Interactive Dynamic Literacy Model: An Integrative Theoretical Framework for Reading-Writing Relations

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Abstract

I propose an integrative theoretical framework for reading and writing acquisition, called the interactive dynamic literacy model, after reviewing theoretical models of reading and writing, and recent efforts in integrating theoretical models within reading and writing, respectively. The central idea of the interactive dynamic literacy model is that reading and writing are inter-related, developing together, largely due to a shared constellation of skills and knowledge. Four core hypotheses of the interactive dynamic literacy model include (1) hierarchical structure of component skills with direct and indirect relations; (2) interactive relations between component skills, and between reading and writing; (3) co-morbidity of reading and writing difficulties; and (4) dynamic relations (relations change as a function of development, learner characteristics, and reading and writing measurement). Implications and future work are discussed.

Key words: Interactive Dynamic Literacy Model, Reading, Writing, Integration, Shared Knowledge

Introduction

Research on reading and writing as well as reading-writing relations has been highly active and productive in the past four decades. In a comprehensive review, Fitzgerald and Shanahan (2000) and Shanahan (2006) summarized work on reading-writing relations into three views/approaches: shared knowledge, functional view, and rhetorical relations. In this chapter, I primarily draw on the shared knowledge approach (reading-writing relations exist because they share or draw on the same or similar knowledge and cognitive systems) while also considering the functional view and rhetorical relations. My goals are (1) to delve deeper and expand our understanding about what is shared between reading and writing development from a component skills perspective (skills and knowledge that are involved in reading and writing processes, and contribute to reading and writing development); (2) to develop an integrative theoretical framework of literacy acquisition; and (3) to discuss implications and future work. To this end, theoretical models of reading and those of writing, and associated evidence are briefly reviewed. This is followed by a review of component skills of oral language and their relations to reading and writing. Then, the interactive dynamic literacy model is proposed to establish a single integrative framework that can explain causal chain of relations among component skills as well as reading-writing relations by consolidating evidence from multiple lines of work.

Theoretical Models of Developmental Reading

One prominent view of reading comprehension that has received substantial attention is the simple view of reading. The central idea of this view is that reading comprehension can be essentially described as two parts, decoding (or word reading) and linguistic comprehension (or listening comprehension; Gough & Tunmer, 1986; Hoover & Gough, 1990). In other words, reading comprehension depends on one's ability to decode words and to comprehend oral language. Empirical evidence for the simple view of reading is robust across languages with varying depths of transparency (e.g., Adlof, Catts, & Little, 2006; Florit & Cain, 2011; Joshi, Tao, Aaron, & Quiroz, 2012; Kim, Wagner, & Foster, 2011). Furthermore, when employing a latent variable approach, word reading and listening comprehension explained almost all the variance in reading comprehension (Adlof et al., 2006; Foorman, Koon, Petscher, Mitchell, & Truckenmiller, 2015; Kim, 2015a; 2016, 2017a; Kim & Wagner, 2015). Despite mounting evidence, the simple view has been widely criticized to be too simple to explain complex processes involved in reading comprehension (e.g., Kirby & Savage, 2008; Pressley et al., 2009). As illustrated below, this is partly due to the simple view's lack of specificity and clarity about component skills and nature of their relations, particularly about linguistic comprehension.

Complementing the simple view of reading, another important line of work has shown that multiple cognitive skills and knowledge (not just word reading and linguistic comprehension) contribute to reading comprehension, including working memory, attention, vocabulary, inference, background knowledge, and comprehension monitoring (Cain, Bryant, & Oakhill, 2004; Nation, Cocksey, Taylor, Bishop, 2010; Oakhill, Cain, & Bryant, 2003; Oullette, 2006). Although a formal theoretical model was not proposed, this line of work was described as a multi-component view of reading (Cain, 2009; also see The Reading Systems Framework by Perfetti & Stafura, 2014). This work was further extended to the nature of relations among component skills. Cromley and her colleagues in their Direct Inferential Mediation model hypothesized that background knowledge, vocabulary, reading strategies, word reading, and inference have direct and indirect relations to reading comprehension (Cromley & Azevedo, 2007; Cromley, Snyder-Hogan, & Luciw-Dubas, 2010; also see Ahmed, Francis, York, Fletcher,

Barnes, & Kulesz, 2016). More recently, integrating these theoretical models and evidence, the direct and indirect effects model of reading (DIER) has been proposed and validated (Kim, 2017a, 2019a). In this model, word reading and listening comprehension, the two component skills of simple view of reading, are hypothesized to be two upper- or summative-tier skills; and the language and cognitive component skills identified by the multi-component view of reading (e.g., working memory, vocabulary, inference) are component skills of listening comprehension (see below for further details) and have direct and indirect relations to reading comprehension. Furthermore, background knowledge (topic or content knowledge and discourse knowledge), text reading fluency, and socio-emotions toward reading are also included as component skills of reading comprehension (see Kim, 2019a for details). DIER fit data very well for Korean-speaking children (Kim, 2015a) and English-speaking children (Kim, 2017a, 2019a).

Theoretical Models of Developmental Writing

One of the influential models of writing was the Flower and Hayes' model (1980, 1981) and their subsequent revisions (Hayes, 1996, 2012). These models focused on cognitive processes involved in writing such as planning, translating, and reviewing, and their interactions with the task environment and the writer's long-term memory. While these were models of proficient writing, subsequent work focused on developing writers. One such a model is the simple view of writing (Berninger et al., 2002; Juel, Griffith, & Gough, 1986). Parallel to the simple view of reading, Juel, Griffith, and Gough (1986) proposed that writing can be described as processes involved in two skills: ideation and spelling. Writing requires generation of written texts, and therefore, one's skill to generate and organize ideas (i.e., ideation) and to encode sounds to written symbols (i.e., spelling or keyboarding, McCutchen, 2000) are two minimum necessary skills for writing. Spelling was hypothesized to draw on cipher knowledge, which is primarily determined by phonological awareness and experience with print. In contrast, details about processes involved in ideation were not offered, but instead, the Flower and Hayes' (1980) model of planning, translating, and reviewing processes were referenced.

