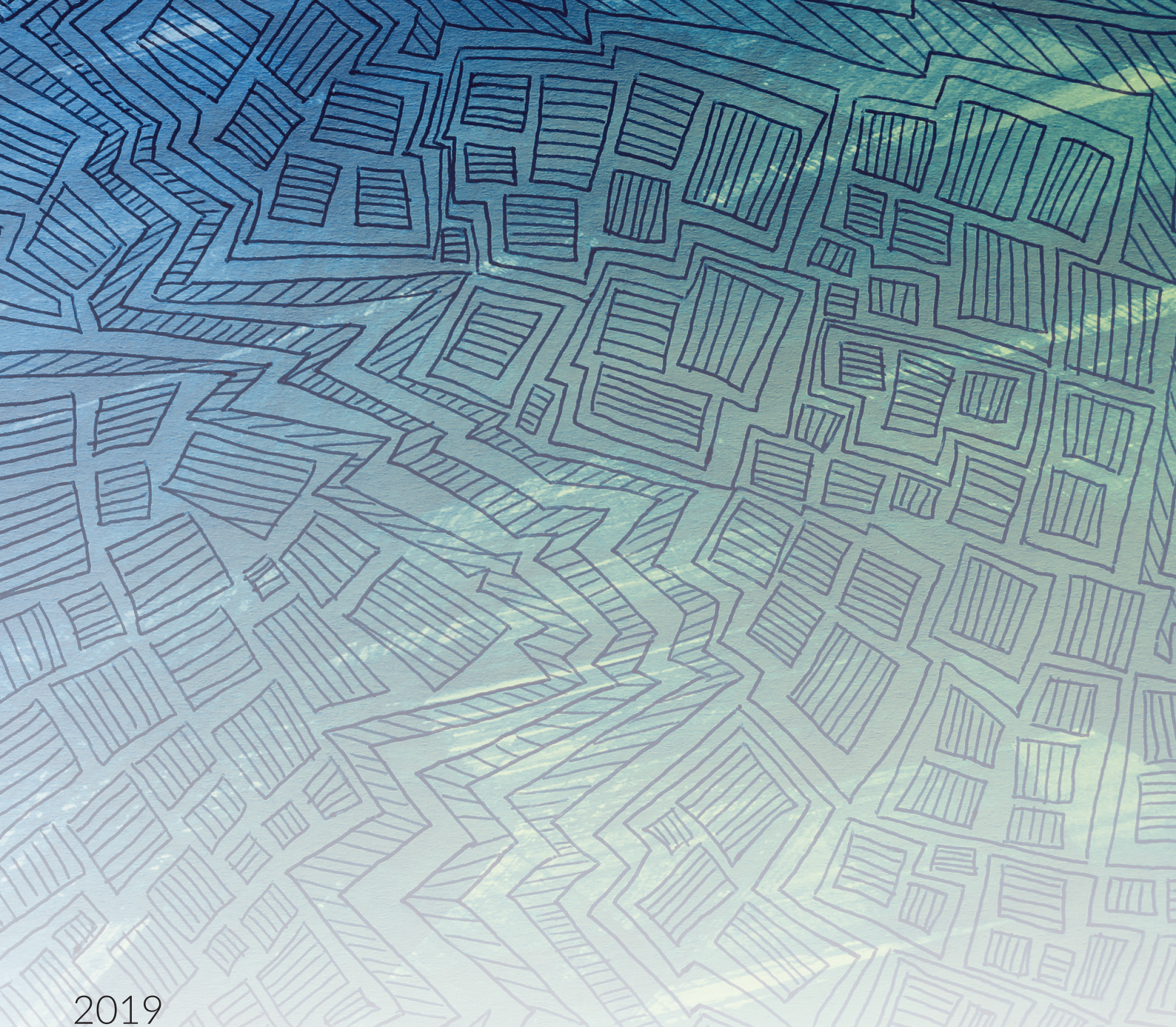

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Disciplinary Literacy in the Primary School

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Disciplinary literacy refers to the specialised ways reading, writing, and oral language are used in academic disciplines such as science, history, or literature (Moje, 2008; Shanahan & Shanahan, 2008; 2012). Each field of study has its own special ways of using text to create, communicate, and evaluate knowledge, and if students are to advance academically within these disciplines it is vital that they become acquainted with these unique or specialised ways of reading and writing. Basic reading and writing abilities are not sufficient for full educational, social, civic, and economic enfranchisement in the 21st century. Students need to gain an understanding and appreciation of how historians, scientists, literary critics, mathematicians, and other experts use literacy along with developing their own nascent abilities to engage successfully in such practices themselves.

