



# Social Emotional Learning through Active Science

The Impact of Merging Social Emotional Learning with Active Science and Engineering Investigations

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It's a simple question, yet one with enormous implications for educators: Would children learn better if their lessons were more emotionally fulfilling?

In *How Your Child Learns Best*, Dr. Judy Willis asserts that the first goal educators should help their students realize is “becoming a joyful, successful learner.” Yet the hard truth is, millions of K–college learners start the school day with a mission to merely survive the daily distress of somnambulistic lectures and an onslaught of worksheets with no cognitive merit. Regrettably, for a vast number of these students, all indicators of academic success will elude them as well.

We must ask: Why don't our students find joy in school, and why do the legions of unsuccessful learners outnumber the rest? The answer may be the predictable absence of social and emotional fulfillment in the way most school curricula are delivered.

# The educational significance of SEL

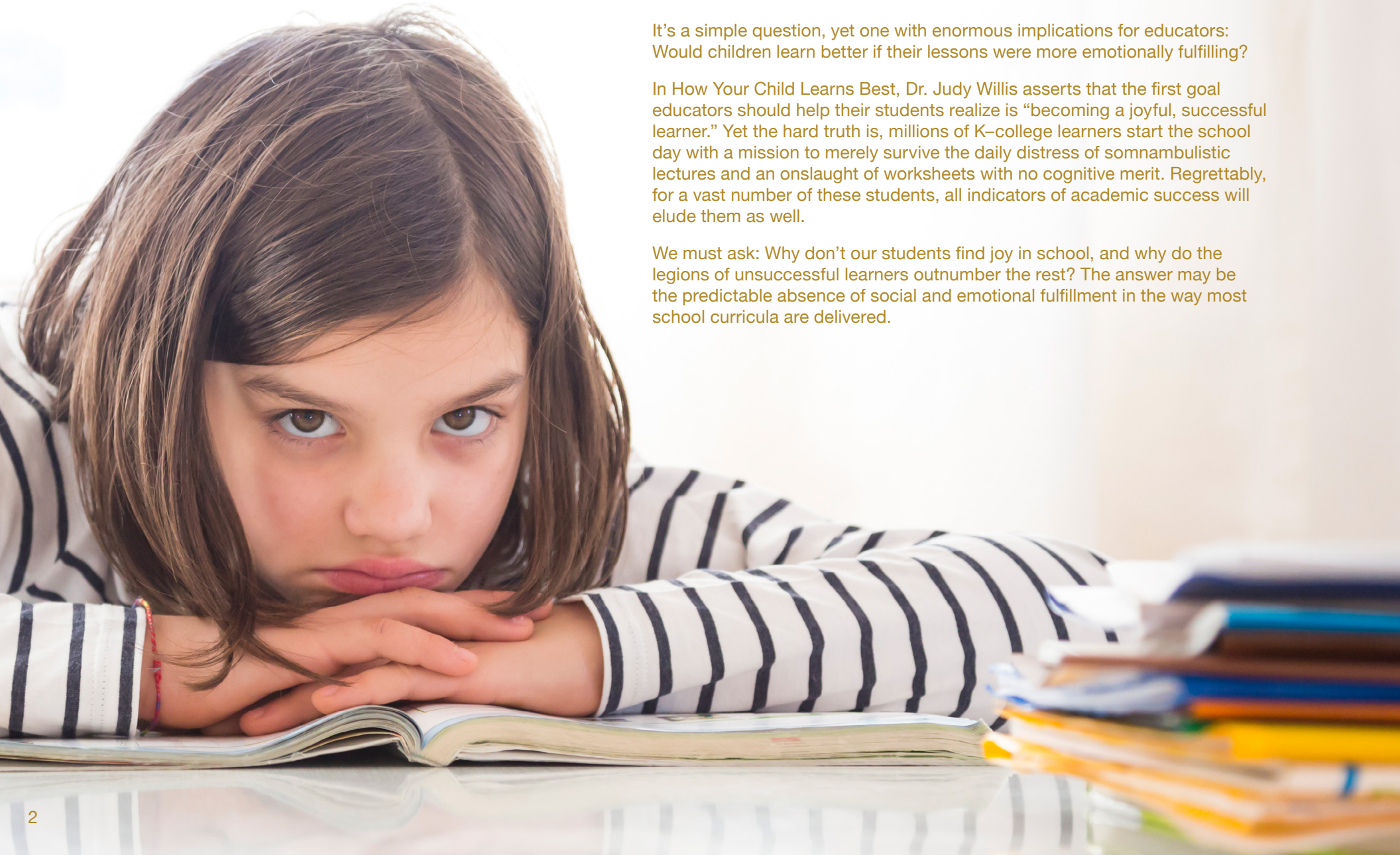
If any silver lining could be found in the recent pandemic, it was the opportunity to reassess the impact of social emotional learning (SEL) on effective education. Let's pause to reflect on the learning conditions that produce successful learners, reexamine what a learner-centered classroom should look like, and modify our instructional strategies accordingly. We should ask ourselves:

- How are we teaching students?
- Are we truly *reaching* the “whole child” inside each student?
- What do we need to change so that students find school enjoyable, the learning meaningful, and success attainable both in school and in life?