The simple view of writing was further modified and expanded to the not-so-simple view of writing (Berninger & Winn, 2006), which, in addition to skills identified by the simple view of writing, includes handwriting fluency as part of transcription skills, executive function, and working memory. Executive function includes a range of skills and processes such as attentional control, planning, reviewing, revising, and self-regulation strategies; and working memory plays a central role in coordinating these component skills and accessing long-term memory.

Component skills identified in the simple view and not-so-simple view of writing have been supported by empirical studies, including transcription skills such as spelling and handwriting fluency (e.g., Abbott & Berninger, 1993; Alves et al., 2016; Berninger et al., 1997; Graham et al., 1997; Kim et al., 2011, 2014; Limpo & Alves, 2013), oral language (e.g., Coker, 2006; Kim et al., 2011, 2014, 2015a; Olinghouse, 2008), self-regulation (Limpo & Alves, 2013; Graham, & Harris, 2000; Graham, McKeown, Kiuhara, & Harris, 2012), and working memory (e.g., Berninger et al., 1994; Bourdin & Fayol, 1994; Hayes & Chenoweth, 2007; Kellogg, 1996; Kim, 2018; Kim & Schatschneider, 2017). Although the role of oral language in writing may not be immediately obvious in these theoretical models of writing, at the core of ideation (in the simple view of writing) or text[1] generation (in the not-so-simple view of writing) is oral

[1] The term, text, is often mistaken to mean only 'written' text. However, text includes both oral and written texts. This clarification is relevant to the discussion of theoretical models of writing because, for instance, in the not-so-

language skills because generated ideas necessarily have to go through translation into oral language before being transcribed.

Another theoretical framework, the knowledge-telling model specifically focuses on text generation process – how knowledge is represented into the writing process and "what happens to writing in that process" (p. 143) for mature and immature writers (Bereiter & Scardamalia, 1987). For immature or developing writers, text generation primarily takes the process of representing or reproducing what they know in terms of content and discourse features – that is, writing is the "think-say" (p. 145) or memory retrieval, linear process until accessible ideas are depleted; and writing does not alter knowledge. In contrast, for mature writers, writing is a strategic goal-oriented and complex problem-solving process, taking a recursive process and drawing on, refining, and transforming knowledge (knowledge-transforming).

Extending and integrating these models, we recently proposed the Direct Indirect Effects model of Writing (DIEW; Kim, 2019b; Kim & Park, 2019; Kim & Schatschneider, 2017). Unlike process-focused models, DIEW is a component model of writing, focusing on and specifying skills and knowledge that are involved in the writing processes and that contribute to writing development. DIEW builds on the component skills identified by the simple view and not-so-simple view of writing, and further specifies additional component skills, including higher order cognitive skills and regulation such as reasoning, inferencing, and perspective taking, background knowledge (content knowledge and discourse knowledge – knowledge about genres, knowledge about procedures and strategies in carrying out specific writing tasks, see Olinghouse & Graham, 2009), and socio-emotions. Moreover, DIEW specifies the nature of relations among component skills (see Kim & Park, 2019 for details) such that the two component skills by the simple view of writing, transcription and discourse oral language skills (i.e., ideation) are upper- or summative-tier skills that capture the other skills specified in the not-so-simple view of writing (e.g., working memory, attention, self-regulation such as monitoring). DIEW fit data well for English-speaking children (Kim, 2019b; Kim & Schatschneider, 2017) as well as Korean-speaking children (Kim & Park, 2019).

Unpacking Oral Language Skills

One central component skill included in the theoretical models of reading and writing is oral language. Yet, its precise roles and mechanisms were underspecified in these models. This is a crucial issue because the main idea of the simple view of reading and writing is that reading and writing essentially involve processes for oral language plus those for print (reading/decoding for reading comprehension and spelling/encoding for written composition). Oral language is widely classified into different aspects such as phonology, morphology, syntax, semantics, and pragmatics. Another useful way of classifying oral language skills is in terms of grain sizes: sublexical-, lexical-, sentence-, and discourse-level skills. Sublexical-level oral language skills include units smaller than the word such as phonemes or morphemes. Lexical-level oral language includes vocabulary; sentence-level language includes comprehension and production of sentences; and discourse-level oral language includes listening comprehension and oral discourse production (comprehending and producing oral texts such as multi-utterances, conversations, stories, informational texts; Kim & Pilcher, 2016). Recognizing and considering grain size of oral language skills is critical because the complexity of abilities and processes differ as a function of the grain sizes or linguistic hierarchy. For example, a lexical-level oral language

simple view of writing, text generation refers to generating ideas and representing those in oral language. If it referred to written texts, the transcription component skill would be redundant or unnecessary.

skill, vocabulary, requires mapping sound sequences to meaning, and thus, one's phonological memory (also called verbal working memory) is essential (Gathercole & Baddeley, 1990; Kim, 2017b). In contrast, discourse-level oral language skills are higher-order skills, requiring a complex set of cognitive skills such as working memory, inhibitory control, attentional control, inference, perspective taking, and comprehension monitoring (Florit et al., 2011, 2014; Kim, 2015a, 2016; Kim & Phillips, 2014; Kim & Schatschneider, 2017; Lepola et al., 2012; Strasser & del Rio, 2014; Tompkins et al., 2013), lower-level language skills such as vocabulary and grammatical knowledge, and background knowledge (Florit et al. 2011; Kendeou, Bohn-Gettler, White, & van den Broek, 2008; Kim, 2015a, 2016, 2017a).

Another recent advance in our understanding about oral language is the *structural* relations among the language and cognitive component skills of discourse-level oral language skills. According to the direct and indirect effects model of text comprehension (DIET, Kim, 2016), the language and cognitive component skills can be classified into domain-general cognitive skills or executive function (e.g., working memory, inhibitory control, attentional control), foundational oral language skills (vocabulary and grammatical knowledge), and higher-order cognition and regulation skills (e.g., reasoning, inference, perspective taking, and monitoring, goal setting, self-assessment or self-evaluation, and self-enforcement). These classes of skills map onto different levels of mental representations constructed during discourse comprehension and production (i.e., surface code, text base, and situation model) and have hierarchical relations (see Kim, 2015a, 2016, 2017a, 2019; Kim & Schatschneider, 2017). Specifically, foundational cognitive skills are necessary for foundational oral language skills, which, in turn, are necessary for higher-order cognition and regulation skills. All these skills are also needed for discourse-level language and literacy skills such as listening comprehension, oral production, reading comprehension, and written composition (see Figure 1).

