The Science of Reading is Incomplete Without the Science of Teaching Reading

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We now know a tremendous amount about early reading development, including the various skills that learners have to master and integrate to be both effective word readers and skilled comprehenders. The body of work referred to as the "science of reading" has helped illuminate these processes, and it offers important guidance for the learning opportunities that educators should be making available to students in kindergarten through third grade. However, the numerous advances of the last 50 years in the science of reading need to be complemented with equivalent attention to the "science of teaching reading." The science of teaching reading is insufficient, and the following topics each deserve a research agenda of their own: how literacy is actually taught in the classroom, and how preservice and in-service teachers learn to teach reading and learn to create and sustain learning environments. If researchers are to effectively collaborate with practitioners to improve reading outcomes, we must ask root cause questions regarding the realities of how preservice and in-service teachers learn to teach reading, and what the barriers are to effective transfer and translation of their learning to student outcomes.

We offer two reasons for this expanded focus. First, knowledge about the cognitive processes that are required in word reading development does not translate directly to knowledge about how to *teach* those processes any more than detailed knowledge about how an airplane engine works translates into skill at piloting the plane. The science of reading highlights the skills that learners need to develop, and it illuminates what learning opportunities may be needed. However, it does not specify precisely what needs to be taught, with what intensity or frequency, in what combination, or what additional components and supports will ensure collaborative relationships among classroom community members to allow for student inquiry, engagement, healthy risk-taking, and motivation. Second, many public opinions about the teaching of reading are infused with science-of-reading perceptions of what should be happening in classrooms rather than evidence about the practices and experiences occurring in primary grade classrooms or teacher education programs. The impressive body of knowledge about reading development should match rigorous direct evidence about how students are being taught to read and how teachers have learned what they know about teaching literacy—whether from preservice courses, professional development opportunities, colleagues and coaches, or classroom experiences. Some knowledge about these topics is starting to accumulate

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(see below), but many of the criticisms about reading outcomes are based on beliefs rather than knowledge about literacy teaching. Only when we know more clearly what teachers are doing in primary classrooms, why they are doing it, and how their practices and beliefs relate to children's literacy outcomes will we be able to make well-founded recommendations for improving practice that is aligned with the science of reading. The following key questions motivate us:

1. What do teachers know (and believe) about how to teach reading?
2. Where did they acquire their knowledge?
3. How does their knowledge manifest itself in the classroom?

We argue for a newly expanded research agenda to build a comprehensive knowledge base about how reading is actually being taught in the primary grades and what levers exist to ensure that what goes on in prima-

ry classrooms is aligned with what we have come to know about literacy development and instruction.

The Science of *Teaching* Reading

The ongoing science of reading debate is often interpreted as being directly translatable into guidance about *teaching* reading, specifically word reading. Accumulated research supports the value of teaching phonological, orthographic, and morphological awareness explicitly and systematically (NICHD, 2000; Rayner et al., 2001), and mastery in reading words accurately and efficiently is achieved through a gradual learning process based on exposure to many examples. It is important to note that while the science of reading dictates that learners come to understand the alphabetic principle—that graphemes represent phonemes—and the roles of phonemes, graphemes, and morphemes in words' spellings, it does not itself directly tell us how learners best acquire that knowledge. The implication that students need to be taught X directly and explicitly based on the evidence that students need to know X seems logical, but it does not hold in all domains. There is accumulating evidence that it does hold in the domain of decoding for many native English speakers, for children learning English as an additional language, and for children from various linguistic, cultural, and economic backgrounds across the world (NICHD, 2000; Kim et al., 2020). Furthermore, there is more than one approach to making the alphabetic principle accessible to young children, ranging from scripted, structured, sequential programs focused on reading or on spelling, to invented spelling, or teaching just enough phoneme-grapheme correspondences that decodable texts become resources for self-teaching, and so on. We are not endorsing any of these in particular, but simply pointing out that the science of reading is not completely sufficient for choosing among them. We need a science of teaching reading as well.

