students' reading and writing (cf., Graham et al., 2012), attention to specific demands of the practices and texts found in the disciplines is markedly missing, and disciplinary writing remains at a basic level.

### *Linguistic navigation across cultural boundaries*

The second approach, teaching linguistic navigation across cultural boundaries, aims to get students to perceive texts as situation-dependent, mutable texts open to negotiation by the communities that use them. Writing instruction revolves around examining young people's knowledge, text practices, and interests as a basis for teaching disciplinary text processes, and providing opportunities for them to practise navigating across the different discursive and linguistic communities of secondary schooling and their everyday lives.

Somerville and Creme (2005) have explored the approach in the discipline of archaeology. They studied the effects of introducing free writing—writing in prose for a set time without worrying about what or how the student writes—into a first-year archaeology course in a university in the UK. In the nine-week course involving 19 students, the development of archaeology as a discipline that encouraged making known diverse viewpoints (Joyce, 2008) was explored alongside three two-hour writing workshops run by a writing specialist. Each workshop ended with a 20-minute free writing task: the first task was to write a short account (500 words) about any archaeological object, site or monument that students found interesting; the second a short account of an archaeologist's work and influence; and the third a short account of the cultural change that the student experienced through the course. The authors concluded that these free writing tasks had a significant effect in allowing students to articulate their own voice more clearly. The work they did in the free writing contributed in a large part to the structure of the final essay. Compared to a previous cohort, the students involved in the study showed greater understanding of the requirement to use 'archaeological imagination' by explicitly developing the distinct viewpoints used (as opposed to simply using a historical recount), and consequently obtained higher scores.

However, this approach is not without its weaknesses. It tends to focus more on documenting and analysing texts written by young people and their cultural practices and to leave the text practices of the disciplines relatively vague. Detailed analyses are not

typically offered as ways of clarifying for teachers how connections can be made between the everyday text practices of youth and the writing practices of the disciplines. Additionally, the focus on linguistic features of the discourse communities is noticeably absent, with attention to language taught as common ways of speaking, performing, reading, and writing, as opposed to specific examinations of the functional linguistic features of the texts written by members of the disciplines (Moje, 2007).

For the purposes of identifying writing-related disciplinary distinctions and examining instructional practices involving disciplinary writing, the two approaches discussed above—cognitive literacy strategies and linguistic navigation across cultural boundaries—present difficulties because of the relative lack of discipline-specificity in studies involving these approaches (Moje, 2007). This Digest focuses, in the following sections, on the remaining two approaches covering the epistemological and linguistic processes of the disciplines.

### *Epistemological processes of disciplines*

Studies involving the teaching of disciplinary epistemological processes are less interested in generic cognitive strategies and instead focus on three main goals: (a) specifying the cognition (i.e., thinking processes) of experts in the disciplines as they produce written and oral texts; (b) comparing the cognitive processes of these experts to learners of the subject; and (c) applying those cognitive processes to educational practice (Moje, 2007, p. 17). The following studies, set in history classrooms, typify these three goals.

A study by Young and Leinhardt (1998) focused on specifying the cognition of an exemplary history teacher, who through the use of primary documents in an Advanced Placement (high school) American History class, engaged her five students in a year-long course to construct an evidenced interpretation of issues through historical reasoning and writing. The teacher, through a continual engagement of the students in the cognition of historical authorship, involved them in active discourse aimed at discussing core disciplinary ideas using primary and secondary source readings rather than textbook chapters using worksheets. It was found that students'

written pieces grew in content knowledge, integrating period knowledge more sensitively, and, in their linguistic dimension, evaluating and qualifying claims and evidence more actively.

Rouet, Favart, Britt, and Perfetti (1997) cast light on the cognition of experts and learners when they are engaging in historical writing. They investigated the influence of discipline expertise on students' reading, evaluation, and use of multiple documents about a historical controversy. Two groups, 11 graduate students in psychology (history novices) and eight graduate students in history (history specialists), both engaged in doctoral programmes in a French university, studied two controversies regarding the history of the Panama Canal. For each controversy, the students studied a set of documents, wrote an opinion essay, and evaluated the documents for usefulness and trustworthiness. It was found that the history novices tended to write general context statements that referred to principles not specific to historical reasoning, while the history specialists tended to write historical context statements that referred to historical knowledge or principles. The authors suggested that it was this discipline expertise that helped the history students connect information sources and interpretations to their representation of the situation or problem, moving towards a more disciplinary act of historical argumentation.

De La Paz et al. (2014) conducted a study in the US to gain preliminary data on the effectiveness of cognitive apprenticeship in improving the abilities of academically and culturally diverse middle school students to compose historical arguments. Cognitive apprenticeship is an instructional approach which makes expert thinking and literacy practices visible to novices through teacher modelling. De La Paz et al. (2014) also measured teachers' level of fidelity (i.e., the degree to which teachers implemented the intervention) to the proposed intervention in order to determine how it influenced students' writing outcomes. The 18-day course, conducted with 157 eighth-grade students, involved the 13

eighth-grade teachers providing students with a scaffolded approach to working with multiple primary historical sources. This approach was premised on research findings indicating that teachers could help students to develop disciplinary writing by assigning argumentative and analytical writing in combination with reading multiple texts (e.g., De La Paz & Felton, 2010; Monte-Sano, De La Paz, & Felton, 2014; Young & Leinhardt, 1998). At the beginning of the year, students in both control and intervention groups demonstrated similar abilities in writing. At the end of year, however, the authors found that there were significant improvements in the intervention group's ability to write historical arguments. Also, higher levels of teacher fidelity to the intervention were associated with higher quality student historical arguments.

Research into teaching epistemological processes (e.g., De La Paz et al., 2014; Rouet et al., 1997; Young & Leinhardt, 1998), by and large, has not emphasised the role of language except where it is required to process the different language cues (e.g., subtexts, technical vocabulary, contextual or temporal cues, place names) demanded by the

discipline. Content experts, however, use distinct language patterns to construct their disciplinary texts (Hyland, 2013). Fang (2012a) argued that recognising discipline-specific ways of using language could help students develop a sense of how a discipline organises knowledge and construes value through language, enabling them to write more effectively in the disciplines. The next approach to disciplinary writing aims to identify these language patterns.

### *Linguistic processes of the disciplines*

Kamberelis et al. (2014) posited that disciplines differ in the way linguistic structures are used by experts to convey knowledge to each other. One approach for differentiating language patterns within writing arose from systemic functional linguistics (Halliday & Matthiessen, 2014). A functional linguistics approach aims to help students reduce difficulties when approaching texts by uncovering meaning that might

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otherwise remain hidden (Fang & Schleppegrell, 2010). For example, Halliday and Martin (1993) identified four linguistic aspects of expository text that challenge readers:

- **Technicality**, the use of technical terms in discipline-specific ways;
- **Abstraction**, which is achieved through the use of technical terms and nominalization (i.e., transforming grammatical constructions such as complex phrases and verbs into nouns);
- **Information density**, a measure of how much information there is in a text; and
- **Authoritativeness**, achieved through the use of technical vocabulary, declarative sentences, passive voice, and generalised participants.