One important observation to note here is that the language and cognitive component skills of discourse-level oral language skills (e.g., listening comprehension) overlap with those for reading comprehension (e.g., working memory, vocabulary, inference; see above). Theoretically, this is not surprising because discourse processes do not differentiate oral texts from written texts (Graesser, Singer, & Trabasso, 1994; Kintsch, 1988). However, discourse comprehension and production have been predominantly studied in the context of *written texts* (i.e., reading; McNamara & Magliano, 2009); and has not been integrated with the literature on other theoretical models such as the simple view of reading. The observation about overlapping language and cognitive component skills for discourse-level *oral* language skills and discourse-level *literacy* skills is the key to

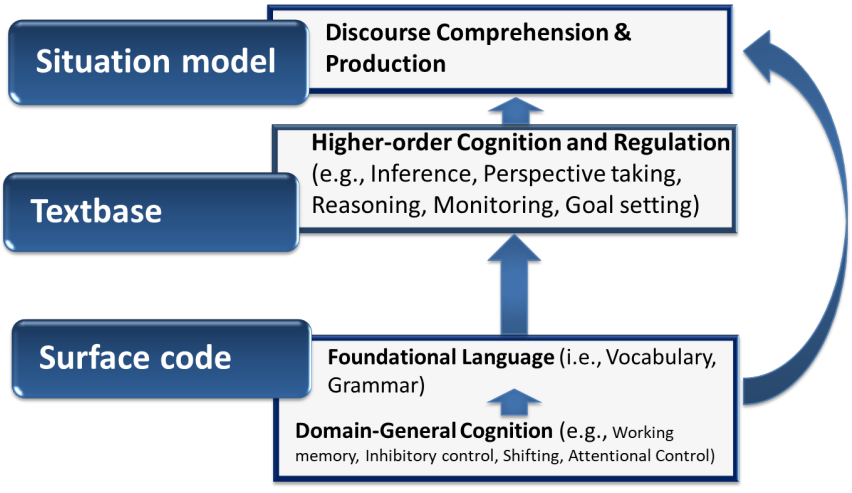

Figure 1. Direct and Indirect Effect Model of Text Comprehension (DIET; modified from Kim, 2016, reprint with permission)

integrating multiple lines of work in reading and writing. In reading, for instance, by integrating evidence from simple view of reading, discourse theory, and component skills of listening comprehension, it was demonstrated that the component skills of listening comprehension and reading comprehension are essentially the same; word reading and listening comprehension are upper-tier skills that are supported by language and cognitive component skills identified by the multi-component view; and word reading and listening comprehension completely mediate the relations of language and cognitive component skills to reading comprehension (DIER, Kim, 2015a, 2017a, 2019a). Similarly, in writing, discourse-level oral language and transcription skills, the two component skills of the simple view of writing, completely mediated the relations of component skills such as working memory, foundational oral language (vocabulary and grammatical knowledge), and higher-order cognitive skills (inference and perspective taking) to writing (DIEW; Kim, 2019b; Kim & Park, 2019; Kim & Schatschneider, 2017).

Reading-Writing Relations

Although the models reviewed above primarily focused on either reading or writing, there is a long history of research investigating the relation between reading and writing (see Fitzgerald & Shanahan, 2000; Langer & Flihan, 2000; Miller, McCardle, & Long, 2013; Shanahan, 2006). The sources of reading-writing relations have been investigated from different perspectives, but the most prominent explanation has been shared knowledge – reading and writing are related because they draw on shared knowledge (see Fitzgerald & Shanahan, 2000; also see Langer & Flihan, 2000). Fitzgerald and Shanahan (2000) summarized shared knowledge into the following four broad categories: metaknowledge (e.g., purposes and functions of reading and writing), domain knowledge (e.g., vocabulary and content knowledge), knowledge about universal text attributes (e.g., graphophonics), and procedural knowledge (e.g., accessing and using knowledge).

In this chapter, I approach shared knowledge from a component skills perspective drawing on the previously reviewed theoretical models of reading and writing. First, lexical-level literacy skills such as word reading and spelling draw on essentially the same component skills such as phonological awareness, orthographic knowledge and awareness, and morphological awareness (Carlisle & Katz, 2006; Kim, 2010; Kim, Apel, & Al Otaiba, 2013; Schatschneider, Fletcher, Francis, Carlson, & Foorman, 2004; Treiman, 1993). This is in line with theoretical models of word reading and spelling (e.g., triangle model; Adams, 1990; Treiman, 1993) which specify that for lexical-level literacy skills, the child needs to develop accurate representations in three interrelated forms or aspects: phonology, orthography, and semantics. Second, discourse-level literacy skills (i.e., reading comprehension and written composition) also rely on a similar set of skills, including lexical-level literacy skills (word reading and spelling) and discourse-level oral language skills (listening comprehension & oral production), and their component skills – foundational, domain-general cognitive skills (e.g., working memory, attention), foundational oral language skills (vocabulary and grammatical knowledge), higher-order cognitive skills (reasoning, inference, perspective taking, monitoring), background knowledge (domain and discourse knowledge), and socio-emotions (e.g., Ahmed et al., 2016; Berninger & Abbott, 2010; Cain et al., 2004; Cromley & Azevedo, 2007; Juel et al., 1986; Kim et al., 2011, 2014, 2015a; Kim & Schatschneider, 2017).

If reading and writing are related to each other due to shared knowledge, what is the nature of their relations? Shanahan and Lomax (1986) hypothesized interactive relations where different aspects and levels of reading and writing skills are interactively related to each other

such that phonetic skills in reading influence spelling, and spelling influences vocabulary in reading, which, then, influences vocabulary diversity in writing. Berninger and colleagues also hypothesized bidirectional relations, conceptualizing reading-writing relations as part of a language-in-four-functional-system: aural (language by ear), oral (language by mouth), reading (language by eye), and writing (language by hand; Berninger & Abbott, 2010; Berninger, Cartwright, Yates, Swanson, & Abbott, 1994). Berninger and Abbott (2010) found that listening comprehension, oral language production, reading comprehension, and written composition predicted each other.

