Journal of Educational Psychology

Expanding the Direct and Indirect Effects Model of Writing (DIEW): Reading–Writing Relations, and Dynamic Relations as a Function of Measurement/Dimensions of Written Composition

Young-Suk Grace Kim and Steve Graham

Online First Publication, October 11, 2021. http://dx.doi.org/10.1037/edu0000564

AMERICAN PSYCHOLOGICAL ASSOCIATION

Journal of Educational Psychology

ISSN: 0022-0663

https://doi.org/10.1037/edu0000564

Expanding the Direct and Indirect Effects Model of Writing (DIEW): Reading–Writing Relations, and Dynamic Relations as a Function of Measurement/Dimensions of Written Composition

Young-Suk Grace Kim[1] and Steve Graham[2]
[1] School of Education, University of California, Irvine
[2] Mary Lou Fulton Teachers College, Arizona State University

Within the context of the Direct and Indirect Effects Model of Writing (Kim & Park, 2019), we examined a dynamic relations hypothesis, which contends that the relations of component skills, including reading comprehension, to written composition vary as a function of dimensions of written composition. Specifically, we investigated (a) whether higher-order cognitive skills (i.e., inference, perspective taking, and monitoring) are differentially related to three dimensions of written composition—writing quality, writing productivity, and correctness in writing; (b) whether reading comprehension is differentially related to the three dimensions of written composition after accounting for oral language, cognition, and transcription skills, and whether reading comprehension mediates the relations of discourse oral language and lexical literacy to the three dimensions of written composition; and (c) whether total effects of oral language, cognition, transcription, and reading comprehension vary for the three dimensions of written composition. Structural equation model results from 350 English-speaking second graders showed that higher-order cognitive skills were differentially related to the three dimensions of written composition. Reading comprehension was related only to writing quality, but not to writing productivity or correctness in writing, and reading comprehension differentially mediated the relations of discourse oral language and lexical literacy to writing quality. Total effects of language, cognition, transcription, and reading comprehension varied largely for the three dimensions of written composition. These results support the dynamic relation hypothesis, role of reading in writing, and the importance of accounting for dimensions of written composition in a theoretical model of writing.

Educational Impact and Implications Statement

Written composition is a multidimensional construct, and various dimensions of written composition draw on different language and cognitive skills. Higher-order cognitive skills such as inference, perspective taking, and monitoring as well as reading comprehension are important to the quality dimension of written composition. In contrast, lexical literacy and handwriting fluency were important contributors of writing productivity (or composition length) and correctness in writing, whereas vocabulary and grammatical knowledge made additional contributions to correctness in writing. These findings imply that dimensions of written composition should be carefully considered and calibrated in assessment and instruction and that systematic integration of reading and writing supports writing development.

Keywords: Direct and Indirect Effects Model of Writing (DIEW), higher-order cognitions, mediation, reading, writing

Supplemental materials: https://doi.org/10.1037/edu0000564.supp

To produce coherent written compositions, one needs to carefully coordinate and regulate complex, recursive processes of generating ideas, translating them into oral language, transcribing them into print, and revising and editing written texts. These complex writing processes draw on multiple language and cognitive skills and knowledge in the context of physical and social environments (see Berninger & Winn, 2006; Graham, 2018; Hayes, 1996; Kim & Park, 2019). The Direct and Indirect Effects Model of Writing (DIEW; Kim, 2020a; Kim & Park, 2019; Kim & Schatschneider, 2017) was recently proposed to describe the

Young-Suk Grace Kim https://orcid.org/0000-0002-4328-3843

This research was supported by grants from the Institute of Education Sciences (IES), U.S. Department of Education, R305A130131 and R305A180055, and National Institute of Child Health and Human Development (National Institute of Child Health and Human Development), P50HD052120, to Young-Suk Grace Kim, and IES R305C190007 to Young-Suk Grace Kim and Steve Graham. The content is solely the responsibility of the authors and does not necessarily represent the official views of the funding agencies. The authors thank participating schools and children.

Correspondence concerning this article should be addressed to Young-Suk Grace Kim, School of Education, University of California, Irvine, 3200 Education Building, Irvine, CA 92697, United States. Email: youngsk7@uci.edu

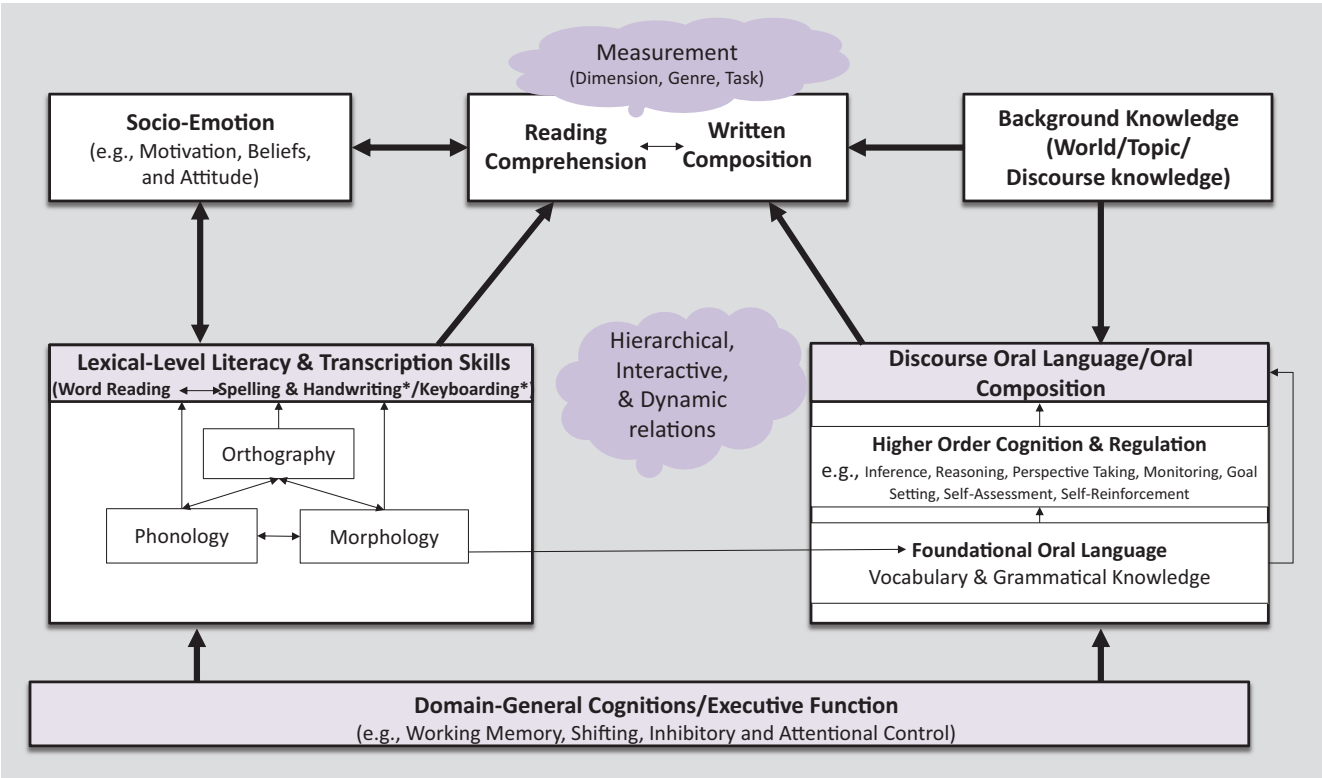
component or contributing skills and knowledge (component skills henceforward) that are involved in the aforementioned writing processes and writing development. In the present study, we expand DIEW by adding a dynamic or differential relations hypothesis as a function of measurement and dimensions of written composition, and by adding reading as a component skill that contributes to writing. We then empirically examined these additional hypotheses of DIEW, using data from English-speaking children in grade 2. Specifically, we examined (a) the relations of higher-order cognitive skills—inference, perspective taking, monitoring—to three dimensions of written composition: writing quality, writing productivity, and correctness in writing; (b) the relation of reading comprehension to the three dimensions of written composition after accounting for oral language, cognition, and transcription skills and the mediating role of reading comprehension in the relations of discourse oral language and lexical-level literacy skill to the three dimensions of written composition; and (c) total effects of oral language, cognition, transcription, and reading comprehension on the three dimensions of written composition.

Direct and Indirect Effects Model of Writing

DIEW hypothesizes that the following skills contribute to writing processes and its product, written composition, as well as writing development (see Figure 1 and Appendix A): background knowledge; socioemotions; transcription skills such as spelling and handwriting/keyboarding; knowledge or awareness of phonology, orthography, and morphology; oral composition or discourse oral language; higher-order cognitive skills and regulation skills such as reasoning, perspective taking, inferencing, goal setting, and monitoring; vocabulary and grammatical knowledge; and domain-general cognitions or executive function such as working memory and attentional control. These component skills are expected to develop interacting with environmental factors, including home language and literacy environment, instruction at school, and larger communities and structures (e.g., Kim et al., 2016; also see Graham, 2018).

DIEW extends previous theoretical models in several ways. First, DIEW explicitly and clearly articulates a comprehensive set of specific component skills of writing. DIEW is a *component skills model* of writing that articulates component information processing systems that are involved in complex and recursive writing processes. Writing processes such as planning, revising and reflection, or text generation were well articulated in previous influential work such as the Hayes and Flower model (Hayes & Flower, 1980) and the knowledge telling and transforming model (Bereiter & Scardamalia, 1987). Although component skills were included in these theoretical models, they did not fully focus on them. For example, the Hayes and Flower (1980) model specified that the planning process requires input from long-term memory.

Figure 1
Expanded Direct and Indirect Effects Model of Writing



Note. The component skills are expected to contribute to writing processes and consequent written composition. *Handwriting and keyboard skills are only relevant to written composition, not reading comprehension. Discourse knowledge includes genre knowledge (e.g., text structures and features associated with different genres) and knowledge about how carry out specific writing tasks. Grammatical knowledge includes morphosyntactic and syntactic knowledge. Although not represented for many skills in the Figure, the skills and knowledge included in DIEW are expected to have interactive developmental relations. See the online article for the color version of this figure.

Hayes and Flower did identify the various types of knowledge stored in long-term memory, but specific component skills and their structural relations were not the foci in the model.

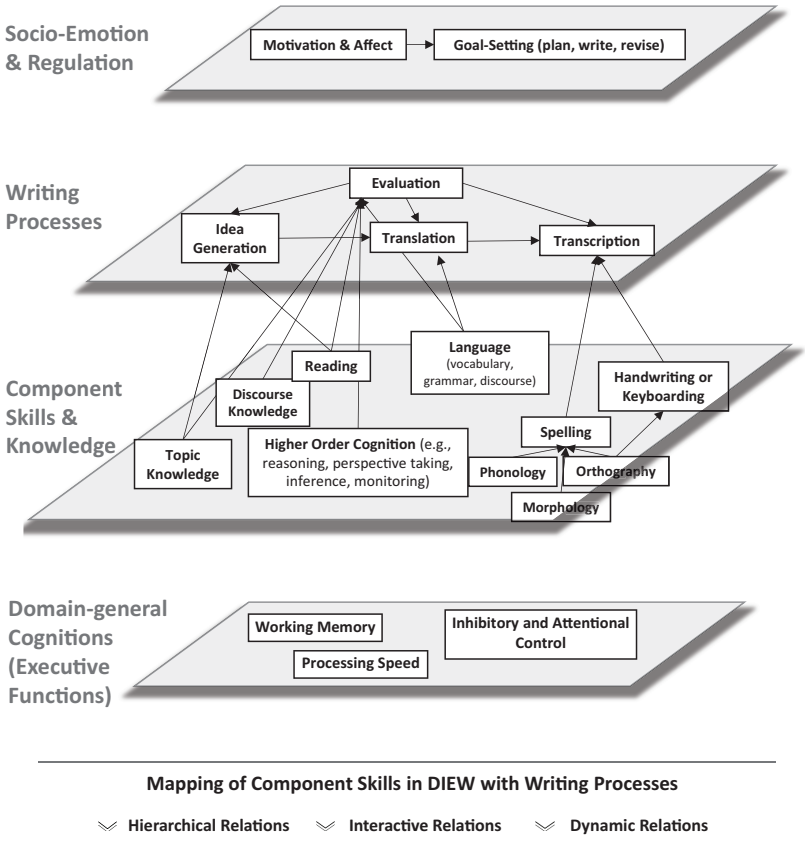
DIEW does a better job of mapping component skills and writing processes than prior models such as the one created and modified over time by Hayes (2012). This is illustrated in Figure 2. The idea generation process primarily draws on topic/content knowledge and reading (when involving reading source materials); the translation process primarily draws on oral language; the transcription process draws on spelling and handwriting or keyboarding skills; and the evaluation process primarily draws on language skills, reading skills, higher-order cognitions, topic knowledge, and discourse knowledge. Domain general cognitions, socioemotions, and self-regulation are involved during the entire writing processes.

Explicit and precise articulation of component skills is an important step to directly and more readily link theory to assessment and instruction. For example, it is not apparent for assessment and instruction how planning, ideation, or text generation should be operationalized (e.g., how to assess and teach ideation). In contrast, specifying component skills that are needed for the planning process such as oral composition or discourse oral language, vocabulary, higher-order cognitions, transcription, and text structure knowledge offer a clearer picture about how to operationalize assessment and instruction. This is a singular advantage of DIEW as well as the principle central to the model that component skills are involved in the writing process only as needed.

Another crucial way that DIEW extends previous theoretical models (e.g., the simple view of writing, the not-so-simple view of writing, the Hayes and Flower model) is articulation of three testable hypotheses regarding *structural relations* of component skills—hierarchical, interactive, and dynamic hypotheses. DIEW hypothesizes and specifies hierarchical relations among the component skills (see Kim & Park, 2019, for a review of evidence). The hierarchical relations hypothesis lays out a chain of multichanneled pathways by which component skills are related to written composition. An important corollary of hierarchical relations is direct and indirect relations of component skills. That is, not all component skills are directly related to written composition, and lower order skills are related to written composition via higher-order skills (see Appendix B for an example).

Figure 2

Expanded Direct and Indirect Effects Model of Writing (DIEW) Where Writing Processes Are Mapped With Component Skills and Knowledge



Note. Domain-general cognitions are involved throughout the writing process via component skills. The arrows in the writing process plane should not be construed as completely sequential. Instead, simultaneous activations (e.g., generation, translation, and evaluation) and recursion are allowed. The component skills and knowledge also have hierarchical, interactive, and dynamic relations among each other but are not represented here.

DIEW also posits an interactive relations hypothesis, which states that relations between component skills and writing, and among component skills are interactive and bidirectional in development (see Kim & Park, 2019, for details). For example, social-emotional aspects about writing are expected to develop in interactive manner with writing; so does content/topic knowledge with writing particularly in an advanced phase such as the knowledge-transforming stage by Kellogg (1996). Other component skills are also expected to have interactive relations, such as vocabulary and grammatical knowledge and their relations with inferencing skills (Currie & Cain, 2015; Kim, 2017; Lepola et al., 2012), and morphological awareness with vocabulary and grammatical knowledge (Kieffer & Lesaux, 2012; McBride-Chang et al., 2008).

The final hypothesis of DIEW is a dynamic relations hypothesis —the relations of component skills to written composition change or differ as a function of development such that transcription skills are expected to exert a large influence on writing process in the beginning phase of writing development, whereas discourse oral language and its component skills such as higher-order cognitions are expected to play greater roles in a more advanced developmental phase (see Kim & Park, 2019).

Expanded DIEW

Dynamic Relations as a Function of Writing Measurement

We are expanding the dynamic relations hypothesis to include that the relations of component skills to the written composition vary as a function of *measurement and dimensions of written composition*. Measurement refers to how writing skills are assessed, whereas dimensions refer to the aspects evaluated in written composition. Measurement is a broader concept and includes multiple facets of assessment of written composition, including assessment format,[1] assessment genre,[2] and evaluation of written composition. The dynamic relations hypothesis in the expanded DIEW includes these various facets of measurement of writing, and each deserves careful attention. However, elaboration of each measurement facet is beyond the scope of this paper, and in the present study, we focus and elaborate on evaluation of written composition (i.e., dimensions of written composition).