Nominalization is a language feature that Fang, Schleppegrell, Lukin, Huang, and Normandia (2008), using a functional linguistics approach, have studied across subjects. Their analyses suggest that while nominalization was frequent in history texts, it was not unique to history, and occurred in all secondary school subjects. However, it served different functions in each type of text. For example, nominalizations in science texts, such as ‘this involuntary dividing of cells’ and ‘the loss of control’, extracted previously presented information and served as the grammatical subject, a point of departure for continuing discussion on the topic (Fang, 2012b). Other nominalizations such as ‘interaction’, ‘production’, and ‘growth’ enabled the compacting of information into nouns, as in the example of the use of ‘interaction’ in the following text:

*The cell cycle is controlled by proteins called cyclins and a set of enzymes that attach to the cyclin and become activated. The interaction of these molecules... controls the cell cycle (Fang, 2012b, p. 25).*

In the given text, the noun ‘interaction’ condensed the information given in the preceding sentence, allowing that information to be further used in its entirety. Halliday and Martin (1993) explained that nouns are a key grammatical resource in scientific discourse for creating technical objects, developing logical reasoning and achieving precision and concision.

Fang (2012b) stated that, in its use of nominalization, history distinguished itself from other disciplines in that texts were populated with ‘metaphoric abstractions’, ‘things’ that were nominalizations derived from processes and qualities (p. 29). The examples cited by Fang (2012b) include ‘the kidnapping and murder’, ‘the trial’, ‘the viewing’, ‘murder’, ‘protests’, ‘decision’, and ‘ruling’. He asserted that it was primarily through these nominal structures that historians conceptualised events as ‘things’ and infused their perspectives into the interpretation and judgement of the historical event.

Hyland (2009) has done extensive research in the field of academic writing, uncovering disciplinary writing distinctions using a 1.5 million word corpus of research articles across eight disciplines together with four million words from student dissertations and interviews with 30 academics. The main differences he found between disciplines were in:

- **Citation practices**, the inclusion of references to the work of other authors;
- **Reporting verbs**, verbs such as ‘suggest’, ‘argue’, and ‘describe’ to refer to their literature;
- **Hedges**, devices such as ‘possible’, ‘might’, and ‘likely’ that function to withhold complete commitment to a proposition;
- **Self-mentions**, instances when writers intrude into their texts through use of ‘I’, ‘we’ or other impersonal forms;
- **Directives**, devices that instruct the reader to perform an action or to see things in a way determined by the writer, expressed largely through imperatives such as ‘consider’, ‘note’, ‘imagine’ and verbs that express obligation like ‘must’, ‘should’ and ‘ought’; and
- **Lexical bundles**, frequently occurring word sequences that help shape texts, such as ‘at the same time’, ‘in the case of’, and ‘on the other hand’.

These differences, Hyland (2009) argued, reflected how writers in the different disciplines drew on different linguistic resources to develop their written texts, establish their credibility and persuade their readers. He stated that the instructional implication of his findings was the need for teachers to take into account in their classroom practices the ways in which texts are

created in these disciplines.

Having reviewed the various approaches to disciplinary literacy, we now turn in the following section to examine a range of studies which focus on instructional practices that involve disciplinary writing.

## Instructional practices across the disciplines

The following studies represent the two approaches foregrounded in this issue of the Digest (i.e., epistemological and linguistic processes), though they may at times overlap. The studies are arranged according to the discipline in which they were undertaken and, where possible, in chronological order of the students' stage of schooling.

### English language arts and literature

It is important to note at the outset that this discussion of the English language arts curriculum is based on the American context.

English language arts has as its primary goal the development of students' capacity to read, respond to, evaluate, and create texts (Christie & Derewianka, 2010). In her review of American syllabus documents, Tay (2009) summarised the key features of the language arts curriculum in the following description:

*It focuses on the development of literacy, cultural understanding, and creative and critical thinking. The processes of speaking, listening, reading, viewing, writing, and representing are to be developed in an integrated manner rather than separately. Students will engage in a range of experiences and interactions with a variety of texts so that they will be able to use language effectively and purposefully in an array of contexts. (p. 299).*

Tay (2009) observed that in Singapore, language arts had been interpreted in a variety of ways according to differing schools' needs. Both American and Singaporean syllabuses were similar in their focus on an integrated approach to

language teaching, which had long been a cornerstone of the Singapore Ministry of Education (MOE) English Language syllabuses. However, a key distinction that distinguished the MOE English Language syllabuses from the American syllabuses was the explicit teaching of language skills and grammar, which Tay (2009) stated was an essential component in English language teaching in the context of Singapore's bilingual policy. This difference is important to note as the majority of studies cited in this section focus largely on language arts in the American context, and thus should not be taken to generalise to the English Language or Literature disciplines in Singapore or elsewhere.

English language arts approaches texts in distinctively personal ways. Divergent understandings of texts are encouraged as students interpret them through personal life experiences (Rosenblatt, 1995). Individual expression is emphasised as students write (Wilson, 2011). This primary purpose of expressing

individuality contrasts with the shared historical contexts and group affiliations in the discipline of history (Wineburg, 1991), and the emphasis on expressing thoughts

contrasts with the practice of reporting observable outcomes related to objective physical phenomena in the disciplines of science (Bazerman, 1988). In the language arts at primary school levels, writing processes emphasise the specific devices and techniques through which individual thoughts can be expressed in a story-telling way, using non-technical vocabulary and simple clauses linked into sentences through coordination (*and*) or subordination (*as, although, until*) to capture the dynamism and fluidity of speech (Fang & Schleppegrell, 2010).

However, English language arts is not exclusively focused on the content of texts: there is an emphasis on processes that students use as they write these texts (Flood, Lapp, Squire, & Jensen, 2003). Thus, explicit instruction on writing processes and strategy instruction is also considered as a central domain of this discipline, and has been consistently shown to produce results with primary and secondary school students (Graham et al., 2012; Graham & Perin,

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2007).

For example, Faggella-Luby et al. (2012) explored the effectiveness of strategy instruction across a number of studies. They analysed studies that looked at students in Grades 4-12, selecting only studies that involved struggling adolescent learners and/or those with learning disabilities. Six of the 33 studies were judged to include discipline-specific strategies (e.g., story planning and monitoring strategies, mnemonic strategies and character development strategies) in writing composition for the English language arts classroom. All six studies showed evidence for the effectiveness of strategy instruction, though one study's results indicated that writing quality was not maintained across time or with another teacher.

According to Fang (2012b), while texts of diverse types and modalities were used in the language arts curriculum, literature remained the focus of study. He suggested that because literature related closely to concerns, emotions, behaviours, imaginations, and other aspects of human life, it drew on the use of everyday language and its creative manipulation for aesthetic ends to give literary texts a special character. He further posited that students might find it challenging to interpret figurative language (e.g., metaphor, simile, symbolism) and peculiar vocabulary (e.g., archaic words) in the literary texts they read, suggesting that instruction in such language patterns, which constructed literary knowledge, was a necessity to develop students' disciplinary writing abilities, an idea shared by Showalter (2003).