Interactive Dynamic Literacy Model

Review of theoretical models and associated empirical evidence suggests largely similar, albeit not identical, processes in reading and writing development. Integrating these insightful theoretical models and associated evidence, I propose an integrative theoretical framework of reading and writing development, called the interactive dynamic literacy model (see Kim & Graham, 2018 for empirical evidence). This framework is informed and influenced by several lines of prior work reviewed here, and directly builds on DIER (Kim, 2015a, 2017a, 2019a) and DIEW (Kim, 2019b; Kim & Park, 2019; Kim & Schatschneider, 2017).

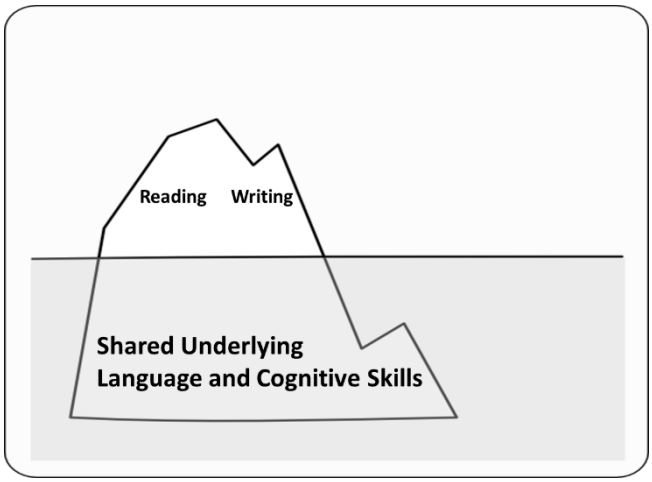

Figure 2. Heuristic Illustration of the Interactive and Dynamic Literacy Model

The central idea of the interactive dynamic literacy model is that reading and writing emerge from multiple shared knowledge cognitive processes in visual, phonological, and semantic systems and memory (see Ellis, 1987) such that reading and writing are not modular or unidirectional systems, but instead interact, influence, mutually reinforce, and develop together. Figure 2 illustrates this, showing that reading and writing are related but different skills, and they are products of underlying common language and cognitive skills. On the surface is manifestations of reading (decoding or comprehension of written texts) and writing (spelling or production of written texts). Under the surface or underlying the manifestations are shared language and cognitive systems that enable and support reading and writing skills.

Figure 3 shows details of the component skills and structure of the component skills according to the interactive dynamic literacy model. What is apparent in Figure 3 is similarities or overlaps in the component skills and knowledge for reading and writing. Both reading comprehension and written comprehension draw on lexical-level literacy skills, oral language skills at various levels (vocabulary, grammatical knowledge and discourse oral language), higher order cognitions and regulations, domain-general cognitions, content and discourse knowledge, and socio-emotions. These component skills are activated and employed involving long-term memory system with constraint of limited processing resources, during the various processes of reading comprehension (decoding, constructing, and integrating propositions) and written composition (generating ideas, translating, transcribing, revising, and editing). Also important in the skill development is accuracy *and* automaticity. Accuracy (e.g., accurate identification of

letters, accurate word reading or spelling, accurate use of vocabulary words) is necessary but not sufficient for literacy acquisition. In tasks involving complex processes such as reading and writing, automaticity (effortless and lack of conscious awareness) in component skills is needed to allow cognitive resources to be available for higher order processes and to access and retrieve relevant information efficiently to support the goal of meaning processing and production (e.g., Kim, 2015b; LaBerge & Samuels, 1974).

The shared nature of components skills for reading and writing does not entail that reading and writing are identical skills (also see Fitzgerald & Shanahan, 2000). Reading is a receptive task where stimuli is given to the reader and thus decoding and comprehension processing is delimited by the given materials. In contrast, writing is a productive/expressive task that requires generating and encoding texts, and managing greater degree of options (e.g., expressing ideas using linguistic and rhetorical choices, structural organization depending on goals and genres). Therefore, although both reading and writing draw on a highly similar set of skills and knowledge, the extent to which skills and knowledge contribute to reading versus writing is likely different, resulting in dissociation between reading and writing.