Written composition has been evaluated in multiple ways (e.g., Kim et al., 2017; Swartz et al., 1999), including writing quality, writing productivity, correctness in writing, spelling and conventions, vocabulary, and syntactic complexity. Studies found that these different dimensions of written composition are related but dissociable (Coker et al., 2018; Kim et al., 2014; Kim, Al Otaiba et al., 2015; Puranik et al., 2008; Wagner et al., 2011). *Writing quality* is the most widely evaluated dimension of written composition, is arguably the most important dimension, and typically includes coherence and quality of ideas, and use of language (vocabulary and sentence structure; e.g., Coker et al., 2018; Graham et al., 2002; Hooper et al., 2002; Kim et al., 2015; Olinghouse, 2008). Another widely examined dimension is *writing productivity*, the amount of writing such as number of words and sentences (e.g., Abbott & Berninger, 1993; Berman & Verhoeven, 2002; Kim et al., 2011, 2014; Mackie & Dockrell, 2004; Olinghouse & Graham, 2009; Scott & Windsor, 2000). Also widely used, particularly in the context of screening and progress monitoring for developing writers, is the Curriculum-Based Measurement (CBM) writing scores, which include indicators for *correctness in writing* such as accuracy in spelling and grammaticality. Note that although writing productivity or correctness in writing in and of themselves are not the ultimate outcomes or dimensions of interest, they have been widely used as important indicators of writing proficiency particularly with developing writers and studies have shown moderate to strong relations with writing quality (Abbott & Berninger, 1993; Kim et al., 2011, 2014; Mackie & Dockrell, 2004; Wagner et al., 2011).

If there are multiple dimensions of written composition or multiple ways of evaluating written composition, then are the relations of component skills to various dimensions of written composition similar or different? Previous theoretical models were silent about dimensionality and its implications. Dimensionality is an important question to consider in a theoretical model because *demands of the component skills are likely to differ by way of focal dimensions of written composition*. In other words, a theoretical model should recognize both sides of the equation—outcome (dimensions of written composition) and predictors (component skills)—particularly if the outcome is multidimensional as is the case with written composition. For instance, if quality of ideas is a focal dimension, then the ability to express ideas using precise vocabulary and sentence structures, and the ability to arrange ideas in a coherent manner considering audience's needs using higher-order cognitive skills should be vital contributors, in addition to transcription skills. In contrast, oral language skills and/or higher-order cognitive skills are not as likely to be particularly important to writing productivity or the length of composition; instead, transcription skills should be. Furthermore, grammatical knowledge and spelling skill should be important to correctness in writing as this dimension evaluates grammatical and spelling accuracy in written composition.

A few previous studies have suggested differential relations of component skills to various dimensions of written composition. Oral language skill composed of vocabulary and grammatical knowledge made an independent contribution to writing quality over and above transcription skills, but not to writing productivity (Kim et al., 2014, 2015). In contrast, transcription skills were more strongly related to writing productivity as well as the spelling and conventions dimension of written composition (Kim et al., 2014). Studies also showed that higher-order cognitions, such as inference, perspective taking, and monitoring, are related to writing quality. In particular, inference was independently related to writing quality even after accounting for language, transcription, and monitoring for first graders (Kim & Schatschneider, 2017), and inference in grade 1 predicted writing quality in grade 3 even after controlling for writing quality in grade 1 (Kim & Park,

[1] Assessment formats, for example, include timed vs. untimed nature; provision of source materials that guide, specify, and/or delimit content generation vs. prompts that are more open; and task specification such as a simple summary vs. evaluation and application.

[2] The dynamic relations hypothesis can also be extended to inter- and intraindividual variation in writing as a function of genres and tasks. Writing in different genres is likely to have differential demands on component skills. For example, writing quality narratives involving multiple characters may draw on perspective taking to a greater extent than writing an expository essay. Tasks within a genre also vary in demands on component skills. For example, writing a summary of a plant's life cycle versus writing an essay synthesizing multiple theories is likely to have differential demands on higher-order cognitive skills.

2019). Perspective taking as measured by theory of mind was related to writing quality for students in grade 4 (Kim, 2020a).

It should be noted that written composition in DIEW, like in other theoretical models of writing such as the Hayes and Flower model or the not-so-simple view of writing, refers to a theoretical construct of a general writing skill. Although one's writing skill is materialized or manifested in varying contexts and tasks, and one's writing skill may vary depending on the genres and tasks, this does not deny the existence of a measurable general writing skill. In practice, one's general writing skill can be measured in multiple genres using multiple tasks and using a latent variable that captures common variance across genres and tasks. The point is that DIEW is not a model of a particular genre or task. Instead, DIEW is a theoretical model of writing that describes component skills that contribute to writing process and writing development across genres and tasks but posits that the extent of contributions of component skills varies as a function of an individual factor such as development, and task and measurement factors.

Reading as a Component Skill of Writing

The second way we expand DIEW is inclusion of reading as an additional component skill of writing. Reading skills, such as word reading and reading comprehension, are essential during the revision and editing processes (Breetvelt et al., 1996; Hayes, 1996; also see Deane et al., 2008). Another rationale for including reading as a component skill of writing is a functional aspect (e.g., Shanahan, 2016)—reading and writing co-occur and are needed to complete a task as writers analyze and interpret meaning from written sources and respond to them in writing. Word reading is necessary as the writer has to decode words she wrote during revision process or those in source materials. Reading comprehension is also expected to contribute to written composition, especially to the writing quality dimension. When the writer reads her own text for revision, she has to construct an accurate mental representation of the text (see Hayes, 1996) and evaluate it compared with her intended goals, which then guides subsequent revision actions—if there are discrepancies between intended goals and draft text, then the writer would make necessary changes. Therefore, by contributing to an accurate mental representation of one's own text during the revision process, reading comprehension is expected to contribute to the quality of one's written composition. The same is true when reading source materials is part of a writing task—an accurate and deep understanding of source texts is important to idea generation and formulation, and subsequent writing processes, and, therefore, influences the quality of written composition. In other words, constructing a rich and accurate mental model or deep understanding of one's own written texts or source materials would lead to rich and coherent written composition (i.e., writing quality), whereas incomplete or shallow understanding of one's written texts or source materials would lead to incomplete or less coherent ideas in written composition.

One key point that should be underscored regarding the hypothesis that reading is a component skill of writing is that reading itself is a complex skill. As shown in Figure 1, both reading comprehension and written composition are constructs built on a highly similar complex set of component skills such as background knowledge, higher-order cognitions, vocabulary, grammatical knowledge, working memory, attentional control, and lexical level literacy skills (Kim, 2020b for a theoretical model on reading). Of course, there is an exception such that handwriting or keyboarding fluency is not relevant to reading comprehension. Furthermore, the relative contributions of component skills to reading comprehension versus written composition are expected to differ (Kim, 2020c, for details regarding reading–writing relations). Similarly, word reading and spelling are built on the same component skills such as phonological, orthographic, and semantic knowledge and awareness (see Adams, 1990) although spelling requires a more precise orthographic representation (see Ehri, 1997; Perfetti, 1997).

The reading–writing relation has been long recognized (Fitzgerald & Shanahan, 2000; Hayes, 1996; Kim, 2020c; Langer & Flihan, 2000; Shanahan, 2016; Shanahan & Lomax, 1986). One hypothesis for the reading–writing relation is that reading and writing draw on common shared skills and knowledge (Fitzgerald & Shanahan, 2000; Kim, 2020c; Langer & Flihan, 2000; Shanahan, 2016; Shanahan & Lomax, 1986). Fitzgerald and Shanahan (2000) elegantly summarized shared sources for reading and writing as follows: metaknowledge (pragmatics such as knowledge about functions and purposes of reading and writing, one's own meaning making), domain knowledge about content, knowledge about universal text attributes (e.g., graphophonics, syntax, and text organization), and procedural knowledge (e.g., accessing and using knowledge). The inclusion of reading in the expanded DIEW is very much in line with Fitzgerald and Shanahan's (2000) conceptualization but with a critical difference—the expanded DIEW articulates specific component skills that are shared in reading and writing based on theoretical models of writing noted above and those of reading (see the triangle model [Adams, 1990], the simple view of reading [Gough & Tunmer, 1986], the direct and mediated model [Cromley & Azevedo, 2007], the reading systems framework [Perfetti & Stafura, 2014]; and direct and indirect effects model of reading [Kim, 2017, 2020b]). DIEW is also in line with a recent literacy model that integrates reading and writing (Kim, 2020c).

As shown in Figure 1, reading comprehension and written composition are hypothesized to have interactive relations, particularly beyond the beginning phase of development characterized as the knowledge-telling phase (see Kim, 2020c for details). In the present study we examined the direction of reading comprehension to dimensions of written composition based on the extant evidence from developing writers (Ahmed et al., 2014; Berninger & Abbott, 2010; Kim et al., 2018). Specifically, two longitudinal studies expressly examined the directionality. Ahmed et al. (2014) conducted a longitudinal study from grade 1 to grade 4 and found the relation of reading to writing at the lexical level (i.e., word reading predicted spelling) and discourse level (reading comprehension predicted written composition), not the other way around. Highly similar findings were reported in a longitudinal study from grade 3 to grade 6 (Kim et al., 2018).

One corollary of reading comprehension as a component skill of written composition is that reading comprehension *mediates*[3] the relations between component skills and different dimensions

[3] Mediation describes the way in which one variable (X) has an effect on another variable (Y) through the influence on an intermediate variable (M). In other words, in a model $X \rightarrow M \rightarrow Y$, the mediator is an explanatory variable for the relation between X and Y (see Baron & Kenny, 1986; Selig & Preacher, 2009). The idea of mediation maps onto the hierarchical relations hypothesis (or the pathways idea) of DIEW. Please see Pearl (2001, 2014) for a detailed discussion on mediation.

of written composition. Reading comprehension and written composition share largely similar component skills (see Figure 1), and reading comprehension is a component skill of written composition (see Figure 2). Then, it is reasonable to posit that reading comprehension mediates the relations of shared component skills to written composition, writing quality in particular (see above). In other words, reading comprehension largely captures the component skills that contribute to written composition, and therefore, mediates their relations to written composition. It should be noted that mediation here does *not* mean that reading comprehension should be part of the writing process for *all* writers in *all* writing tasks. Writers, beginning or advanced writers, differ in the extent to which they reread their own written texts for revision purposes in different writing tasks; and writing tasks vary in the extent to which source materials are included. What we are examining is that theoretically reading comprehension, which captures or draws on highly similar set of component skills as for written composition, would mediate the relations of component skills to dimensions of written composition. When writers engage in reading while writing, reading comprehension would clearly play a mediating role, and when writers do not engage in reading, it would not. The latter, however, does not entail that we cannot test the theoretical idea that reading comprehension plays a mediating role just because writers do not always employ reading during the writing process.

In line with the dynamic relations hypothesis, the relation of reading comprehension to written composition is expected to vary as a function of development *and* dimensions of written composition. In the initial phase of development when students are just learning to write, reading comprehension is largely constrained by lexical-level literacy skill (i.e., word reading), and therefore reading comprehension captures lexical-level literacy skill to a greater extent than discourse oral language (Adlof et al., 2006; Kim & Wagner, 2015; Reed et al., 2016). This does not, however, mean that reading comprehension is identical to word reading in the initial phase. Studies have shown that discourse oral language does uniquely contribute to reading comprehension over and above word reading even for beginning readers such as English-speaking students in grade 1 (Hoover & Gough, 1990; Kim, Wagner, & Foster, 2011; Ouellette & Beers, 2010), and thus reading comprehension captures and is a function of both word reading and discourse oral language and their associated component skills even during the initial phase of development. Given the greater dominance of lexical-level literacy skill in reading comprehension during the initial phase, then, reading comprehension is likely to partially, not completely, mediate the relations of discourse oral language or component skills of discourse oral language to dimensions of written composition in the beginning phase of development. In contrast, as students develop reading skills, reading comprehension is less constrained by lexical-level literacy skills and thus captures language and higher-order cognitions to a greater extent (Adlof et al., 2006; Foorman et al., 2015; Kim & Wagner, 2015) so that reading comprehension might completely mediate the relation of discourse oral language to written composition in an advanced phase of development.

The Present Study

Like any theoretical model, DIEW should undergo rigorous testing using data from writers from different developmental phases, and those learning to read and write in different writing systems and learning in L1 and L2. The roles of component skills of DIEW, their hierarchical relations and dynamic relations as a function of development have been examined in prior work with students in elementary grades (Kim, 2020a; Kim & Park, 2019; Kim & Schatschneider, 2017). In the present study, we focused on the two additionally proposed hypotheses of DIEW, the dynamic relations hypothesis as a function of dimensions of written composition and reading comprehension as a component skill of writing, using data from readers and writers in grade 2. The following were specific research questions and associated hypotheses.

1. Is the dynamic relations hypothesis supported for the relations of higher-order cognitive skills to different dimensions of written composition? Specifically, do higher-order cognitive skills such as inference, perspective taking, and comprehension monitoring differentially relate to writing quality, writing productivity, and correctness in writing after accounting for transcription skills (spelling and handwriting fluency) and domain-general cognitions (working memory and attentional control)? We anticipated that higher-order cognitive skills would be related to writing quality but not to writing productivity or correctness in writing because higher-order cognitions are expected to contribute to establishing global coherence (see Appendix A), which is primarily captured in writing quality.

2. Is reading comprehension differentially related to writing quality, writing productivity, and correctness in writing after controlling for language, cognition, lexical literacy (word reading and spelling), and handwriting fluency? Does reading comprehension partially or completely mediate the relations of discourse oral language and lexical literacy to written composition, and do the mediating relations vary for writing quality, writing productivity, and correctness in writing? We posited that reading comprehension would predict writing quality (see above; e.g., Berninger & Abbott, 2010; Kim et al., 2018), but not writing productivity or correctness in writing, after accounting for language, cognition, lexical literacy, and handwriting fluency skills. We also anticipated that reading comprehension would differentially mediate the relations of discourse oral language and lexical literacy to written composition—partial mediation for discourse oral language and full mediation for lexical literacy—given that English-speaking children in Grade 2 are, on average, in the beginning phase of literacy development (see above).

3. Do the total effects of language (discourse oral language, vocabulary, grammatical knowledge), cognition (inference, perspective taking, monitoring, working memory, attention control), lexical literacy (word reading and spelling), handwriting fluency, and reading comprehension vary for writing quality, writing productivity, and correctness in writing? We expected variation in the total effects of component skills on the different dimensions of written composition. Specifically, we anticipated that all the component skills would be important to writing

quality although the magnitudes of total effects would vary (Kim et al., 2014, 2015). For writing productivity, we anticipated that lexical literacy and handwriting fluency would make large contributions. For correctness in writing, we expected that spelling and grammatical knowledge would be particularly important.

Method

Participants

Data for the present study came from 350 children in grade 2 from 30 classrooms in seven public schools in a southeastern semirural area of the United States (53% boys; mean age = 7.54 years, *SD* = .64). The data were collected as part of a larger longitudinal study on children's literacy development, and results on reading comprehension were reported earlier (Kim, 2017; the research question was predictors of reading comprehension). In the present study, we used cross-sectional data from children in grade 2. These children were composed of two cohorts of children from two consecutive years in the same schools (n = 165 for cohort 1; n = 185 for cohort 2). The protocol, order, and timing of the assessment within the academic year were identical in this study across the two cohorts. Because the distributions, performance levels (e.g., raw scores and standard scores), and correlation patterns (directions and magnitudes) were similar for the two cohorts, the combined sample was used in the present study for statistical power (see further details in Kim, 2017). The racial/ethnic composition of the sample children was as follows: 53% Caucasians, 34% African Americans, and 6% Hispanics. Approximately three fourths of the children were eligible for free or reduced-price lunch, and approximately 1.8% of the sample were considered English learners according to the district records. All children in participating classes were invited to participate in the study, but children with identified intellectual disabilities were excluded. School personnel indicated an absence of a formal district-wide writing curriculum, but many teachers reported using a writer's workshop approach.

Measures

Children's responses for the majority of tasks were scored dichotomously (1 = correct, 0 = incorrect) for each item. Exceptions include written composition, discourse oral language production (oral retell), handwriting fluency, working memory, attention, and a few items in the Narrative Comprehension of the Test of Narrative Language (see below). Unless otherwise noted, all the items were administered to children.