One of the major points of contention in the discussion of word reading development is the relevance, or perhaps irrelevance, of language acquisition as a model. Language is acquired universally and naturally without direct teaching, though it is greatly facilitated by enriched language environments. "Whole language" approaches invoke the natural development of language skills as support for the claim that children can infer meaning from print (Goodman, 1970). However, word reading is an unnatural act (Castles et al., 2018)—different from language learning and language ac-

quisition in that reading is *not* universal across cultures, languages, or individuals. It could be argued that oral language comprehension is natural in a way that word reading is not, and thus only word reading requires instruction. The evidence is strong that oral language skills are foundational for comprehension (Castles et al., 2018). However, it is becoming increasingly clear that natural language acquisition without enrichment of the oral language environment fails to provide sufficient exposure to vocabulary and academic language structures that students in later grades will encounter in texts (Castles et al., 2018). Incorporating language comprehension into the design of early literacy requires giving attention to the sophisticated language structures, content knowledge, critical thinking skills, and conceptual challenges that will later influence reading comprehension (Kim, 2020).

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Skilled reading comprehension involves simultaneously constructing and extracting meaning from print. It also requires evaluating newly encountered information, integrating it with pre-existent concepts, and analyzing and critiquing it. Comprehension is complex, and research indicates the importance of developing comprehension early in oral language contexts (i.e., listening comprehension) and continuing to develop it in written language contexts (i.e., reading comprehension). Because comprehension and knowledge acquisition are the ultimate goals of reading, procedures that promote word reading skill without attending to comprehension do not serve students well. Yet comprehension and knowledge acquisition are often ignored in the popular version of the science of reading debate, which focuses on drawing implications about the best methods for teaching decoding and early reading. This omission is a major source of miscommunica-

tion among the various participants in the debate. The emphasis on explicit and systematic teaching of word reading does not diminish the importance of laying the groundwork for successful comprehension. Also underrecognized in the current science of reading debate is a need for a better understanding about the science of teaching reading in later grades (e.g., adolescent readers).

The Teaching of Reading in the Classroom

Educating the child to be a competent reader is the collective responsibility of multiple stakeholders. Teachers have a particularly crucial role for students who are more dependent on school-based experiences to develop adequate literacy skills, general knowledge, and critical thinking. Teaching reading is highly skilled work. It requires well-trained teachers and educators who are knowledgeable about reading development, data-based and assessment-based instructional decisions, and a wide array of evidence-based and personalized teaching strategies.

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Evidence clearly indicates the role of teachers in children's learning, including literacy skills. However, teachers vary considerably in their knowledge about language and literacy development and the teaching of literacy (e.g., Washburn et al., 2016). Teachers' practices for teaching reading also vary widely, and this variation is linked to both their knowledge and their students' achievement (e.g., Connor et al., 2014). In other words, teachers who have greater specialized knowledge about reading development and teaching reading provide higher quality reading instruction, which, in turn, predicts students' literacy outcomes. This begs the question, "What do we know about the teaching of reading in the primary classroom across different settings and with different students?" Popular media articles have recently criticized

the lack of research-based approaches to teaching word reading in classrooms, reporting findings from interviews with teachers, principals, and parents (e.g., Goldstein, 2020; Hanford, 2019). Although valuable for conveying the voices of immediate stakeholders, media articles do not provide a comprehensive and precise picture about what really goes on in the classroom, contributing to imbalance between rigorous studies of early reading and secondhand reports about teaching reading. The classroom is a complex ecosystem, and the teaching of reading in most primary grades likely reflects a mixture of approaches. We simply do not have sufficient evidence about how the conditions that support access to word reading are created—methods used, time invested, attention to motivation, whether or how phonics approaches are integrated with meaningful and motivating activities, and how the precursors to comprehension are simultaneously supported.