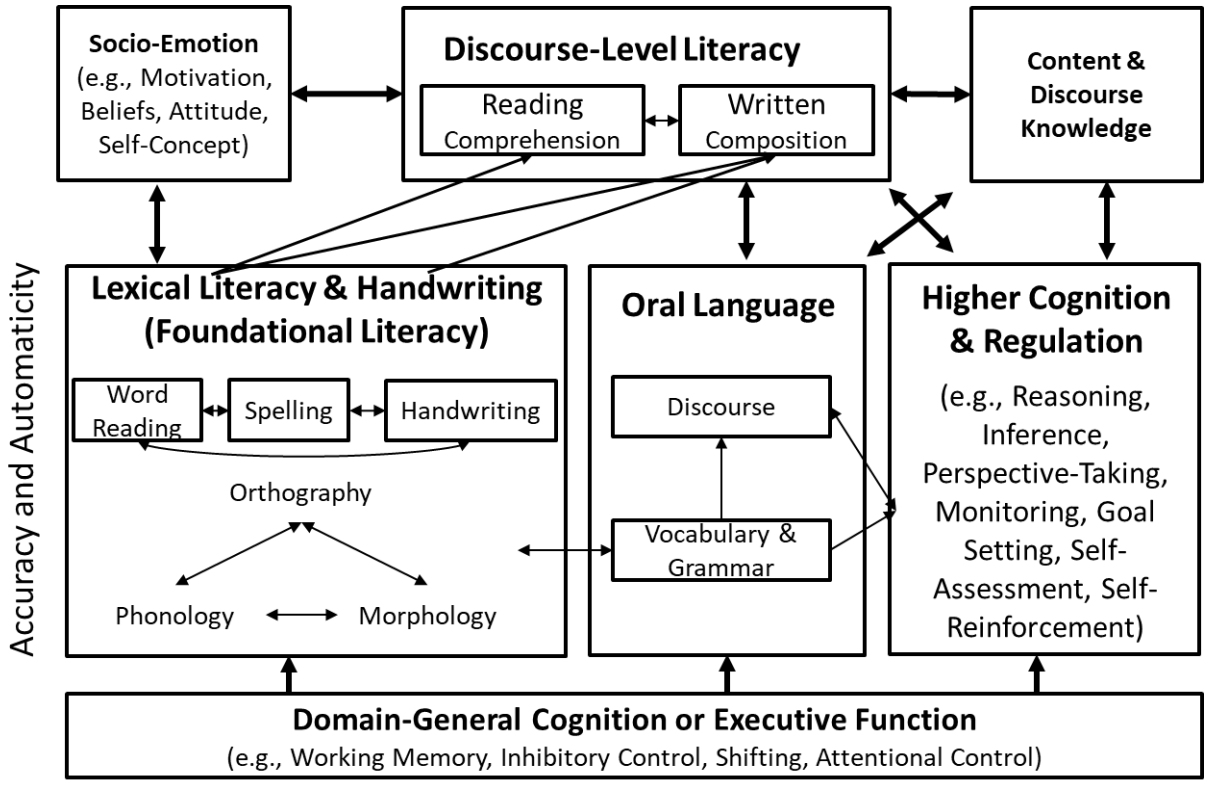

Figure 3. Interactive Dynamic Literacy Model

Working Hypotheses of Interactive Dynamic Literacy Model

Based on the central ideas described above, below are four working hypotheses of the interactive dynamic literacy model. These hypotheses are not expected to vary across languages and writing systems. However, the relative contributions of component skills and developmental timing are expected to vary as a function of orthographic depth. For instance, in transparent orthographies, with appropriate instruction, lexical-level literacy skills develop at a faster rate (Seymour, Aro, & Erskine, 2003s), and thus, its constraining role will be short-lived compared to

that in deep orthographies (e.g., Babayiğit & Stainthorp, 2010; Kim, 2015b), and oral language and higher order cognitions may exert their influences earlier than in deep orthographies (Kim, 2019a; Kim & Park, 2019).

Hypothesis 1. Hierarchical structure with direct and indirect relations. As shown in Figure 3 (also see Figure 5), the interactive dynamic model hypothesizes hierarchical relations among component skills where discourse-level literacy skills (reading comprehension and written composition) are built upon lexical-level literacy skills and discourse-level oral language skills, which, in turn, are dependent on language and cognitive component skills. Lexical-level literacy skills (word reading and transcription skills) rely on emergent literacy skills, including orthography (print awareness, orthographic knowledge and awareness), phonology (phonological awareness), and semantics (e.g., morphological awareness). Discourse-level oral language skills (listening comprehension or oral production) draw on higher-order cognitions and regulation such as inference, perspective taking, reasoning, and self-regulation and monitoring as well as foundational oral language skills such as vocabulary and grammatical knowledge. All these rely on domain-general cognitive skills or executive function such as working memory, inhibitory control, shifting, and attentional control. Knowledge including content/topic knowledge and discourse knowledge as well as socio-emotions toward literacy interact with reading and writing development. The hierarchical relations indicate that lower-level skills are necessary for higher-level skills. That is, development of lower-level skills is required for higher-order skills, or lower-level skills feed forward high-level skills. This does not, however, indicate that mastery of lower-level skills is necessary for the development of higher-order skills. Instead, the lower-level and higher-level skills develop in an emergent, overlapping, parallel manner, co-developing with one another.

Hierarchical relations specify mechanisms and pathways by which component skills influence reading and writing development. For instance, emergent literacy skills are important for reading development but their influence on reading comprehension is *indirect* via word reading (Juel et al., 1986; Kim & Petscher, 2016; Vellutino et al., 2007). Furthermore, language and cognitive component skills such as working memory, vocabulary, and inference have direct and indirect relations to listening comprehension (Kim, 2015a, 2016, 2017a, 2019a; Kim & Phillips, 2014), and indirect relations to reading comprehension (Kim, 2015a, 2017a) and written composition (Kim, 2019b; Kim & Park, 2019; Kim & Schatschneider, 2017) via lexical-level literacy and discourse oral language skills. For example, the role of working memory in reading comprehension (see Peng et al., 2018) and writing (Bourdin & Fayol, 1994; Hayes & Chenoweth, 2007; Kellogg, 1996) is well-established. Also well-established is its role for the other component skills of reading comprehension and writing such as vocabulary and grammatical knowledge (see Kim, 2017b for a review). Then, the influence of working memory on reading comprehension and writing would be largely indirect via the component skills. Indeed, working memory was not directly related to reading comprehension (Kim, 2017a, 2019a) or written composition (Kim & Park, 2019; Kim & Schatschneider, 2017) once other higher order skills (e.g., discourse oral language skills) were accounted for and when discourse oral language skills were measured in an equivalent manner as discourse literacy skills. Despite lack of a direct effect, the indirect effect of working memory via other component skills were substantial (Kim, 2017a; Kim & Park, 2019; Kim & Schatschneider, 2017).

Hypothesis 2. Interactive relations. This hypothesis states that component skills of reading and writing are dynamically inter-related, developing together (see double headed arrows in Figure 3). For instance, evidence indicates the relation of morphological awareness to

vocabulary (Kieffer & Lesaux, 2012); and vocabulary to morphological awareness (Wysocki & Jenkins, 1987). Discourse-level literacy skills also interact with discourse-level oral skills and content/domain knowledge. Reading comprehension draws on content knowledge while it also builds content knowledge via reading experience. Reading comprehension relies on oral language skills, but reading experiences also likely facilitate the development of oral language (Quinn et al., 2019). Writing also draws on content knowledge, and also builds knowledge, particularly at an advanced level (see Bereiter & Scardamalia, 1987). Socio-emotional aspects (e.g., motivation, engagement, attitude, self-efficacy, and anxiety in reading and writing; Graham, Berninger, & Fan, 2007; Katzir, Lesaux, & Kim, 2009) also likely develop interacting with literacy acquisition (e.g., see Katzir, Kim, & Dotan, 2018).

Reading and writing are also hypothesized to have an interactive relation, stemming from two sources: shared knowledge and processes reviewed above as well as rhetorical relations between reading and writing. As shown above, if reading and writing largely rely on highly similar sets of skills, then their development is likely mutually supportive and interdependent. From the rhetorical viewpoint, the processes of reading and writing acquisition themselves might result in interactive relations (Fitzgerald & Shanahan, 2000). For instance, reading experiences (i.e., reading texts) might provide readers the opportunity to understand the meaning-construction process in writing. Writing experience, on the other hand, is likely to afford one to reflect on how information is presented in written texts, promoting awareness of text structure and text meaning.