Written Composition: Dimensions of Written Composition (Writing Quality, Writing Productivity, and Correctness in Writing)

Children were administered two expository prompts, using one normed task and one experimental task: the Essay Composition task of Wechsler Individual Achievement Test – 3rd edition (WIAT-III; Wechsler, 2009) and a Beaver prompt. In the WIAT-III task, the child was asked to write about his or her favorite game and provide at least three reasons. In the Beaver task, the child was provided with a passage about beavers (297 words), with three accompanying illustrations. The passage about beavers was adapted from the Qualitative Reading Inventory – 5th edition (QRI; Leslie & Caldwell, 2011; Level 3). The original beaver text did not have accompanying illustrations and is designated as a third grader text in QRI. We used the adapted beaver text with illustrations in a pilot study and found it to be adequate for second graders (i.e., majority of children were able to write about beavers at least to some extent). After reading the given text, the child was asked to write "details about what beavers do and how they do it." They were asked to use information from the given text and illustrations to facilitate their writing process. Children were told not to copy sentences verbatim from the provided passage. Children were given 15 minutes for each prompt, excluding reading time for the Beaver prompt, based on our extensive experiences with primary grade children. The format of the Beaver task, writing based on source materials, was used to reflect the emphasis of writing in response to source materials in the Common Core State Standards and other similar state standards in the United States.

Children's handwritten compositions were typed up verbatim. Then, another typed-up version was created where words that were incorrectly spelled but decodable by people who are familiar with children's writing (two former classroom teachers) were converted to real words for evaluation purposes. However, strings of letters that were not reasonably decodable were retained verbatim in both typed versions. Children's written compositions were scored in three dimensions: quality, productivity, and correctness. Writing quality and productivity were evaluated using the typed versions with corrected spelling, and therefore, children's spelling was not taken into consideration in evaluation. This decision was based on evidence that legibility of handwriting and spelling errors influence evaluators' judgment of writing quality (see Graham et al., 2011b, for a review). Children's original handwritten versions were used for the evaluation of correctness in writing following protocols of CBM-Writing literature (McMaster & Espin, 2007).

Writing quality was operationalized as the extent and clarity of idea development and organization. We modified the "ideas" and "organization" traits of the 6 + 1 Trait Rubric so that a single score on a scale of 1 to 7 considering both ideas and organization aspects was assigned to a student's written composition. A zero was assigned to clearly unscorable compositions because of illegibility, for example, which was rare. Compositions that clearly and explicitly presented on-topic ideas with relevant supporting details were rated high. In addition, overall structural organization and logical sequences of ideas were taken into consideration so that compositions with a clear beginning, middle, and end as well as tight coherent sequencing of ideas were rated high, in line with previous studies (e.g., Hooper et al., 2002; Kim et al., 2015; Olinghouse, 2008). For the Beaver prompt, when the vast majority of written composition was verbatim copy of the given source text, compositions were scored as a zero (six students' compositions). When only a few sentences were directly taken from the provided text, these sentences were excluded from evaluation. Two raters were extensively trained, and interrater reliabilities (Cohen's kappa) were .87 for the WIAT-III and .95 for the Beaver prompts, using a total of 80 written samples.

Writing productivity was measured by the number of words written, following previous studies (e.g., Abbott & Berninger, 1993; Kim et al., 2011, 2014; Puranik et al., 2008; Wagner et al., 2011). Words that were recognizable as real words (those listed in the dictionary, including slang expressions) in the context of the child's written composition, despite spelling errors, were given credit. Reliability, exact percent agreement, was estimated to be .95, using 42 written samples. Fewer written samples than for writing quality were used to establish reliability for the number of words written because a high agreement rate was observed during the training session.

Correctness in writing was measured using one of the CBM writing scores, correct minus incorrect word sequences (CIWS), because of strong validity evidence (Graham et al., 2011a; McMaster & Espin, 2007). CIWS is derived by subtracting the number of incorrect word sequences from the number of correct word sequences. Correct word sequences are two adjacent words that are grammatically correct and spelled correctly. Students' handwritten version was used for CBM writing scores, following CBM conventions. Reliabilities, using a similarity coefficient, were estimated to be .95 and .94 for correct word sequences and incorrect word sequences, respectively, using 60 written samples. A similarity coefficient, which indicates proximity of the coders' scores (Shrout & Fleiss, 1979), was used because these data are interval not categorical.

Component Skills

Reading comprehension, discourse oral language, spelling, handwriting fluency, inference, perspective taking, monitoring, vocabulary, grammatical knowledge, working memory, and attention were measured.

Reading Comprehension

Two widely used normed tasks were used: the Passage Comprehension of Woodcock Johnson-III (WJ-III; Woodcock et al., 2001) and the Reading Comprehension of WIAT-III (Wechsler, 2009). The former is a cloze task where the child was asked to read sentences and passages and to fill in blanks. In the latter task, the child was asked to read passages and to answer multiple choice questions. Cronbach's alpha estimates of the scores were .83 and .82 for WJ-III and WIAT-III, respectively.

Discourse Oral Language

Oral language proficiency at the discourse level was measured by three listening comprehension and two oral retell and production tasks. It may be argued, based on theoretical models such as the simple view of reading (Hoover & Gough, 1990) and simple view of writing (Berninger et al., 2002; Juel et al., 1986), that listening comprehension tasks and oral retell/production tasks should be used for reading comprehension and written composition, respectively. However, listening comprehension and oral retell/production tasks were used as a single latent variable for two reasons. First, in the statistical model of the present study, discourse oral language skill was used to predict reading comprehension *and* written composition and, therefore, including either listening comprehension or oral retell, but not both, would not appropriately capture the relation of discourse language skill to reading comprehension and written composition. Second, a previous study showed that listening comprehension and oral retell/production were best described as having a bifactor structure, composed of a common factor and residual comprehension-specific and production-specific factors. Importantly, it was the common factor—the common variance between listening comprehension and oral retell and production tasks—that was related to reading comprehension and written composition, not the comprehension- and production-specific factors (Kim, Park, & Park, 2015). Note that analyses for Research Questions 2 and 3 were replicated after excluding listening comprehension tasks from the discourse oral language construct. Patterns of results are essentially identical to those reported in the main text.

Listening comprehension was measured by three tasks: the Listening Comprehension Scale of the Oral and Written Language Scales–II (OWLS-II; Carrow-Woolfolk, 2011), the Narrative Comprehension subtest of the test of Narrative Language (TNL; Gillam & Pearson, 2004), and an experimental informational task. In the OWLS-II task, the child heard sentences and was asked to point to a picture that best represents the answer to a question (α = .94). Testing discontinued after four consecutive incorrect items. In the TNL task, the child heard three narrative stories and was asked 30 open-ended comprehension questions (25 literal questions & 5 inferential questions) for each story (α = .74). The majority of the items were scored dichotomously, but six items were scored 0 to 2 and two items were scored 0 to 3 according to the TNL manual (maximum possible score = 40). In the experimental informational task, the child heard three informational texts (*Changing Matter*, *Whales and Fish*, and *Where Do People Live?*) from the Qualitative Reading Inventory-5 (Leslie & Caldwell, 2011) and was asked eight comprehension questions about each passage for a total possible score of 24 (14 literal questions & 10 inferential questions; α = .72).

Oral retell and production tasks were measured by children's retell after hearing the three TNL stories and three experimental informational passages. Children were asked to tell everything they remembered. Children's oral retell was digitally recorded and transcribed using the Systematic Analysis of Language Transcription guidelines (SALT; Miller & Iglesias, 2006) and then coded for overall quality. In the TNL task, retell was coded for the quality of story structure elements such as main characters, setting, main events, problem, and resolution. The majority of story structural elements were rated on a scale of 0 (*absence of relevant information*) to 3 (*precise information*) except for the resolution element, which was scored 0 to 2. For example, for character description of TNL task 1, a score of 0 was given when the child's retell did not include any names of the characters, a score of 1 was given when only one of the characters was correctly named, a score of 2 was given when two of the three characters were correctly named, and a score of 3 was given when all three characters were named correctly. In addition, retell was coded on the inclusion of important details (1 for each important detail included), inclusion of introduction (1 = *introduction was present [e.g., This story is about . . .]*; 0 = *introduction was absent*) and closing (1 = *closing was present [e.g., That is all]*; 0 = *closing was absent*), and logical sequencing of the story (1 = *order of mainline events was logical*; 0 = *order of mainline events was not logical*; see Kim & Schatschneider, 2017; for a similar approach). Maximum possible scores varied a bit depending on the nature of the story, and

they were as follows: 23 for the TNL Task 1, 21 for the TNL Task 2, and 24 for the TNL Task 3.

In oral retell of informational texts, we evaluated the extent to which main ideas were stated and key details were included. Main ideas were scored on a scale of 0 to 2 depending on accuracy. Key details were counted (1 point for each key idea; see Wagner et al., 2011, for a similar approach). Maximum possible scores were as follows: 18 for the *Matter* text, 21 for the *Whales and Fish* text, and 34 for the *Where Do People Live?* text. The maximum possible score for the last passage (*Where Do People Live?*) was relatively high because the passage was about comparing and contrasting different places where people live, rendering many possible points for explicitly noting similarities and differences. Percent agreement ranged from .90 to .99, using 50 sample retells. All the retells were double scored, and final scores were determined after discussion of discrepant scores.

Spelling

To capture the ability to spell words appropriate for children in grade 2 (e.g., CVCe words, vowel digraphs, multisyllabic words), an experimental dictation task was used. Target words were first presented in isolation, then in a sentence, and, last, in isolation again. There were 22 items. Cronbach's alpha was estimated to be .88.

Word Reading

Three widely used normed word reading tasks were used. In the Letter Word Identification of the WJ-III, the child was asked to read aloud a list of words of increasing difficulty (α = .91). Test administration discontinued after six consecutive incorrect items. The other tasks were two forms (A & B) of the Sight Word Efficiency task of the test of Word Reading Efficiency–II (Torgesen et al., 2012), where the child was asked to read words of increasing difficulty with accuracy and speed in 45 seconds (test–retest reliability = .93, Torgesen et al., 2012).

Handwriting Fluency

Handwriting fluency was measured by sentence copying tasks, using three sentences. In each task, the child was shown a sentence and was asked to copy it as many times as possible in 1 minute. The sentences were as follows: "The quick brown fox jumps over the lazy dog," "My dog jumps and runs when I tell him to jump and run," and "My mom put the lid on the pan to cook the food." The first sentence is a pangram and has been used in previous studies (e.g., Wagner et al., 2011). The second and third sentences were experimental. Children's responses were scored by counting the number of letters copied correctly. Alternate form reliability (correlations among the three sentences) ranged from .63 to .72.

Inference

Inference was measured by the Inference task of the Comprehensive Assessment of Spoken Language (CASL; Carrow-Woolfolk, 1999). The child heard a one- to three-sentence story and was asked a question that required inference drawing on background knowledge. For instance, the child heard "Mom, Dad, and Sam were at the dinner table when Mom looked at Sam and said, 'I forgot to get the water.' What do you think Mom wanted Sam to do?" The correct responses include "get the water" or something similar. Test administration discontinued after five consecutive incorrect items. Cronbach's alpha was .91.

Perspective Taking

Perspective taking was measured by a theory of mind task (Caillies & Le Sourn-Bissaoui, 2008; Kim, 2015, 2016; Kim & Phillips, 2014). Three second-order false belief scenarios, appropriate to the developmental stage of the participating children (7-year-olds), were used (Kim, 2015 for details). These second-order scenarios required the child to infer a story character's mistaken belief about another character's knowledge. The child heard scenarios about the context of a bake sale, going out for a birthday celebration, and visiting a farm, which were presented with a series of illustrations, and was then asked questions related to understanding characters' mental states (e.g., "What does Sam think they are selling at the bake sale? Why does he think that?"). There were 18 questions (six per scenario). Cronbach's alpha was .71.

Monitoring

Children's ability to monitor comprehension was assessed using an inconsistency detection task (Cain et al., 2004; Kim, 2015). In this task, the child heard a short story and was asked whether the story made sense. If the child stated that the story did not make sense, then he or she was asked to provide a brief explanation and to fix the story so that it made sense. There were two practice items (one consistent and one inconsistent) and nine test items (three consistent and six inconsistent). For all nine items, accuracy of the child's answer about whether a story was consistent or inconsistent was dichotomously scored. For the six inconsistent stories, the accuracy of children's explanation and repair of the story were also dichotomously scored; thus, the total possible score for this task was 21. Cronbach's alpha was estimated to be .69.

Vocabulary

A normed task, the Picture Vocabulary of the Woodcock Johnson-III, was used. In this task, the child was asked to name pictured objects or provide synonyms. Test administration discontinued after six consecutive incorrect items. Cronbach's alpha was estimated to be .69.

Grammatical Knowledge

A normed task, the Grammaticality Judgment task of the Comprehensive Assessment of Spoken Language (CASL; Carrow-Woolfolk, 1999), was used. In this task, the child heard a sentence (e.g., "The boy are happy") and was asked whether the sentence was grammatically correct. If grammatically incorrect, the child was asked to correct the sentence. Test administration discontinued after five consecutive items that were answered wrongly. Cronbach's alpha was estimated to be .94.

Working Memory

Working memory was measured by a listening span task (Cain et al., 2004; Kim, 2015, 2016). The child was presented with a sentence (e.g., "Apples are red") and asked to identify whether the heard sentence was true or not. After hearing sentences, the child was asked to recall the last words in the sentences. There were four practice items and 14 test items. Testing discontinued after

three consecutive incorrect responses. Children's responses regarding the veracity of the statements (yes/no responses) were not scored; only children's word recall was scored. Recall of the correct last words in correct order was given a score of 2, recall of the correct last words in incorrect order was given a score of 1, and recall of incorrect last words was given a score of 0. Therefore, the maximum possible total score was 28 (14 items × 2). Cronbach's alpha was estimated to be .71.

Attentional Control

The first nine items in the Strengths and Weaknesses of ADHD Symptoms and Normal Behavior (SWAN; Swanson et al., 2012), which are related to sustained attention on tasks or activities (Sáez et al., 2012) were used. SWAN includes 30 items on children's behaviors related to attention and hyperactivity on a 7-point scale (1 = *far below average*; 7 = *far above average*). The maximum possible score was 63 (9 items × 7). Teachers of the participating children completed the SWAN checklist. Cronbach's alpha was estimated to be .99.

Procedures

Rigorously trained research assistants (assessors had to pass a 99% fidelity check) worked with children in a quiet space in the school. The assessment batteries were administered in several sessions, and each session lasted approximately 30 to 40 minutes to reduce fatigue effects. The vast majority of assessment batteries were administered to children individually, except for the written composition, spelling, and handwriting fluency tasks, which were administered in groups (typically four children). Language and cognitive skills were measured in the fall, reading skills were measured in the winter, and writing skills (transcription and written composition) were measured in the spring. Assessment time for the included tasks varied depending on the child, but individual assessments took approximately 160 minutes, on average, and group assessments took approximately 70 minutes per group, on average. Evaluation of written compositions and coding of oral retell were conducted by project staff who had extensive experiences in evaluating children's written compositions and oral retell in previous work led by the first author and who were trained rigorously in several sessions for each dimension of written composition (i.e., writing quality, productivity, and correctness in writing).

Results

Descriptive Statistics and Preliminary Data Analysis

Prior to the estimation of the descriptive statistics and correlations, missing data were evaluated for the measures. Missing data rates were minimal, ranging from 0% on the TNL retell to 4% on the CIWS for the WIAT writing task. Data from all children were used in the analysis, using full information maximum likelihood in confirmatory factor analysis and SEM (e.g., see Enders & Bandalos, 2001, for use of full information maximum likelihood for missing data).

Descriptive statistics are displayed in Table 1. Mean scores of writing quality were 2.99 and 2.74 for the WIAT Essay Composition and Beaver tasks, respectively, and there was sufficient variation around the means (*SDs* = 1.06 and .99 for each task, respectively). Children wrote, on average, 65 (*SD* = 32.52) to 68 (*SD* = 42.73) words in the two written composition tasks. Children's mean performances on the normed and standardized tasks such as reading comprehension, word reading, listening comprehension, inference, vocabulary, and grammatical knowledge were in the average range (e.g., mean standard score for the WJ Passage Comprehension = 96.88). Skewness ($< \pm 2$) and kurtosis values (< 7; West et al., 1995) were in the acceptable ranges. Subsequent analysis was conducted using raw scores.