One data source from popular media based on the use of a particular reading curriculum suggests that approximately 20% of U.S. schools are spending less than the recommended amount of time on systematic teaching of decoding (Goldstein, 2020). Responding to a survey administered to a national sample of kindergarten, first, and second grade teachers, 50 to 60% reported teaching the five instructional targets ratified by the National Reading Panel Report (phonemic awareness, phonics, reading fluency, vocabulary, and comprehension; NICHD, 2000) daily, and 20 to 30% reported teaching them once or twice per week (Kretlow & Helf, 2013). Another survey with 674 primary grade and special education teachers presents a more detailed but concerning picture (Loewus, 2019). More than a quarter of the teachers reported telling beginning readers to look at pictures to figure out how to read a word, and another 13% reported telling children to use context clues to make a guess rather than using their knowledge of internal structures of words, such as grapheme-phoneme correspondences and grapheme-morpheme correspondences. Considering context clues, including pictures, is appropriate for the purpose of confirming children's comprehension of texts. However, using these as *word reading* strategies disrupts attention to the internal structures of words—children need to be able to decode words without accessing context clues or pictures. Although informative, these data sources do not provide precise or comprehensive information. Surveys, although helpful, may not paint an accurate picture as responders may feel pressure to give answers that are

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socially acceptable. Curriculum is an important source of teaching practices, but it certainly does not fully capture enacted curriculum—how teaching is co-constructed by students and teachers and how curriculum materials are interpreted and used by teachers.

Ultimately, a precise understanding of teaching practices requires classroom observation. Classroom observations can reveal the extent to which various approaches to teaching reading (content, type, amount, and quality of teaching) are employed and the conditions that support or interfere with student learning. For example, recent classroom observation data from 56 primary grade classrooms in southern California, Columbus, Ohio, and Lincoln, Nebraska showed less than the recommended amount of phonics teaching in primary grades (Connor et al., 2020). Other studies found large variation in the amount of teaching time expended on non-instructional activities (e.g., Piasta et al., 2009). These studies illustrate the need to capture teaching practices as a critical part of efforts to improve the teaching of reading and student outcomes. An accurate picture about how reading is really taught in classrooms provides a basis for systematic efforts to improve teaching practices, so they are aligned with the science of reading and are practical, feasible, scalable, and sustainable. For example, by now a body of studies has shown effective research-based practices of teaching reading and writing in controlled settings. However, more often than not, these practices do not make it to real classrooms, and their effects are not borne out in scale up efforts. Systemic and systematic efforts are needed in multiple dimensions such as translation, dissemination, and implementation sciences (see Solari et al., 2020, for details).

Although the debate on the science of reading has largely focused on the presence or absence of phonics, another important aspect that should not be omitted is the presence of effective teaching practices. Phonics

itself does not guarantee good outcomes if it is poorly implemented. Similarly, whole-language approaches do not guarantee the development of a love for reading and literature if they fail to provide the instruction needed for independent reading. Good or poor teaching can be found everywhere across the phonics and whole-language spectrum. Effective teaching is multidimensional, encompassing appropriate content, appropriate methods, effective scaffolding and feedback, efficient use of time, enriching teacher talk and discussion, a positive learning climate, and teacher warmth and responsiveness (e.g., Connor et al., 2014). Therefore, the science of teaching reading should focus not just on the presence or absence of phonics, but also on the elements of effective teaching in general.

Teacher Education

In a recent survey, only 5% of teachers reported learning about the teaching of reading in preservice programs; the majority of teachers reported learning about the teaching of reading on the job via curricula, colleagues, and/or in-service professional development (Loewus, 2019). On one hand, these findings indicate a need for greater attention to teachers' learning

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beyond teacher preparation programs, which is well recognized in the field of teacher development and education (e.g., Darling-Hammond & Bransford, 2005; Snow et al., 2005). On the other hand, these results also dictate a need to think carefully about preservice teachers' learning in teacher education programs. Teacher education in the U.S. takes place primarily in certification programs at colleges or universities, although there are other pathways to obtaining teaching credentials (e.g., district programs and exams). Therefore, necessary participants in the debate about teacher development are teacher education programs and associated regulatory bodies. Teacher education programs respond to many demands, but

relevant to the current topic is how preservice elementary teachers learn about teaching literacy, including the content of literacy methods courses and field experiences, and the knowledge of teacher educators teaching these courses.