In 2016, the European Commission declared "the right to literacy" for everyone in Europe. One of the essential conditions to ensuring this right was that all teachers be prepared to teach "discipline-specific reading and writing skills ('content area literacy') in every subject and in all grades" (European Literacy Policy Network, 2016a, p. 10). Furthermore, it put forth a "framework of good practice in raising literacy levels of children, adolescents, and adults" (European Literacy Policy Network, 2016b). This framework describes pedagogical practices vital to ensuring this right for all, including "teaching reading and writing across all subjects" in primary schools, and "explicit incorporation of content-specific (disciplinary) and cross-curricular literacy instruction in all school subjects and year groups" (p. 19); the latter is characterised, in the same document, as an "urgent need" in Europe.

The purpose of this paper is to explain the concept of disciplinary literacy, to place it in its proper context within literacy learning and the overall school curriculum, and to

describe some of the special text features and literacy approaches used in literature, science, history, and mathematics. Finally, it proposes a series of pedagogical recommendations with regard to disciplinary literacy instruction in the Irish primary school. Disciplinary literacy is a complex concept and one that takes years to develop. This paper attempts to describe this sophisticated concept in sufficient detail that should allow educators to fully appreciate its difficulty and importance, but then focuses upon those specific nascent efforts that can be undertaken in the primary school to prepare students adequately to eventually face these more complex demands.

The Concept of Disciplinary Literacy

Definitions of literacy have evolved over the years, but such definitions have consistently included the abilities to read and write. Newer definitions have expanded in some ways—more fully specifying some of the higher-order skills or abilities entailed in reading and writing—mainly for the purpose of distinguishing between rudimentary literacy (such as the ability to recognise or sign one's name) that is insufficient for success in today's society, and the more advanced literacy abilities central to 21st century work and social life. For instance, Ireland's Department of Education and Skills (2011, p. 8) explains that "literacy includes the capacity to read, understand, and critically appreciate various forms of communication, spoken language, printed text, broadcast media, and digital media." Whereas UNESCO describes it as the ability to "identify, understand, interpret, create, communicate, and compute using printed and written materials" (UNESCO, 2017, p. 14).

Not only have the most recent literacy definitions been expanded to include such skills and abilities, but these definitions also recognise the importance of social milieu in how and why literacy skills are deployed. That UNESCO definition of literacy noted above includes one more important point. The complete definition finishes with, "using printed and written materials *associated with varying contexts"* [italics added]. As Tobin (2018) explains,

it is necessary to recognise "that such [literacy] skills vary in relation to social contexts" (Tobin, 2018, p. 15).

We, for instance, change how we speak or act on the basis of social context. One would likely speak less formally when talking with friends than when at a job interview. Such linguistic adjustments are more than a courtesy, they can determine effectiveness or success in communication and work. It is from this insight into the impact of social milieu that the disciplinary literacy concept arises. Disciplinary literacy—including oral language—refers to literate practices that are specific to the particular social milieus of the various academic disciplines; milieus that are formed, at least in part, by the nature of what is studied, how it is studied, and what its rules of evidence may be.

An academic discipline is a branch of knowledge commonly defined by college faculties or learned societies. Disciplines were first designated in the German universities of the early 19th century and have been modernised as knowledge has developed over time. Most basically, at this time one may describe the following disciplines: humanities, social sciences, natural sciences, formal sciences, and professions and applied sciences (Abbott, 2001).

What makes a discipline different from typical post-primary curricula (aside from these obvious topical differences) is that post-primary curricula usually focus mainly or solely on the development of basic content knowledge and the mastery of a limited set of related skills. However, the disciplines—while certainly including such knowledge and skills—are more properly characterised as social milieus that include a much more extensive collection of expertise, people, projects, communities, challenges, agendas, studies, language, and research areas. In other words, a discipline is a kind of learned society built around purposes, research methods, content knowledge and so on, and participation in a discipline or

even just gaining a deep understand of its products requires an appreciation of the ways and whys of how a discipline creates, communicates, and evaluates that knowledge.

Research over the past three decades has begun to identify some of the unique or specialised ways that disciplinary experts use reading and writing, and the reasons for these disciplinary differences (Shanahan & Shanahan, 2018). As a result, there has been a growing realisation that successful learning in the disciplines, particularly at more advanced levels, depends upon the ability to use literacy in ways consistent and compatible with the methods and content of those fields; in other words, knowing literacy requires more than general literacy skills that can be applied in all subjects, but also includes a facility with some of the literacy skills that are unique or specialised to particular disciplines and how to apply both these general and specialised skills in sophisticated ways in the various disciplinary social contexts.

Of course, there are general literacy skills—those reading and writing skills that are highly generalisable and useful no matter what the social context. For instance, the ability to decode print to language underlies all reading, as do basic conceptions of reading comprehension (such as recognising that text is to be understood or that texts will not include all relevant or necessary information for understanding which means readers must draw appropriate logical inferences to make sense of a text). Everyone, if they are to be literate, needs to develop phonological awareness, phonics, oral reading fluency, general vocabulary knowledge, along with basic abilities to comprehend and compose. What disciplinary literacy adds is awareness, insights, and abilities that will allow students to adjust and deepen their literacy practices appropriately to match the specific academic social contexts and intellectual demands of the disciplines.