Note that the interactive relations hypothesis is flexible about bidirectional relations across grain sizes. For example, morphological awareness (sublexical skill) would predict vocabulary (lexical skill) and vice versa; or vocabulary and inference might have bidirectional relations (Kim, 2017a, b; Lepola et al., 2012). Of the same grain size, word reading and spelling may have a bidirectional relation. Furthermore, the interactive hypothesis does not imply symmetric contributions – it is likely that one skill (e.g., reading) may be more important contributor to development of the other skill (e.g., writing) or relative contributions may change as children develop reading and writing skills. For example, Hayes' (1996) model for proficient writers and DIEW (Kim, 2019b) include reading as a component skill of writing whereas theoretical models of reading comprehension do not include writing as a component skill. However, this does not indicate that writing development does not play a facilitative role in reading development (e.g., Graham & Hebert, 2010). However, this might indicate that reading contributes to writing to a greater extent than writing does to reading.

Extant literature provides some evidence about interactive and bidirectional relations between reading and writing. As for correlational evidence, word reading predicted transcription skills (spelling and handwriting fluency) (Kim, Petscher, Wanzek & Al Otaiba, 2018) and transcription skills predicted word reading (Berninger et al., 2002); and reading comprehension predicted quality of written composition (Berninger & Abbott, 2010; Kim et al., 2015a, 2018) and vice versa (Berninger & Abbott, 2010). However, a study which explicitly investigated bidirectional relations reported mixed findings. Ahmed, Wagner, and Lopez (2014) investigated bidirectional reading-writing relations at the lexical-, sentence-, and discourse-level using longitudinal data from Grades 1 to 4. A bidirectional relation was found at the sentence level, but a unidirectional relation from reading to writing was found at the lexical- and discourse-level literacy skills. Similar results of reading to writing relations, but not the other way around, at the lexical and discourse level literacy skills were found for students in Grades 3 to 6 (Kim et al., 2018).

Causal evidence from intervention studies also supports the interactive and bidirectional relations. For the lexical-level literacy skills, a recent meta-analysis concluded that spelling instruction improved word reading (effect size = .40) and reading comprehension (effect size = .66) (Graham & Santangelo, 2014). Instruction on word reading, via phonics instruction, also enhanced spelling (effect size = .35) (see a review by Ehri, Nunes, Stahl, & Willows, 2001). At the discourse level, writing (i.e., written composition) intervention improved reading comprehension (effect sizes = .22-.27; Graham & Hebert, 2011) and reading instruction improves writing (Graham et al., 2018).

These studies reveal one important pattern regarding the nature of reading-writing relations: different magnitudes of reading-writing relations as a function of grain size – the relation at the lexical level literacy skills is stronger than that at the discourse level literacy skills. Correlations between lexical-level literacy skills such as word reading and spelling are moderate to strong ($.50 \leq r\text{s} \leq .84$; Ahmed et al., 2014; Berninger & Swanson, 1994; Ehri, 2000; Juel et al., 1986; Kim, 2011; Kim, Al Otaiba, & Wanzek, 2015). In contrast, the relation between discourse-level skills (reading comprehension and written composition) tends to be weaker. Reading comprehension and writing 'productivity' (e.g., number of words and phrases) have weak relations ($.01 \leq r\text{s} \leq .34$; e.g., Abbott & Berninger, 1993; Berninger et al., 1994) whereas reading comprehension and writing 'quality' have more consistent and relatively weak to moderate correlations, ranging from .26 to .39 (Juel et al., 1986); .24 to .54 (Abbott & Berninger, 1993); .47 to .59 (Ahmed et al., 2014); .35 to .37, Berninger & Abbott, 2010); .38-.43 (Berninger et al., 1993); and .33 to .50 (Kim et al., 2015a). The differences in the magnitude of the relations might be attributed to the fact that lexical-level literacy skills rely on a limited number of sources (i.e., emergent literacy skills) whereas discourse-level skills (reading comprehension and written comprehension) rely on a wide array of skills and knowledge.

Hypothesis 3. **Co-morbidity of reading and writing difficulties**. If reading and writing develop based on many shared many language and cognitive component skills and knowledge, an important corollary hypothesis is that students with reading difficulties are likely to have writing difficulties and vice versa. As depicted in Figure 4, according to the interactive dynamic literacy view, most common student profiles will be found in the 'low-low' and 'high-high' regions with some in the 'low-high' or 'high-low' regions. This, of course, would depend on the strengths of the relations between reading and writing such that the stronger the relation, the greater concentration of students in the high-high, and low-low quadrants compared to the low-high and high-low quadrants. An example is the case for the lexical-level literacy skills, given a strong correlation between word reading and spelling. In contrast, when the relations are moderate or weak, the number of children in the low-high and high-low profiles would increase. Profiles would also depend on the nature of reading-writing relations. If writing relies on reading to a greater extent than vice versa, the likelihood of having low reading and high writing would be lower. Limited but extant evidence does indicate co-morbidity of reading and writing difficulties. For example,

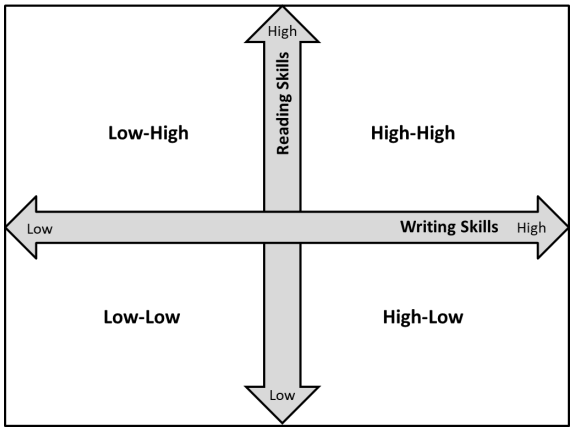

Figure 4. Four Quadrants of Reading-Writing Skill Profiles.

children with dyslexia had impaired transcription skills and written composition. In addition, these children's emergent literacy skills were related to their reading skills as well as written composition (Berninger, Nielson, Abbott, Wijsman, & Raskind, 2008).