At its core, formal education exists to equip students for life and for their chosen careers. But this preparation goes beyond the subject matter itself. Yes, we want students who are well educated, rational thinkers, and problem solvers. But we also need citizens who are emotionally competent, caring, and socially conscious decision makers. These nonacademic proficiencies powerfully influence success in life and in the workplace. In fact, according to the *World Economic Forum's Future of Jobs* report, emotional intelligence will be one of the top 10 most sought-after job skills of this decade.

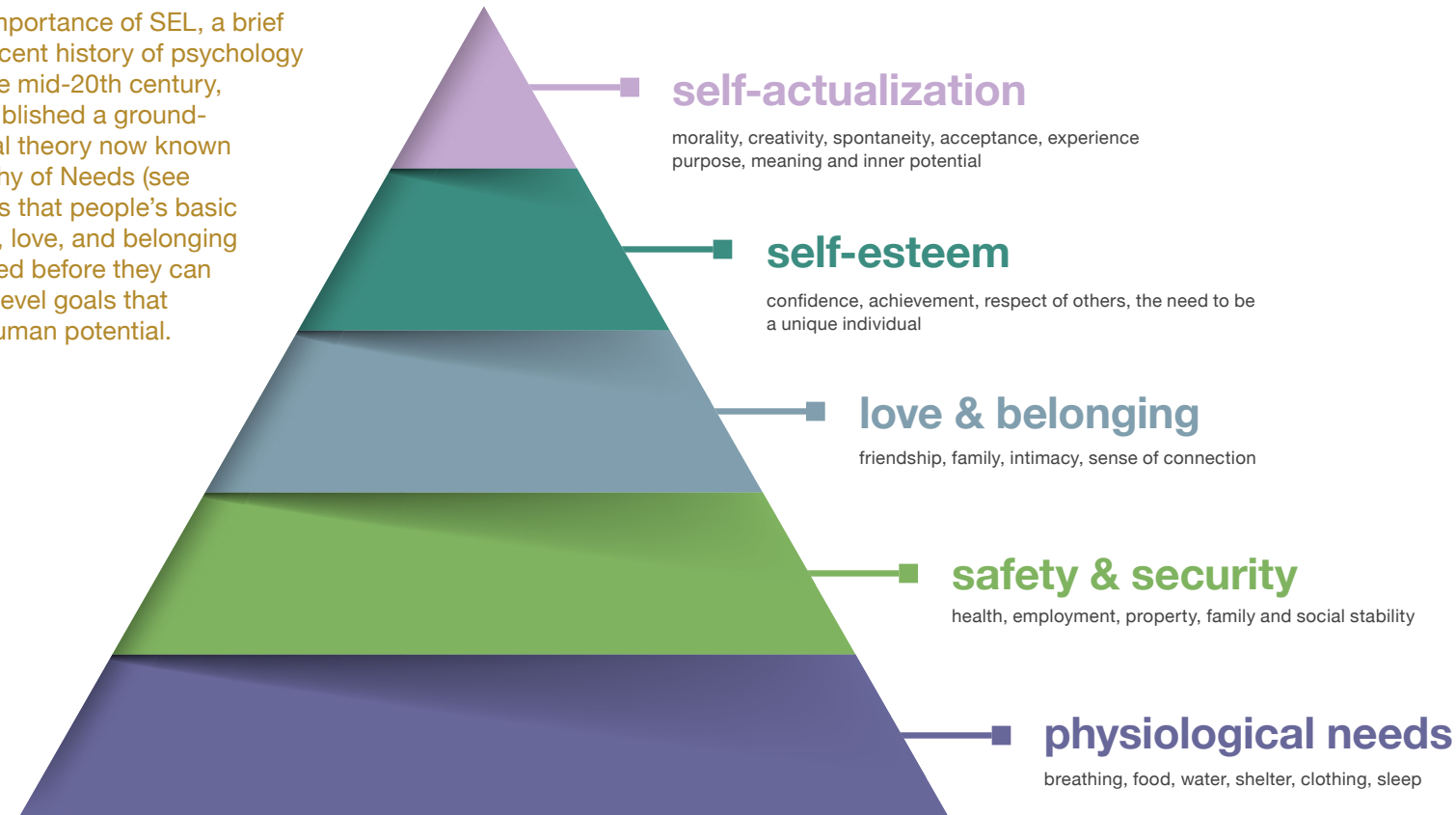
For all these reasons, schools educate best when they integrate efforts to promote children's academic, social, and emotional learning (Elias et al., 1997). Educators who incorporate SEL into daily classroom instruction improve student outcomes not just in the classroom, but across multiple domains of functioning (Greenberg et al., 2017). A 2013 survey of educators found that SEL promotes:

1. Improved classroom behavior
2. Health and well-being, including a greater ability to manage stress and depression
3. Communication skills and teamwork
4. Positive attitudes about self, school, peers, and teachers
5. Academic success



## Human needs precede learning

To understand the importance of SEL, a brief excursion into the recent history of psychology is in order. During the mid-20th century, Abraham Maslow published a ground-breaking motivational theory now known as Maslow's Hierarchy of Needs (see figure 1). It postulates that people's basic physiological, safety, love, and belonging needs must be fulfilled before they can focus on the higher-level goals that maximize their full human potential.