Just as it is important to distinguish between general and disciplinary literacy practices, it can be misleading to talk about disciplinary literacy without some reference to

where these practices fit within the disciplines. Disciplinary instruction—including that given in primary and post-primary schools—tends to include four basic dimensions. Each discipline includes a body of information about the world, a set of research methods used to create that knowledge, a way of thinking about or approaching the world, and a set of disciplinary-literate practices.

For example, let's take science. Ireland's Primary School Curriculum requires that students be taught about living things, energy and forces, materials, and environmental awareness and care. Depending on the class, this content would include information on plant growth, energy conservation, and chemical reactions. Some of the facts about the world that students are expected to gain through their science studies include an understanding of the relationship between "useful input" and "input" in electrical energy use or the substances produced when petrol is burned (water, sulfur dioxide, carbon dioxide).

Additionally, science students would learn about some of the observational and experimental methods scientists use to develop such knowledge, along with gaining insights into how scientists think about the world, such as how to formulate useful hypotheses or to distinguish between testable and non-testable ones, or the importance of reliability in creating scientific knowledge.

These areas of disciplinary learning are all crucially important if students are eventually to be successful university students, productive workers, and responsible citizens. Disciplinary literacy does not take the place of any of these things but is an important adjunct to them. For example, reliability is so foundational to the scientific enterprise that Irish schools introduce it in the primary school, yet that currently is done without any apparent consideration of the role that literacy plays in the scientific concepts of reliability and replicability. Scientific writing is necessarily painstaking and detailed because without such reportage it is impossible to accomplish replicability (the possibility of repeating scientific

observations or experiments so exactly that identical results can be obtained across social circumstances). Learning about the role literacy plays in such a concept, and then learning some of these relevant literacy practices is basic to disciplinary literacy.

Disciplinary Literacy Research

Disciplinary literacy has been developed largely through two types of research: studies of expert practices and functional linguistic investigations. Expert-practice studies start with the premise that experts and novices are different, and that those differences reveal what it takes to become an expert. Experts and novices can be separated across several dimensions (Bereiter & Scardamalia, 1986). They possess knowledge that is more extensive and better organised, and an enhanced ability to solve novel problems; they recognise how their skills may be adapted to the nuances of situations. Novices tend to get bogged down in concrete details, whereas experts recognise abstract aspects of problems and how to deploy relevant and appropriate problem-solving routines based on their past experiences.

Expert-practice studies have begun identifying how disciplinary experts read and write differently than novices. Such research has been carried out in history/social studies, science, literature, and mathematics (there are also some studies in music and law, but most work so far has been in these four disciplines). These studies have depended heavily upon observation and the analysis of think-aloud protocols. Basically, disciplinary experts are given a literacy task and are encouraged to talk about what they are thinking and doing while implementing that task. Historians, for instance, may be asked to read a history text and to stop every six paragraphs to describe what they are thinking about and how they are processing the information. Such studies may summarise these practices (e.g., Bazerman, 1985), compare experts and novices—usually secondary or college students (e.g., Wineburg, 1991), or compare experts and experts (e.g., Shanahan, Shanahan, & Misichia, 2011).

A different approach to researching these issues has been taken up by functional linguists. Linguists employ their language tools to examine the special characteristics of the texts, not the readers. Although functional linguists examine the same structural aspects of language as other linguists (e.g., semantics, syntax, pragmatics), they analyse language as a set of choices made for particular functional or social purposes (Halliday, 1994). That is, they identify unique or special language structures or text formats and then try to infer their intended functions.

Linguists, for example, have studied the genre features of texts in science and history (Martin, 1993; Veel, 1997; Wignell, 1994). Science text genres include experimental processes, procedural recounts (records of what has been done in past experiments), reports (listing of properties, steps or parts, categorising taxonomies), and explanations (explaining how and why phenomena occur). History genres, on the other hand, include recounts (the "story" of an event), accounts (the why of an event), explanations (detailing the causes and effects of an event), and arguments that advocate for particular accounts or explanations (Coffin, 1997). In a recount, the author is telling the "story" of an event, in sequence; an "account" explains the why of an event; an explanation details the causes and effects of an event; and, an argument advocates for a particular recount, account, or explanation.

Both these kinds of research have important limitations. They depend upon qualitative analysis and the numbers of participating subjects or texts tend to be small; often no more than two or three experts or texts representing a discipline. Of course, each discipline has subdisciplines and how adequately such studies are able to represent these different divisions may vary. Science, for example, may be divided any number of ways: life sciences and physical sciences; biology, chemistry, physics; descriptive and problem-solving sciences, and so on. The universe of scientists may engage in particular literate practices or the universe of science texts may share particular features or characteristics, however there may be

important—but as yet unidentified—variation among the subdisciplines. Nevertheless, these studies so far have uncovered several disciplinary strategies or approaches to reading and writing or particular text characteristics that are important.

