



Science in the Service of Humanity: The Astonishing Contributions of Siegfried Engelmann

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Accepted: 30 April 2021 / Published online: 28 May 2021
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Abstract

A pioneering scientist and educator for more than 50 years, Siegfried (“Zig”) Engelmann was among the first to apply the scientific method to the design and delivery of instruction. He stood alone for his ability to create programs that accelerate learning in even the hardest to teach children and that most teachers can learn to use. He wrote or cowrote more than 100 curricula, covering the major subjects from preschool to high school. As a professor of education at University of Oregon and founder of the National Institute for Direct Instruction, he attracted students from around the world. No one did more to help the underdog. Millions of poor children learned when taught by teachers trained in his methods, often when nothing else worked. He never gave up on a child or blamed children for the failings of adults. He lived by his motto: “If the student hasn’t learned, the teacher hasn’t taught.” More scientific evidence validates DI’s effectiveness than any other mode of teaching. I will present an overview of Zig’s life and achievements.

Keywords Siegfried Engelmann · Direct Instruction · Clear Teaching

Zig Engelmann came from a rough section of Chicago. When he was 15 he lied about his age and got a job at a steel plant, stacking plow disks that came white-hot out of the furnace. Years later Engelmann wrote that “the person who may have influenced me most, who taught me how to think straight and solve difficult problems” was a fellow worker at that plant, an African American named Joshua Baker (Engelmann, 2017).

So it’s perhaps fitting that upon Zig’s demise, the most perceptive tribute to his genius came not from a fellow educator, or scientist, or professor in North America. It

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came from an aborigine in the northernmost tip of Australia, the great advocate for indigenous peoples there, Noel Pearson.

Writing in *The Australian* the week after Zig's death, Pearson declared:

Among the lauded educational theorists of the 20th century—Dewey, Piaget, Friere, Vygotsky—Engelmann was the greatest. His seminal work, *Theory of Instruction* (Engelmann & Carnine, 1982), is the educational equivalent of Isaac Newton's *Principia Mathematica* or Charles Darwin's *Origin of Species*, a first-principles description of the science and logic behind direct instruction. If ideology continues to deny the benefit of his pedagogy to the children who so require it, the science underpinning Engelmann's art of effective teaching will stand the test of time regardless. (Pearson, 2019)

The science underpinning Engelmann's art is a wonderful phrase because it distills the essence of Zig's enterprise. Of course, his list of discoveries and inventions rivals that of any *great scientist*. But Engelmann's programs are also *works of art*—not only in the beauty of their design and organization of knowledge, but in the artistic demands they make on anyone who tries to use them. Teaching is acting, he often said. He meant it as a compliment. Zig's adherents are even more metaphorical. One likens DI to a dance between the student and teacher, a dance that the teacher leads (V. Vachon, personal communication, 2011). Another refers to the rhythm of mastery—that distinctive sound of a roomful of children being taught to mastery in a DI school (C. Schneider, personal communication, 2020).

Now all this would seem a long way from toiling in 110-degree heat at an Ingersoll steel mill. And indeed it was. Like Odysseus, Homer's hero of many twists and turns, Zig found what became the outlet for his genius not straightaway, but after an epic series of adventures and misadventures. His grandmother called him the *Wunderkind* (T. Engelmann, personal communication, 2011), but if the stamp of greatness was upon him, it was probably not so evident to others.

In junior high he failed algebra and had to repeat it in summer school. In high school he was proud of the fact that he didn't read a book. "He thought it was entertaining and showed his prowess to figure out enough by talking to people," his son Kurt said (K. Engelmann, personal communication, 2020). "He told me he was a big bull-shitter," Kurt's twin brother Owen said. "He got fairly decent grades, but he confided in me that inside he knew he didn't know anything, that he was a fraud" (O. Engelmann, personal communication, 2020).

He did show prowess as a cheat. Kurt says:

He was the stage manager for the school's theatrical productions, which among other things meant that he had a master key that would get him into anywhere in the building. And so he would go into the offices of teachers and steal the exams and look at 'em the day before the tests. One of his teachers rigged up a camera so that if you opened the door it would take your picture. Somehow he got word that that was going to happen, so he and his buddy dressed up as Donald Duck and

Mickey Mouse and went in there and still stole everything. (K. Engelmann, personal communication, 2020)

“My dad was a bit of a lady’s man,” Owen says, “and the gal who tipped him off was one of the assistant secretaries in the office” (O. Engelmann, personal communication, 2020).

