

*Introduction to The Science of Reading:
What Educators Need to Know and Apply*

The science of reading represents an extensive body of research explaining the cognitive and neural pathways involved in reading. Much is known about how children learn to read, why some struggle, and how to effectively instruct and intervene. The fields of neurology, linguistics, cognitive psychology, learning science, school psychology and educational psychology have generated vast information that bears on teaching reading, however, much of this information is not known by classroom teachers. Making better use of the existing research literature on the components of language, reading, and effective instruction is an opportunity to increase the literacy levels of all students.

How Students Learn to Read

One hundred years ago there were multiple theories about how children learn to read. It was acceptable to believe that reading was primarily a visual memory task, or that there are multiple ways that children can learn to read, or even that reading develops naturally. Decades of scientific research have disproven each of these beliefs and concluded that although there are many approaches to teaching reading, all children learn to read in the same way. Researchers have identified the neurological circuit that must be created for students to become skilled readers. These findings have been replicated across decades by multiple researchers, from multiple disciplines, and in multiple countries. This body of knowledge is what is known as the science of reading. All teachers should have knowledge of what is required to create a reading brain so they can apply this knowledge to assessment, instruction, and intervention.

Humans are genetically wired for language, but not for print. There is no single area of the brain devoted to reading. Areas of the brain that are specialized for other skills and tasks have to be coordinated to produce reading. Teachers need to know that reading is not natural. Children do not become readers by being read to, being in a print-rich environment, or by acquiring background knowledge alone.

Reading is a relatively recent human accomplishment that is the result of the complex process of translating symbols into sounds, then into words, and ultimately sentences that carry meaning. Beginning readers must use letter-sound relationships, through phonology, to access the meaning of a written word that is in their oral vocabulary. Once a word has been read correctly multiple times, it can be stored in long-term memory so that the meaning can be automatically retrieved from the print, without having to go through the phonological circuit. Automatic recognition of words in connected text frees the brain to focus on the meaning of what is being read. Fluent reading of text is the first step toward students who can talk and write about what they have read. Reading comprehension is the goal of reading all instruction. Research can inform the most effective and efficient ways to get to that goal.

Beginning reading instruction and intervention instruction that includes phonological awareness, phoneme-grapheme matching, vocabulary, and practice in controlled text is more likely to result in reading comprehension. Brain imaging from fields outside of education shows that new young readers and older struggling readers are different from skilled readers in terms of

the brain circuits they use, the regions of the brain involved in decoding, and the amount of effort involved in reading. Perhaps the most optimistic finding is that effective instruction changes the brains of struggling readers to look and perform more like skilled readers. These physical changes to the brain can be seen on scans such as fMRIs. One clear finding in the educational research is that what we do in the classroom matters a great deal. A knowledgeable teacher is a child's best opportunity for better literacy outcomes.

When teachers know how the cognitive processes interact in the brain, they can teach reading effectively, detect struggling readers even earlier, prevent reading failure for the vast majority of students, and provide effective, perhaps even intensive, support for those who need it. What happens in primary grade reading instruction can make the difference in whether or not students learn to read. Secondary teachers who can intervene early and intensely can change outcomes for their students. Teachers have a responsibility to apply the research in their classrooms. Putting the science of reading into the hands of classroom teachers is the goal of teacher educators.

What to Teach

In April of 2000, The National Reading Panel released a report of its meta-analysis of the reading research to date. The findings were based on rigorous reviews of experimental studies resulting in a summary of the scientific evidence for what and how to teach beginning and struggling readers. The report was organized around five essential skill areas required of skilled readers. Since publication, subsequent research has only confirmed and extended the original findings, thus providing even greater scientific support for the essential skills. *Ohio's Plan to Raise Literacy Achievement* references the National Reading Panel and refers to these essential skills as the five components of reading.

Component	Definition
Phonemic Awareness	Manipulating individual speech sounds.
Phonics	Matching sounds to letters for use in reading and spelling.
Fluency	Reading connected text accurately and fluently.
Vocabulary	Knowing the meaning of words in speech and print.
Reading Comprehension	Understanding what is read.

Simple View of Reading. The Simple View of Reading is based on research indicating that reading comprehension is the product of decoding (word-level reading) and language comprehension. The equation depicted in The Simple View articulates that neither decoding nor language comprehension alone can produce reading comprehension. When one or the other is absent, reading comprehension won't occur. Although depicted simply, the skill domains of decoding and language comprehension include complex constructs, each of which needs to be understood separately and as it relates to the others. Decoding (word level reading) includes decoding, print concepts, phonological awareness, phonics and word recognition, and word knowledge. Language Comprehension includes background knowledge, academic language, academic vocabulary, inferential language skills, and narrative language skills.

Understanding this model helps teachers provide appropriate evidence-based instruction. Although these skills are represented in most state standards for teaching English Language Arts, the low percentage of students who read at grade level highlights teachers' lack of understanding and application of the concepts and skills represented by this model.

Coursework for beginning teachers should include details about what each skill is, why it is important, and how it is related to other skills. All teachers must learn how to assess these foundational skills and become familiar with the research on how best to teach and intervene on these skills.

Reading Rope. Hollis Scarborough expanded on the relationship between the components represented in The Simple View of Reading in her classic rope model. The rope represents the components of decoding and language comprehension as they come together to support reading comprehension. Not only are the many components of decoding and language comprehension inter-related, the two skill areas must be integrated in order for reading comprehension to take place.