Portraits of Disciplinary Literacy

The following pages will provide brief descriptions of some of these findings. The point here is not to provide a detailed inventory of what is known about disciplinary literacy or even to propose the specifics of a primary school curriculum; those are beyond the scope of this paper. With few exceptions, most of the specifics of disciplinary literacy are likely more directly relevant to post-primary education. However, if primary school is to adequately prepare students for future success in the disciplines, then it is essential that the specific recommendations for primary school education that are provided here be grounded in an understanding of the specifics of disciplinary literacy.

History

Historians create a particular kind of knowledge, which leads them to construct texts with certain features and to read and critique texts in particular ways. Apprenticing students into the literate practices of a discipline entails both developing their awareness of the epistemological demands of a field (in this case, how historians create historical writing) as well as enabling them to adopt some of these discourse practices in their own reading.

Students often believe that historians do no more than chronicle historical events, recording what happened completely, objectively, and accurately. But historians don't record the "story" of the past, as much as they grapple with the varied records (e.g., audiotapes, videos, photographs, legal documents, letters) and historical accounts, trying to construct a theory of what happened, what was significant, what motivated the actions, what actions caused which outcomes, what were the competing goals of the various participants, and so on. The main way we know the past is through the perspectives of the various participants or observers. Perspectives by their very nature are diverse, disparate, and confusing, and consequently, historians emphasise the weighing of perspective in the evaluation of evidence. Historians strive—not for truth—but for plausible and coherent interpretations, and history reading requires an analogous set of processes.

Historians employ interpretive frameworks to guide their reading of historical evidence. These frameworks may be societal (e.g., economics, religion, race), institutional (e.g., slavery, despotism), or philosophical (e.g., the great man in history vs. grass roots), and they serve as interpretive lenses that shape the historical accounts they produce. Historians also recognise that they are engaged in an ongoing argument about the past that will forever be contested and rewritten by future historians who will interpret the same evidence differently based upon the context in which they are analysing that evidence, or who may rely on different or new evidence. The awareness that history is incomplete, dependent upon the

evaluation of varied perspectives, and shaped by the historians' interpretive lenses rather than factual and complete truth is perhaps the single-most important difference between historians and students.

Research has identified some of the ways that historians read and interpret history. For instance, Wineburg's landmark study (1991) compared historians and secondary school students as they read historical documents. The historians read the documents as arguments written by authors to particular audiences for particular purposes within particular historical contexts, whereas students read to get "the facts". The historians engaged in what Wineburg called sourcing, contextualisation, and corroboration. That is, historians thought about who the author was and what the author's intentions may have been (sourcing), considered how the context of the time period may have shaped the message (contextualisation), and tried to confirm information across texts, looking for inconsistencies and disagreements (corroboration). The students did none of these things.

Functional linguists have found that history texts attempt to make causal connections (what led to rather than what simply preceded) and to attribute agency (whose intentions led to particular actions or events) (Fang & Schleppegrell, 2008). Students often focus on the chronological aspects of history but fail to recognise the causal claims or their evidentiary basis. Historical claims and explanations may be implicit within the narratives that they write. Students without disciplinary awareness may not read such texts with a nuanced understanding or a sufficiently-critical eye.

English/Literature

English or literature is more unequivocally about reading and writing than the other disciplines. This is because literature (the literary texts themselves) constitute the fundamental "knowledge" of the field. Scientists write about phenomena in the natural world, historians about past events, but English professors and literary critics write about texts. Works of literature are created from authors' imaginations and memories, and do not need to deal with real people, situations, or events. Authors of poems, stories, and novels do not create "knowledge" in the conventional sense. But literature provides insight into the human condition through the creation of imaginary worlds. Because of this, arguments about meaning in English studies are often based upon ideological stances.

Because of the fictional nature of literature and the ideological nature of literary criticism, interpretation necessarily becomes "rules-based". A literary critic interprets literature based on particular traditions of interpretation. For instance, someone with a New Critical stance believes literature should be read with no heed to author or context. What the text means is in the text itself, and a close reading of the diction, symbolism, and text structures is the only way to that meaning. In contrast, a reader-response stance downplays the importance of what is in the text in favour of the readers' personal connections and reactions. Readers in this tradition may think more about "how does this text make me feel?" than "what does this text mean?" And, those with a more scholastic stance will emphasise the text's biographical or historical roots. There are many other interpretive traditions as well; literature can be given Marxist, feminist, Christian, or Freudian readings, for instance.