Hypothesis 4. Dynamic relations. Another key hypothesis of the interactive dynamic literacy model is dynamic relations among component skills as a function of a) development; b) learner characteristics, and c) reading and writing measurement. For the differential relations as a function of development, the strengths of relations between component skills and literacy skills are expected to vary, depending on the one's developmental phase because lexical-level literacy skills place greater constraints on discourse-level literacy skills during the beginning phase whereas language and higher order cognitive skills would play greater roles at a more advanced phase because the influence of lexical-level literacy skills would reach plateau with development. Furthermore, linguistic complexity of texts to comprehend and produce increases as children develop literacy skills (i.e., upper grades), placing greater demands on language and higher order cognitive skills. In reading, texts in upper grades contain complex ideas and language structure (e.g., vocabulary and syntactic structure). In writing, according to the knowledge-telling framework, at a more advanced phase, writing shifts to knowledge-transforming where students write to expand upon their knowledge with new ideas (Bereiter & Scardamalia, 1987).

Relations may also vary as a function of individual characteristics such as students' language learner status and learning disability status. For example, for students who learn to read and write in a second language and have limited proficiency in the target L2 oral language, L2 oral language skills might play greater constraining roles in writing (Silverman et al., 2015). Similarly, students with learning disabilities (e.g., language impairment, dyslexia) might be differentially impacted on their writing skills. For instance, we found that students with language impairment, but not those with speech impairment, had consistently lower writing scores across the year although their rate of growth did not differ from that for typically developing children (Kim, Puranik, & Al Otaiba, 2015).

Finally, the contributions of component skills to reading and writing would vary, to some extent, depending on how reading comprehension and written comprehension are measured and evaluated. In reading comprehension, the extent of contributions of component skills has been found to vary as a function of measurement or assessment of comprehension (e.g., cloze tasks, retell, open-ended or multiple choice questions after reading passages; Cutting & Scarborough, 2006; Keenan, Betjemann, & Olson, 2008) and text features (e.g., texts vary in the demands of language and cognitive skills, Kim, 2019a). Written composition is also evaluated in multiple ways for developing writers, including writing quality (quality and clarity of ideas and organization), writing productivity (amount of written text), and writing fluency ("efficiency and automaticity in writing connected texts"; Kim, Gatlin, Al Otaiba, & Wanzek, 2018, p. 322); and these different aspects are related but dissociable dimensions (Kim et al., 2014, 2015a, 2017; Puranik, Lombardino, & Altmann, 2008; Wagner et al., 2011). These different aspects of written composition rely on component skills differentially such that oral language and higher order cognitions make greater contributions to writing quality than to writing productivity (Kim et al., 2014, 2015a; Kim & Graham, 2019). Similarly, reading comprehension is primarily related to writing quality, not productivity (Kim & Graham, 2019).

Implications, Future Directions, and Further Considerations

Figure 5[2] is a simplified, heuristic representation of the interactive dynamic literacy model to help illustrate practical implications. Discourse literacy skills (reading comprehension and written composition) are supported by two necessary pillars, lexical-level literacy skills and discourse oral language skills. The building foundation for the lexical level literacy skill pillar is emergent literacy skills; the foundations for discourse oral language skills are higher order cognitions and regulation, and foundational language skills; and all these are built upon domain general cognitive skills (executive function). Without either pillar (lexical level literacy skills or discourse oral language skills), the structure does not hold or successful reading comprehension or written comprehension cannot be achieved; and without foundational blocks (emergent literacy skills and language and cognitive skills), the two pillar skills are not supported. Knowledge (content and discourse knowledge) and socio-emotions also contribute to reading and writing skills.

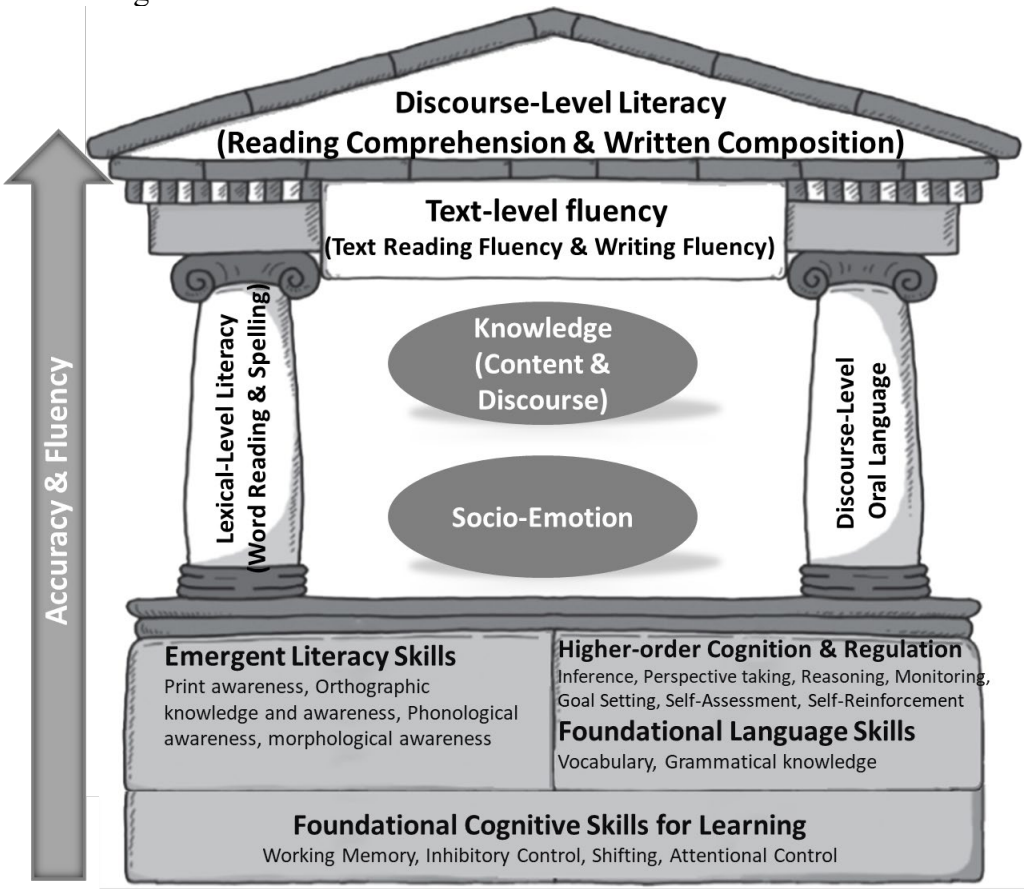

Figure 5. Heuristic Representation of the Interactive Dynamic Model of Literacy Development. Adapted from Kim, 2017b. Note: The boundaries do not indicate lack of relations among component skills.