Four-Part Processor. Research by cognitive psychologists suggests the two processes represented in The Simple View of Reading (decoding and language comprehension) are generated by three neural systems (semantic, phonological, and orthographic) Those neural systems are depicted and extended in Seidenberg & McClelland's Four-Part Processor model of reading. The model is a representation of the cognitive processes of the anatomy and function of the reading brain that provides a framework for why reading instruction should focus on certain skills, and what to consider as targets of intervention when reading problems occur.

The above research models converge around scientific evidence of the essential components of reading. They show why automatic processing of sounds, letters, and morphemes, as well as language comprehension, word meanings and background knowledge come together in what we recognize as reading comprehension. Teachers must know the five components of reading, how these skills are developed and work together in the brain to result in reading, how to assess these skills, and what research says about the best ways to teach these skills. This knowledge will equip teachers to provide assessment, instruction, and intervention that will increase reading outcomes.

How to Teach

While some children seem to learn to read regardless of the instruction they receive, for most students, instruction can make the difference between reading or not reading. Undergraduate students select the field of education because they want to make a difference in children's lives. They understand intuitively that what they do in the classroom can change the future. Research-based instruction provides the bridge between this fundamental belief and how to make this a powerful reality in daily classroom practices.

Research has determined that explicit and systematic instruction is essential for beginning readers and older struggling readers, and also helps high-performing students. Systematic instruction follows a logical sequence from easier to harder skills, building more complex skills

after establishing pre-requisite skills. Explicit instruction is errorless learning. Based on the science concluding that reading is an "unnatural" skill, explicit instruction does not assume children will learn the core components of reading on their own, but instead provides a controlled and supportive environment in which to learn the skills correctly the first time through modeling, differentiation, guided practice with immediate corrective feedback, and sufficient repetition in multiple contexts to support mastery and automaticity.

Although all children benefit from explicit and systematic reading instruction, these practices are essential when the student is new to a skill, the skill has one correct answer, the student has little background knowledge or the student has a history of failure

Teaching reading is a high-stakes endeavor that must be approached by a skilled professional with a sense of urgency. Waiting for failure is not an option. The path to reading is established very early, and trends over time are quite stable. Students who struggle with reading at the end of first grade are likely to still struggle at the end of fourth grade. Intervening with struggling readers may take intensive resources and support. Teachers need the benefit of instructional approaches that have been proven to work in experimental studies. The best opportunity for better reading outcomes involves teachers who know how students learn to read, know what component skills are essential, and know how to match student needs to instruction on those skills.

Structures for Delivering High-Quality Reading Instruction: Multi-Tiered Systems of Support (MTSS)

MTSS involves the application of collaborative problem solving to the design of systems of increasingly intensive instructional supports that improve reading outcomes for all students. The approach originated as a way to prevent reading failure for the vast majority of students, through the application of three tiers of prevention, now thought of as three tiers of instructional support.

Tier 1 (Primary Prevention)	Instruction that is done with all students in the general education classroom, that is research-based, highly differentiated in whole group and skill-based small group formats, and causes at least 80% of students to reach reading goals.
Tier 2 (Secondary Prevention)	Small-group instruction for a small number of students who are at risk, provided in addition to (not instead of) Tier 1, that is more explicit and systematic, for the purpose of accelerating learning and catching up another 15% of students.
Tier 3 (Tertiary Prevention)	Even more individualized and intensive instructional support for students who are not making adequate progress with Tiers 1 and 2, for the purpose of supporting the remaining 5% of students to reach reading goals.

Collaborative Problem Solving. The systematic process of asking and answering questions with data is called collaborative problem solving. In spite of the broad evidence base that should inform reading instruction, what is known can't reliably predict what will work with every individual. In addition, the scientific knowledge base is constantly growing and evolving. Therefore, teachers need to adopt something like the scientific method in their classroom through theory development and hypothesis testing. The problem solving process is applied at all levels of the school system, from individual students to building-level concerns.

Step	Question
1	Which systems and which students need instructional support?
2	Why is the problem happening?
3	What should be done to help?
4	Did the help work?

Assessment. Teachers are both consumers and producers of the assessment data used within the problem solving process. Direct measurement of the five components of reading informs the creation of multi-tiered systems of support. Schools that implement MTSS engage teachers in using assessment data to guide decisions about infrastructure (scheduling, grouping, resource allocation), curriculum and instruction, intervention planning and evaluation, and communicating with parents.

Implementation of MTSS requires four types of assessment:

- universal screening
- diagnostic
- progress monitoring
- outcome evaluation

Teachers need to know how to read research, and how to select instructional and intervention materials that are based in scientific evidence. At the core of this knowledge is the rejection of the statement "there is research to support every belief or practice." Teachers must know the difference between a publication that includes opinion or experience (example) and a scientific journal (example); and between experimental and quasi-experimental or qualitative research designs.

Conclusion

How the brain learns to read is now confidently referred to by those outside of education as "settled science." Unfortunately, teachers are not always equipped with the widely known information about how children learn to read, why some children struggle with reading, and what can be done to prevent and intervene. As a result, many students are not reading at grade level. This complex problem will require a multi-faceted solution. Skilled and knowledgeable teachers are a student's best opportunity for better reading outcomes.