Experts and novices both derive meaning from a character's goals and actions, the arc of a story's plot, and the connections that can be made to human experience. But literary experts construct more abstract or universal interpretations than novices (Zeitz, 1994). For example, a student might say a story is about a boy who lost his dog, whereas a literary

expert might conclude it is about the yearning people have to return to innocence. Experts are more likely to ground their interpretations in the language and structure of the text and in literary theory. Literary experts, unlike novices, reread a poem multiple times, attending to structural elements, linguistic cues, and images; exploring significance, author's craft, and poetic conventions, and making allusions to other literary works (Peskin, 1998).

Ways of using language are particularly important to literary interpretation. Literature creates an imaginary world through an author's linguistic choices, and it is those choices that are examined and evaluated. Literary analysis includes the analysis of literary devices and patterns of discourse such as repetition, foregrounding, ambiguity, metaphor, and tone. These literary text features are distinct from those evident in other disciplinary texts (Martin, 1992).

Mathematics

Studies of mathematicians are rare, but they do exist, albeit the focus of these studies is usually more on how mathematicians think than read. Such studies of mathematical thinking suggest that mathematicians view their concepts as being deeply interconnected, malleable abstractions that may or may not be applicable to real-world phenomena (Sfard, 1992; Tall, 1991). Novices, conversely, tend to view mathematical concepts in terms of examples specific to particular situations and lacking flexibility. Linguistic analyses of mathematics echo these findings. Mathematics is concerned with "definitions, axioms, theorems, and problems" (Fulda, 2009, p. 1437), and the language of mathematics is inherently abstract. For example, in the equation $x > 3$, x represents the entire universe of numbers greater than 3, not just a particular instantiation of it, such as 5 or 4, or 100, as novices tend to think of it.

There are some studies that involve expert reading of mathematics, specifically the reading of proofs (Weber, 2008; Weber & Mejia-Ramos, 2011). For instance, one study explored the thinking of eight mathematicians as they determined whether or not an argument

was valid. As they read, the experts first noted the overall structure and thread of the argument getting the "big picture", and then read the proof line by line, verifying each statement with formal logic. Inglis and Alcock (2012) compared eye movements during reading of proofs by experts and novices and found that novices focused solely on the surface features of a proof, whereas experts shifted attention back and forth between the lines, suggesting that they were paying more attention to the logical structure or the connections within the proof.

In a think-aloud study of theoretical mathematicians (Shanahan, Shanahan, & Misischia, 2011), the experts explained that mathematics was the most precise of disciplines, so they were always on the lookout for error and read every word and symbol carefully. They emphasised that even simple words ("the" and "a") may make big differences in meaning. These mathematicians emphasised the importance of rereading. Their reading approaches intentionally attempted to banish the kind of author awareness that is so central to historical reading, emphasising the information on the page above all. But mathematicians do not always accomplish this reading ideal, sometimes suspending their criticality and thoroughness by trusting a particular source (Weber & Mejia-Ramos, 2011.

Mathematical text tends to be especially economical and condensed in how it conveys information, and it is also highly linear (O'Halloran, 2008). Even when maths texts provide figures or equations these are usually embedded directly into the text rather than appearing as an offset or on another page; directives like "see Figure 2" are uncommon in maths, as Figure 2 is likely to appear as the next element of the text in the page formatting. The brevity of maths text may lead novices to view maths as a "quick read", but mathematicians recognise that maths text is written in this way to limit the possibility of error or misinterpretation; texts should be elegant, including only absolutely necessary information, which is also why mathematics requires so much intensive, repetitive reading.

Science

Scientists try to describe the workings of the natural world. They are well aware of the fallibility and limitations of their methods and results. Their scientific knowledge of the world depends upon the accuracy of measurements, what they observe or fail to observe, their theories, and so on. Scientists attempt to create organising principles about the way the world works, but these principles are inventions, not reality itself. What scientists "know" today may not be what they will "know" in the future. As instrumentation becomes more accurate, as theories are borne out or falsified by research, scientists revisit and re-determine their conclusions. They engage in arguments based upon scientific evidence within the community of scientists and in the public arena (such as arguments about global warming).

Scientists, unlike historians, do not have wait for an event to have occurred prior to undertaking an investigation. With experiments, they can control circumstances in ways that allow them to focus on a particular variable of interest. They strive for objectivity by determining what would count as a significant finding before they start a study. Even their observations must follow rigorous rules to ensure validity. The goal of scientists is to use scientific results to predict, with a degree of confidence, what will happen under similar circumstances in the future.

The content knowledge of science is classificatory (including putting information into hierarchical form), definitional, and process oriented. Biologists, for instance, place life forms into a hierarchy of kingdom, phylum, class, order, family, genus, and species and describe the characteristics of life within and across those categories. Chemists identify substances and their atomic structure, describe their characteristics, how they are implicated in various scientific processes, and note their interactions with other substances.