He must have been popular. Among other things, as a teenager he taught weightlifting to the neighborhood kids—his first known attempt at systematic instruction (O. Engelmann, personal communication, 2020).

He got into endless scrapes. “He came from a place where there was conflict all over,” said Kurt.

It was a fighter atmosphere, of male dominance to a very high degree. We heard story after story. They were almost folkloric. It started when he was 10 years old, and his brother Monty, who was 12, got beat up at school. My dad went over to the guy’s house and hit him in the face and beat *him* up, even though he was older. In high school, he played football; they’d practice on this gravelly dirt field. He said he always looked forward to the away games because you would get to play on grass and beat up pansies. (K. Engelmann, personal communication, 2020)

The story of his first foray into book learning sounds a bit folkloric as well. Owen said:

He got this job at a plant where an alarm would go off and one object would come down and he had to choose which conveyor belt it went on, but he’d have 20–30 minutes at a time when he wasn’t doing anything. And so he decided he was going to get smart, and he read the dictionary—the whole dictionary. He knew tens of thousands of words. (O. Engelmann, personal communication, 2020)

I suspect he at least got through the As, because when I sent him a draft of my first piece about him, he commented that some of my sentences were *anfractuous*—characterized by windings and turnings, sinuous, circuitous (Zig Engelmann, personal communication, 2008). He brought clarity to whatever he put his mind to and was the best editor I ever had.

But of course the big question back then was, what should the young lad put his mind to? He was a good auto mechanic and—no surprise—a great boxer: runner-up in the Midwest heavyweight Golden Gloves tournament one year. He once confided to Kurt that he was made to be a blue-collar worker, and that he related most to people who worked with their hands (K. Engelmann, personal communication, 2020).

Zig’s tribute to Josh Baker, one of the last things he wrote, concludes:

I have very vivid memories of Josh, what he did, and the messages he conveyed to me. Over the years, I’ve tried to think in the manner he taught me to think. I have tried to make work something I look forward to. And I have faithfully followed his maxim that big pictures are composed of details, and the only way to

engineer the big picture is to become aware of all the details and configure them so they work harmoniously together. Thank you, Josh. (Engelmann, 2017)

On the other hand, after his last book, *Could John Stuart Mill Have Saved Our Schools?* (Engelmann & Carmine, 2013), near the end of his life, he told Kurt that “*Aristotle* was his measure, that he had always wanted to produce a body of work that was equal to or exceeded *Aristotle’s*—and that he was satisfied—he thought he had done it” (K. Engelmann, personal communication, 2020).

The factory worker and the philosopher. That was Zig: drawing knowledge and inspiration from disparate sources, seeing common threads where others saw only difference.

His path was anfractuous. He went to the University of Illinois, dropped out, worked on oil rigs in Texas and at a warehouse back home, talked his way back into college, played football, dove on the diving team—and graduated with honors in philosophy. He sold cars, edited a children’s encyclopedia, sold his services as an investment advisor, then went into advertising (Barbash, 2012).

His final turn was an odd one. The president of a candy company wanted to know how many times kids would need to be exposed to a sales pitch for a chocolate bar before they remembered it well enough to go buy it. Zig surveyed the research on learning and memory and found nothing that helped him answer the question. He set up a class to see what it took to teach kids different slogans and became enthralled by the bigger question—how can we help the mind learn? He began teaching Owen and Kurt, and made a short film of them solving linear equations as 4-year-olds (Barbash, 2012).

Confident he’d be able to find work writing educational programs, he quit his advertising job, shopped his film to 26 publishers, and was ignored or rejected by them all. He was finally hired as a research associate by the Institute for Research on Exceptional Children at the University of Illinois. This was 1964 (Barbash, 2012).

Direct Instruction grew out of an experiment he did that summer to see what young children could learn when taught with the same techniques he had developed teaching his sons. His goal was to show that all children, not just the precocious, could learn much more and much faster than the psychologist Jean Piaget had predicted. For the next half century, he demonstrated that and much more (Barbash, 2012).