Wilder's (2012) review of syllabuses, assignments, exams and interviews from 20 professors who taught literature courses at an American university aimed to uncover the goals and methods of the literature courses. She found that while the professors' descriptions of their expectations for students' writing strongly suggested the disciplinary genre of literary analysis, the writing of assignments was not emphasised due to logistical constraints such as large cohort sizes. The professors who did

emphasise writing seemed to teach it without explicit instruction in discourse practices specific to the discipline of literature. They stressed instead issues of mechanics, coherence, and identification of technical terms, reasoning that there was no expectation to impose literature-specific writing strategies on their students, since they were not expected to go on to become literature experts themselves. Links were not made between the subject content knowledge and the students' own writing. The advice consistently given to students related to generic writing strategies, leaving the rhetorical choices that students could make in their disciplinary writing largely implicit. Wilder (2012) attributed the wide variation in students' writing abilities to the professors' methods of teaching. More importantly, she observed that explicit instruction in literary discourse practices would support less adept students or students less familiar with the subject in acquiring better writing. She found that students that received occasional help from

teaching assistants to use special topoi (i.e., traditional literature themes or formulae) were significantly more likely to receive higher grades in the course.

In the UK, Beattie (2007) investigated the effects of

talk on improving her students' literature writing in her all-boys classrooms across various grades from Year 7 to Year 10. She observed that despite excellent student oral presentations of characters that they had read about in texts, their subsequent written pieces on the same topics were poor in quality. Through interviews, her students explained that they lacked the confidence to write, but thrived on the reciprocal nature of oral work. She found that getting her students to talk about their writing to her and their peers, in order to make explicit their thinking processes as they wrote, motivated them to interact with their peers to seek approval and clarification. Her students became more open to reframing and reviewing their ideas as they shared excerpts of their writing with their peers. This externalisation of ideas, followed up with redrafts, modelled the disciplinary practices of process writing that experts engaged in as they wrote, resulting in the development of keenly voiced written pieces.

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It is worth noting the suggestions by McConachie and Petrosky (2010) to encourage greater disciplinary writing in the language arts classroom: (a) offer opportunities to learn core concepts and habits of thinking; (b) follow a rigorous curriculum that mirrors the work of the discipline in its tasks, texts, and talk and that positions learners as apprentices; (c) offer opportunities to engage in meta-understandings of their learning through reflection on their studies; (d) encourage practices that enable socialising intelligence by encouraging risk taking, help seeking, question asking, problem solving, and reflective analysis; and (e) have practice assessed through multiple forms of informal and formal assessments that gauge student mastery of literature concepts, their habits of thinking, investigating, problem-solving, and talking.

The studies reviewed here suggest that the two approaches, that of explicitly teaching epistemological processes—through instruction in writing processes and strategies—and of teaching linguistic processes—through instruction in language patterns that construct literary knowledge, use of topoi, and literary discourse practices—represent useful interventions for developing disciplinary writing within the language arts classroom. In the following section, we turn to writing in the disciplines of the natural sciences, with a sustained focus on instructional practices from these two approaches.

### *Natural sciences*

Duschl, Schweingruber, and Shouse (2007) suggested that children come to school with a foundational knowledge of the natural world and are constantly making sense of the world around them, linking their understanding to the domains of science, such as those corresponding to mechanics, human cognition, matter, and the living world. Duschl and his colleagues argued that this basic scientific knowledge and their daily experiences are important starting points for building deeper expertise. Various studies support this: Juel, Hebard, Park Haubner, and Moran (2010) described young learners learning about how scientists and historians think; through an

extended science curriculum, Metz (2008) demonstrated that first graders could develop the ability to frame questions for investigation and to continue with ‘elaboration of research design, data collection and analysis’ (p. 158) modelled after scientists; and Cervetti et al. (2012) described a study in America in which primary school students were engaged in doing science and were simultaneously learning about reading and writing practices in science.

Cervetti et al. (2012) developed an instructional programme for 47 fourth grade classrooms that involved students in reading and writing as they planned, conducted, and made sense of their own investigations. The authors used every opportunity to share with students the values, dispositions, forms of reasoning, and methods of inquiry that are part of scientific knowledge building. In their inquiries, students read an account about a professional scientist describing his own investigations, including the processes that he used to record information and reason

about the evidence he gathered. They then used this as a model for their own inquiry process and to compare their results with his, just as professional scientists use the work of

other scientists to make sense of and interpret their own results. Cervetti et al. (2012) found that these opportunities to use language to talk, read, and write about science had a positive impact on students’ literacy learning. In the writing measure, the treatment group (47 classrooms), when compared to the control group (another 47 classrooms), made significant gains in five out of seven writing dimensions: use of evidence, introduction, clarity, science conceptual understanding, and vocabulary count. Other studies of science-literacy integrated programmes corroborate these positive effects on writing (e.g., Goldschmidt & Jung, 2010; Palincsar, Magnusson, Collins, & Cutter, 2001; Romance & Vitale, 2001).

Learning the vocabulary of a discipline is the basis for the forming of rich conceptual networks of words and the understanding of how these words are related to each other (Nagy & Scott, 2000). In Morgan’s (2012) study (elaborated on in Issue 4 of this volume), it was observed that the science

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teacher of an Australian middle school, upon assessing her students' level of technical language knowledge in science and finding it to be lacking, provided instruction for scientific vocabulary that students required in order to engage in scientific writing. As a result, the advanced students developed more complex, concise and precise writing pieces, while students who had written little before the intervention were able to write longer pieces.

Wilson, Smith, and Householder (2014) examined the ways in which two groups of 17-year-old students from an American high school used writing to solve authentic problems through engineering design processes (i.e., define a problem, gather information, generate ideas, evaluate ideas, and communicate the solution). The group that engaged in the greater number of writing practices created more convincing problems. However, both groups forgot important discussion points in presenting their ideas. Both teams also faced difficulties in communicating their solutions, frequently expressing frustration at being unable to select words that were peculiar to the field of engineering. The authors asserted that teachers could support adolescents' engineering activity by modelling how engineers approach problems, including making their thought processes explicit and visible through the use of writing artefacts, and providing structured opportunities for students to evaluate their own literacy practices at each stage of the design process.

The high degree of specificity in disciplinary writing is evident at the university level. Nesi and Gardner (2012), through a large scale corpus study of close to 3,000 assignments of over six million words across 30 disciplines in UK higher education, identified 13 different 'genre families', ranging from case studies through empathy writing (i.e., accounting for different perspectives in writing to answer questions of why people acted as they did) to research reports, which differ in social purpose, generic stages, and the networks they form with other genres. Gimenez (2012) noted in his study that students in supposedly similar fields such as nursing and midwifery were given very different writing assignments and were expected to write differently according to their fields' different perspectives of criticality, evidence and

impersonality. He stated that examining the relationship between disciplines, attributes, and written communication could provide ways in which novices of a discipline could gain access to disciplinary writing and thus become more central members of their professional community.