Classroom practitioners are reminded daily that students who are hungry often struggle to learn. Educator Nicholas Ferroni observed, "Students who are loved at home come to school to learn. Students who aren't, come to school to be loved." Likewise, children who feel unsafe in class seldom pay attention and will underperform academically (Pratt, Tallis, & Eysenck, 1997). (These children are instead attending to countless cues to evaluate potential threats, but not fixing attention on the teacher—and then being abruptly reprimanded for it.)

To the human brain, attending a school with the best-trained teachers and the latest technology is still not enough to offset an absence of emotional or physical safety. This has clear implications for our strategies as educators. Only when the physiological and social emotional needs of students are addressed, can they then proceed through the sequence of learning set out in Benjamin Bloom's taxonomy of educational goals. Hence the saying, "You have to Maslow before you Bloom, and Bloom before any standards."

## The evolving view of emotion in education

Half a century ago, researchers studying cognitive development did not recognize emotion as a vital contributor to the learning process. The spotlight instead was primarily on child development, visual and auditory perception, language development, problem solving, developmental delay, reading, memory, and recall. Emotions were viewed as little more than an interruption to education, an intellectual diversion for teachers and students. Some researchers went so far as to warn that too much love was detrimental to child development.

In the late 1980s, researchers began to investigate the possibility that emotions may play a positive role in schools when drug use, youth suicide, high dropout rates, teen pregnancy, on-campus violence surfaced as the most pressing K-12 campus concerns. However, each of these emerging problems was an emotionally based crisis that seriously impacted the normal operations of schools. This set the stage for siloed instruction in citizenship, life skills, values training, and character education in the 1980s and 90s. SEL appeared a decade later, finally recognized as a formidable force shaping contemporary education.

### From the nascent field of social neuroscience, we have discovered that:

- The human brain evolved as a social brain.
- Nearly everything we recall has a social aspect to it.
- We live in socially constructed environments by deliberate design.
- We have transformed Planet Earth to accommodate our social behaviors.
- Cities, neighborhoods, homes, and schools are all organized around social connections.
- Relative to other large mammals, we are fragile, vulnerable, and weak individually. The two greatest contributors to our survival lie in our intelligence and being members of connected (protective) communities.
- Given a choice of working alone, in pairs or in small groups, students of all ages prefer to work face-to-face with others. Few will self-select isolation and loneliness.



A guiding principle for enhancing learning can be found in the acronym “SAIL,” which theorizes that learners must experience:



This implies that a student’s felt experience of acceptance, respect, and inclusion by adults and peers includes constructs such as emotional engagement (Gillen-O’Neil & Fuligni, 2013). The “SAIL” concept is foundational to healthy human functioning and learning across developmental periods, school environments, and contexts.

SEL is defined as “learning how to understand, manage, and express the social and emotional aspects of one’s life” (Elias et al., 1997). It is the capacity to recognize and manage emotions, solve problems effectively, and establish positive relationships with others (CASEL, 2003). Prior to the current acceptance of SEL, it was commonly said that one could be either intellectual or emotional – an unambiguously binary choice. However, recent research has demonstrated that this is a false dichotomy, because emotions undergird both intelligence and memory.

Social emotional learning is now a top priority for many schools, districts, and departments of education throughout the country. The overwhelming majority of school administrators (96%), teachers (93%), and parents (81%) agree that social emotional learning should be just as important as academic learning in schools. And rightly so. SEL research has shown:

- Students in schools with high-quality SEL programs show an average gain of 11% in academic achievement, as verified in a 2011 meta-analysis (Durlak et al.).
- Behavior problems, emotional distress, and drug use are all significantly lower among students who participated in SEL programs.
- The development of a positive attitude toward self, others, and school is higher in students who are taught SEL strategies.
- SEL contributes to an increase in high school graduates, who also attend college, are employed more often and arrested less. They enjoy better emotional and mental health outcomes in life, with less involvement in various forms of substance abuse.
- SEL can play an important role in influencing nonacademic outcomes, and can improve children’s academic performance while laying a foundation for lifelong learning (Zins et al., 2004).

- SEL has been shown to improve student engagement, motivation, and academic success.
- Three out of five parents say it is more important that their children are happy and not overly stressed than performing well academically.
- Reflecting this principle, students lag in both social adjustment and academic performance when their teachers are highly stressed (Greenberg et al., 2016).
- The majority of high school students and recent high school graduates agree that attending schools that focus on developing SEL skills will better prepare them for life after high school.
- SEL is essential to educating the “whole child” and leads to successful learning (Educating the Whole Child: Improving School Climate to Support Student Success, Darling-Hammond and Cook-Harvey, 2018).