I describe many of his discoveries and accomplishments in my book *Clear Teaching*, in the chapter “Engelmann Did It First, A Pioneering Scientist in the Field of Education” (Barbash, 2012).

He was the first to figure out that to learn to read one must first be able to hear and manipulate the sounds that make up words—a skill others recognized only decades later and gave a fancy name: phonemic awareness. He was the first to appreciate the significance of the language gap between middle-class and poor students (a gap quantified by Betty Hart and Todd Risley 30 years later), and the first to create programs that enabled teachers to close it. He is one of the unrecognized pioneers of modern cognitive psychology—the study of how the mind thinks, learns and remembers.

Scholarly literature today is filled with findings that explain and justify what Engelmann put into his programs forty years earlier. Developmental Psychology, for instance, reported the results of a study showing that the ability to understand

and follow directions predicts the ability to learn math. Engelmann's very first program, *Language for Learning*, written to bridge the language gap, teaches children to pay close attention to the teacher by giving them tricky commands like "When the teacher says 'Go!'—stand up" or "If the teacher says 'Now!'—hold up your hand."

Children also learn to follow sequences of directions like: "Take your coat off, hang it up, sit down, and take out your book." Engelmann's first math programs anticipated research showing the sequence by which young children develop number sense. His reading programs anticipated the discovery that comprehension depends on background knowledge, general language skill (not simply vocabulary), and the ability to decode words fluently.

They also anticipated findings on the amount of practice needed to learn and remember new words. Engelmann was also ahead of the research showing that students are more motivated to work hard when they are set up to succeed and when they can see that they are making progress on meaningful tasks. Response to Intervention, touted as a major advance in how children are diagnosed and taught for special education, reinvents another Engelmann wheel. Engelmann's first pre-school did much the same thing RTI purports to do, fifty years earlier, with greater scientific rigor and without labeling any child disabled. Another new tool, magnetic resonance imaging, vindicates Engelmann's abiding faith that the human mind is malleable and magnificent. MRIs have shown that scientifically-based instruction like DI produces lasting and beneficial changes in the brain, thereby confirming in the lab what Engelmann found through logical analysis and experience in the classroom. (Barbash, 2012)

The last chapter in *Clear Teaching*, Great Teachers, summarizes his achievements.

Engelmann's mark on education, though it might have been larger, has not been slight. He analyzed three of the most complex subjects—oral language development, writing and math—and created the tools to teach them systematically, even to low performers. He made educators aware of the importance of curriculum. He showed that poor and disabled children can learn at reasonable rates using standard levels of funding, and that it is therefore fair that we hold ourselves accountable for their learning. He showed that student behavior is inseparable from instruction: the better the instruction, the better students behave. He showed that teacher quality is inseparable from curriculum: the better the program, the better teachers teach. He disproved the stereotype that learning must be painful and full of furrowed brows: good instruction turns learning into a game students can win. (Barbash, 2012)

One thing *Clear Teaching* missed was Engelmann's profound impact on the field of behavior analysis. He showed us that if you want good behavior, you have to *teach* it. Zig's coauthor and close friend Geoff Colvin tells me that "if you grabbed a discipline manual from the 70s, you'd see: 'Here are the rules, here are the negative consequences for breaking them.' The emphasis now is on establishing the behaviors you want up front. That's a paradigm shift," Colvin says—from consequences to antecedents, from managing behavior to anticipating it (G. Colvin,

personal communication, 2020). Positive behavior support, an outgrowth of Engelmann's work, is taught today in 21 countries and 74 languages (R. Horner, personal communication, 2020).

Zig also reminded us that inappropriate behavior is not innate: it's learned, like most everything else—which means that to correct it we need to figure out why kids misbehave the way they do, what they're really after, and then, whenever possible, teach them a more appropriate way to meet their needs.

Most important, he showed that the best way to *teach* good behavior is by using the same principles and techniques that we use to teach academic skills—or the violin, or weightlifting, or football. If you want your kids to be orderly going to the library, show them how and *practice* it—same as you do when you want them to read a word correctly. He resembled Einstein in his search for a unified theory of teaching and learning.