Bivariate correlations between measures were overall in expected directions and magnitudes (see Table 2). Higher-order cognitive skills (inference, theory of mind, and comprehension monitoring) were consistently, although weakly ($.17 \leq r\text{s} \leq .27$), related to writing quality, but not writing productivity ($-.09 \leq r\text{s} \leq .06$). For correctness in writing, comprehension monitoring was weakly but significantly related ($.17 \leq r\text{s} \leq .19$). Reading comprehension was weakly to moderately related to writing quality ($.26 \leq r\text{s} \leq .42$), weakly related to writing productivity ($.03 \leq r\text{s} \leq .20$), and moderately related to correctness in writing ($.33 \leq r\text{s} \leq .43$). Furthermore, discourse oral language, vocabulary, grammatical knowledge, and working memory were weakly to moderately related to writing quality and correctness in writing but were not related or very weakly related to writing productivity.

The following latent variables were created using confirmatory factor analysis, using Mplus 8.4 (Muthén & Muthén, 2020): writing quality, writing productivity, correctness in writing, reading comprehension, lexical literacy, handwriting fluency, and discourse oral language. It should be noted that the lexical literacy latent variable was created instead of a word reading latent variable and an observed spelling variable because of their strong correlation ($r = .81$), and a consequent multicollinearity issue when they are entered together in a model. As presented in Table 3, loadings of indicators to latent variables were moderate to strong, ranging from .47 to .91 ($p\text{s} < .001$). Correlations between latent variables are presented in Table 4. Different dimensions of written composition were moderately to fairly strongly related ($.39 \leq r\text{s} \leq .65$). Discourse oral language was fairly strongly related to writing quality (.62) and reading comprehension (.68) whereas it was not related to writing productivity (.09, $p = .21$). Lexical literacy was moderately to strongly related to the different dimensions of written composition ($.43 \leq r\text{s} \leq .71$), and it was very strongly related to reading comprehension (.93).

Research Question 1: Dynamic Relations of Higher-Order Cognitive Skills to Writing Quality, Writing Productivity, and Correctness in Writing

The unique contributions of higher-order cognitive skills to the three dimensions of written composition—writing quality, writing productivity, and correctness in writing—were examined by fitting the three structural equation models in Figure 3a–3c, where higher-order cognitive skills were predictors of the three dimensions of written composition after accounting for spelling, handwriting fluency, working memory, and attention—the essential skills for writing identified in the not-so-simple view of writing (Berninger & Winn, 2006) and DIEW (Kim & Park, 2019). Model fit was evaluated using multiple indices: chi-square statistic, comparative fit index (CFI), Tucker-Lewis index (TLI), root mean

Table 1
Descriptive Statistics

Measure	*M*	*SD*	Min–Max	Skewness	Kurtosis
Writing quality					
WIAT Writing: quality	2.99	1.06	0–6	−0.22	−0.20
Beaver Writing: quality	2.74	0.99	0–6	−0.10	0.77
Writing productivity					
WIAT Words written	68.10	42.73	0–222	0.90	0.26
Beaver Words written	64.72	32.52	7–167	0.80	0.27
Correctness in writing					
WIAT Correct word sequences	44.21	31.14	0–139	1.02	0.37
WIAT Incorrect word sequences	31.87	22.93	1–149	1.57	3.24
WIAT CIWS	12.35	28.65	−89–106	.68	1.79
Beaver Correct word sequences	42.31	28.94	1–154	1.05	0.86
Beaver Incorrect word sequences	30.60	21.17	0–115	1.16	1.50
Beaver CIWS	11.71	35.40	−82–142	.43	.59
Word reading					
WJ Letter Word Identification	42.01	6.47	18–63	.38	.62
WJ Letter Word Identification—SS	104.18	12.90	47–135	−.49	.91
TOWRE SWE 1	51.64	12.08	7–75	−.56	.08
TOWRE SWE 1—SS	98.95	16.10	55–131	−.54	.01
TOWRE SWE 2	52.01	12.18	9–78	−.44	.21
TOWRE SWE 2—SS	99.24	16.45	55–135	−.45	.00
Spelling					
Spelling	12.52	4.98	0–22	−0.18	−0.74
Handwriting fluency					
Sentence copying 1	10.43	3.61	0–23	0.24	0.29
Sentence copying 2	14.93	4.55	1–29	0.12	0.45
Sentence copying 3	18.85	5.36	0–34	−0.09	0.33
Reading comprehension					
WJ Passage Comprehension	22.98	4.22	9–33	.08	−.43
WJ Passage Comprehension—SS	96.88	11.70	44–122	−.58	1.05
WIAT Reading Comprehension	50.94	11.30	3–83	−.08	.81
WIAT Reading Comprehension—SS	96.71	13.18	40–138	.03	1.23
Discourse oral language					
OWLS Listening Comprehension	76.46	13.03	37–103	−0.17	−0.49
OWLS Listening Comprehension—SS	97.05	15.15	44–124	−0.45	0.08
TNL Comprehension	25.87	4.98	5–36	−0.79	0.94
TNL Comprehension—SS	8.30	2.87	1–15	−0.09	−0.03
Informational text comprehension	9.70	3.48	1–20	0.47	0.07
TNL Retell	30.29	12.30	0–53	−0.61	−0.08
Informational text retell	10.39	7.16	0–42	1.07	1.52
Knowledge-based inference					
CASL Inference	10.89	6.98	0–31	0.59	−0.43
CASL Inference—SS	92.51	13.29	56–127	0.25	−0.32
Perspective taking					
Theory of mind	7.79	3.92	0–17	0.08	−0.76
Monitoring					
Comprehension monitoring	6.77	2.96	1–16	0.36	−0.50
Vocabulary					
WJ Picture Vocabulary	20.48	2.90	7–29	−0.10	1.14
WJ Picture Vocabulary—SS	96.91	10.52	43–126	−0.43	1.81
Grammatical knowledge					
CASL Grammaticality	32.43	12.71	2–66	0.02	−0.15
CASL Grammaticality—SS	95.84	13.54	40–134	−0.43	0.75
Working memory					
Working Memory	8.21	3.91	0–20	0.02	0.20
Attentional control					
SWAN Attention	35.69	12.03	9–63	0.36	−0.23

Note. Unless otherwise noted, all the scores are raw scores. Theory of mind is a measure of perspective taking. WIAT = Wechsler Individual Achievement Test; CIWS = correct minus incorrect word sequences; WJ = Woodcock Johnson; SS = standard score; TOWRE SWE = The Sight Word Efficiency task of test of Word Reading Efficiency; OWLS = Oral and Written Language Scales; TNL = test of Narrative Language; CASL = Comprehensive Assessment of Spoken Language; SWAN = Strengths and Weaknesses of ADHD Symptoms and Normal Behavior.

square error of approximation (RMSEA), and standardized root mean square residuals (SRMR). RMSEA values below .08, CFI and TLI values equal to or greater than .95, and SRMR equal to or less than .05 indicate excellent model fit (Hu & Bentler, 1999). CFI and TLI values greater than .90 and SRMR equal to or less than .10 are considered acceptable (Kline, 2005).

These models shown in Figures 3a–3c fit the data very well: $\chi^2(22) = 24.50$, $p = .32$, CFI = 1.00, TLI = .99, RMSEA = .02,

Table 2
Bivariate Correlations Between Measures

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1. WIAT W. Quality	—																									
2. Beaver W. Quality	.32	—																								
3. WIAT W. Words	.12	.03	—																							
4. Beaver W. Words	.20	.24	.50	—																						
5. WIAT CIWS	.38	.16	.34	.29	—																					
6. Beaver CIWS	.38	.14	.22	.33	.60	—																				
7. WJ Letter Word Iden.	.35	.23	.20	.27	.49	.49	—																			
8. TOWRE SWE 1	.31	.19	.30	.33	.40	.39	.76	—																		
9. TOWRE SWE 2	.29	.19	.29	.32	.39	.39	.74	.92	—																	
10. Spelling	.36	.23	.28	.31	.54	.56	.76	.65	.65	—																
11. Sentence Copying 1	.24	.17	.35	.45	.30	.35	.28	.39	.41	.31	—															
12. Sentence Copying 2	.20	.20	.31	.48	.30	.31	.29	.36	.38	.31	.67	—														
13. Sentence Copying 3	.28	.13	.38	.50	.26	.35	.26	.36	.38	.33	.69	.74	—													
14. WJ Passage Comp	.38	.29	.17	.20	.39	.43	.75	.66	.63	.64	.24	.18	.18	—												
15. WIAT Reading Comp	.42	.26	.03	.12	.33	.37	.54	.51	.47	.48	.24	.18	.20	.58	—											
16. OWLS Listening Comp	.32	.20	−.06	−.06	.07	.14	.28	.14	.08	.18	.06	.05	.06	.36	.35	—										
17. TNL Comp	.34	.28	−.02	.05	.13	.19	.30	.18	.11	.22	.09	.06	.06	.48	.43	.44	—									
18. Informational Comp	.33	.30	−.03	.05	.19	.18	.27	.12	.11	.22	.05	.05	.05	.42	.41	.43	.60	—								
19. TNL Retell	.20	.17	.05	.12	.13	.09	.22	.16	.15	.19	.16	.08	.06	.31	.35	.23	.52	.44	—							
20. Informational Retell	.26	.13	.03	.10	.15	.18	.23	.15	.15	.19	.11	.06	.07	.34	.35	.30	.48	.67	.54	—						
21. Inference	.20	.17	−.09	−.04	.03	.05	.23	.13	.11	.15	−.01	−.02	.00	.38	.43	.40	.56	.48	.38	.40	—					
22. Perspective (ToM)	.23	.22	−.08	−.01	.04	.15	.16	.08	.05	.13	.03	.01	−.01	.37	.34	.37	.51	.47	.33	.41	.44	—				
23. Comp Monitoring	.27	.19	.00	.06	.17	.19	.23	.10	.07	.19	.04	.04	.06	.34	.29	.30	.46	.42	.30	.41	.48	.33	—			
24. WJ Vocabulary	.26	.19	−.07	.00	.14	.15	.35	.25	.20	.27	.06	−.01	.00	.49	.38	.47	.46	.41	.24	.30	.45	.35	.29	—		
25. Grammaticality	.33	.31	.01	.10	.22	.25	.44	.29	.27	.40	.13	.10	.10	.47	.45	.41	.53	.44	.29	.33	.58	.32	.41	.44	—	
26. Working Memory	.28	.14	.02	.04	.14	.15	.31	.18	.18	.24	.13	.05	.08	.39	.27	.33	.34	.28	.21	.27	.25	.24	.21	.36	.33	—
27. SWAN Attention	.38	.18	.17	.21	.38	.44	.50	.45	.44	.52	.26	.23	.26	.55	.46	.32	.29	.34	.19	.29	.27	.29	.25	.26	.33	.32

Note. Values equal to or smaller than .10 are not statistically significant at the $p < .05$ level. WIAT = Wechsler Individual Achievement Test; W = Writing; CIWS = correct minus incorrect word sequences; WJ = Woodcock Johnson; Iden = Identification; TOWRE SWE = The Sight Word Efficiency task of test of Word Reading Efficiency; Comp = Comprehension; OWLS = Oral and Written Language Scales; TNL = test of Narrative Language; ToM = Theory of Mind; SWAN = Strengths and Weaknesses of ADHD Symptoms and Normal Behavior.

SRMR = .02 for writing quality; $\chi^2(22) = 13.23$, $p = .92$, CFI = 1.00, TLI = 1.00, RMSEA = .00, SRMR = .02 for writing productivity; and $\chi^2(22) = 18.23$, $p = .92$, CFI = 1.00, TLI = 1.00, RMSEA = .00, SRMR = .02 for correctness in writing. Figure 3 shows standardized path coefficients for the three dimensions of written composition. For writing quality (Figure 3a), perspective taking (.17, $p = .02$) and comprehension monitoring (.18, $p = .01$) were uniquely related, whereas inference (.03, $p = .74$) was not, after accounting for all other predictors in the model. For writing productivity (Figure 3b), none of the higher-order cognitive skills was uniquely related ($ps \geq .28$). For correctness in writing (Figure 3c), comprehension monitoring (.13, $p = .01$) had a unique, positive relation whereas inference had a suppression effect (−.12, $p = .03$), and perspective taking (.03, $p = .47$) was not related. Approximately 53%, 52%, and 64% of total variance in writing quality, productivity, and correctness in writing were explained, respectively.

Research Question 2: Dynamic Relations of Reading Comprehension to Writing Quality, Writing Productivity, and Correctness in Writing, and the Mediating Role of Reading Comprehension

Prior to examining the mediating roles of reading comprehension using the Figure 4 models, we fitted structural equation models without reading comprehension to establish relations of discourse oral language, lexical literacy, handwriting fluency, and the other skills to the three dimensions of written composition. The results supported the existence of relations of these component skills to written composition and their differential relations (see Table S1 and Figure S1 in online supplemental materials). We then fitted the three alternative models in Figure 4, which includes reading comprehension for each dimension of written composition, writing quality, writing productivity, and correctness in writing, for a total of nine structural equation models (three models × three dimensions of written composition). In all these models, reading comprehension was hypothesized to be directly predicted by discourse oral language and lexical literacy skills and indirectly predicted by their associated component skills according to theoretical models of reading comprehension and empirical evidence (Florit & Cain, 2011; Hoover & Gough, 1990; Kim, 2017, 2020b). However, the three alternative models differed in the nature of mediating role of reading comprehension. In Figure 4a, reading comprehension was hypothesized to completely mediate the relations of discourse oral language and lexical literacy to the three dimensions of written composition. In Figure 4b, reading comprehension partially mediates the relation of lexical literacy to the three dimensions of written composition while it completely mediates the relation of discourse oral language to the three dimensions of written composition. In Figure 4c, reading comprehension partially mediates the relation of discourse oral language to the three dimensions of written composition while it completely mediates the relation of lexical literacy to the three dimensions of written composition. The

Table 3
Loadings for Latent Variables

Latent variable	Observed variable	Loading	*p* value
Writing quality	WIAT Essay Composition Quality	.69	<.001
	Beaver Quality	.47	<.001
Writing productivity	WIAT Essay Composition Number of words	.61	<.001
	Beaver Composition Number of words	.82	<.001
Correctness in writing	WIAT Essay Composition CIWS	.77	<.001
	Beaver Composition CIWS	.79	<.001
Reading comprehension	WJ Passage Comprehension	.85	<.001
	WIAT Reading Comprehension	.68	<.001
Discourse oral language	OWLS Listening Comprehension	.52	<.001
	TNL Comprehension	.76	<.001
	Informational text comprehension	.82	<.001
	TNL retell	.62	<.001
	Informational text retell	.73	<.001
Lexical literacy	WJ Letter Word Identification	.91	<.001
	TOWRE SWE 1	.82	<.001
	TOWRE SWE 2	.81	<.001
	Spell	.83	<.001
Handwriting fluency	Sentence copying task 1	.77	<.001
	Sentence copying task 2	.83	<.001
	Sentence copying task 3	.86	<.001

Note. WIAT = Wechsler Individual Achievement Test; CIWS = Correct minus incorrect word sequences; WJ = Woodcock Johnson; OWLS = Oral and Written Language Scales; TNL = test of Narrative Language; TOWRE SWE = The Sight Word Efficiency task of test of Word Reading Efficiency.

Figure 4a was nested in Figure 4b and Figure 4c, and therefore model fits between Figure 4a versus Figure 4b and Figure 4c were compared using chi-square difference tests. The Figure 4b and Figure 4c models were equivalent models and could not be statistically compared. Therefore, these were examined for any problems with estimation (e.g., Heywood case) for model choice.

Given the complexity of these models, preliminary analysis was conducted to examine relations among component skills. In all the models, handwriting fluency was not hypothesized to have a relation with reading comprehension, based on DIEW (see Figure 1) and on our preliminary analysis confirming no such relation. Covariances between higher-order cognitive skills and transcription skills were not allowed based on theory (see Figure 1), prior findings (Kim & Schatschneider, 2017), and the preliminary analysis. Preliminary analysis also showed that attentional control had direct relations to perspective taking and monitoring, but not to inference, after accounting for vocabulary, grammatical knowledge, and working memory. Furthermore, attentional control was directly related to spelling and handwriting fluency, whereas working memory was not related to either of these skills after accounting for the other variables in the model. These preliminary findings were applied to all models in the Figure 4a–4c.