**“The development of SEL competencies in school predicts a variety of positive outcomes later.”**

These include participation in postsecondary education, success in the workforce, civic engagement, and personal health and well-being. The benefits were consistent across multiple demographic groups in ethnicity, social economic status, and school location. Children with strong social skills in kindergarten were found to be more likely to thrive as adults (Jones, D., Greenberg, M., & Crowley, M., 2015). Positive emotional experiences play an integral role in how we perceive and navigate the world around us, as well as in our subsequent ability to cope and thrive.



## Why SEL in science education?

Today, educational psychologists no longer view emotions as disruptive intrusions on the learning cycle, but as valuable catalysts enhancing learning and memory. Contemporary research in neuroscience indicates that cognition and emotions work in tandem to facilitate learning and to produce our deepest and longest-lasting memories. Regardless of age, we learn what we care about to some significant measure. The more we care about an event or fact, the more likely we are to recall it later. Students find that what they care about is often easiest to learn; they remember best what they felt was useful or important to know and understand. What they find emotionally and personally impactful, they remember — whether positive or negative (which illuminates the power of traumatic experiences).

Emotions serve as a “key lever” in the science classroom. They determine what students will pay attention to (personally relevant), what they will enthusiastically learn (personally interesting, providing motivation), and what they will remember (personally meaningful experiences, facts, or information). When students are engaged in science investigations or engineering lessons that they find enjoyable, interesting, or relevant to their personal lives beyond the school walls, they are eager to learn. They perceive the subject as worthy of their attention, time, and effort. If work — including schoolwork — is viewed as fun, it tends not to *feel* like work.

Human emotions did not develop in the mammalian brain by happenstance. Nor were they preserved by evolution over the eons by accident. Instead, emotions are essential to our ability to pay attention, to learn, to remember, and thus to our survival. In neuroscience, we assert that:

**emotions drive attention**

**attention drives learning**

and what we have **learned** determines what we are able to **remember** in the future.

In survival terms, the purpose of having a brain is not to remember the past, but to navigate the future by making use of what was learned in the past. We can have no memory now of any useful information unless, at some earlier point, we have learned it — and we could never have learned any lesson if we paid no attention to it.

Accordingly, our first job as educators is to set the stage for learning. Students learn and remember more when they are *enjoying*:

**what they are learning,**

**how they are learning it, and**

**with whom and where the learning takes place.**

Together, emotions and attention are the vital ingredients that foster student engagement. Positive student emotions are one of the most effective measures of this engagement. When students are happy, they remember more and will more readily transfer the knowledge gained. When they enjoy

both what and how they learned, they demonstrate higher levels of recall during assessment. In all these ways, teaching and learning in schools have strong social, emotional, and academic components (Zins, Weissberg, Wang, & Walberg, 2004).

Overall, students who regularly activate their SEL competencies are:

- More engaged in learning
- Less likely to drop out of school
- Less likely to have behavior issues
- More confident with higher self-esteem

For teachers who believe they have a discipline problem in their classroom, often it is merely an engagement problem. When students are emotionally and physically engaged, classroom management improves. Teachers gain more time for effective teaching, resulting in greater student achievement. Conversely, when schools focus only on academic instruction and classroom management, their students are highly likely to fall short of academic success (Adelman and Taylor, 2000).

SEL is not an intervention program or strategy. SEL is not adding something else to a teacher’s already-full plate. Instead, it is the glue that holds our educational plate together. Several studies have found that students who exhibit strong SEL competencies are considerably more affable to peers and teachers. They participate more in the classroom, are more accepted by classmates and teachers, and are given more instruction and positive feedback by their teachers.

In light of these findings, educators are increasingly interested in finding effective methods for developing the interpersonal skills that allow classrooms to run smoothly — including cooperation, collaboration, emotion-behavior regulation, and social awareness.



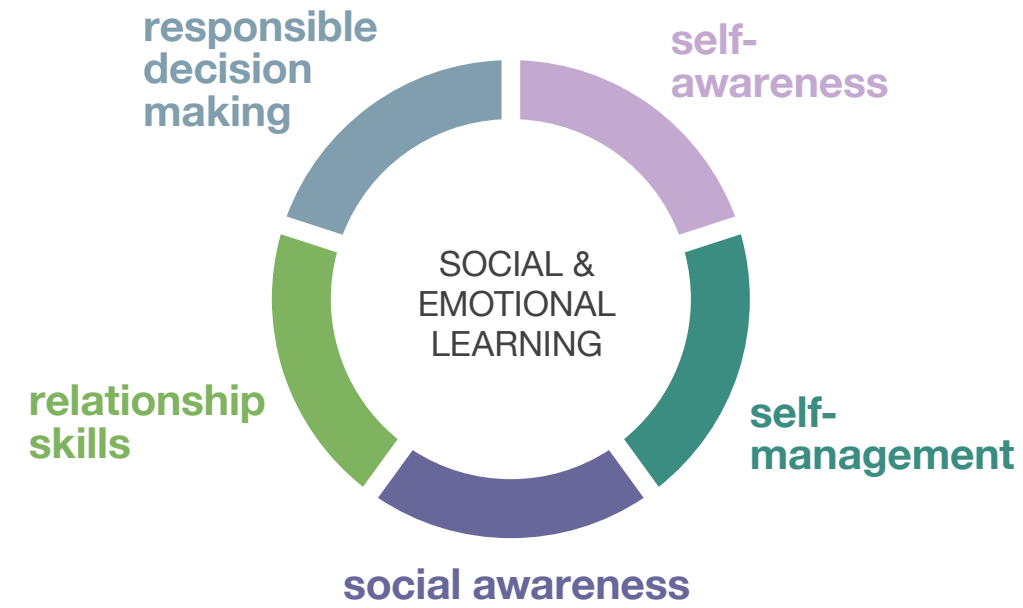
## Learning the five SEL competencies by doing