Scientific knowledge—and how it is determined—is complex, and to accurately describe and explain it requires multiple forms of expression. The water cycle, for instance,

can be described in words, shown in diagrams such as flow charts, and summarised in a series of mathematical or computational formulas that allow prediction. The content of science is by its very nature multimodal (Lemke, 2004).

Science uses a particularly noun-centric language; approximately 60% of the words in science text are nouns (Biber & Gray, 2017). Scientists often string nouns together (e.g., monkey cortex) making specific objects (a monkey's cortex) general and objective. They also nominalise verbs and other parts of speech more than in other fields of study. The verb distil becomes the noun distillation, which converts a specific action into a general, abstract, and objectified process (Halliday & Martin, 1993). Noun phrases in science are particularly long because of nominalisation and the use of phrases instead of adjectives to modify. For instance, look at the subject of this sentence:

> The solar wind, a stream of charged particles flowing outwards from the Sun, creates a bubble-like region in the interstellar medium known as the heliosphere.

It is 13-words long, which pushes the verb further to the right than is usual in English sentences. To read sentences like that successfully, one must break down the phrases, which contain specialised vocabulary, and connect those phrases with the verb appropriately.

Science texts also frequently use passive voice, minimising the role of intention in causation. In history and literature, one is concerned with intentionality; the goals of the historical figures or literary characters. But in science, causation does not rely upon intention. Atoms do not intend to move, though they do move. Scientific processes do not depend upon human intentions, so science adopts a language that focuses on the processes as opposed to the humans who are studying those processes (Fang & Schleppegrell, 2008). Thus, "A random effects analysis showed that the proportion of men in the sample was not significantly related to gender", may be reported rather than, "We conducted a random effects

analysis that showed that the proportion of men in the sample was not significantly related to gender".

As already noted, scientists demand precision, which is necessary both as the foundation of replication, and to allow their abstract concepts to be fully understood. It is precision that leads to the demands for mathematical and graphical representations within texts. Scientists also strive for stability and recoverability in their descriptions of scientific concepts. For this reason, they make heavy use of Greek and Latin combining forms in the construction of their vocabulary (e.g., eutrophication, deoxyribonucleic acid). Science texts are generally dense, highly structured, technical, abstract, objective, and multi-modal. These characteristics make special demands upon readers who seek to understand science from reading.

Pedagogical Recommendations

These portraits of the disciplines illustrate the specialised approaches and text characteristics common in these fields of study. They demonstrate how different literacy in these fields can be. Since each discipline creates particular kinds of knowledge and does so in particular ways, it is necessary that the products of these efforts be communicated just as particularly, and this requires different, more sophisticated and disciplinary-specific ways of reading. The reader who fails to source when reading historical texts is at a serious disadvantage; whereas one who reads a mathematical proof or scientific experiment in that way will likely miss the point.

These differences become quite profound by the time students enter university, so it is important to develop some aspects of disciplinary literacy explicitly in secondary school and to give all students experience in reading and writing disciplinary texts. But what of the primary school? Of course, no one is going to teach young children to read literature with an ideological stance, nor do young students need to learn to work through extended

mathematical proofs or to develop highly-abstract notions of an isosceles triangle. But that does not mean that the foundations of disciplinary literacy should not be laid during these years (Shanahan & Shanahan, 2014). These are subtle and complex concepts and processes and their arcs of development are likely long; starting early is advantageous.

The following recommendations are made for better preparing primary school students for success with disciplinary literacy:

1. **Build basic literacy skills and abilities.**

Disciplinary literacy refers to socially-specialised uses of literacy that require specific kinds of texts and specific ways of reading those texts. As such, disciplinary literacy depends upon or is an offshoot of basic literacy. Boys and girls need to learn to read and write in more general ways before they can be expected to grasp unique or specialised ways of applying these skills. All children should receive a sufficient amount of high-quality teaching in phonemic awareness, phonics, oral reading fluency, vocabulary, reading comprehension, and writing. The acquisition of these fundamental literacy skills alone is insufficient for creating disciplinary readers, but they will enable students to eventually enter into disciplinary worlds as participants rather than observers.

2. **Develop extensive content knowledge.**

Even before children become readers, they can start experiencing and learning about the social and natural worlds. Disciplinary literacy makes up a small part of what it means to be proficient in a discipline, and it is related to and depends upon a substantial body of content knowledge. Reading comprehension depends upon prior knowledge—the knowledge a reader brings to the reading of a text (Willingham, 2017). Readers, in order to make sense of any text, must make connections between the text and what they already know. Prior knowledge allows readers to make inferences, clarify ambiguities, and reduce demands on memory during reading. From their earliest schooling students should receive instruction in

science, mathematics, literature, history, and so on. The combination of basic literacy ability and content knowledge should enable students to read successfully in the various subject areas early on.