Table 4
Correlations Between Latent Variables

Variable	1	2	3	4	5	6
1. Writing quality	—					
2. Writing productivity	.39	—				
3. Correctness in writing	.65	.52	—			
4. Reading comprehension	.73	.29	.66	—		
5. Discourse oral language	.62	.09^{+}	.30	.68	—	
6. Lexical literacy	.56	.43	.71	.93	.35	—
7. Handwriting fluency	.49	.70	.59	.33	.13	.45

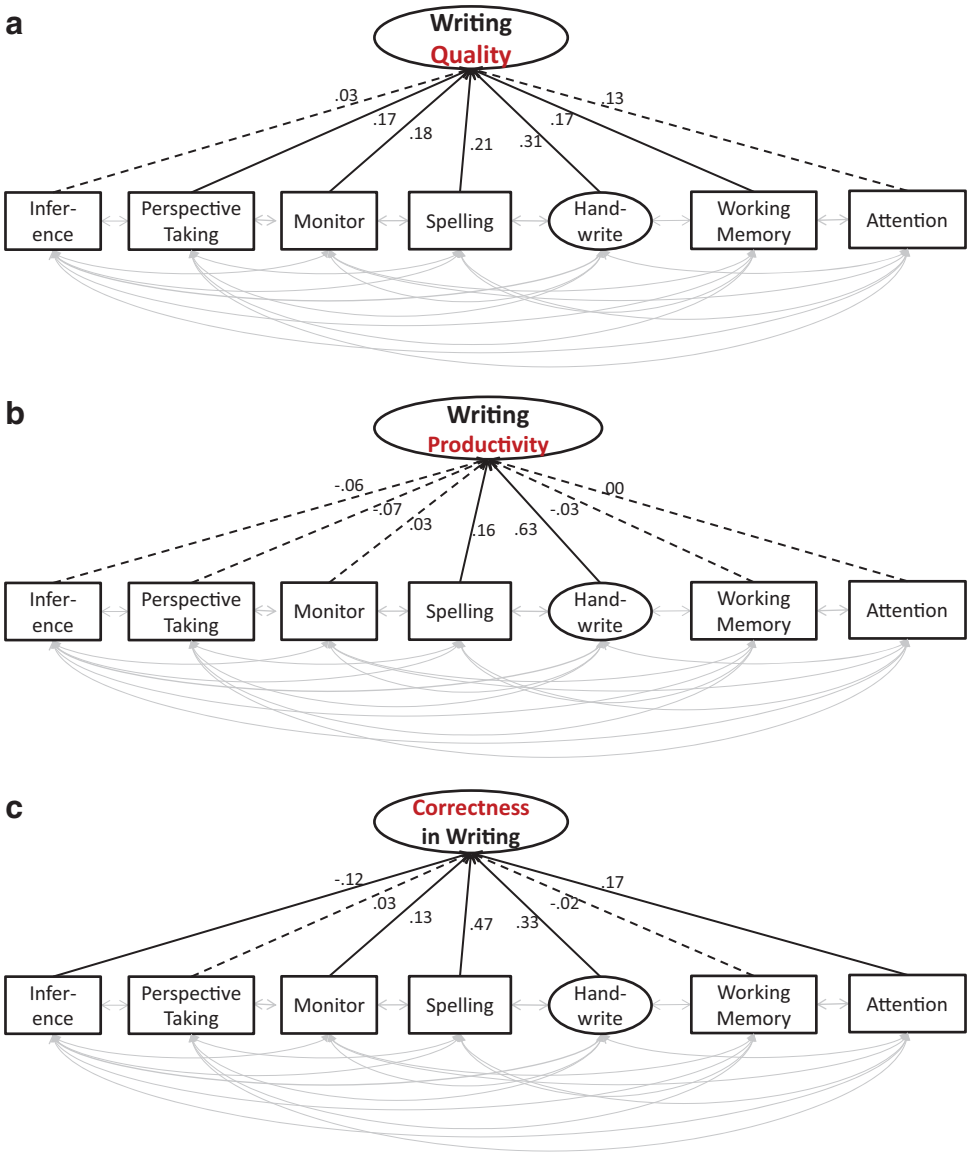
Note. All values are statistically significant at .05 level except for $^{+}$.

Table 5 presents model fits of the three alternative models (Figure 4a–4c) for each dimension of written composition, writing quality, writing productivity, and correctness in writing. For writing quality, Figure 4c was the best fitting model because Figure 4a had a statistically significantly worse fit than Figures 4b and 4c, and Figure 4b suffered from Heywood case where the standardized coefficient for the relation of reading comprehension to writing quality was greater 1. Results of the Figure 4c model are shown in Figure 5a. Reading comprehension (.30, $p < .001$) and handwriting fluency (.32, $p < .001$) were independently related to writing quality after accounting for the other variables in the model, including the lexical literacy. Lexical literacy was independently related to reading comprehension (73, $p < .001$) but not to writing quality, and discourse oral language was independently related to reading comprehension (.44, $p < .001$) and writing quality (.40, $p < .001$) after accounting for the other variables in the model. These results indicate that reading comprehension and writing quality are directly predicted by discourse oral language and lexical literacy skills and indirectly predicted by their component skills, such as inference, perspective taking monitoring, vocabulary, grammatical knowledge, working memory, and attention control. The results also indicate that the relations of lexical literacy and its component skills to writing quality are completely mediated by reading comprehension skill. In contrast, the relations of discourse oral language and its component skills to writing quality was partially mediated by reading comprehension. Approximately 67% of total variance in writing quality was explained by the included predictors.

Given the relation of reading comprehension to writing quality over and above all the other skills included in the model, a posthoc analysis was conducted to explore the directionality of reading

Figure 3

Standardized Path Coefficients of Relations of Higher-Order Cognitive Skills (Inference, Perspective Taking as Measured by Theory of Mind, and Comprehension Monitoring) to the Three Dimensions of Written Composition: (a) Writing Quality, (b) Writing Productivity, and (c) Correctness in Writing



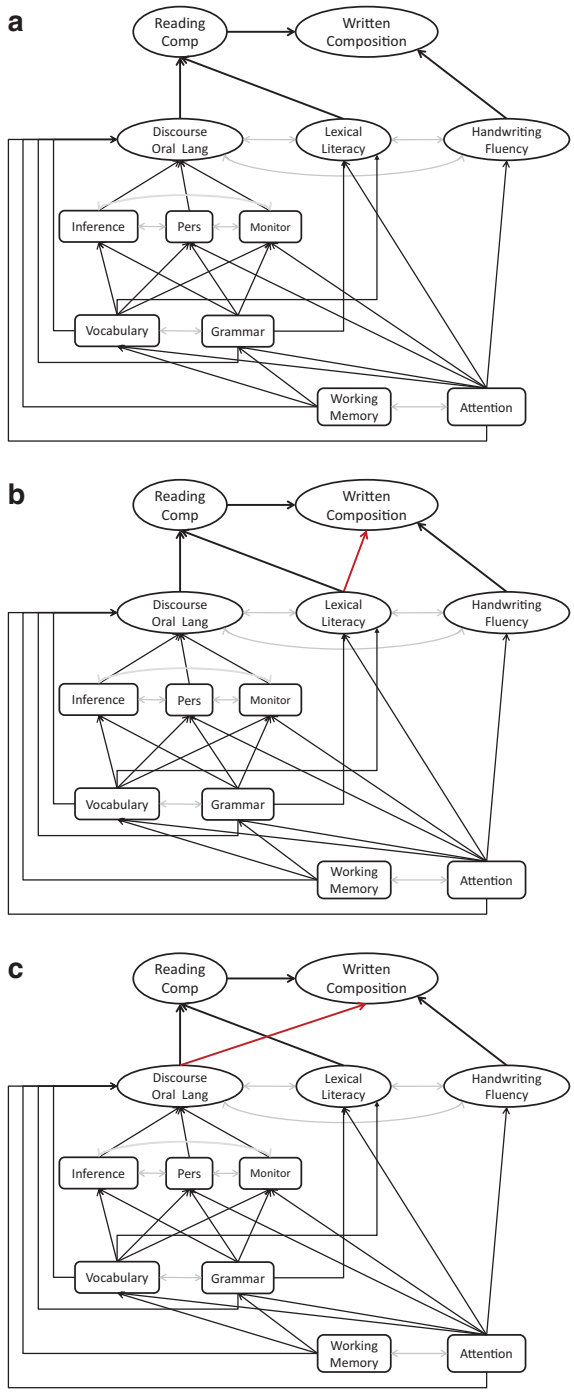
Note. Black solid lines represent statistically significant relations, whereas black dashed lines represent nonsignificant relations. Gray lines represent covariances, which were included in the analysis, but results are not shown. Monitor = comprehension monitoring; Handwrite = handwriting fluency; Attention = Attentional control. See the online article for the color version of this figure.

comprehension-writing quality relation. As stated above, DIEW posits developmentally bidirectional relations between reading comprehension and written composition. However, the bidirectionality is anticipated at an advanced phase of writing development, and we anticipated the direction of reading comprehension to writing relation in the beginning writing phase examined in the present study (see Ahmed et al., 2014; Kim et al., 2018, for empirical evidence). Although the directionality question is better addressed using longitudinal data, we explored whether the writing quality-to-reading comprehension model fits the data better than the reading comprehension-to-writing quality model shown in Figure 5a. The results indicate that the reading comprehension-to-writing quality model (Figure 5a) fit the data better than the writing quality-to-reading comprehension model (see Appendix C).

For writing productivity dimension, Figure 4b was chosen as the final model. Both Figure 4b and 4c were superior to Figure 4a,

Figure 4

Alternative Models of the Relation of Reading Comprehension to Written Composition, Which Were Fitted to Each of the Three Dimensions of Written Composition: Writing Quality, Writing Productivity, and Correctness in Writing



Note. Black lines represent predictive paths (the red line indicates how the alternative models differ), and gray lines represent covariances. Comp = comprehension; Lang = language; Lexical literacy = Word reading and spelling; Pers = perspective taking (theory of mind); Monitor = comprehension monitoring; Attention = Attentional control. See the online article for the color version of this figure.

but the Figure 4c model had a statistically significant suppression effect of discourse oral language to writing productivity (i.e., no relation [.09, $p = .21$] in bivariate correlation, but a negative relation [–.23, $p = .01$] in Figure 4c). The same pattern was found for correctness in writing so that Figure 4b was chosen as the best fitting model. Standardized path coefficients are presented in Figure 5b and 5c for writing productivity and correctness in writing, respectively. In both models, reading comprehension was not related (–.27, $p = .07$ for writing productivity, and .08, $p = .52$ for correctness in writing) but lexical literacy and handwriting fluency made independent contributions ($\geq .36$, $ps < .001$) after accounting for the other variables. In other words, reading comprehension is not related to writing productivity and correctness in writing while lexical literacy and handwriting fluency skills are, after accounting for the other variables in the model. Therefore, reading comprehension does not act as a mediator for writing productivity and correctness in writing. No post hoc analysis with regard to the directionality was conducted, given the absence of the unique relation between reading comprehension and writing productivity and correctness in writing. Approximately 51% and 61% of variance in writing productivity and correctness in writing, respectively, were explained.

Research Question 3: Dynamic Relations in Terms of Total Effects of Component Skills

To examine whether the relations of component skills on written composition differ by dimensions of written composition, total effects (standardized beta weights) that include both direct and indirect effects of component skills on writing quality, writing productivity, and correctness in writing, based on Figure 5 were estimated (see Table 6). For writing quality, substantial total effects were found for discourse oral language (.53), attentional control (.41), handwriting fluency (.34), and reading comprehension (.30), followed by grammatical knowledge (.25), lexical literacy (.22), vocabulary (.22), working memory (.20), perspective taking (.17), inference (.12), and monitoring (.10). For writing productivity, the total effect was largest for handwriting fluency (.64), followed by attentional control (.29) and lexical literacy (.18). The total effects of the other component skills (e.g., vocabulary, inference, perspective taking) were not statistically significant for the writing productivity outcome. For correctness in writing, lexical literacy (.53) and attentional control (.51) had the large effects, followed by handwriting fluency (.36), grammatical knowledge (.13), vocabulary (.10), and working memory (.07).

Discussion

In this study, we expanded DIEW by proposing dynamic relations of component skills to writing as a function of writing measurement and dimensions of written composition and by including reading as a component skill of writing. We then tested dynamic relations hypothesis by examining the relations of higher-order cognitive skills and reading comprehension to the three dimensions of written composition—writing quality, writing productivity, and correctness in writing—and total effects of a comprehensive set of component skills on the three dimensions of written composition. We also examined the relation of reading comprehension to written composition, including its mediating role. The results overall

Table 5
Model Fit Comparisons

Dimension of written composition	Figure	$\chi^2(df)$, p value	CFI (TLI)	RMSEA (SRMR)	nBIC	Model comparison: $\Delta\chi^2(\Delta df, p$ value)
Writing quality	Figure 4a	382.41 (200), <.001	.96 (.95)	.05 (.05)	45,207.28	
	Figure 4b[a]	367.99 (199), <.001	.96 (.95)	.05 (.05)	45,195.55	
	Figure 4c	**367.99 (199), <.001**	**.96 (.95)**	**.05 (.05)**	**45,195.55**	4a vs. 4c: 12.42 (1, <.001)
Writing productivity	Figure 4a	354.45 (200), <.001	.96 (.96)	.05 (.05)	50,008.26	
	Figure 4b	**347.98 (199), <.001**	**.97 (.96)**	**.05 (.05)**	**50,004.47**	
	Figure 4c[b]	347.98 (199), <.001	.97 (.96)	.05 (.05)	50,004.47	4a vs. 4b & 4c: 6.47 (1, .01)
Correctness in writing	Figure 4a	392.70 (200), <.001	.96 (.95)	.05 (.05)	49,673.95	
	Figure 4b	**380.95 (199), <.001**	**.96 (.95)**	**.05 (.05)**	**49,664.88**	
	Figure 4c[b]	380.95 (199), <.001	.96 (.95)	.05 (.05)	49,664.88	4a vs. 4b & 4c: 9.75 (1, .002)

Note. CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual; nBIC = sample size adjusted Baysian Information Criterion. Bolded values are final models. Bolded values are final models.
[a] Heywood case. [b] Statistically significant suppression effects.

support the dynamic relations hypothesis as a function of dimensions of written composition and the relation of reading comprehension to writing quality. Below are discussions on each.

Dynamics Relations Hypothesis as a Function of Dimensions of Written Composition

The findings supported the dynamic relations hypothesis as a function of writing measurement, specifically dimensions of written composition. When higher-order cognitive skills were investigated, their relations differed for the three dimensions of written composition. Bivariate correlations (see Table 2) showed that higher-order cognitive skills were related to writing quality and correctness in writing, but not to writing productivity. When transcription skills and domain-general cognitions, working memory and attention, were controlled for, perspective taking and comprehension monitoring were independently related to writing quality; none of the three higher-order cognitive skills was related to writing productivity; and monitoring was independently related to correctness in writing while inference had a suppressor effect (see Figure 3). These results indicate that higher-order cognitive skills are more relevant to writing quality and correctness in writing, but not writing productivity. These are largely in line with our hypothesis that one's skills in reasoning, making inference, understanding multiple perspectives, and monitoring are particularly important for coherent, clear articulation and arrangement of ideas—writing quality—but not writing productivity.