Over the past 20 years, multiple studies analyzing educational outcomes have demonstrated the importance that positive social behaviors have in fostering academic achievement (Blake et al., 2015). According to Greenberg et al. (2003), educators, parents, students, and other members of the educational community believe that today's schools must teach beyond basic skills (reading, writing, counting).

The Collaborative for Academic, Social, and Emotional Learning (CASEL) has set the gold standard in evidence-based social and emotional learning. CASEL identifies the five SEL competencies as:

1. self-awareness
2. self-management
3. social awareness
4. relationship skills
5. responsible decision making

These represent large categories or conceptual buckets for organizing a range of intra- and interpersonal knowledge, skills, and abilities (Weissberg et al., 2015). Each of the five competencies (See Figure 2) can be immediately observed in action during hands-on science investigations and engineering challenges. There each skill can be taught, reinforced, and refined, laying a foundation for success both in the classroom and later in the career space.





The five SEL competencies include intrapersonal (self-awareness and self-management) and interpersonal (social awareness and relationship skills) dimensions. Collectively, these four associated components help students make responsible decisions – the fifth competency. Some researcher and educational institutions have extended this list of five competencies to include (a) a growth mindset, (b) culturally responsive teaching, (c) positive psychology, (d) mindfulness, and (e) resilience, as additional essential features of a more comprehensive SEL program. In greater detail, the five SEL components include:

**1 Self-Awareness** (*Intrapersonal*): The ability to accurately recognize one’s own emotions, thoughts, and values, and how they influence one’s behavior. This entails accurately self-assessing an individual’s strengths and limitations. One should develop a well-grounded sense of confidence, enthusiasm, and a “growth mindset” in the process.

**2 Self-Management** (*Intrapersonal*): This encompasses the ability to effectively regulate one’s emotions, thoughts, and behaviors under a wide range of circumstances. Managing stress, controlling impulses, and motivating oneself towards personal goals fall into the self-management skills category. This requires that an individual must master concentration, impulse control, and emotional regulation (Lopes and Salovey, 2004).

**3 Social Awareness** (*Interpersonal*): This involves taking other persons’ perspectives and empathizing with others, including those from different backgrounds and diverse cultures, who may approach a situation from an unfamiliar starting point or a novel perspective. Central to social awareness is acknowledging that there is a continuum of social and ethical norms of behavior. Caring about the feelings of others also acknowledges that everyone needs a network of support. Families, classmates, and communities are key features of this SEL element.

**4 Relationship Skills** (*Interpersonal*): The ability to develop and maintain positive healthy interpersonal connections with others is a key feature of this competency. Relationship-building includes the ability to associate with individuals from diverse backgrounds, as well as avoiding negative behaviors that can sabotage existing positive relationships. Included among these skills are communicating clearly with others, listening attentively, cooperating with others, resisting inappropriate social pressure, negotiating conflicts constructively, as well as seeking help from others when needed and offering help to others when it might be beneficial.

Current scientific research has determined that children do best when they receive demonstrative love and caring (Brackett, 2016). For many students, the classroom constitutes a primary source for developing meaningful relationships and constitutes the first venue for developing long-term interpersonal relationships outside of the immediate family. School belongingness is considered among the most important factors associated with students’ social and emotional well-being, academic self-efficacy, motivation, school satisfaction, and academic achievement (McMahon, Parnes, Keys, & Viola, 2008). To solve the problems of today and the future, our students must know how to work together as people, communities, nations, and a world with finely honed interpersonal relationship skills.

**5 Responsible Decision-Making:** Making positive choices about the actions one should take, the personal behaviors to engage in, resisting inappropriate social pressure, and how to interact socially based on ethical standards, safety concerns, acknowledging social norms and expectations, and respectful considerations for others are key features of responsible decision-making. This may also involve making practical assessments of one’s behavior in different situations and predicting the likely consequences of those behaviors, as well as a compassionate interest in the well-being of others who may be affected.

Working collaboratively is frequently undervalued in education. Working relationships make students feel connected, plain and simple. When they are immersed in successful working and/or learning relationships, they feel a sense of connectedness and belongingness, and they ascend to a more optimal level of performance – they learn better. This applies specifically to students learning science. All aspects of successful relationship building are interconnected with the four interpersonal and intrapersonal SEL competencies.