3. **Expose students to disciplinary texts.**

Someone adept at disciplinary literacy will possess a strong awareness of the special characteristics of disciplinary texts, the nature of the information they contain, and how they communicate. There is little point in trying to develop such awareness and skill if students are not provided with opportunities to work with disciplinary texts. Certainly, by the time students are 7- or 8-years-old, they should have science, history, maths, and literary texts available. School and classroom libraries often focus on literary works alone for younger children, but there is no reason to delay making available a wide range of informational texts as well. Likewise, teachers of young children tend to choose storybooks to read to their students, and there is no reason to omit informational texts from those activities either.

The informational texts used in primary school should represent a wide range of text types (e.g., biographies, scientific explanations, letters, speeches), modalities (e.g., pictures, maps, graphs, charts, prose), and purposes (e.g., explanation, argument). Students need to learn to distinguish between such texts and their features; recognising and using the insets and keys of maps, or the chronological arrangement of a biography, and so on.

4. **Guide student reading and discuss informational texts.**

Providing informational texts in the various content areas and in school and classroom libraries is only one part of the equation. It is also necessary that students be granted the opportunity to read them and discuss them. Often teachers dismiss the use of such texts, saying that they can explain the content more clearly themselves. Although that may be true, students need to read such texts themselves and to try to surmount whatever interpretive barriers these texts might present. It is possible, for instance, to use books in maths as more

than a source of problems on which students practice computation. Having students read an explanation in maths, discuss it with a partner, and then question the teacher for guidance on specific portions that were not understood can be a good way to scaffold such reading. Likewise, teachers should minimise practices like "round robin reading" in which students take turns reading aloud successive paragraphs from a history or science book. Instead of having these materials read to them, students need to engage in trying to make sense of these through their own reading efforts, with whatever teacher guidance might be necessary.

5. **Develop disciplinary vocabulary.**

The nexus between language and content is vocabulary. To understand a field of study is to know its nomenclature. Primary school teachers should accord particular attention to helping their students gain the vocabulary of the various disciplines. Students should learn the terms for the special constructs of a field of study (e.g., place value, symmetry, multiplication, rath, dun, Bronze Age, force, diversity, habitat, bog, moor, headland, plot, stanza), but also need to master those academic words that are general across fields of study though they might have specialised meanings within a given discipline (e.g., analyse, investigate, distinguish, compare, observe, alternative, proportion, locate, specify). Although the language of the disciplines differs, what it takes to learn vocabulary is general across fields of study (Beck & McKeown, 2013), and includes learning to use this vocabulary in both oral and written language.

Not only should students master the vocabulary of a discipline, but they should become knowledgeable of the most frequent morphemes of a content area. Research shows that, despite much overlap, the frequency with which particular prefixes, suffixes, and combining forms appear differs greatly by discipline (Gutlohn & Bessellieu, 2014). There are well worked out routines useful for teaching morphology effectively to primary school students (Bowers, Kirby, & Deacon, 2010; Manyak, Baumann, & Manyak, 2018).

6. **Work with multiple texts.**

Disciplines differ with regard to how much they emphasise the reading of multiple texts. In history it is essential because of the nature of history; weighing up different perspectives on an event is requisite. One cannot teach history satisfactorily without the availability of multiple texts to evaluate and compare. Similarly, it is common in literary studies to examine multiple texts by an author to identify voice or to trace the biographical sources of poems or stories; or, perhaps, multiple texts may be drawn from a particular culture, historical period, or subgenre in search of commonalities, or a work and some of the literacy criticism elicited by it may be explored.

In mathematics and science, such forays into multiple texts are not as central to their disciplinary purposes. But that does not mean that multiple texts have no place at all in these curricula. For example, students might read a text that describes an experiment, and then try to replicate that experiment themselves, keeping explicit lab notes of their investigation. Then, at the end, they might compare the original description with their own notes to see if they erred in any regard.

In any event, to foster a readiness for disciplinary literacy it would be wise to expose students to multiple texts—instead of or in addition to traditional single textbooks—in those classes where it is relevant and appropriate. Creating opportunities for comparing and synthesising information from multiple sources will permit students to gain experience with such disciplinary practices (Hynd-Shanahan, Holschuh, & Hubbard, 2004).