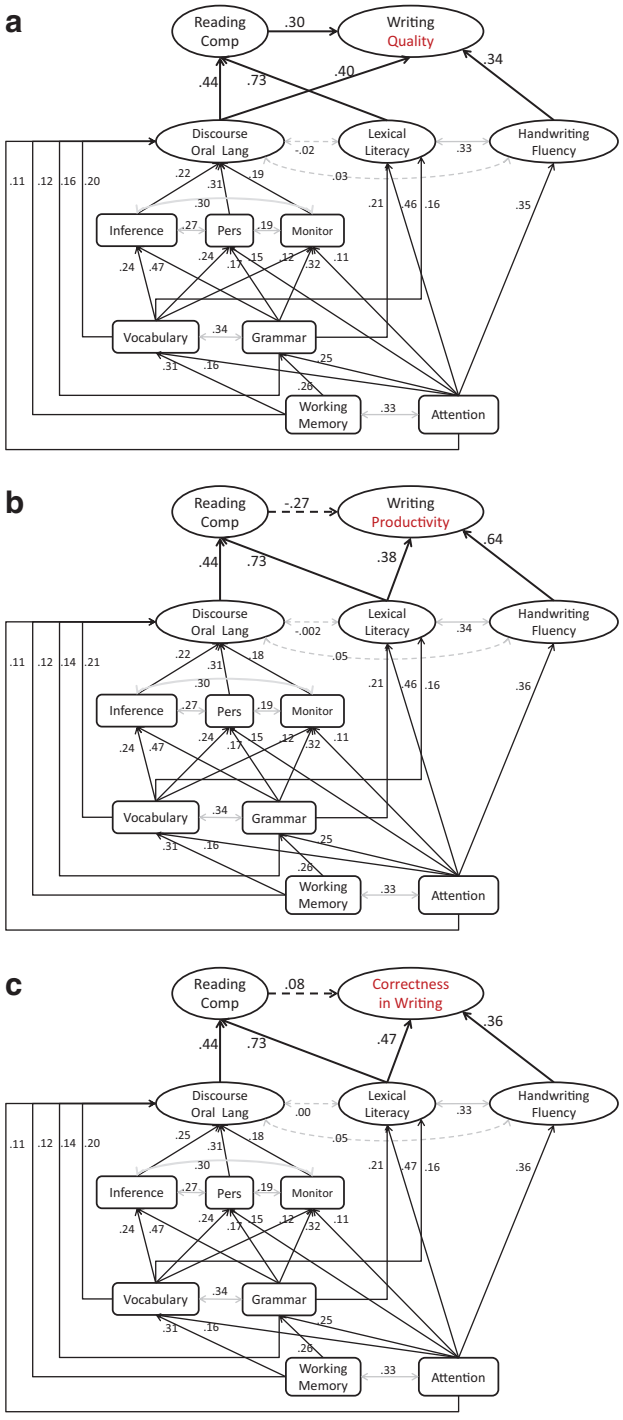
However, there were also unexpected and/or new findings. Unlike previous studies (Kim & Park, 2019; Kim & Schatschneider, 2017), inference was not independently related to writing quality. Although the cause of the discrepant finding is unclear, it appears that the relation of inference to writing quality is largely shared with comprehension monitoring. One difference of the present study compared with Kim and Schatschneider's (2017) study with first graders is the inclusion of monitoring in the current study, which had a moderate correlation with inference (r = .48). The unique contribution of perspective taking to writing quality is in line with its role according to DIEW and recent evidence with fourth graders (Kim, 2020a) and indicates that children's ability in understanding others' perspectives adds to writing quality. It is also of note that monitoring was independently related to writing quality and correctness in writing after accounting for transcription skills, working memory, attention, inference, and perspective taking. These results suggest that children's monitoring of their own performance is important to quality of ideas and correctness in writing. Taken together, these results support the relations of higher-order cognitive skills to written composition, and indicate that their relations to written composition are not uniform, but vary for different dimensions of written composition.

The dynamic relations hypothesis was also supported beyond the higher-order cognitive skills such that the total effects of component skills to the three dimensions of written composition differed (see Table 6). All the component skills examined in this study had statistically significant total effects on writing quality, indicating that writing quality draws on all the component skills included in the present study. In fact, all the component skills in the expanded DIEW are expected to contribute to writing quality. In contrast, for writing productivity, only handwriting fluency, lexical literacy, and attentional control had substantial total effects, indicating that writing productivity (text length or amount of text) primarily relies on transcription skills and attentional control. For correctness in writing, lexical literacy, handwriting fluency, and attentional control had substantial, statistically significant total effects, and grammatical knowledge, vocabulary, and working memory also had statistically significant, albeit relatively small, contributions. These results are in line with how correctness in writing was operationalized in the present study using the correct minus incorrect word sequence—the extent of accuracy in spelling and grammaticality (see Graham et al., 2011a; McMaster & Espin, 2007). The contribution of vocabulary to correctness in writing also makes sense because vocabulary knowledge includes not only meanings of words but also grammatical usage of words.

The dynamic relations hypothesis underscores the importance of carefully thinking about measurement and evaluation of written composition in a theoretical model, in addition to identifying processes and component skills of writing. Prior theoretical models of writing were silent or agnostic about implications of measurement of written compositions, including various dimensions, but in this study, we proposed and validated the dynamic relations of component skills to written composition as a function of dimensions of written composition. The measurement issue has been acknowledged for reading comprehension (Francis et al., 2006; Keenan et al., 2008; Kim, 2020b), but it is particularly relevant to writing as written composition is widely evaluated in multiple ways. For

Figure 5

Standardized Path Coefficients of Expanded DIEW, Where Reading Comprehension Is a Mediator for (a) Writing Quality, (b) Writing Productivity, and (c) Correctness in Writing



Note. Solid lines represent statistically significant relations, whereas dashed lines represent nonsignificant relations. Gray lines represent covariances. Comp = comprehension; Lang = language; Lexical literacy = Word reading and spelling; Pers = perspective taking (theory of mind); Monitor = comprehension monitoring; Attention = Attentional control. See the online article for the color version of this figure.

writing quality, richness and clear, coherent presentation of ideas are focal aspects, and therefore, writing quality draws on use of precise and descriptive words and effective use of appropriate sentence structures (Kim et al., 2014), and higher-order cognitions and reading comprehension (the present study). This was not the case for writing productivity.

Reading as a Contributing or Component Skill of Writing

Another important way the present study expands DIEW is the addition of reading as a component skill of written composition. In line with our hypothesis, we found that reading comprehension was strongly related to writing quality (see Figure 5), which is convergent with previous studies (e.g., Ahmed et al., 2014; Berninger & Abbott, 2010; Kim et al., 2015, 2018). The importance of reading in writing (see Deane, 2008; Hayes, 1996) and the nature of their relations (Fitzgerald & Shanahan, 2016; Langer & Flihan, 2000; Shanahan, 2016) were discussed before. The expanded DIEW extends these prior studies in several ways. First, the expanded DIEW identifies specific language, cognition, and print-related component skills that are shared in reading and writing. As hypothesized, we found that reading comprehension and written composition draw on discourse oral language, inference, perspective taking, monitoring, vocabulary, grammatical knowledge, working memory, attentional control, and lexical literacy (see Figure 5a). These are very much in line with theoretical models of and empirical evidence on reading comprehension (see Kim, 2020b, for a review) as well as DIEW (see above). Second, in line with the dynamic relations hypothesis, reading comprehension is hypothesized to be important to the writing quality dimension, but not to writing productivity or correctness in writing. This speculation was supported. Successful reading comprehension requires constructing a coherent mental representation on the given written texts (whether the writer's own texts or source texts), and this skill is related to the quality aspect—coherence in written compositions—but not productivity or correctness in writing as operationalized by the CBM correct minus incorrect word sequences.

Third, our study revealed the nature of a mediating role of reading comprehension in the relation of component skills to different dimensions of written composition. If reading comprehension and written composition draw on similar skills such as discourse oral language and lexical literacy, and reading comprehension is a component skill of written composition, then reading comprehension would mediate the relations of component skills to written composition, writing quality in particular, at least to some extent. We found a different pattern of mediation for lexical literacy versus discourse oral language such that reading comprehension completely mediated the relation of lexical literacy and partially mediated the relation of discourse oral language to writing quality in our sample (Figure 5a). We believe that these findings reflect that beginning phase of development of the participants, English-speaking grade 2 students in the present study. In line with the hypothesis of DIEW and extant evidence for beginning readers, the bivariate relation between lexical literacy skill and reading comprehension was very strong. Note, however, that the strong correlation should not be taken to suggest that they are identical skills. Although the strong relation indicates a substantial influence of lexical literacy on reading comprehension, discourse oral

Table 6
Standardized Coefficients (Standard Errors) of the Direct, Indirect, and Total Effects of Component Skills on Writing Quality, Writing Productivity, and Correctness in Writing, Based on the Results in Figure 5

	Writing quality			Writing productivity			Correctness in writing		
Variable	Direct	Indirect	Total	Direct	Indirect	Total	Direct	Indirect	Total
Reading comprehension	.30 (.11)*	—	.30 (.11)*	−.27 (.15)	—	−.27 (.15)	.08 (.13)	—	.08 (.13)
Discourse oral language	.40 (.11)*	.13 (.05)*	.53 (.07)*	—	−.12 (.06)	−.12 (.06)	—	.04 (.06)	.04 (.06)
Lexical literacy		.22 (.08)*	.22 (.07)*	.38 (.15)*	−.20 (.11)	.18 (.07)*	.47 (.14)*	.06 (.10)	.53 (.06)*
Handwriting fluency	.34 (.08)*	—	.34 (.08)*	.64 (.06)*	—	.64 (.06)*	.36 (.06)*	—	.36 (.06)*
Inference	—	.12 (.03)*	.12 (.03)*	—	−.03 (.02)	−.03 (.02)	—	.01 (.01)	.01 (.01)
Perspective taking	—	.17 (.03)*	.17 (.03)*	—	−.04 (.02)	−.04 (.02)	—	.01 (.02)	.01 (.02)
Monitoring	—	.10 (.03)*	.10 (.03)*	—	−.02 (.01)	−.02 (.01)	—	.01 (.01)	.01 (.01)
Vocabulary	—	.22 (.04)*	.22 (.04)*	—	−.01 (.02)	−.01 (.02)	—	.10 (.03)*	.10 (.03)*
Grammatical knowledge	—	.25 (.04)*	.25 (.04)*	—	−.00 (.02)	−.00 (.02)	—	.13 (.03)*	.13 (.03)*
Working memory	—	.20 (.04)*	.20 (.04)*	—	−.02 (.02)	−.02 (.02)	—	.07 (.02)*	.07 (.02)*
Attention	—	.41 (.05)*	.41 (.05)*	—	.29 (.05)*	.29 (.05)*	—	.43 (.04)*	.51 (.05)*

Note. Discourse oral language was composed of listening comprehension and oral production; Lexical literacy was composed to word reading and spelling; perspective taking was measured by theory of mind.
* $p < .05$.

language was also a unique predictor of reading comprehension after accounting for lexical literacy (see Figure 5), indicating that reading comprehension even in the beginning phase draws on discourse oral language over and above lexical literacy. As hypothesized above and has been shown in previous studies (Adlof et al., 2006; Hoover & Gough, 1990; Kim & Wagner, 2015), reading comprehension in a beginning phase of development is constrained by word reading skill and does not fully capture other contributing skills such as language and higher-order cognitive skills. Therefore, although reading comprehension completely mediates the relation of lexical literacy to written composition, it only partially mediated the relation of discourse oral language to written composition at least for beginning readers and writers. According to the dynamic relations hypothesis, the nature of mediation would differ a function of development—reading comprehension captures language and higher-order cognitive skills to a greater extent in a more advanced phase such that the relation of discourse oral language to writing quality might be completely captured/mediated by reading comprehension. This hypothesis requires future investigations.

Limitations, Future Work, and Implications

DIEW is a theoretical model for all phases of writing development. In the present study we used data from children in grade 2, and therefore generalizability of the findings is limited to beginning readers and writers with demographic characteristics similar to those in the present study. Therefore, future studies are needed to replicate and extend the present study with different populations, including those at more advanced phases of development (e.g., high school), second language learners, struggling readers and writers, and students learning to read and write in different writing systems and orthographies. Future studies should also test the dynamic relations hypothesis as a function of development, using longitudinal data.

Examining mediation using cross-sectional data has limitations (e.g., Maxwell & Cole, 2007), and the structural equation models fitted in the present study assumed no interactions between predictors and mediators, and mediators and outcomes (see literature on causal mediation, e.g., Pearl, 2014). For a more rigorous investigation of mediated relations among skills that are hypothesized in DIEW, longitudinal studies are also needed. Although language and cognitive skills, reading skills, and writing skills in the present study were measured at times that are in line with the mediated relations in DIEW (i.e., language and cognitive skills in the fall, reading skills in the winter, and writing skills in the spring), these were measured within an academic year and the statistical models in this article are not of a longitudinal investigation. Future work should include a longitudinal study with careful consideration about modeling (e.g., predicting change over time vs. status; see Gu et al., 2014; Maxwell & Cole, 2007). Future work should also examine whether and to what extent reading processes are employed during writing processes for writers at various developmental phases and across different writing tasks as we examined the relation of reading comprehension to written composition using products which are outcomes of reading and writing processes. Furthermore, intervention work or studies with experimental designs are needed to test mediation roles hypothesized in DIEW. For example, the mediating role of reading comprehension can be investigated by testing whether improvement of component skills of reading comprehension such as discourse oral language and lexical literacy skills leads to improvement in reading comprehension, which, in turn, improves writing quality.

Finally, as is the case in any study, the present results reflect how each construct was operationalized. Although measures were carefully chosen based on theoretical models and previous empirical evidence (Kim, 2015, 2016; Kim & Phillips, 2014; Mackie & Dockrell, 2004; McMaster & Espin, 2007; Puranik et al., 2008; Wagner et al., 2011), not all the constructs were measured with multiple tasks due to practical constraints in school-based research, that is, limited assessment time available to the research team. Writing tasks in this study were limited to expository texts, and thus future studies including different genres would be informative. As noted above, DIEW is a model of writing across genres and tasks. Therefore, theoretically DIEW should apply to all genres and tasks. However, the relative contributions of component skills might differ depending on genres and the nature of tasks according

to the dynamic relations hypothesis. Future work is warranted. Additionally, replication is needed using different approaches to evaluating written composition. For example, in the present study, writing quality primarily focused on the quality of ideas and organization, but overall writing quality measured by holistic scoring which evaluates other aspects such as spelling and writing conventions in addition to ideas and organization can be examined in future studies. Furthermore, attentional control in this study was measured by a survey that focuses on behavioral attention which has been shown to be valid and predictive of academic achievements (e.g., Arrington et al., 2014; Blair & Razza, 2007), and future studies can examine the roles of cognitive attention such as inhibitory control.

The component skills included in the expanded DIEW develop interacting with environmental factors, including instruction at school. Below are preliminary but vital implications for instructional practice. According to the hierarchical and interactive relations hypotheses, which posit systematic chains of interactive relations, multicomponent instruction with systematic assessment on lower-level skills *and* higher-order skills would be necessary to make a sustainable and robust impact on writing development. In fact, DIEW provides a detailed systematic picture about further assessment and instructional needs—development of discourse oral language requires higher-order cognitive skills and vocabulary and grammatical knowledge, and development of lexical literacy and handwriting/keyboarding fluency skills requires knowledge of phonology, orthography, and morphology (see Figure 1 and Kim & Park, 2019).

The dynamic relations hypothesis implies that assessment and instruction should consider and be mindful of focal dimensions of written composition. To promote development of writing quality, which is arguably the most important dimension, instruction is needed in all the multiple component skills identified in the expanded DIEW. Instruction or intervention that primarily focuses on transcription skills would improve writing quality (e.g., Graham et al., 2002), but larger effects are expected on writing productivity or correctness in writing. The dynamic relations hypothesis may be applied to various writing processes in instruction. Juggling many different aspects during writing processes is challenging, particularly for beginning writers. Thus, multiple demands may be coordinated by aligning different dimensions of written composition with the writing processes in instruction such as first draft, revision, and editing. When writing a first draft, students can be encouraged to focus on generating and encoding as many on-topic or relevant ideas in print (productivity dimension). During the revision process, teachers can bring students' attention to quality of ideas such as use of rich and precise vocabulary, and logical and coherent arrangement of ideas (quality dimension). During the editing process, instruction can focus on the correctness dimension such as grammaticality, spelling, and conventions (e.g., capitalization, punctuation). This mapping between writing process and different focal dimensions, of course, is just an illustration of how different dimensions of writing can be applied to the writing process in service of the ultimate goal of quality writing—accurately and effectively conveying one's ideas in line with the task goal and audience's needs.

The findings about the relation of reading comprehension to writing quality are in line with integrating reading and writing instruction, particularly to improve the quality dimension of writing. Quality writing requires reading one's own work for revision as well as reading source materials, which is particularly emphasized in academic work such as Common Core State Standards in the United States and content area instruction such as social studies and science. Systematic integration of reading and writing instruction with a focus on their shared component skills, in addition to reading-focused and writing-focused instruction, is supported by recent meta-analyses (Graham et al., 2017, 2018).

Overall, the present study was an effort to explicate the nature of relations among multiple skills that contribute to written composition for developing writers and revealed dynamic relations as a function of focal dimensions of written composition and reading as a component skill of writing. Future replications are needed for children in various developmental phases and from different backgrounds.