Data suggest that attention to the basics of teaching decoding as one part of teaching reading may be limited in many preservice education programs. Although a recent review by the National Council on Teacher Education (2020) showed an increasing inclusion of such elements between 2013 and 2020, one third to one half of teacher education programs are still not providing their graduates with knowledge about the basics of teaching literacy. The local organization of education in the United States generates enormous difficulty in creating or enforcing rules, standards, or guidelines for teacher education. Teachers are being prepared for generic positions in any of a large number of districts, sometimes distributed across states. Efficiency of preparing teachers to use a particular curriculum or model in a particular grade or grade band (e.g., licensure for prekindergarten and kindergarten, and a separate licensure for elementary grades), something relied upon in centralized education systems such as Finland, South Korea, Singapore, and Japan, are lost. As a result, there is not a lot of time to focus on early literacy—a fact which no doubt accounts for teachers frequently reporting that they have to rely on curriculum-linked professional development and colleagues for knowledge about how to teach reading. This situation raises the urgency of several issues: (a) deciding what knowledge and skills all preservice education students should have access to; (b) exploring how to create a better and more universal induction system to recognize that new teachers' knowledge needs to be adapted to local school settings and precise job descriptions; and (c) studying the supports to both teacher learning and student progress offered by various literacy curricula. Such efforts would likely reveal that there are few sources of accountability to ensure high quality in teacher education programs, and that most teacher preparation programs are too short to cover the full range of skills and knowledge required.

Implications

There are several areas that need support and investment to extend our knowledge base of the science of teaching reading. First, systematic investment is needed to develop an honest picture about the teaching of reading in K-12 classrooms. It is important to point out that the teaching of reading here refers to reading as a whole, not just beginning reading which is the primary focus in the science of reading debates. Learning about what is really being taught in classrooms via surveys, interviews, and observations is a first step. Grant opportunities should be expanded to fund classroom-based, implementation research on current effective and ineffective teaching practices and their links to student achievement. Of course, the goal of the observations should not be to find fault with teachers, but rather to describe and characterize teaching strategies used for the teaching of reading and to support teachers who are eager to improve their practice. Several reliable observation tools and approaches are available for this work (Connor et al., 2020). Classroom observation can be highly resource-intensive, but advances and innovations (e.g., automated transcription) can make it feasible at a larger scale without prohibitive costs.

In addition, a better understanding is needed about how and where teachers gain knowledge and beliefs about how to teach literacy. A large body of studies exists on teacher education in general (e.g., Darling-Hammond & Bransford, 2005), but we need a clearer picture of what preservice teachers are learning in their literacy courses, as well as a clearer picture of the role of curriculum publishers that provide professional development and how the quality of their offerings is assured. In addition, we need to understand more about the focus and content of district professional development related to literacy instruction.

Similar questions are also raised about teacher education programs. Research on teacher educators in general is extremely limited, let alone teacher educators of future primary grade teachers. Consequently, little is known about foundational questions, including:

1. Who teaches reading methods courses and field experiences (e.g., permanent faculty, adjunct faculty, doctoral students)?
2. What consequences result from who teaches these courses, and how they are taught?
3. How do teacher educators' beliefs and experiences shape, influence, and interact with their design for these courses?
4. What features of reading methods courses relate to preservice teachers' short-term and long-term outcomes?
5. How do teacher educators' knowledge and teaching practices develop over time, and what factors and conditions influence their professional developmental trajectories?

There is also a need to expand support for continuous professional development of practicing teachers and teacher educators in both traditional and non-traditional certification programs. Learning in teacher education programs and certification are only the beginning of teachers' development as adaptive experts, and professional growth continues throughout a lifetime of practice (Snow et al., 2005). A majority of teachers in the U.S. expressed that they learned about the teaching of reading on the job (Loewus, 2019), which indicates the importance of in-service professional development for the teaching of reading (Snow et al., 2005). Despite its importance, however, a national survey revealed that a third of the teachers reported never having received any professional development on the teaching of reading, and 20% reported having received professional development more than 10 years earlier (Kretlow & Helf, 2013).