The call for disciplinary literacy programmes where content teachers collaborate with literacy experts to create appropriate, discipline-specific writing assessments has been supported by several academics (Moje, 2008; Perin, 2001; T. Shanahan & Shanahan, 2008). A paper by Stoller et al. (2007) reported on a sustained collaboration between applied linguists and chemistry faculty to create and validate writing assessment instruments for a 'Write Like a Chemist' course in an American university, a multiple-year effort to form valid analytic and holistic assessment instruments to be used by chemistry faculty to assess the writing performance of chemistry majors. Early in the project, applied linguists introduced the chemists to the idea of analysing genres in terms of context, organisational features, vocabulary and grammar features, and scientific conventions in three professional genres (i.e., journal articles, scientific posters, and research proposals). The chemists then conducted analyses that required an understanding of chemistry content and suggested additional features for further investigation. As a result of the sustained efforts, the authors identified the most common moves in the three genres. For instance, they illustrated that the move structure of a journal article's 'results' section showed how writers moved from 'setting the stage'—by reminding readers about the project and methods—to 'telling the story of scientific discovery'—by highlighting unexpected results. Another notable outcome was the creation of a 1.5 million-word corpus of chemistry texts using tools from the field of corpus linguistics, which made it possible to analyse the language of chemistry in order to identify common and generalisable linguistic patterns for instructional purposes.

These studies suggest that the disciplinary writing in the natural sciences can be developed in the following ways: (a) through an epistemological approach of providing opportunities to use language—through model texts, inquiry practices, collaborative talk, and authentic

problems for pupils to inquire into to scaffold their own scientific thinking processes; and (b) through a linguistic approach of examining the relationship between disciplines and language features common in scientific texts, as well as through the explicit teaching of scientific vocabulary. As will be seen in the next section, the same principles can be applied in the discipline of mathematics.

### Mathematics

Burton and Morgan (2000) argued that mathematics is a language of words, numerals, and symbols that are at times interrelated and interdependent, and at other times disjointed and autonomous. Schleppegrell's (2007) synthesis of research by applied linguists and mathematics educators focused on identifying the linguistic structures used in mathematics. She found that the linguistic aspects of mathematics that distanced it from everyday use of language included: (a) the multiple semiotic (meaning-making) systems—symbols, oral language, written language, and visual representations—that go beyond what ordinary language can express; (b) the highly technical vocabulary that make oral and written language challenging; (c) the grammatical patterning that brings together long, dense noun phrases in clauses and sentences constructed with *being* and *having* verbs that present a variety of meaningful relationships; and (d) the frequent use of conjunctions that have specific mathematical meanings different from their everyday use. Hillman (2014), in her review of literature on mathematical literacy, offered instructional suggestions to teach mathematical linguistic features not unlike those identified by Schleppegrell (2007).

The identification of these linguistic distinctions highlights the need for teachers to explicitly teach the language of mathematics. Adams (2003) observed that, more than in any other discipline, the construction of mathematical knowledge depends on the spoken explanations and student interactions with the teacher. She suggested that teachers could move students in the elementary classroom from everyday language into the mathematics register by helping them recognise

and use mathematical language rather than informal language when they were defining and explaining concepts; by working with them to clarify ambiguous meanings of words that exist in both everyday vocabulary and mathematical texts; and by explicitly evaluating students' ability to use technical language appropriately, for instance through having students talk about mathematics as they solved problems, encouraging them to articulate patterns and generalisations.

Pugalee (2004) suggested that teachers could help students to construct mathematical understanding by requiring them to share their reasoning and verification processes in writing. In an exploratory study investigating the impact of writing during mathematical problem solving, he found that his ninth-grade algebra students ( $n = 20$ ), after a two-week enrichment period where they engaged in journal writing that focused on describing their thinking, were significantly more successful in problem solving tasks than students who merely verbalised their thinking.

Sinclair and Pimm (2008) examined forms of spoken mathematical reasoning that undergraduate mathematics students ( $n = 40$ ) employed when working in pairs on geometric tasks. They wanted to distinguish how experienced mathematical students spoke when working on problems from the conventional way that formal mathematics was supposed to be written. Through an analysis of 20 videotaped episodes of students working in pairs at computers to solve tasks, the authors identified significant differences between students' speech and writing. A major difference was in the precision of language used. Sinclair and Pimm (2008) argued that mathematical writing was more precise than verbal explanations, with logical uses of connectives such as 'because' (i.e., to state an effect and explain its cause), as exemplified in this extract from a book by Birkhoff and Mac Lane (1953)—'Because of the correspondence between matrices and linear transformation, we need supply the proof only for one case' (p. 227). In the students' utterances, however, 'because' was used far more often in a

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*Teachers could help students to construct mathematical understanding by requiring them to share their reasoning and verification processes in writing.*

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pragmatic sense (i.e., to assert a claim and posit justifications), for example: ‘No, because the rotation point is gonna be over here’, and ‘Yeah, the original one because then...That didn’t work. We did it wrong’ (Sinclair & Pimm, 2008, p. 875). Similarly, Sinclair and Pimm (2008) claimed that mathematical writing expressed a high degree of certainty. In contrast, it was observed in the students’ speech that clauses with modality were used frequently to express students’ uncertainty, as evidenced in the following examples: ‘Maybe that’s the line’; ‘But I don’t know if that’s right’; and ‘That would work, wouldn’t it?’ (Sinclair & Pimm, 2008, p. 878).

The authors concluded that having shown how written mathematical explanations were generally more precise than verbal ones, there was a case for engaging students in writing during mathematical problem-solving.

O’Halloran (2005) stated that any analysis of classroom discourse ‘must necessarily take into account the multisemiotic nature of mathematics, and the shifts between the written/ spoken modes and the shifts between language, symbolism and visual display’ (p. 206). She observed that the functions and grammar of mathematical symbolism and visuals were not typically discussed, and argued that mathematics teachers needed to explain, from a linguistic perspective, how these devices had developed historically as semiotic resources fulfilling particular functions. This understanding, she explained, would allow students to make use of the options provided not just by language, but also by these devices in order to solve mathematical problems.

These studies from the discipline of mathematics indicate the importance of explicitly teaching mathematical language in order to disambiguate everyday language for the purpose of precise mathematical writing. They suggest that teachers should have students construct both verbal and written explanations of their mathematical reasoning in order to evaluate their explanations more accurately. Having seen the importance of spoken and written language in mathematics, in the next section, we will go on to review studies that highlight the epistemologies in the social

sciences and humanities disciplines, and reiterate the need for the explicit teaching of linguistic features, in order to improve disciplinary writing.

### *Social sciences and humanities*

Wineburg (1991) argued that the act of writing in history was not simply a process of recording or even imagining how the participants felt as an event was happening. Instead, writing in history was an act that required one to ‘understand the bias’ (p. 496) of a source. In his study, he observed the think-aloud procedures of eight historians and eight high-ability undergraduates as they read historical documents and ‘wrote’ their own texts in their minds—a pretence of deliberating with the authors of those historical documents by talking to themselves (Wineburg, 1991, p. 503). He found that it was not the literal text or the inferred text that historians comprehended in order to write, but the subtext, a text of hidden and latent meanings. Subtexts of historical documents have two spheres: the first sees the text as a rhetorical artefact from which

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*It is incumbent on history educators to apprentice their students in historical habits of mind.*

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historians try to reconstruct the authors’ purposes through an examination of the use of language for persuasion (i.e., the words authors use to convince);

and the second sees the text as a human artefact, which relates to how texts frame reality and disclose information about their authors’ assumptions, world views, and beliefs (i.e., the types of people the authors are). He found that historians used this ‘sourcing heuristic’ (Wineburg, 1991, p. 510)—the strategy of reading the subtext—nearly all the time (98%), while students used it less than a third of the time (31%), suggesting that it was incumbent on history educators to apprentice their students in historical habits of mind.