References

Abbott, R. D., & Berninger, V. W. (1993). Structural equation modeling of relationships among developmental skills and writing skills in primary- and intermediate-grade writers. *Journal of Educational Psychology*, *85*(3), 478–508. https://doi.org/10.1037/0022-0663.85.3.478

Adams, M. A. (1990). *Beginning to read: Thinking and learning about print*. MIT Press.

Adlof, S. M., Catts, H. W., & Little, T. D. (2006). Should the simple view of reading include a fluency component? *Reading and Writing*, *19*(9), 933–958. https://doi.org/10.1007/s11145-006-9024-z

Ahmed, Y., Wagner, R. K., & Lopez, D. (2014). Developmental relations between reading and writing at the word, sentence, and text levels: A latent change score analysis. *Journal of Educational Psychology*, *106*(2), 419–434. https://doi.org/10.1037/a0035692

Arrington, C. N., Kulesz, P. A., Francis, D. J., Fletcher, J. M., & Barnes, M. A. (2014). The contribution of attentional control and working memory to reading comprehension and decoding. *Scientific Studies of Reading*, *18*(5), 325–346. https://doi.org/10.1080/10888438.2014.902461

Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, *51*(6), 1173–1182. https://doi.org/10.1037/0022-3514.51.6.1173

Bereiter, C., & Scardamalia, M. (1987). *The psychology of written composition*. Erlbaum.

Berman, R A., & Verhoeven, L. (2002). Cross-linguistic perspectives on the development of text-production abilities. *Written Language and Literacy*, *5*(1), 1–43. https://doi.org/10.1075/wll.5.1.02ber

Berninger, V. W., & Abbott, R. D. (2010). Discourse-level oral language, oral expression, reading comprehension, and written expression: Related yet unique language systems in grades 1, 3, 5, and 7. *Journal of Educational Psychology*, *102*(3), 635–651. https://doi.org/10.1037/a0019319

Berninger, V. W., Abbott, R. D., Abbott, S. P., Graham, S., & Richards, T. (2002). Writing and reading: Connections between language by hand and language by eye. *Journal of Learning Disabilities*, *35*(3), 39–56. https://doi.org/10.1177/002221940203500104

Berninger, V. W., & Winn, W. D. (2006). Implications of advancements in brain research and technology for writing development, writing instruction, and educational evolution. In C. MacArthur, S. Graham, & J. Fitzgerald (Eds.), *Handbook of writing research* (pp. 96–114). Guilford Press.

Berninger, V. W., Vaughan, K. B., Abbott, R. D., Abbott, S. P., Rogan, L. W., Brooks, A., Reed, E., & Graham, S. (1997). Treatment of handwriting problems in beginning writers: Transfer from handwriting to composition. *Journal of Educational Psychology*, *89*(4), 652–666. https://doi.org/10.1037/0022-0663.89.4.652

Bishop, D. V. M., & Snowling, M. J. (2004). Developmental dyslexia and specific language impairment: Same or different? *Psychological Bulletin*, *130*(6), 858–886. https://doi.org/10.1037/0033-2909.130.6.858

Blair, C., & Razza, R. P. (2007). Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. *Child Development*, *78*(2), 647–663. https://doi.org/10.1111/j.1467-8624.2007.01019.x

Bourdin, B., & Fayol, M. (1994). Is written language production more difficult than oral language production? A working memory approach. *International Journal of Psychology*, *29*(5), 591–620. https://doi.org/10.1080/00207599408248175

Breetvelt, I., van den Bergh, H., & Rijlaarsdam, G. (1996). Rereading and generating and their relation to text quality. An application of multilevel analysis on writing process data. In G. Rijlaarsdam, H. van den Bergh, & M. Couzijn (Eds.), *Theories, models, and methodology in writing research* (pp. 10–20). Amsterdam University Press.

Caillies, S., & Le Sourn-Bissaoui, S. (2008). Children's understanding of idioms and theory of mind development. *Developmental Science*, *11*(5), 703–711. https://doi.org/10.1111/j.1467-7687.2008.00720.x

Cain, K., Oakhill, J., & Bryant, P. (2004). Children's reading comprehension ability: Concurrent prediction by working memory, verbal ability, and component skills. *Journal of Educational Psychology*, *96*(1), 31–42. https://doi.org/10.1037/0022-0663.96.1.31

Carrow-Woolfolk, E. (1999). *Comprehensive assessment of spoken language*. Pearson Assessment.

Carrow-Woolfolk, E. (2011). *Oral and written language scales* (2nd ed.). Western Psychological Services.

Coker, D. L., Jr., Ritchey, K. D., Uribe-Zarain, X., & Jennings, A. S. (2018). An analysis of first-grade writing profiles and their relationship to compositional quality. *Journal of Learning Disabilities*, *51*(4), 336–350. https://doi.org/10.1177/0022219417708171

Cromley, J. G., & Azevedo, R. (2007). Testing and refining the direct and inferential mediation model of reading comprehension. *Journal of Educational Psychology*, *99*(2), 311–325. https://doi.org/10.1037/0022-0663.99.2.311

Currie, N. K., & Cain, K. (2015). Children's inference generation: The role of vocabulary and working memory. *Journal of Experimental Child Psychology*, *137*, 57–75. https://doi.org/10.1016/j.jecp.2015.03.005

Deane, P., Odendahl, N., Quinlan, T., Fowles, M., Welsh, C., & Bivens-Tatum, J. (2008). Cognitive models of writing: Writing proficiency as a complex integrated skill (ETS Research Report No. RR-08-55). Educational Testing Service. https://doi.org/10.1002/j.2333-8504.2008.tb02141.x

Ehri, L. C. (1997). Learning to read and learning to spell are one and the same, almost. In C. A. Perfetti, L. Rieben, & M. Fayol (Eds.), *Learning to spell: Research, theory, and practice across languages* (pp. 237–269). Erlbaum Publishers.

Enders, C. K., & Bandalos, D. L. (2001). The relative performance of full information maximum likelihood estimation for missing data in structural equation models. *Structural Equation Modeling*, *8*(3), 430–457. https://doi.org/10.1207/S15328007SEM0803_5

Fitzgerald, J., & Shanahan, T. (2000). Reading and writing relations and their development. *Educational Psychologist*, *35*(1), 39–50. https://doi.org/10.1207/S15326985EP3501_5

Florit, E., & Cain, K. (2011). The simple view of reading: Is it valid for different types of alphabetic orthographies? *Educational Psychology Review*, *23*(4), 553–576. https://doi.org/10.1007/s10648-011-9175-6

Foorman, B. R., Koon, S., Petscher, Y., Mitchell, A., & Truckenmiller, A. (2015). Examining general and specific factors in the dimensionality of oral language and reading in 4th-10th grades. *Journal of Educational Psychology*, *107*(3), 884–899. https://doi.org/10.1037/edu0000026

Francis, D. J., Fletcher, J. M., Catts, H., & Tomblin, J. B. (2005). Dimensions affecting the assessment of reading comprehension. In S. G. Paris & S. A. Stahl (Eds.), *Children's reading comprehension and assessment* (pp. 35–49). Erlbaum.

Francis, D. J., Snow, C. E., August, D., Carlson, C. D., Miller, J., & Iglesias, A. (2006). Measures of reading comprehension: A latent variable analysis of the diagnostic assessment of reading comprehension. *Scientific Studies of Reading*, *10*(3), 301–322. https://doi.org/10.1207/s1532799xssr1003_6

Gathercole, S. E., & Baddeley, A. D. (1990). The role of phonological memory in vocabulary acquisition: A study of young children learning new names. *British Journal of Psychology*, *81*(4), 439–454. https://doi.org/10.1111/j.2044-8295.1990.tb02371.x

Gillam, R. B., & Pearson, N. A. (2004). *Test of narrative language*. PRO-ED.

Gough, P. B., & Tunmer, W. E. (1986). Decoding, reading, and reading disability. *RASE: Remedial & Special Education*, *7*(1), 6–10.

Graham, S. (2018). A writer(s) within community model of writing. In C. Bazerman, V. Berninger, D. Brandt, S. Graham, J. Langer, S. Murphy, . . . M. Schleppegrell (Eds.), *The lifespan development of writing* (pp. 271–325). National Council of English. https://doi.org/10.1080/00461520.2018.1481406

Graham, S., Berninger, V. W., Abbott, R. D., Abbott, S. P., & Whitaker, D. (1997). Role of mechanics in composing of elementary school students: A new methodological approach. *Journal of Educational Psychology*, *89*(1), 170–182. https://doi.org/10.1037/0022-0663.89.1.170

Graham, S., Berninger, V., & Fan, W. (2007). The structural relationship between writing attitude and writing achievement in first and third grade students. *Contemporary Educational Psychology*, *32*(3), 516–536. https://doi.org/10.1016/j.cedpsych.2007.01.002

Graham, S., Harris, K. R., & Chorzempa, B. F. (2002). Contribution of spelling instruction to the spelling, writing, and reading of poor spellers. *Journal of Educational Psychology*, *94*(4), 669–686. https://doi.org/10.1037/0022-0663.94.4.669

Graham, S., Harris, K., & Hebert, M. A. (2011a). *Informing writing: The benefits of formative assessment. A Carnegie Corporation Time to Act report*. Alliance for Excellent Education.

Graham, S., Harris, K., & Hebert, M. A. (2011b). It is more than just the message: Presentation effects in scoring writing. *Focus on Exceptional Children*, *44*(4), 1–12. https://doi.org/10.17161/foec.v44i4.6687

Graham, S., Liu, X., Aitken, A., Ng, C., Bartlett, B., Harris, K. R., & Holzapfel, J. (2017). Effectiveness of literacy programs balancing reading and writing instruction: A meta-analysis. *Reading Research Quarterly*, *53*(3), 279–304. https://doi.org/10.1002/rrq.194

Graham, S., Liu, X., Bartlett, B., Ng, C., Harris, K. R., Aitken, A., Barkel, A., Kavanaugh, C., & Talukdar, J. (2018). Reading for writing: A meta-analysis of the impact of reading interventions on writing. *Review of Educational Research*, *88*(2), 243–284. https://doi.org/10.3102/0034654317746927

Gu, F., Preacher, K. J., & Ferrer, E. (2014). A state space modeling approach to mediation approach. *Journal of Educational and Behavioral Statistics*, *39*(2), 117–143. https://doi.org/10.3102/1076998614524823

Hayes, J. R. (1996). A new framework for understanding cognition and affect in writing. In C. M. Levy & S. Ransdell (Eds.), *The science of writing: Theories, methods, individual differences, and applications* (pp. 1–27). Erlbaum.

Hayes, J. R. (2006). New directions in writing theory. In C. A. MacArthur, S. Graham, & J. Fitzgerald (Eds.), *Handbook of writing research* (pp. 28–40). Guilford Press.

Hayes, J. R. (2012). Modeling and remodeling writing. *Written Communication*, *29*(3), 369–388. https://doi.org/10.1177/0741088312451260

Hayes, J. R., & Chenoweth, N. A. (2007). Working memory in an editing task *Written Communication*, *24*(4), 283–294. https://doi.org/10.1177/0741088307304826

Hayes, J. R., & Flower, L. S. (1980). Identifying the organization of writing processes. In L. W. Gregg, & E. R. Steinberg (Eds.), *Cognitive processes in writing* (pp. 3–29). Erlbaum.

Hooper, S. R., Swartz, C. W., Wakely, M. B., de Kruif, R. E. L., & Montgomery, J. W. (2002). Executive functions in elementary school children with and without problems in written expression. *Journal of Learning Disabilities*, *35*(1), 57–68. https://doi.org/10.1177/002221940203500105

Hoover, W. A., & Gough, P. B. (1990). The simple view of reading. *Reading and Writing*, *2*(2), 127–160. https://doi.org/10.1007/BF00401799

Hu, L.-T., & Bentler, P. M. (1999). Cutoff criteria for fit indices in covariance structure analysis. Conventional criteria versus new alternatives. *Structural Equation Modeling*, *6*(1), 1–55. https://doi.org/10.1080/10705519909540118

Juel, C., Griffith, P. L., & Gough, P. B. (1986). Acquisition of literacy: A longitudinal study of children in first and second grade. *Journal of Educational Psychology*, *78*(4), 243–255. https://doi.org/10.1037/0022-0663.78.4.243

Keenan, J. M., Betjemann, R. S., & Olson, R. K. (2008). Reading comprehension tests vary in the skills they assess: Differential dependence on decoding and oral comprehension. *Scientific Studies of Reading*, *12*(3), 281–300. https://doi.org/10.1080/10888430802132279

Kellogg, R. T. (1996). A model of working memory in writing. In C. M. Levy & S. E. Ransdell (Eds.), *The science of writing* (pp. 57–71). Erlbaum.

Kendeou, P., Bohn-Gettler, C. M., White, M. J., & van den Broek, P. (2008). Children's inference generation across different media. *Journal of Research in Reading*, *31*(3), 259–272. https://doi.org/10.1111/j.1467-9817.2008.00370.x

Kieffer, M. J., & Lesaux, N. K. (2012). Direct and indirect roles of morphological awareness in the English reading comprehension of native English, Spanish, Filipino, and Vietnamese speakers. *Language Learning*, *62*(4), 1170–1204. https://doi.org/10.1111/j.1467-9922.2012.00722.x

Kim, G. Y., Schatschneider, C., Wanzek, J., Gatlin, B., & Al Otaiba, S. (2017). Writing evaluation: Rater and task effects on the reliability of writing scores for children in Grades 3 and 4. *Reading and Writing*, *30*(6), 1287–1310. https://doi.org/10.1007/s11145-017-9724-6

Kim, Y. G. (2020a). Structural relations of language and cognitive skills, and topic knowledge to written composition: A test of the direct and indirect effects model of writing. *The British Journal of Educational Psychology*, *90*(4), 910–932. https://doi.org/10.1111/bjep.12330

Kim, Y. G., & Schatschneider, C. (2017). Expanding the developmental models of writing: A direct and indirect effects model of developmental writing (DIEW). *Journal of Educational Psychology*, *109*(1), 35–50. https://doi.org/10.1037/edu0000129

Kim, Y. G., Petscher, Y., Wanzek, J., & Al Otaiba, S. (2018). Relations between reading and writing: A longitudinal examination from Grades 3 to 5. *Reading and Writing*, *31*, 1591–1618. https://doi.org/10.1007/s11145-018-9855-4

Kim, Y.-S. (2015). Language and cognitive predictors of text comprehension: Evidence from multivariate analysis. *Child Development*, *86*(1), 128–144. https://doi.org/10.1111/cdev.12293

Kim, Y.-S. G. (2016). Direct and mediated effects of language and cognitive skills on comprehension of oral narrative texts (listening comprehension) for children. *Journal of Experimental Child Psychology*, *141*, 101–120. https://doi.org/10.1016/j.jecp.2015.08.003

Kim, Y.-S. G. (2017). Why the simple view of reading is not simplistic: Unpacking the simple view of reading using a direct and indirect effect model of reading (DIER). *Scientific Studies of Reading*, *21*(4), 310–333. https://doi.org/10.1080/10888438.2017.1291643

Kim, Y.-S. G. (2020b). Hierarchical and dynamic relations of language and cognitive Skills to reading comprehension: Testing the direct and indirect effects model of reading (DIER). *Journal of Educational Psychology*, *112*(4), 667–684. https://doi.org/10.1037/edu0000407

Kim, Y.-S. G. (2020c). Interactive dynamic literacy model: An integrative theoretical framework for reading and writing relations. In R. Alves, T. Limpo, & M. Joshi (Eds.), *Reading-writing connections: Towards integrative literacy science* (pp. 11–34). Springer. https://doi.org/10.1007/978-3-030-38811-9_2

Kim, Y.-S. G., & Park, S. (2019). Unpacking pathways using the Direct and Indirect Effects Model of Writing (DIEW) and the contributions of higher order cognitive skills to writing. *Reading and Writing*, *32*(5), 1319–1343. https://doi.org/10.1007/s11145-018-9913-y

Kim, Y.-S. G., & Wagner, R. K. (2015). Text (Oral) reading fluency as a construct in reading development: An investigation of its mediating role for children from Grades 1 to 4. *Scientific Studies of Reading*, *19*(3), 224–242. https://doi.org/10.1080/10888438.2015.1007375

Kim, Y.-S. G., Boyle, H., Zuilkowski, S., & Nakamura, P. (2016). *The landscape report on early grade literacy skills*. United States Agency for International Development (USAID). https://globalreadingnetwork.net/publications-and-research/landscape-report-early-grade-literacy

Kim, Y.-S. G., Park, C., & Park, Y. (2015). Dimensions of discourse-level oral language skills and their relations to reading comprehension and written composition: An exploratory study. *Reading and Writing*, *28*(5), 633–654. https://doi.org/10.1007/s11145-015-9542-7

Kim, Y.-S., Al Otaiba, S., Folsom, J. S., Greulich, L., & Puranik, C. (2014). Evaluating the dimensionality of first-grade written composition. *Journal of Speech, Language, and Hearing Research*, *57*(1), 199–211. https://doi.org/10.1044/1092-4388(2013/12-0152)

Kim, Y.-S., Al Otaiba, S., Puranik, C., Folsom, J. S., Greulich, L., & Wagner, R. K. (2011). Componential skills of beginning writing: An exploratory study. *Learning and Individual Differences*, *21*(5), 517–525. https://doi.org/10.1016/j.lindif.2011.06.004

Kim, Y.-S., Al Otaiba, S., Wanzek, J., & Gatlin, B. (2015). Towards an understanding of dimensions, predictors, and gender gap in written composition. *Journal of Educational Psychology*, *107*(1), 79–95. https://doi.org/10.1037/a0037210

Kim, Y.-S., & Phillips, B. (2014). Cognitive correlates of listening comprehension. *Reading Research Quarterly*, *49*(3), 269–281. https://doi.org/10.1002/rrq.74

Kim, Y. S., Wagner, R. K., & Foster, E. (2011). Relations among oral reading fluency, silent reading fluency, and reading comprehension: A latent variable study of first-grade readers. *Scientific Studies of Reading*, *15*(4), 338–362. https://doi.org/10.1080/10888438.2010.493964

Kline, R. B. (2005). *Principles and practice of structural equation modeling* (2nd ed.). Guilford Press.