7. **Don't forget disciplinary writing.**

Although disciplinary literacy as an area of study had its beginnings in investigations of disciplinary writing, most of the work done since that time has emphasised reading over writing. Likewise, most of the instructional emphasis on disciplinary literacy in primary and secondary school has been reading dominant. Nevertheless, it would be a mistake to ignore

writing when it comes to the development of disciplinary literacy with younger students. Writing can play an important role in children's development of knowledge in the disciplines, but only if the writing instruction and practice is appropriate to the disciplines. For example, it makes sense for students to write about mathematics (Colonnese, Amspaugh, LeMay, Evans, et al., 2018) using writing to make sense of problems and to describe and evaluate mathematical arguments (National Council of Teachers of Mathematics, 2000); the kinds of writing that mathematicians actually do. But having students write "maths poetry" or expressing their feelings about maths (Bosse & Faulconer, 2008), whatever their pedagogical value, would be decidedly undisciplinary and unproductive. Disciplinary-appropriate writing in maths leads to stronger mathematical reasoning and use of mathematical vocabulary by 7-year-olds (Cohen, Casa, Miller, & Firmender, 2015), and to greater conceptual understanding and procedural knowledge in maths (Jurdak & Zein, 1998).

Research shows that writing about texts in science, history, and literature also enhances both reading comprehension and content learning (Graham & Hebert, 2010. Having students use writing to summarise, analyse, and evaluate the information in disciplinary texts, synthesising information across such texts, and composing their own texts based on disciplinary models should be regular activities in the Irish primary school (Håland, 2018; Shanahan, 2015).

8. Introduce disciplinary approaches.

Although there are many more opportunities for explicitly teaching disciplinary literacy in the secondary school, that does not mean that there are no such occasions to do so earlier. If students have appropriate texts drawn from the disciplines and teachers are permitting (and supporting) student reading of these texts, there are sure to be legitimate reasons for providing explicit teaching of disciplinary literacy strategies or for making

students aware of particular disciplinary text features and this kind of instruction can be beneficial and successful quite early on (Connor, Dombeck, Crowe, Spencer, et al., 2017).

For example, engaging 10-year-olds in bias analysis of primary and secondary sources and discussions about sources' trustworthiness has been found to increase their knowledge of the historical content under study (Ferretti, MacArthur, & Okolo, 2001). Including a mix of primary and secondary sources helped these young students to see how the pieces of the historical puzzle might fit together, and teacher guidance through techniques like "SOAPSTone" can help them to evaluate the primary sources by identifying the speaker, occasion, audience, purpose, subject, and tone (Popp & Hoard, 2018).

Young students can also learn to identify the argument inherent in an historical narrative (Shanahan & Shanahan, 2014) using the "historical events chart". This approach guides students to summarise and connect the various events that appear in a narrative sequence. Ten- and eleven-year-old students are able—with guidance—to determine whether one event causes another or simply precedes it and to make suppositions about an author's purpose based upon the events that are strung together in a secondary account. Similarly, primary school students can learn to identify the intentions of historical players and to track these intentions across an historical account (Fang & Schleppegrell, 2008).

Primary school students can benefit from disciplinary approaches early on in science, too. Science texts, for example, unlike literary texts, tend to be read less linearly. One does not necessarily read a science text from beginning to end, but instead actively seeks for information in pursuit of the reader's own purposes. Modelling this kind of purposeful science reading—and then teaching students to use the various science text features (e.g., table of contents, index, headings and subheadings) to engage in it works successfully even in the primary classes (Barber, Pearson, & Cervetti, 2014). Similarly, students can learn to

interpret scientific graphics by sorting them into categories (e.g., spatial, sequential, comparative, classification/hierarchy, causal).

The roots of scientific argument can be introduced successfully as early as age 5 (Wright, Gotwals, 2017). A language-oriented science curriculum for kindergarteners resulted in students being able to make scientific claims, provide evidence-based supports, and use scientific vocabulary appropriately. Teaching somewhat older students the Science Writing Heuristic has been found to have similar results in teaching students to interpret and make scientific arguments (Norton-Meier, Hand, & Ardasheva, 2013).

Again, the purpose here is not to try to describe an entire primary school curriculum for disciplinary literacy, but simply to show that there are a number of specific disciplinary concepts and strategies that can be introduced even in the primary classes. Some of these (such as interpreting scientific graphics or translating historical narrative into argument) have to wait until the content texts merit such attention. Whereas, other concepts (such as teaching students to identify scientific claims or to distinguish claims from evidence) can be introduced as oral language concepts from the beginnings of schooling.

Conclusions

This paper defined disciplinary literacy, provided disciplinary literacy portraits of literature, history, mathematics, and science, and provided pedagogical recommendations for introducing disciplinary literacy in the Irish primary school. Although disciplinary literacy is usually discussed as a secondary school concern (MacMahon, 2014), there are good reasons for believing that it can play an important role earlier in Irish education (Burke & Welsch, 2018), and, as this paper has illustrated, there are research-based practices that support such an early introduction of disciplinary literacy. If students are to be taught to read, it is essential that they be taught to read something—and, in the 21st century, it would make sense that something would be high-quality disciplinary texts drawn from literature, science, history,

and mathematics. But that kind of reading requires that students have the disciplinary sophistication and insight to read such texts effectively. It is for this reason that disciplinary literacy should find itself in the curriculum of the Irish primary school.

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