In history, the most frequent written genre is that of argumentation, which usually involves taking a set of documents and creating a new text with them. Historical argumentative essays follow a particular discourse type and require the ability of students to produce knowledge transformation, as opposed to simply knowledge telling (Scardamalia & Bereiter, 1987).

Young & Leinhardt’s (1998) earlier cited study

involved analysing how five students responded to four document-based questions over a year, tracing how organisation, document use, and citation language indicated the degree to which the students transformed and integrated information in disciplinary ways. It was found that students moved from knowledge telling (listing period and document content as discrete information bits) to knowledge transformation (integrating content as interpreted evidence for an argument) over the period of the study. This strongly suggests that history instruction—one that engages students in the discipline by providing multiple source readings, that involves students in active discourse aimed at reasoning about historical ideas using textual evidence, and that invites students to act as authors constructing an evidenced argument rather than as memorizers of content—can support the development of complex writing skills even when these writing skills are not the object of explicit instruction.

Coffin's (2006) study used linguistic analysis to develop a description of the types of written texts typically required by secondary school history curricula. She found three dominant genres required for successful writing in the classes: recording, explaining, and arguing. She also found that as students progressed through secondary school, they were expected to use more technical language, to engage in more abstract writing, and to use linguistic processes such as nominalization. This description informed the subsequent professional development intervention in which 17 history teachers worked with Coffin and other linguistic specialists to integrate the teaching of these genre-specific language practices to facilitate students' writing skills with the development of historical knowledge. Evidenced in their vocabulary and grammar choices, teachers showed a significant growth in their level of explicitness with reference to the language system, which they began to see as integral to learning history. They also focused more on raising students' awareness of the form and function of different history genres. Consequently, students' writing improved, demonstrating more purposeful text organisation and clearer structure than before the intervention.

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*Meta-analyses have identified the instructional approach of studying model texts to be effective for teaching writing.*

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Meta-analyses have also identified the instructional approach of studying models to be effective for teaching writing (Graham et al., 2012; Graham & Perin, 2007). The use of mentor texts in an economics high school class was explored in a study conducted by Pytash et al. (2014) in a private school in America. The study sought to understand the development of disciplinary writing of 12 students as they used a mentor text in an economics class over a four-week period. Each class was 90 minutes long and alternated between three and two days a week. For two weeks, students read and deconstructed a white paper. Each day began with a teacher leading and modelling the analysis of the text for both content and form. She emphasised the language choices that the author of the white paper used to make claims and support his positions, and explored the author's background to identify biases that might sway his positions and purposes

for writing the white paper. Students then worked in collaborative groups to examine additional sections of the text, discussing their ideas and thinking

subsequently as a class. The remaining two weeks were spent on students' research and drafting of their own policy paper. The authors found the mentor texts provided students with knowledge of: (a) how to structure their paper; (b) the discourse of economics including tone, specific vocabulary use, and the persuasive use of statistics; and (c) why economists write—to inform one another of current policies or economic theories.

Hunter and Tse (2013) evaluated a programme by an Australian university seeking to integrate the processes of writing and knowledge construction in the context of a macroeconomics classroom. They found that when cohorts of around 300 to 400 students went through writing workshops conducted independently of the discipline, students performed worse in their macroeconomics writing assignment. In contrast, when a cohort (n = 309) went through an embedded programme addressing discipline-specific writing processes and providing macroeconomics concepts, they performed better. This offers evidence that subject lecturers who explicitly teach the writing processes in their discipline, coupled with the use of subject

content, can benefit students in terms of helping them improve the quality of their writing. The findings also suggest that general writing strategies that are taught outside of a discipline, such as in the cognitive literacy approach, do not contribute to enhancing disciplinary literacy.

In the disciplines of the social sciences and humanities, the studies reviewed indicate the following useful practices to develop disciplinary writing: (a) providing instruction in the strategy of reading the subtext of history texts or in the 'sourcing heuristic'; (b) providing multiple source readings which engage students in active discourse aimed at reasoning about historical ideas using textual evidence, and mentor texts that provide scaffolds on discourse structure, tone, vocabulary use, and conventions in economics writing; and (c) giving explicit instruction in vocabulary, grammar, and text organisation choices.

## **Teacher professional development and support**

This issue of the Digest has focused on studies that suggest the importance of the teacher in providing instructional interventions to improve students' disciplinary writing, such as disambiguating technical vocabulary, using mentor texts, making thinking processes explicit, and engaging in the work of professionals of the discipline. Reviewing the literature from the past two decades, however, Lesley (2014) reported that very little research exists on methods for preparing teacher educators to support the development of disciplinary literacies. Moreover, she found that most textbooks preparing undergraduate pre-service teachers for literacy instruction were predicated on a generalisable knowledge base of strategies that can be used across the curriculum, as opposed to being discipline-specific. Mac Mahon (2014) conducted a study in Ireland, reporting on the level of disciplinary literacy support provided by three subject teachers for students with literacy difficulties in the subjects of history, geography, and science. It was found that the teachers' lack of professional knowledge in (a) conceptualising literacy, (b) supporting students with literacy problems and (c) teaching subject vocabulary was a significant challenge to pedagogical change at

the classroom level.

Reflections by Monahan (2013), a science and English teacher, exemplify this problem. Through a six-week writing programme, she aimed to develop her sixth grade pupils' expository writing which she had found lacking in voice. She believed that teaching her students about argumentative writing through a simultaneous investigation of science topics would promote greater voice and engage students in the collaborative building of subject knowledge. She engaged her students in a variety of writing activities such as journaling, graphic organisers, quick-writes, and reflections, and participation in a debate. Finally, students wrote an argumentative essay within the confines of a science topic. The author concluded that she had succeeded in achieving her aim of developing students' scientific knowledge and argumentative writing. However, she conceded that their arguments were outside the disciplinary boundaries of scientific writing, and that their authorial and aggressive voice undermined their persuasiveness within the field of science. She suggested that this outcome could have been avoided had she collaborated with other language arts and content area teachers to mine mentor texts for the voicing practices of disciplinary experts.

Studies cited earlier in this Digest validate the usefulness of a collaborative programme in developing disciplinary writing (e.g., Coffin, 2006; De La Paz et al., 2014; Stoller et al., 2007). One teacher education programme at the University of Michigan has an innovative solution: it offers subject-specific teaching coursework and clinical rounds practice, modelled on the rotations that medical interns do through various specialties, that provide opportunities for novice and veteran teachers to examine similarities and differences in language use, text structures and genres, and assumptions about knowledge and learning across disciplines (Bain, 2012).

The work of Johnson, Watson, Delahunty, McSwiggen, and Smith (2011) in mathematics and geography exemplifies a team approach to understanding these disciplines and exploring similarities and distinctions between them, as viewed by the subject matter experts. Johnson and colleagues, who were literacy educators in teacher preparation programmes at two

universities, explored literacy practices with two mathematicians and a geographer in order to identify the skills that teachers would need to pass on to their students.

One major result of their collaboration was the identification of useful disciplinary strategies that were subject-specific. They found that mathematics students needed opportunities to play with or work through the knowledge they were learning, which could occur when students worked in small groups to (a) think aloud about their mathematical thinking, (b) engage in 'what if' conversations about the patterns they identified, and (c) use the language of mathematics with think-alouds while creating proofs.