Langer, J. A., & Flihan, S. (2000). Writing and reading relationships: Constructive tasks. In R. Indrisano & J. R. Squire (Eds.), *Writing: Research/theory/practice* (pp. 112–129). International Reading Association.

Lee, J. (2013). Can writing attitudes and learning behavior overcome gender difference in writing? Evidence from NAEP. *Written Communication*, *30*(2), 164–193. https://doi.org/10.1177/0741088313480313

Lepola, J., Lynch, J., Laakkonen, E., Silvén, M., & Niemi, P. (2012). The role of inference making and other language skills in the development of narrative listening comprehension in 4- to 6-year-old children. *Reading Research Quarterly*, *47*(3), 259–282. https://doi.org/10.1002/rrq.020

Leslie, L., & Caldwell, J. S. (2011). *Qualitative Reading Inventory* (5th ed.). Pearson.

Mackie, C., & Dockrell, J. E. (2004). The nature of written language deficits in children with SLI. *Journal of Speech, Language, and Hearing Research*, *47*(6), 1469–1483. https://doi.org/10.1044/1092-4388(2004/109)

Maxwell, S. E., & Cole, D. A. (2007). Bias in cross-sectional analyses of longitudinal mediation. *Psychological Methods*, *12*(1), 23–44. https://doi.org/10.1037/1082-989X.12.1.23

McBride-Chang, C., Tardif, T., Cho, J.-R., Shu, H., Fletcher, P., STOKES, S. F., Wong, A., & Leung, K. (2008). What's in a word? Morphological awareness and vocabulary knowledge in three languages. *Applied Psycholinguistics*, *29*(3), 437–462. https://doi.org/10.1017/S014271640808020X

McCutchen, D. (1986). Domain knowledge and linguistic knowledge in the development of writing ability. *Journal of Memory and Language*, *25*(4), 431–444. https://doi.org/10.1016/0749-596X(86)90036-7

McMaster, K., & Espin, C. (2007). Technical features of curriculum-based measurement in writing: A literature review. *The Journal of Special Education*, *41*(2), 68–84. https://doi.org/10.1177/00224669070410020301

Miller, J. F., & Iglesias, A. (2006). *Systematic analysis of language transcripts (SALT)*. University of Wisconsin.

Muthén, L. K., & Muthén, B. O. (2020). *Mplus 8.4*.

Olinghouse, N. G. (2008). Student- and instruction-level predictors of narrative writing in third-grade students. *Reading and Writing*, *21*(1–2), 3–26. https://doi.org/10.1007/s11145-007-9062-1

Olinghouse, N. G., & Graham, S. (2009). The relationship between discourse knowledge and the writing performance of elementary-grade students. *Journal of Educational Psychology*, *101*(1), 37–50. https://doi.org/10.1037/a0013462

Olinghouse, N. G., Graham, S., & Gillespie, A. (2015). The relationship of discourse and topic knowledge to fifth graders' writing performance. *Journal of Educational Psychology*, *107*(2), 391–406. https://doi.org/10.1037/a0037549

Ouellette, G., & Beers, A. (2010). A not-so-simple view of reading: How oral vocabulary and visual-word recognition complicate the story. *Reading and Writing*, *23*(2), 189–208. https://doi.org/10.1007/s11145-008-9159-1

Pajares, F. (2003). Self-efficacy beliefs, motivation, and achievement in writing: A review of the literature. *Reading and Writing Quarterly*, *19*(2), 139–158. https://doi.org/10.1080/10573. 56030. 8222

Pajares, F., & Valiante, G. (1999). Grade level and gender differences in the writing self-beliefs of middle school students. *Contemporary Educational Psychology*, *24*(4), 390–405. https://doi.org/10.1006/ceps.1998.0995

Pearl, J. (2001). Direct and indirect effects. In J. Breese & D. Koller (Eds.), *Proceedings of the Seventeenth conference on uncertainty in artificial intelligence* (pp. 411–420). Morgan Kaufmann.

Pearl, J. (2014). Interpretation and identification of causal mediation. *Psychological Methods*, *19*(4), 459–481. https://doi.org/10.1037/a0036434

Perfetti, C. A. (1997). The psycholinguistics of spelling and reading. In C. A. Perfetti, L. Rieben, & M. Fayol (Eds.), *Learning to spell: Research, theory, and practice across languages* (pp. 21–38). Erlbaum Publishers. https://doi.org/10.4324/9781410604583

Perfetti, C., & Stafura, J. (2014). Word knowledge in a theory of reading comprehension. *Scientific Studies of Reading*, *18*(1), 22–37. https://doi.org/10.1080/10888438.2013.827687

Perin, D., Keselman, A., & Monopoli, M. (2003). The academic writing of community college remedial students: Text and learner variables. *Higher Education*, *45*(1), 19–42. https://doi.org/10.1023/A:1021237532056

Puranik, C. S., Lombardino, L. J., & Altmann, L. J. (2008). Assessing the microstructure of written language using a retelling paradigm. *American Journal of Speech-Language Pathology*, *17*(2), 107–120. https://doi.org/10.1044/1058-0360(2008/012)

Raftery, A. E. (1995). Baysian model selection in social research. *Sociological Methodology*, *25*, 111–163. https://doi.org/10.2307/271063

Reed, D. K., Petscher, Y., & Foorman, B. R. (2016). The contribution of vocabulary knowledge and spelling to the reading comprehension of adolescents who are and are not English language learners. *Reading and Writing*, *29*(4), 633–657. https://doi.org/10.1007/s11145-015-9619-3

Sáez, L., Folsom, J. S., Al Otaiba, S., & Schatschneider, C. (2012). Relations among student attention behaviors, teacher practices, and beginning word reading skill. *Journal of Learning Disabilities*, *45*(5), 418–432. https://doi.org/10.1177/0022219411431243

Scott, C., & Windsor, J. (2000). General language performance measures in spoken and written discourse produced by school-age children with and without language learning disabilities. *Journal of Speech, Language, and Hearing Research*, *43*(2), 324–339. https://doi.org/10.1044/jslhr.4302.324

Selig, J. P., & Preacher, K. J. (2009). Mediation models for longitudinal data in developmental research. *Research in Human Development*, *6*(2–3), 144–164. https://doi.org/10.1080/15427600902911247

Shanahan, T. (2016). Relationships between reading and writing development. In C. A. MacArthur, S. Graham, & J. Fitzgerald (Eds.), *Handbook of writing research* (pp. 194–207). Guilford Press.

Shanahan, T., & Lomax, R. G. (1986). An analysis and comparison of theoretical models of the reading–writing relationship. *Journal of Educational Psychology*, *78*(2), 116–123. https://doi.org/10.1037/0022-0663.78.2.116

Shrout, P. E., & Fleiss, J. L. (1979). Intraclass correlations: Uses in assessing rater reliability. *Psychological Bulletin*, *86*(2), 420–428. https://doi.org/10.1037/0033-2909.86.2.420

Swanson, J. M., Schuck, S., Porter, M. M., Carlson, C., Hartman, K., Sergeant, J. A., Clevenger, W., Wasdell, M., McCleary, R., Lakes, K., & Wigal, T. (2006). Categorical and dimensional definitions and evaluations of symptoms of ADHD: History of SNAP and SWAN Rating Scales. *The International Journal of Educational and Psychological Assessment*, *10*(1), 51–70.

Swartz, C. W., Hooper, S. R., Montgomery, J. W., Wakely, M. B., de Kruif, R. E. L., Reed, M., Brown, T. T., Levine, M. D., & White, K. P. (1999). Using generalizability theory to estimate the reliability of writing scores derived from holistic and analytical scoring methods. *Educational and Psychological Measurement*, *59*(3), 492–506. https://doi.org/10.1177/00131649921970008

Torgesen, J. K., Wagner, R. K., Rashotte, C. A. (2012). *Test of word reading efficiency* (second edition). Pro-Ed.

Wagner, R. K., Puranik, C. S., Foorman, B., Foster, E., Wilson, L. G., Tschinkel, E., & Kantor, P. T. (2011). Modeling the development of written language. *Reading and Writing*, *24*(2), 203–220. https://doi.org/10.1007/s11145-010-9266-7

Wechsler, D. (2009). *Wechsler Individual Achievement Test* (3rd ed.). Pearson.

West, S. G., Finch, J. F., & Curran, P. J. (1995). Structural equation models with nonnormal variables: Problems and remedies. In R. H. Hoyle (Ed.), *Structural equation modeling: Concepts, issues and applications* (pp. 56–75). Sage.

Woodcock, R. W., McGrew, K. S., & Mather, N. (2001). *Woodcock–Johnson III Tests of Achievement*. Riverside.

(*Appendices follow*)

Appendix A

Component Skills of Writing According to the Direct and Indirect Effects Model of Writing (DIEW; Kim & Park, 2019)

Component skills	Characteristics
Background knowledge	• Content/topic knowledge & discourse knowledge (knowledge about characteristics of different genres such as text structure and associated key words, and about procedures and strategies to present content appropriate for the genre such as narrative and different types of informational texts). • Needed for generating content and presenting content/texts using structures and conventions expected in various genres and tasks (Bereiter & Scardamalia, 1987; Hayes, 2006; McCutchen, 1986; Olinghouse et al., 2015; Perin et al., 2003)
Social-emotions about writing	• Attitude, interest, motivation, efficacy, self-concept, anxiety • Needed to support writing process and tasks (Graham et al., 2007; Lee, 2013; Pajares, 2003; Pajares & Valiante, 1999) • Develop in tandem with writing development
Transcription	• Spelling, handwriting, keyboarding • Necessary for production of written compositions; automaticity in transcription skills allows cognitive resources such as attention and working memory to be available for higher-order processes (Berninger & Winn, 2006; Bourdin & Fayol, 1994; Graham et al., 1997)
Emergent literacy skills and metalinguistic awareness	• Knowledge and awareness of phonology, orthography, and semantics (e.g., morphology) • Needed for word reading and spelling (Adams, 1990; Bishop & Snowling, 2004)
Oral composition or discourse oral language	• The skill to generate ideas and represent them in oral language at the discourse level such as telling a story or generating informational oral texts • Similar to "ideation" in the simple view of writing (Juel et al., 1986) or "text generation" in the not-so-simple view of writing (Berninger & Winn, 2006). • The terms "oral composition" and "discourse oral language," instead of ideation or text generation, are used in DIEW for a couple of reasons. First, the term "oral" composition clarifies the construct—it is one's ability to compose in oral mode, not in written mode. Second, the term, discourse oral language, aligns this ability with oral language literature, and indicates that this is a "discourse-level" oral language skill—one's skill to participate in extended conversations, and comprehend and produce stories and expository oral texts. As a discourse-level language skill, it is supported by background knowledge, vocabulary, grammatical knowledge, and higher-order cognitions and regulation as well as domain-general cognitions (Kim, 2015, 2016).
Foundational oral language	• Vocabulary, grammatical knowledge [morphosyntactic and syntactic knowledge]), sentence comprehension and construction • Needed for syntactic maturity, use of varied and appropriate sentence structures, and precise and rich vocabulary (Kim et al., 2011, 2015; Olinghouse, 2008)
Higher-order cognitions & regulation	• Reasoning, inference, perspective taking (including audience awareness), goal setting, monitoring, self-assessment, self-reinforcement • Needed to establish local and global coherence, to detect and correct any errors, and to monitor and regulate one's performance and employ appropriate strategies throughout the reading and writing process (Kim, 2020a, 2020b; Kim & Schatschneider, 2017).
Executive functions (Domain-general cognitions)	• Working memory, inhibitory and attentional control, and shifting • Necessary for all learning tasks and processes, including writing and its component skills noted above.

Note. See Kim and Park (2019) for details of the hierarchical relations hypothesis, dynamic relations hypothesis as a function of development, and interactive relations hypothesis.

(*Appendices continue*)

Appendix B

A Chain of Multichanneled Indirect Effects, Using the Example of Working Memory on Writing

Studies have shown that working memory is a necessary skill for writing (e.g., Bourdin & Fayol, 1994; Hayes & Chenoweth, 2007) *and* for component skills of writing: Working memory contributes to vocabulary, grammatical knowledge, and higher-order cognitions (Gathercole & Baddeley, 1990; Kim, 2017), which are related to discourse oral language (Kendeou et al., 2008; Kim, 2016). and discourse oral language is related to written composition (Berninger & Abbott, 2010; Juel et al., 1986; Kim & Schatschneider, 2017). These findings suggest the following chain of relations: working memory → vocabulary and grammatical knowledge → higher-order cognitions → discourse oral language → written composition. In other words, working memory likely makes a contribution to writing process indirectly via vocabulary, higher-order cognitions, and discourse oral language. Working memory is also posited to influence writing via transcription skills (working memory → phonological, orthographic, and semantic knowledge/awareness → spelling and handwriting → written composition; see Figure 1).

Appendix C

Writing Quality-to-Reading Comprehension Model

Three structural equation models, Figure 4a+, Figure 4b+, and Figure 4c+, were fitted to examine the relation of writing quality to reading comprehension. These models were identical to those in Figure 4 except that writing quality predicted reading comprehension.

Table C1

Model Fit of Writing Quality-to-Reading Comprehension Model

Figure	$\chi^2(df)$, p value	CFI (TLI)	RMSEA (SRMR)	nBIC	Model fit comparison
Figure 4a+	452.82(200), <.001	.94 (.93)	.06 (.09)	45,277.69	
Figure 4b+	418.50(199), <.001	.95 (.94)	.06 (.06)	45,246.05	Figure 4a+ vs. Figure 4b: $\Delta\chi^2$ ($\Delta df = 1$) = 34.32, $p < .001$
Figure 4c+	374.10(199), <.001	.96 (.95)	.05 (.05)	45,201.65	Figure 4a+ vs. Figure 4c: $\Delta\chi^2$ ($\Delta df = 1$) = 78.72, $p < .001$ Figure 4a+ vs. Figure 4c: ΔnBIC = 44.4

Note. CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual; nBIC = sample size adjusted Baysian Information Criterion. The Figure 4c+ model was the best fitting model according to chi-square values and nBIC values. To compare the Figure 4c model here with that of Figure 5a, nBIC values were compared because these models are not nested. The nBIC value of the Figure 5a model is smaller by 6.10 than that of the Figure 4c+, indicating superiority of the Figure 5a model according to the criteria by Raftery (1995). That is, the reading comprehension-to-writing quality model shown in Figure 5a fits the data better than the writing quality-to-reading comprehension model (Figure 4c+ model).

Received May 3, 2020
Revision received March 3, 2021
Accepted April 12, 2021 ■