## How active science learning engages SEL competencies



Students learn best, not alone, but rather in close collaboration with their peers and teacher. When students are immersed in active science investigations in the company of their classmates, they are engaged in each of the five SEL competencies at varying points in time as they do the following:

- Start the learning experience together at the same initial learning point, as they are introduced to a simple or complex phenomenon (the initial “hook”) in science or engineering.
- Begin interest-driven interactions.
- Ask questions (surface-level to deep questions). Try to find their own answers. And discuss their opinions.
- Investigate together at a cognitively appropriate pace.
- Create drawings or build models of the subject under investigation.
- Make predictions and share observations (using informal language that later serves as the foundation for the formal terminology used to describe a complex notion in science or engineering).
- Participate in coherent developmentally-appropriate conversations with peers about the phenomenon, its context and related ideas (here, the more difficult-to-understand concepts become easier to grasp through student-centered discourse and dialogue).
- Engage in shared dialogues where they can apply the formal science vocabulary via word substitution in their speech or writing.

- Work collaboratively towards the same goal or objective.
- Provide feedback to one another throughout the learning journey.
- Celebrate their findings and their success (or the end point of the investigation).
- Communicate their findings to others through oral presentations or written summaries (in science notebooks).
- Prepare to argue in support of their conclusions from
  - the evidence they gathered,
  - the data they collected, and
  - the conclusion(s) at which they arrived.
- Revise their thinking to accommodate the socially-constructed conclusions they make as a whole class. (Meaning is “co-constructed” for young learners, not merely constructed).
- Self-evaluate their success and shortcomings encountered during the science investigation or engineering challenge.
- Reflect on ways to improve the procedures for producing reliable results in the future (the “analysis of error”).
- Discuss the social-emotional skills that were deployed and practiced in their peer-to-peer networks that promoted their
  - understanding,
  - connectedness, and
  - sense of belonging.





A carefully sequenced series of learning events of this nature, distributed over time, has a high probability of entering into long-term memory storage. That memory source later becomes the “go to” site when students are asked to:

1. solve a novel problem with similar attributes,
2. complete a new (somewhat comparable) assignment,
3. engage in a related discussion, or
4. draw from this memory source during formal assessment.

Rather than teaching the five CASEL competencies in isolation without a realistic, meaningful or memorable context, we recommend learning, practicing, and enhancing these competencies by embedding them in a single active science or engineering investigation (See Chart #1). The chart can be copied, enlarged, and posted in classrooms, allowing students to become familiar with the SEL skills associated with their daily participation in active science investigations.

While reading can elicit thinking about a concept, direct “hands-on, minds-on, hearts-in” experiences generate far more opportunities for transferable content. Student A reads a book stating that the basic needs of animals and plants include food, water, sunlight, air, oxygen, shelter, and

protection from weather, disease, and predators. However, if Student B gets engaged with the same concept by (a) planting a seed and watching a plant grow to maturity, (b) raising an animal to adulthood, or (c) caring for an insect until it can reproduce. Student B provides each of the basic needs at each developmental stage in the life of the animal, plant or insect, giving Student B a far greater understanding and appreciation of the concept “meeting the basic needs of animals and plants” than Student A who simply read the words on a page.

Just as importantly, during the process of plant, animal or insect care, it is quite predictable that a child would develop an emotional attachment to the organism by caring for its basic needs almost in the same manner that a parent would. The sense of belonging or connectedness represents a fundamental need for relatedness (Baumeister & Leary, 1995) and experiential memory.

A study conducted by Michigan State University and the University of Michigan found that students actively learning in small groups using phenomenon-based hands-on investigations (“FUN-omena”) performed better on a test aligned with the Next Generation standards than did students using a textbook. More importantly, the results were similar across students of different racial and ethnic backgrounds.



101 SEL SKILLS THAT ARE LEARNED, REINFORCED, AND REFINED DURING HANDS-ON SCIENCE		SELF-AWARENESS	SELF-MGMT	SOCIAL AWARENESS	RELATIONSHIP SKILLS	RES. DECISION-MAKING
1	Accepting of others' individual differences			X	X	
2	Accepts constructive criticism	X			X	
3	Accommodates divergent viewpoints			X		X
4	Accurate self-assessment	X				
5	Acknowledges personal shortcomings and attempts to improve	X				
6	Adaptability		X		X	
7	Ambitious (commensurate with ability)	X				
8	Analytical thinking	X				X
9	Approaches relationships with a positive presupposition		X	X	X	
10	Asks for help when needed	X			X	X
11	Avoids using or thinking in stereotypes		X		X	X
12	Believes the best of others			X	X	
13	Bonds well with others/accepts love			X	X	
14	Brainstorms for consensus of opinions/solutions			X	X	
15	Brings out the best in others ("BOBO")			X	X	
16	Builds and maintains healthy relationships		X	X	X	
17	Calmly discusses a problem or conflict		X		X	X
18	Capitalizes on personal assets	X	X			
19	Cares about the well-being of others			X	X	
20	Checks for clarification and understanding			X	X	X
21	Civility		X			
22	Communicates clearly and effectively		X		X	
23	Compassionate			X	X	
24	Controls impulsivity		X			
25	Cooperative		X		X	
26	Courteous to others				X	
27	Demonstrates empathy and compassion			X	X	
28	Demonstrates self-control/self-discipline		X	X		
29	Dependability		X		X	
30	Determination		X			X
31	Easily takes others' perspectives to see their point of view		X	X		X
32	Embraces ethical standards even in the face of daunting challenges					
33	Engages in service to others			X	X	
34	Engages others comfortably			X	X	X
35	Enthusiastic	X				X
36	Examines social cues (verbal and physical) to "read" how others are feeling			X		
37	Faith in others			X	X	
38	Finds and gives support in relationships			X	X	
39	Flexibility in thinking		X			X
40	Forgiveness				X	
41	Friendliness	X		X	X	
42	Generous with praise and compliments				X	
43	Gives considerate/appropriate verbal responses			X		
44	Gracious and humble	X				
45	Healthy self-confidence	X				
46	Helps others grow and develop				X	
47	Honest		X			
48	Identifies verbal and physical cues to determine how others feel			X		
49	Initiates contact with others to develop working relationships				X	
50	Invites input from others to negotiate a compromise			X	X	X