The authors noted that the language of geography was specific. It also borrowed from multiple fields such as social and physical sciences, and as technology advanced, so did the terminology specific to these technologies, which fed into the fields that the language of geography comprises. They suggested that students read geography texts with specific, up-to-date vocabulary and then practise by taking and making notes in graphic organisers, in order to identify intertextual patterns as well as for the collection and organisation of information to make those intertextual connections.

Importantly, they garnered three learning points with implications for teacher preparation and development in the field of disciplinary literacy.

First, they found that what occurred in primary and secondary schools, to a large degree, was knowledge transmission through lectures and talk about the disciplines, rather than the actual practices of the disciplines of mathematics and geography. Teacher educators and teacher candidates need to be apprenticed into gaining adeptness in these practices.

Second, teacher educators need to be able to read and write successfully within their disciplines in order to apprentice their own students. Programmes that promote or even require such expertise within the disciplines should be

developed for teacher candidates.

Third, both literacy teachers and subject teachers are, in essence, teacher educators, and there is value in exploring the topic of disciplinary literacy collaboratively for improving the opportunities that learners may have in constructing knowledge of content and practice in the disciplines.

Christie and Derewianka (2010) conducted comprehensive research for over 20 years with Australian primary and secondary school students, analysing approximately 2,000 of their written texts from English, history and science disciplines using systemic functional linguistics. They summarised how major linguistic resources developed from early childhood to late adolescence, and across the three subjects. Through their findings, the authors proposed that teachers should be informed about how writing developed from early childhood to late

adolescence in order to better monitor their students' progress, anticipate challenges ahead, identify sources of difficulty, and teach writing skills that might otherwise remain implicit. Additionally, the authors presented

important principles to consider when creating writing programmes:

1. It is important to understand how students learn to write according to their stage of writing development;
2. Teachers of all subjects should be encouraged to use a framework of language;
3. The teaching of writing should focus on the genres to be written, the raising of students' awareness of language resources and a repertoire of knowledge and skills;
4. Teachers should introduce and use a metalanguage for talking about, interpreting, playing with and critiquing written language from the early years of schooling in order to raise students' consciousness of language; and
5. The metalanguage used should slowly progress across the years, using selected traditional and functional terms.

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*Both literacy teachers and subject teachers are, in essence, teacher educators, and there is value in exploring disciplinary literacy collaboratively for improving the opportunities that students have for learning.*

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## Conclusion

The studies reported in this issue of the Digest highlight that the approaches of teaching epistemological and linguistic processes to students comprise a host of instructional practices. The studies suggest that these instructional practices or strategies have the potential to develop students' writing in the disciplines at their varying levels of study.

Table 1 summarises the strategies covered in each of the disciplines. Some of the strategies were not part of the studies' interventions, but raised as instructional implications by the respective authors.

These approaches and strategies may present useful starting points for subject teachers endeavouring to develop their students' writing. While implementing these strategies requires sophisticated skills that call for collaborative disciplinary literacy programmes involving both subject teachers and literacy consultants, the models reported in the studies indicate that there are schools that have found solutions to fit their varied contexts. It is incumbent on curriculum planners, schools, and partners to find their own way to build teachers' professional knowledge and capacity in developing these strategies, such that students in turn are apprenticed into creating written pieces that are valued and celebrated in the different disciplines.

Table 1

<i>Instructional Practices to Develop Disciplinary Writing</i>	
Subjects	Epistemological and linguistic processes
English language arts	<ul style="list-style-type: none"> <li>• Explicit instruction on writing processes and strategy instruction (Graham et al., 2012)</li> <li>• Teaching the creative use of everyday language, figurative language, and peculiar vocabulary in literary texts (Fang, 2012b; Showalter, 2003)</li> </ul>
Literature	<ul style="list-style-type: none"> <li>• Instruction on literary discourse practices, including the use of special topoi (Wilder, 2012)</li> <li>• Modelling expert practice and getting pupils to talk about their thinking processes and seek help as they write (Beattie, 2007)</li> </ul>
Science	<ul style="list-style-type: none"> <li>• Modelling the scientific inquiry processes of a professional scientist involved in his own investigations (Cervetti et al., 2012)</li> <li>• Instruction for scientific vocabulary that students require for scientific writing (Morgan, 2012)</li> </ul>
Nursing/midwifery	<ul style="list-style-type: none"> <li>• Examining relationships between epistemologies, attributes of disciplinarians and written communication (Gimenez, 2012)</li> </ul>
Engineering	<ul style="list-style-type: none"> <li>• Using writing to solve authentic problems through engineering design processes (Wilson et al., 2014)</li> </ul>
Chemistry	<ul style="list-style-type: none"> <li>• Collaboration between applied linguists and chemistry faculty to create valid writing assessment instruments (Stoller et al., 2007)</li> </ul>
Mathematics	<ul style="list-style-type: none"> <li>• Moving students from everyday language into the mathematical register by having them practice technical language when defining and explaining, and clarifying ambiguous words (Adams, 2003; Hillman, 2014; Schleppegrell, 2007)</li> <li>• Getting students to share their mathematical reasoning and verification processes in writing (Pugalee, 2004)</li> <li>• Contrasting verbal and written explanations to increase precision and certainty in mathematical writing (Sinclair &amp; Pimm, 2008)</li> <li>• Working in small groups to think aloud thinking, engage in hypothetical conversations about identified patterns, and use of the mathematical register with think-alouds while creating proofs (Johnson et al., 2011)</li> <li>• Explaining how mathematics symbolism and visual were developed historically as a semiotic resource in order to fulfil particular functions, from a linguistics perspective (O'Halloran, 2005)</li> </ul>
History	<ul style="list-style-type: none"> <li>• Engaging in cognition of historical authorship (Young &amp; Leinhardt, 1998)</li> <li>• Engaging in cognition of historical argumentation (Rouet et al., 1997)</li> <li>• Making expert thinking and literacy practices visible through modelling (De La Paz et al., 2014)</li> <li>• Using multiple primary historical sources with analytical writing (Monte-Sano et al., 2014)</li> <li>• Teaching the sourcing heuristic, or strategy of reading the subtext (Wineburg, 1991)</li> <li>• Collaboration between linguistic specialists and history teachers to integrate genre-specific language practices in history curricula (Coffin, 2006)</li> <li>• Use of mentor texts (Pytash &amp; Morgan, 2014)</li> </ul>
Economics	<ul style="list-style-type: none"> <li>• Use of mentor texts (Pytash et al., 2014)</li> </ul>
Macroeconomics	<ul style="list-style-type: none"> <li>• Integrated programme with explicit instruction in writing processes and delivery of subject content (Hunter &amp; Tse, 2013)</li> </ul>
Geography	<ul style="list-style-type: none"> <li>• Use of geography texts with specific, technical, up-to-date vocabulary and the practice of taking and making notes in graphic organisers (Johnson et al., 2011)</li> </ul>