Evidence indicates that professional development can change teachers' mental models of reading development and teaching, increase teacher knowledge about teaching literacy,

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change teaching practices, and meaningfully enhance student literacy outcomes. A recent meta-analysis revealed an effect size of .22 on student reading outcomes for professional development focused on teaching decoding, and .17 for professional development on meaning-focused teaching (Didion et al., 2020). These findings dictate a need for systematic, structured, and continuous professional development for teachers on teaching reading. Similar support and professional development are necessary for school and district leadership, and teacher educators as well. The science of reading debate highlights ways to strengthen the pipeline of teacher education. Research on this topic is extremely limited, but recent efforts are growing (e.g., Folsom et al., 2017).

Third, there is a need to develop and expand bidirectional communication between the research community and the community of practice, including teacher educators, teachers, school administrators, policy makers, and parents. Two major gaps have become noticeable: between what is known and what is done, and between the research community and the community of practice. Research findings have difficulty traversing the long road into the classroom, and ideas and voices from the classroom are not systematically reflected in research. Investment in strategies for making research more directly relevant to practice in ways that transcend dissemination challenges is sorely needed. There is considerable information available about what is needed for quality teaching of literacy (e.g., Aaron et al., 2008; International Dyslexia Association, 2018), and the community of practice offers tremendous funds of knowledge. However, less known is how to build and co-construct knowledge between the research community and the community of practice to generate and contribute to research on teaching literacy and to improve student literacy outcomes.

One way to accomplish bidirectional communication is by cultivating knowledge brokering in the field of literacy to create linkages and help knowledge travel between researchers and the community of practice. Knowledge brokering involves the identification of knowledge, the redistribution and dissemination of knowledge, and the rescaling and transformation of knowledge. A knowledge broker is a person or organization "that facilitate[s] the creating, sharing, and use of knowledge" (Meyer, 2010, p. 119) and that bridge[s] the gap between knowledge producers (e.g., scientists) and those who use knowledge (e.g., policy makers, the general public, practitioners). The gap between research and practice is not due entirely to a lack of access to research-based knowledge and practices, although it is certainly an important part of the challenge. Philosophical orientations and styles of science (e.g., Stanovich, 2003) have a large influence on the beliefs held by the public, teacher educators, teachers, and policy makers, determining both what one considers to be evidence and to what extent they embrace guidance from research findings (Kahan, 2013). Therefore, efforts in knowledge brokering and communication should include learning about and understanding factors that influence one's beliefs about learning and teaching, conditions and environments that support public understanding of science, and effective ways to build communication channels.

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Finally, the debate on the science of reading also compels colleges of education to support teacher education programs, training of teacher educators, and committed partnerships with local schools and communities. Regardless of where teacher education programs are housed (regional state universities where teacher professional preparation is the focus or research-intensive universities where research is the main focus) and the roles teacher education programs historically played in these different contexts, it is important for colleges of education to see teacher education programs as a critical, not peripheral, part of their mission, and to provide necessary support. In particular, the emphasis on research and academic training in research-intensive doctoral programs may have inadvertently drawn attention away from training of doctoral students as teacher educators. Doctoral students who concentrate on literacy may not always have an adequate opportunity to develop the skills needed to work with and mentor teacher candidates. Striking the balance between academic rigor and professional relevance (i.e., practice) is difficult, yet critical to educational improvement.

Conclusion
We propose a new, expanded agenda designed to develop an understanding about a critical educational practice, teaching reading. Over the last 50 years, the research community has devoted considerable time and energy to arguments about reading development, and to testing the effectiveness of a wide array of possible approaches to understanding and improving the teaching of reading. Indeed, the *First Grade Studies* (Bond & Dykstra, 1967) offered a model for investigating classroom practice that needs to be replicated, as so much about teaching reading has changed since 1967. We need data about how reading is taught and how preservice and inservice teachers learn about teaching reading for collaboration between the research community and the community of practice. The *science of reading* is incomplete without the *science of teaching reading*. ∎

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