101 SEL SKILLS THAT ARE LEARNED, REINFORCED, AND REFINED DURING HANDS-ON SCIENCE		SELF-AWARENESS	SELF-MGMT	SOCIAL AWARENESS	RELATIONSHIP SKILLS	RES. DECISION-MAKING
51	Kindness		X	X		
52	Knows how to remain focused		X			
53	Learns and understands body language, facial expressions, and gestures			X		
54	Learns from errors and experiences	X				X
55	Listens objectively		X	X	X	
56	Looks for personal opportunities to grow and learn (growth mindset)	X	X			
57	Looks to find common ground				X	X
58	Loyalty	X			X	
59	Makes appropriate eye contact			X	X	
60	Makes an effort to understand what others are saying and responds appropriately		X	X	X	
61	Makes ethical and respectful choices about personal behavior and relationships				X	X
62	Manages conflict and stress		X		X	
63	Manages "emerging talents" (weaknesses) and builds on "strengths"	X	X			
64	Offers emotional support and help when needed			X	X	
65	Participates in conversations willingly	X		X		
66	Practices collaborative problem-solving				X	
67	Predicts how others feel and how they might react			X	X	
68	Pursues harmony and fairness			X	X	
69	Recognizes emotions and understands how they influence behavior		X		X	
70	Recognizes that all people have similar needs, desires and hopes			X		
71	Regulates his/her personal behaviors		X			
72	Regulates thinking to eliminate distractions		X			
73	Resists negative social pressure		X			X
74	Resolves conflicts constructively				X	
75	Respectful of others			X	X	
76	Responds to another person's questions with civility		X			
77	Seeks inclusiveness for all			X	X	
78	Seeks personal connectedness with others	X			X	
79	Sets and achieves positive personal and academic goals	X	X			X
80	Shows a wholesome sense of humor	X	X			
81	Shows perseverance and persistence		X			
82	Sensitive to the fact that inequities and privileges affect individuals and groups			X		
83	Shares personal thoughts and feelings appropriately	X	X		X	
84	Shows a concern for the feelings of others			X		
85	Shows empathy for diverse groups of people			X	X	
86	Shows leadership in group settings	X				
87	Sincerity	X			X	
88	Stands up for the rights of others			X		
89	Stands up for what is right, rather than what is safe or convenient		X	X		X
90	Takes turns (group etiquette)		X			
91	Teaches others by example/mentorship		X			
92	Thinks independently		X			X
93	Tolerance - respecting other's thoughts, feelings, and opinions			X		
94	Trusting of others			X		
95	Trustworthy	X		X		
96	Understands and expresses gratitude	X		X		
97	Understands diverse social norms	X		X		
98	Uses verbal and nonverbal skills to express oneself effectively	X				
99	Welcomes/invites positive change	X	X	X		
100	Wins others over (the "WOO" factor)	X		X	X	
101	Works through influence (not intimidation)			X		



## Cognitive rehearsal: from physical interactions to abstract ideas

Active learning is not merely about the physical interaction with content and materials, but instead is a deeply engaging cognitive interaction with ideas, connections, and possibilities (a.k.a., thinking), where each stage of learning serves as a “cognitive rehearsal” that strategically guides the learner from processing concrete experiences to abstract thinking (See below).

### Cognitive Rehearsals

When playing with objects, learners are simultaneously mentally manipulating and playing with ideas (including the internal dialogues where children attach the words and meaning to their actions inside the “mind’s eye”) building the foundational circuitry in the brain.

Exploring and experimenting involve examining relationships, interactions and systems, where learners formulate their own personal “theories” (hypothetical constructs). Here is where:

1. **Doing** becomes a cognitive rehearsal for **thinking**.
2. **Thinking** serves as a cognitive rehearsal for **discourse**.
3. **Discourse** (including the phonological loop or one’s “inner voice”) is a cognitive rehearsal for **writing**.
4. Playing with objects and ideas, exploring and experimenting, thinking, talking, drawing, and writing become cognitive rehearsals for reading (the preceding events build background knowledge for successful reading comprehension). Writing and **reading** refine one’s thoughts, generate coherent thinking, and cultivate linguistic precision in expressing one’s thoughts.
5. Most important, **doing, thinking, discourse, writing and reading** become the critical cognitive rehearsals for **formal assessment**. They are “test prep”.