## References

- Adams, T. L. (2003). Reading mathematics: More than words can say. *The Reading Teacher*, 56(8), 786-795.
- Bain, R. B. (2012). Using disciplinary literacy to develop coherence in history teacher education: The clinical rounds project. *History Teacher*, 45(4), 513-532.
- Bangert-Drowns, R. L., Hurley, M. M., & Wilkinson, B. (2004). The effects of school-based writing-to-learn interventions on academic achievement: A meta-analysis. *Review of Educational Research*, 74(1), 29-58.
- Bazerman, C. (1988). *Shaping written knowledge: The genre and activity of the experimental article in science*. Madison, WI: University of Wisconsin Press.
- Beattie, A. (2007). Exploring the value of dialogue in improving boys' writing. *Changing English*, 14(2), 161-174.
- Birkhoff, G., & Mac Lane, S. (1953). *A survey of modern algebra*. New York, NY: Macmillan.
- Burton, L., & Morgan, C. (2000). Mathematicians writing. *Journal for Research in Mathematics Education*, 31(4), 429-453.
- Cervetti, G. N., Barber, J., Dorph, R., Pearson, P. D., & Goldschmidt, P. G. (2012). The impact of an integrated approach to science and literacy in elementary school classrooms. *Journal of Research in Science Teaching*, 49(5), 631-658.
- Christie, F., & Derewianka, B. (2010). *School discourse: Learning to write across the years of schooling*. London and New York: Continuum.
- Coffin, C. (2006). Learning the language of school history: The role of linguistics in mapping the writing demands of the secondary school curriculum. *Journal of Curriculum Studies*, 38(4), 413-429.
- Cutler, L., & Graham, S. (2008). Primary grade writing instruction: A national survey. *Journal of Educational Psychology*, 100(4), 907-919.
- De La Paz, S., Felton, M., Monte-Sano, C., Croninger, R., Jackson, C., Deogracias, J. S., & Hoffman, B. P. (2014). Developing historical reading and writing with adolescent readers: Effects on student learning. *Theory & Research in Social Education*, 42(2), 228-274.
- De La Paz, S., & Felton, M. K. (2010). Reading and writing from multiple source documents in history: Effects of strategy instruction with low to average high school writers. *Contemporary Educational Psychology*, 35(3), 174-192.
- Draper, R. J., Broomhead, G. P., Jensen, A. P., Nokes, J. D., & Siebert, D. (2010). *Reimagining content-area literacy instruction*. New York, NY: Teachers College Press.
- Duschl, R. A., Schweingruber, H. A., & Shouse, A. W. (2007). *Taking science to school: Learning and teaching science in Grades K-8*. Washington, DC: National Academies Press.
- Faggella-Luby, M. N., Graner, P. S., Deshler, D. D., & Drew, S. V. (2012). Building a house on sand: Why disciplinary literacy is not sufficient to replace general strategies for adolescent learners who struggle. *Topics in Language Disorders*, 32(1), 69-84.
- Fang, Z. (2012a). Approaches to developing content area literacies: A synthesis and a critique. *Journal of Adolescent & Adult Literacy*, 56(2), 103-108.
- Fang, Z. (2012b). Language correlates of disciplinary literacy. *Topics in Language Disorders*, 32(1), 19-34.
- Fang, Z., & Coatoam, S. (2013). Disciplinary literacy: What you want to know about it. *Journal of Adolescent & Adult Literacy*, 56(8), 627-632. doi: 10.1002/JAAL.190
- Fang, Z., & Schleppegrell, M. J. (2010). Disciplinary literacies across content areas: Supporting secondary reading through functional language analysis. *Journal of Adolescent & Adult Literacy*, 53(7), 587-597. doi: 10.1598/JAAL.53.7.6
- Fang, Z., Schleppegrell, M. J., Lukin, A., Huang, J., & Normandia, B. (2008). *Reading in secondary content areas: A language-based pedagogy*. Ann Arbor, MI: University of Michigan Press.
- Flood, J., Lapp, D., Squire, J. R., & Jensen, J. M. (2003). *Handbook of research on teaching the English language arts*. Newark, DE: International Reading Association/ERIC.
- Freebody, P., & Muspratt, S. (2007). Beyond generic knowledge in pedagogy and disciplinary: The case of science textbooks. *Pedagogies: An International Journal*, 2(1), 35-48.
- Gillespie, A., & Graham, S. (2014). A meta-analysis of writing interventions for students with learning disabilities. *Exceptional Children*, 80(4), 454-473.
- Gimenez, J. (2012). Disciplinary epistemologies, generic attributes and undergraduate academic writing in nursing and midwifery. *Higher Education*, 63(4), 401-419.
- Goldman, S. R. (2012). Adolescent literacy: Learning and understanding content. *The Future of Children*, 22(2), 89-116.
- Goldschmidt, P., & Jung, H. (2010). *Evaluation of seeds of science/roots of reading: Effective tools for developing literacy through science in the early grades*. Los Angeles, CA: National Center for