When developing programs he would often ask, “What's the rule?”—by which he meant: what is the idea we can use to explain the biggest chunk of content possible, thereby organizing the subject for the teacher and reducing the memory load on the student. Thus in earth science, one rule might be: when something gets hot it expands. This helps explain everything from the formation of continents to the vagaries of the weather.

Zig may not have *invented* the science of instructional design, but he advanced it farther than anyone ever has. And unlike Newton, who had his Kepler, or Aristotle, who had his Plato and Socrates, Engelmann had no obvious forebears. Besides thanking Josh Baker, Kurt says his dad credited his college roommate, a guy named Shelby, for teaching him how to read critically. That's it. No one else. Shelby became an electrical engineer (K. Engelmann, personal communication, 2020). Kurt says:

Zig really admired the hard sciences and lamented the social sciences. He explained to me one time very visually that the hard sciences were moving upward like a sloping line that over time were always building upon each other. The social sciences were simply vacillating back and forth between one extreme and another and not moving forward. And he admonished all of us *not* to follow his footsteps, and to go into the hard sciences instead. In education it was just so difficult to build on a body of work, and to show progress in your *own* work. That's one of the reasons he loved manual labor—not just for the exertion, but for the satisfaction of seeing what you've done with your labor. (K. Engelmann, personal communication, 2020)

Zig also lamented the narrowness of our senses. Kurt recalls him once launching into a discourse on the electromagnetic spectrum and all the light we can't see, and then on vibrations and all the sounds we can't hear. He grabbed a pillow. “This!” he cried. “This pillow vibrates and makes a sound! And I can't hear it!” Kurt says it was almost as if he was doing a monologue in a play about the frustrations of the limitations of our existence, of how little we know. He envied dogs their sense of smell. He loved hounds (K. Engelmann, personal communication, 2020).

If something interested him, he would take data on it with almost freakish intensity. On his morning commute, for instance, Kurt says he would count and memorize how

long the different stoplights were green and how many times the white walk sign would flash before it turned to yellow. He knew the data for all the possible routes and he would take the fastest route. “He loved going fast, and the feeling of going fast” (K. Engelmann, personal communication, 2020). He liked motorcycles and boats, and went notoriously fast on both.

One of his core dictums when designing programs was “Do it the fast way.” Of course here it wasn’t about thrill seeking but about satisfying the requirement to be efficient. Zig said to me, in that piece of mine he called anfractuous:

Time is the great enemy of the at-risk child. He must learn more in less time, he is less experienced at learning, and he needs more practice. You can’t reproduce the *form* of the middle-class upbringing; you’ve got to try to reproduce the *function*. That means teaching kids the *fast way*. (Barbash, 2008)

His programs do that. He wrote or cowrote more than a hundred of them, covering all the major subjects from preschool to high school.

He often referred to himself as a teacher, but he spent most of his time writing. He wrote 6 hr a day for 50 years. As one colleague describes it: “Sometimes he wouldn’t move for hours. He’d just sit at his Remington, kind of furious the whole time, furiously typing. He’d drink dark coffee and smoke cigarettes and eat nothing” (G. Singer, personal communication, 2020). At 3:30 he’d break for beer and peanuts, joined by his coworkers. He’d go home for dinner and come back and write some more. He wrote on weekends.

A typical program took him anywhere from 3 to 10 years to develop, depending on how much field testing and rewrite it required. His ironclad rule was that every student would learn everything in the program, and that the average teacher would be able to teach it.

There’s a Buddhist saying that mountains make their own weather. Zig certainly made his. He inspired people around him to do remarkable things. “He didn’t just teach us how to teach,” one of his students said. “He taught us how to look at the world” (J. Sherman, personal communication, 2020).

He may have been in Darwin’s league—he told me that Darwin was the person he most identified with (S. Engelmann, personal communication, 2010). But what made him *sui generis* was that he was a great thinker *and* a great observer *and* a great inventor *and* a great teacher. His *Theory of Instruction* may have only been read by a few thousand people, but his programs have been used to teach millions—and not just any millions, but our most vulnerable and least fortunate millions, overwhelmingly children.

For Zig, it was always about the kids. The last thing he would see as he lay dying, he said to a friend, were the kids (G. Singer, personal communication, 2020). He gave them his life so that their lives might be better.

Declarations

Ethics Approval Not Applicable.

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