[2] Figure 5 includes text level fluency (text/oral reading fluency and text writing fluency) as a partial bridge between the pillars and discourse literacy skills. Theoretical and empirical details of text level fluency is beyond the scope of this chapter, but see Kim et al. (2018) for text writing fluency and Kuhn, Schwanenflugel, and Meisinger (2010) and Kim and Wagner (2015) for oral/text reading fluency.

There are several practical implications of the interactive dynamic literacy model. First, the shared knowledge and processes imply that to improve reading and writing, explicit and systematic instruction is needed on the shared underlying skills. This is important to promote successful development and to prevent difficulties in reading and writing skills (see the co-morbidity hypothesis). Second, the shared knowledge and interactive nature imply that teaching reading and writing in an integrative manner would promote synergistic development. Recommendations include incorporating spelling in phonics instruction (e.g., see Ehri et al., 2001), having students write about texts they read, and increasing opportunities to write as part of reading instruction (Graham & Hebert, 2010). Third, the hierarchical structure offer implications for assessment and instruction: to develop discourse literacy skills (reading comprehension and written composition), assessment should include the two pillars, lexical-level literacy skills and discourse oral language skills, and their component skills, depending on the student's developmental phase. This is represented in Figure 6 where children's profiles are classified into four categories. If a student struggles with reading comprehension and/or written composition, the student's lexical-level literacy skills and discourse oral language skills should be assessed as a starting point, followed by a systematic diagnostic assessment to identify sources of difficulties by evaluating the student's performance on the component skills of lexical-level literacy skills and discourse oral language skills. That is, for lexical-level literacy skills emergent literacy skills need to be assessed. For discourse-level oral language skills, not only foundational oral language skills such as vocabulary and grammatical knowledge, but also higher-order cognitive skills need to be assessed. The profiles and sources of difficulties are then used as a basis to make instructional decisions in order to meet the student's needs. Finally, the hierarchical structure also implies that instruction to promote development of reading and writing skills and prevention of difficulties can and should start early before children can read and write by addressing the foundational skills – emergent literacy skills, language skills, and higher order cognitive and regulation skills. This is particularly critical for children from disadvantaged backgrounds who often have weaknesses in these skills (Hart & Risley, 1995; National Research Council, 1998).

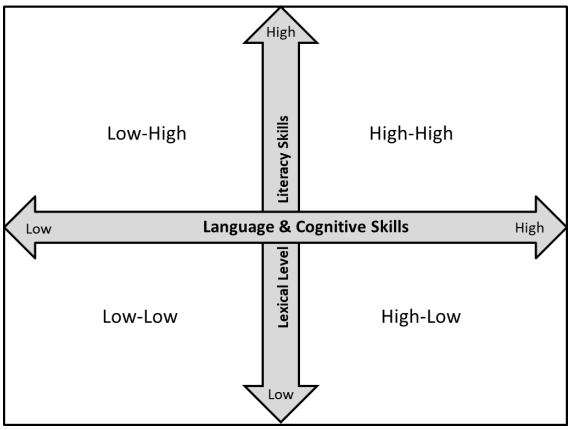

Figure 6. Four Profiles of Skills to Inform Development of Reading and Writing

Although the interactive dynamic literacy model is informed by extant theoretical models and associated empirical evidence, future work is necessary to test the specification shown in Figure 3 by including the component skills for reading and writing simultaneously (see e.g., Kim & Graham, 2019). Furthermore, studies should examine the core hypotheses using data from different languages and writing systems to examine its validity. For example, the interactive hypothesis and dynamic hypothesis should be further investigated using longitudinal data, and experimental studies where both reading and writing skills are measured regardless of their focal instructional target skill (either reading or writing) – a review of the literature revealed many missed opportunities to examine the bidirectional relations because many prior experimental studies measured either reading or writing, but not both. Also warranted is systematic research on the co-morbidity of reading and writing difficulties. While some important work has been

conducted in this area (e.g., Berninger et al., 2008; Puranik, Lombardino, & Altmann, 2006), much of previous work has focused on difficulties in one domain, but not co-morbidity.

The theoretical models and frameworks presented above, including the interactive dynamic literacy model, focused on the processes and skills within the individual reader or writer. An individual's skill, of course, is an outcome of characteristics of the individual and his or her interactions with the environment. Development of reading and writing, and their component skills involves interactions with and is influenced by multiple layers of environmental factors (Bronfenbrenner, 1979). For reading development, the reader, text, and activity elements were recognized (Snow, 2002). In writing, Hayes (1996) laid out the task environment (i.e., audience, collaborators, text so far, composing medium) that interacts with the individual during the writing process. Graham (2018) also expanded this to include the community in which writing occurs. Beyond these immediate task and text environments surrounding reading and writing, development of the component skills and knowledge is embedded within larger socio-cultural contexts such as homes, classrooms (instruction), schools, neighborhoods, and districts. The list can go on, but the point is that although beyond the scope of this chapter, these larger socio-cultural contexts should be recognized for reading and writing development.

Conclusion

Tremendous progress has been made in our understanding of acquisition and instruction of literacy skills in the last four decades. However, although literacy skills include both reading and writing, they have been largely studied separately. Thorough and careful look into reading and writing, respectively, is necessary and insightful, but it is also imperative to consider and study reading and writing as a co-developing system rather than as isolated systems. As an extension of previous efforts in this line of work, in this chapter, I reviewed prominent theoretical models and evidence in reading and writing, and proposed an integrative framework, the interactive dynamic literacy model. The core of this view is that reading and writing draw on a highly similar set of shared language and cognitive. Central hypotheses about structural relations include hierarchical relations, interactive relations, co-morbidity of reading and writing difficulties, and dynamic relations. Future work is needed to examine, refine, and further enhance ideas elaborated in the interactive dynamic literacy model.

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