- Research on Evaluation, Standards, and Student Testing and University of California.
- Graham, S., McKeown, D., Kiuahara, S., & Harris, K. R. (2012). A meta-analysis of writing instruction for students in the elementary grades. *Journal of Educational Psychology*, 104(4), 879-896.
- Graham, S., & Perin, D. (2007). A meta-analysis of writing instruction for adolescent students. *Journal of Educational Psychology*, 99(3), 445-476.
- Guthrie, J. T., Wigfield, A., Barbosa, P., Perencevich, K. C., Taboada, A., Davis, M. H., . . . Tonks, S. (2004). Increasing reading comprehension and engagement through concept-oriented reading instruction. *Journal of Educational Psychology*, 96(3), 403-423.
- Halliday, M. A. K., & Martin, J. R. (1993). *Writing science: Literacy and discursive power*. London, UK: Falmer Press.
- Halliday, M. A. K., & Matthiessen, C. M. I. M. (2014). *An introduction to functional grammar*. Abingdon and New York: Routledge.
- Hillman, A. M. (2014). A literature review on disciplinary literacy. *Journal of Adolescent & Adult Literacy*, 57(5), 397-406.
- Hunter, K., & Tse, H. (2013). Making disciplinary writing and thinking practices an integral part of academic content teaching. *Active Learning in Higher Education*, 14(3), 227-239.
- Hyland, K. (2009). Writing in the disciplines: Research evidence for specificity. *Taiwan International ESP Journal*, 1(1), 5-22.
- Hyland, K. (2013). Faculty feedback: Perceptions and practices in L2 disciplinary writing. *Journal of Second Language Writing*, 22(3), 240-253.
- Johnson, H., Watson, P. A., Delahunty, T., McSwiggen, P., & Smith, T. (2011). What it is they do: Differentiating knowledge and literacy practices across content disciplines. *Journal of Adolescent & Adult Literacy*, 55(2), 100-109.
- Jones, A. (2009). Redisciplining generic attributes: The disciplinary context in focus. *Studies in Higher Education*, 34(1), 85-100.
- Joyce, R. (2008). *The languages of archaeology: Dialogue, narrative, and writing*. Oxford, UK: Wiley-Blackwell.
- Juel, C., Hebard, H., Park Haubner, J., & Moran, M. (2010). Reading through a disciplinary lens. *Educational Leadership*, 67, 13-17.
- Kamberelis, G., Gillis, V. R., & Leonard, J. (2014). Disciplinary literacy, English learners, and STEM education. *Action in Teacher Education*, 36(3), 187-191.
- Lesley, M. K. (2014). Policy, pedagogy, and research: Three issues affecting content area literacy courses for secondary-level teacher candidates. *Literacy Research and Instruction*, 53(1), 50-71.
- Lillis, T., & Scott, M. (2007). Defining academic literacies research: Issues of epistemology, ideology and strategy. *Journal of Applied Linguistics*, 4(1), 5-32.
- Mac Mahon, B. (2014). Making the invisible visible: Disciplinary literacy in secondary school classrooms. *Irish Educational Studies*, 33(1), 21-36.
- McConachie, S. M., & Petrosky, A. R. (Eds.). (2010). *Content matters: A disciplinary literacy approach to improving student learning*. San Francisco, CA: Jossey-Bass.
- Metz, K. E. (2008). Narrowing the gulf between the practices of science and the elementary school science classroom. *The Elementary School Journal*, 109(2), 138-161.
- 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), 1-44.
- Moje, E. B. (2008). Foregrounding the disciplines in secondary literacy teaching and learning: A call for change. *Journal of Adolescent & Adult Literacy*, 52(2), 96-107.
- Moje, E. B. (2010). Comprehending in the subject areas: The challenges of comprehension, grades 7-12, and what to do about them. In K. Ganske & D. Fisher (Eds.), *A comprehensive look at reading comprehension K-12* (pp. 46-72). New York, NY: Guilford.
- Monahan, M. B. (2013). Writing “voiced” arguments about science topics. *Journal of Adolescent & Adult Literacy*, 57(1), 31-40.
- Monte-Sano, C., De La Paz, S., & Felton, M. (2014). Implementing a disciplinary-literacy curriculum for us history: Learning from expert middle school teachers in diverse classrooms. *Journal of Curriculum Studies*(4), 1-36.
- Morgan, A. -M. (2012). Subject-specific literacies and transition in the middle years: Examples of teacher thinking, research and practice. *Literacy Learning: The Middle Years*, 20(3), 39-51.
- Nagy, W. E., & Scott, J. A. (2000). Vocabulary processes. In M. L. Kamil, P. B. Mosenthal, P. D. Pearson & R. Barr (Eds.), *Handbook of reading research* (Vol. 3, pp. 269-284).
- Nesi, H., & Gardner, S. (2012). *Genres across the disciplines: Student writing in higher education*. Cambridge, UK: Cambridge University Press.
- O'Halloran, K. L. (2005). *Mathematical discourse: Language, symbolism and visual images*. London and New York: Continuum.
- Palincsar, A. S., Magnusson, S. J., Collins, K. M., & Cutter, J. (2001). Making science accessible to all: Results of a design experiment in inclusive classrooms. *Learning Disability Quarterly*, 24(1), 15-32.

- Paltridge, B. (2004). Academic writing. *Language Teaching*, 37(02), 87-105.
- Perin, D. (2001). Academic-occupational integration as a reform strategy for the community college: Classroom perspectives. *The Teachers College Record*, 103(2), 303-335.
- Pugalee, D. K. (2004). A comparison of verbal and written descriptions of students' problem solving processes. *Educational Studies in Mathematics*, 55(1-3), 27-47. doi: 10.1023/B:EDUC.0000017666.11367.c7
- Pytash, K. E., Edmondson, E., & Tait, A. (2014). Using mentor texts for writing instruction in a high school economics class. *Social Studies Research & Practice*, 9(1), 95-106.
- Pytash, K. E., & Morgan, D. N. (2014). Using mentor texts to teach writing in science and social studies. *The Reading Teacher*, 68(2), 93-102. doi: 10.1002/trtr.1276
- Rampey, B. D., Dion, G. S., & Donahue, P. L. (2009). *NAEP 2008: Trends in academic progress*. Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.
- Romance, N. R., & Vitale, M. R. (2001). Implementing an in-depth expanded science model in elementary schools: Multi-year findings, research issues, and policy implications. *International Journal of Science Education*, 23(4), 272-304.
- Rosenblatt, L. M. (1995). *Literature as exploration*. (5th ed.). New York, NY: Modern Language Association.
- Rouet, J. -F., Favart, M., Britt, M. A., & Perfetti, C. A. (1997). Studying and using multiple documents in history: Effects of discipline expertise. *Cognition and Instruction*, 15(1), 85-106.
- Scardamalia, M., & Bereiter, C. (1987). Knowledge telling and knowledge transforming in written composition. *Advances in Applied Psycholinguistics*, 2, 142-175.
- Schleppegrell, M. J. (2007). The linguistic challenges of mathematics teaching and learning: A research review. *Reading & Writing Quarterly*, 23(2), 139-159.
- Shanahan, C., & Shanahan, T. (2014a). Does disciplinary literacy have a place in elementary school? *The Reading Teacher*, 67(8), 636-639.
- Shanahan, C., & Shanahan, T. (2014b). The implications of disciplinary literacy. *Journal of Adolescent & Adult Literacy*, 57(8), 628-631.
- Shanahan, T., & Shanahan, C. (2008). Teaching disciplinary literacy to adolescents: Rethinking content-area literacy. *Harvard Educational Review*, 78(1), 40-59.
- Shanahan, T., & Shanahan, C. (2012). What is disciplinary literacy and why does it matter? *Topics in Language Disorders*, 32(1), 7-18. doi: 10.1097/TLD.0b013e318244557a
- Showalter, E. (2003). *Teaching literature*. Oxford, UK: Wiley-Blackwell.
- Sinclair, N., & Pimm, D. (2008). Surface signs of reasoning. Proceedings of CERME 6. 873-883. Retrieved from <http://ife.ens-lyon.fr/publications/edition-electronique/cerme6/wg6-05-sinclair-pimm.pdf>
- Somerville, E. M., & Creme, P. (2005). 'Asking Pompeii questions': A co-operative approach to writing in the disciplines. *Teaching in Higher Education*, 10(1), 17-28.
- Stoller, F. L., Horn, B., Grabe, W., & Robinson, M. S. (2007). Creating and validating assessment instruments for a discipline-specific writing course. *Journal of Applied Linguistics and Professional Practice*, 2(1), 75-104.
- Tay, M. Y. (2009). Teaching 'language arts' in the Singapore classroom: What is and what is not. In P. Teo, M. Y. Tay & C. Ho (Eds.), *Exploring new frontiers: Challenging students in the language and literature classroom* (pp. 289-313). Singapore: Pearson/Longman.
- Wilder, L. (2012). *Rhetorical strategies and genre conventions in literary studies: Teaching and writing in the disciplines*. Carbondale, IL: Southern Illinois University Press.
- Wilson, A. A. (2011). A social semiotics framework for conceptualizing content area literacies. *Journal of Adolescent & Adult Literacy*, 54(6), 435-444. doi: 10.1598/JAAL.54.6.5
- Wilson, A. A., Smith, E., & Householder, D. L. (2014). Using disciplinary literacies to enhance adolescents' engineering design activity. *Journal of Adolescent & Adult Literacy*, 57(8), 676-686.
- Wineburg, S. S. (1991). On the reading of historical texts: Notes on the breach between school and academy. *American Educational Research Journal*, 28(3), 495-519.
- Young, K. M., & Leinhardt, G. (1998). Writing from primary documents: A way of knowing in history. *Written Communication*, 15(1), 25-68.