Source: Kenneth Wesson (2011). *Education for the Real World: six great ideas for parents and teachers.*, Brain World. Issue 2. Volume 2

Students learn best and remember most by doing. Students who are engaged in active science observe, examine, and drawing conclusions about phenomena in the physical world (culminating in sense-making). By providing ample active learning experiences, science teachers can more successfully introduce new related abstract concepts (learning progressions) in science and engineering. The most important feedback that accelerates student learning during “hands-on, minds-on, hearts-in” learning experiences is derived from the activity itself rather than from the teacher. Students comprehend the validity of a concept because of their firsthand engagement with the concept instead of placing blind faith in what they were told, what they read, or what they gleaned from in an Internet simulation of a scientific principle.

Today’s school must enhance students’ social emotional competence, character, health, and civic engagement (Greenberg et al., 2003, p. 466). Social emotional learning is the process through which students achieve this. They learn to recognize and manage their emotions, care about others, make good decisions, behave ethically and responsibly, develop positive relationships, and avoid negative behaviors (Elias et al., 1997). And always remember: One of the most effective strategies for encouraging students to exhibit appropriate social behaviors is to be a role model for them when working with your students, colleagues, or other adults.

## SEL-based science learning: Finish by checking your work

While active collaborative learning of science and engineering is a proven way to promote SEL, one key to maximizing its emotional effectiveness is to culminate with a brief Collaborative Team Self-assessment. Useful questions include:

1. What went right?
2. What could have been done better?
3. How can our group improve next time?
4. What did I learn from my groupmates?
5. What did I learn that will make me a better team member next time?

Providing time for students to pause and reflect on the SEL aspects of their learning is just as essential as taking time to assess their gains in the knowledge of science content. SEL competencies warrant a place in informal student evaluations once teachers have been adequately trained to conduct such assessments. Students should occasionally be given the task of SEL self-assessment as well.

Using the self-assessment below will yield high SEL dividends (see Chart #3: Follow-up SEL Skills Appraisal sheet). This appraisal tool illustrates one means by which students are able to self-assess for their support of selected SEL goals during a collaborative effort with classmates.

From 1-5 points (five being the highest), circle the one that reflects your performance.

FOLLOW-UP SEL SKILLS APPRAISAL	1	2	3	4	5
Enthusiasm and keeping team morale up					
Effective communication					
Offering solutions to problems					
Motivating self and others					
Seeking and providing help when needed					
Giving positive/constructive feedback					
Listening to others for understanding					
Clarifying ideas/information for a teammate who was struggling					
Resolving differences of opinion					
Remaining focused on the goals					
Being patient with others					
Welcomes/invites positive change					
Wins others over (the “WOO” factor)					
Works through influence (not intimidation)					



Students who work in collaborative groups feel more engaged in the classroom and are more likely to persevere through complex assignments. Solving a challenge together is extremely motivating for children, and it builds a sense of community and belongingness among the learners (problem-solvers). Whether it is labeled cooperative learning, collaborative learning, peer-to-peer learning, pair-share learning, or group work, students relish making progress together towards finding an answer or a solution, and they rejoice in the collective success at the end. It is considerably more enjoyable to celebrate with others than it is to celebrate alone.

There is a distinct euphoria that permeates our shared celebrations, almost regardless of our culture or the tangible significance of the event. It is purely social and emotional. It is quite comparable to listening to jazz in that we know when and where it starts, and we know when it will end. Everything in the middle is what keeps the audience in their seats fully enjoying every minute of the performance. The middle is what the audience came for. The end of the jazz piece links the audience back to the beginning rhythms. Similarly, science students get hooked initially by the introductory phenomenon, but they stay engaged for the middle of “hands-on, minds-on, hearts-in” science and engineering investigations (such as FOSS) — not exclusively for the learning of science and engineering, but because that’s where the excitement is!

## Kenneth Wesson

A former higher education faculty member and administrator, Kenneth Wesson delivers keynote addresses on the neuroscience of learning for educational organizations and institutions throughout the United States and overseas. His international audiences have included educators and administrative officers from six of the world’s seven continents. His research is frequently published and referenced in Parents Magazine, HealthNet, and the journal Brain World. Wesson has contributed to the development of several instructional programs.

## School Specialty

School Specialty is the only science curriculum provider that creates not just curricula, but comprehensive learning ecosystems to harmonize with them and optimize student outcomes. For generations, School Specialty and its affiliates have proudly supported phenomenon-based science education and the professional development of those who teach it.

## Delta Education

Delta Education is the largest publisher of curriculum-based elementary school science kits in the United States. Working in partnership with premier academicians, Delta Education distributes the K-8 science curriculum that pioneered learning through exploration of phenomena, turning students from passive spectators at a computer screen to active investigators performing science — expressing the philosophy of hands-on learning that has distinguished Delta Education for over a quarter century. Delta Education is part of the School Specialty family of brands.





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