Welcome to Neuroscience & the Classroom: Making Connections. This is a course for committed educators genuinely eager to engage in new ideas about learning and to use these ideas to invent solutions to problems they and their students encounter. It is a course for experienced teachers, rookie teachers, aspiring teachers, student teachers, administrators—anyone who wants to understand more about how students learn.

The goals for this course are:

- To foster an understanding of the unity of emotion and thinking and learning.
- To help educators connect brain research to classroom practice and school designs.
- To illustrate the benefits of collaboration between researchers and teachers so that research informs what happens in the classroom, and what happens in the classroom informs research.
- To recognize and strengthen two roles of the teacher:
  1. Teacher as designer who creates the context for learning (environment, lessons) and who is able to take the perspective of learners.
  2. Teacher as researcher who treats student responses as data that reveal the effectiveness of lessons and that provide information for the next step in the learning process.

This course provides insight into some of the current research from cognitive science and neuroscience about how the brain learns. The major themes include the deep connection between emotion, thinking, learning, and memory; the huge range of individual cognitive strengths and weaknesses that determine how we perceive and understand the world and solve the problems in it presents us; and the dynamic process of building new skills and knowledge. The course invites you to examine the implications of these insights for schools and all aspects of the learning environments we create for our children—teaching, assessment, homework, student course loads, graduation requirements. It is not a course that offers easy answers or proposes teaching methods that can be universally applied. Rather, it provides new lenses through which to view the teaching and learning challenges you face and invites you to discover your own answers to your own questions. If you want a brief preview of where we hope the course will take you, read the sidebar "Analyzing Classroom Problems through New Lenses." (Unit 6)
The greatest benefit of this course is that, instead of providing simple answers or "tricks" or teacher-proof lesson plans, it treats you as a professional capable of finding your own answers to the specific teaching challenges you face in your particular circumstances. The course focuses on how learners learn and invites you to consider how teachers teach. As a result, you will become more skilled at inventing teaching strategies to improve the learning of your students.

Along the way, the course offers you an important opportunity to revisit the experience of being a learner. It will remind you of the ways in which your students struggle with new material. In the language we use in this course, you will be "building new neural networks" for understanding and for applying ideas and principles that emerge from the research you study. To get the most from this experience (and from the course), we urge you to become conscious of your own learning—the struggles, the misunderstandings, the moments when ideas gel, the need to revisit a new idea repeatedly, your emotional responses, the conditions under which you do your best learning, the effort required—the whole messy, non-linear process. To this end, you may find it useful to keep a journal of your learning: thoughts, feelings, observations, and insights.
Section 2: Thinking big, starting small

This course has two main layers:

- It provides new insights into learning based on research.
- It stimulates your thinking about how to connect your teaching and lessons to these insights.

Some of the ideas in the course may challenge your current beliefs about learning and teaching. Some of the ideas may reinforce your beliefs, especially by making you conscious of feelings you have had about learning as a result of your years of experience as both learner and teacher. Either way, you will be filled with ideas, and you may feel a desire to start changing and fixing right away. You may even feel obligated to become agents of change. We can offer only one bit of advice: relax.

Change takes time, and most teachers don’t have a lot of that (except in the summer, which is a great time to think deeply about new ideas). The scope of what you can change also depends on how much autonomy, authority or responsibility you have. An experienced division head may be able to implement new ideas more quickly and with wider impact than can a new teacher. You can only do what you can do. What’s important is that you start somewhere.

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But even starting can be a challenge. Change is rarely comfortable, even when conditions support it. Some of you will come to this course from schools where you enjoy relative freedom, schools perhaps with small classes and a culture of innovation, but others will come from overcrowded classrooms in rigid systems that discourage change. And, just about all of us are products of over a century of tenacious assumptions about how children learn. Because we tend to internalize these assumptions and teach as we were taught and because the education-testing complex relies on these assumptions, new ideas can feel threatening. What we hope you will find here is a connection to a community of learners who understand both the need and the difficulty of change and who support your efforts no matter how limited or far-reaching. There are no small changes.
Gary managed to sit in his chair by resting on the lower vertebrae of his long spine, legs thrust well under the seat in front of him. His head rested on the top rung, and he glared at Jim, his teacher. Gary didn't seem to like Jim's sophomore English class despite months of Jim's trying to cajole Gary into participating. It was now winter, and Jim asked Gary to stay after class to discuss yet another dreadful essay. Though, as a young teacher in his fourth year, Jim had pretty much used up his limited strategies. "Come on, Gary, you could be a terrific writer if you'd just do some work. What's the matter?" "Nothing," he mumbled.

And on it went, frustration mounting in both of them until finally Gary looked at Jim and screamed, "I don't work because I hate your guts."

"Good," Jim shouted back. "Good, now we are getting somewhere." Whatever that meant.

But they did get somewhere. Jim had no idea how or why, but from that day on Gary became one of his best students. Years later, as Jim learned more about the connection between emotion and learning, he gained more insight into this incident. It appeared that Gary needed some sort of emotional catharsis to tell Jim how he felt in order to move on. Although Jim hadn't known it at the time, he and Gary had managed to align their emotional goals so that Gary could begin to learn how to write.

Most teachers know that emotion is important to learning. Math teachers certainly know how past classroom traumas paralyze students. Science teachers know that explosions, rockets, and snakes can crack the walls of student resistance. Many history, English, and foreign language teachers have become virtual stand-up comics attempting to make their classroom a funhouse of positive experiences. And arts teachers have long encouraged students to rummage about in their emotions seeking inspiration for their paintings, dances, and plays.

So, what is the point of more research into emotion and learning? What can neuroscience teach teachers that they don't already know? Fun and positive emotions enhance learning; fear and negative emotions prevent learning. What's new?

Well, a lot is new, and you'll discover some of that here. While these are reasonable questions, they also may miss the point as they suggest that the relationship between teacher and neuroscientist is similar to that between supplicant and oracle. Many of the conferences on learning and the brain feel like visits to Delphi—omniscient scientists lecturing a host of teachers looking for answers.

But the truth is that teachers don't need answers to questions about how to teach or how to bring the insights from research into their classrooms. And
neuroscientists don't have these answers anyway. Teachers and neuroscientists are members of a professional community of educators who seek to help young people learn. They are part of the village needed to raise a child. Both groups, though looking at learning from different perspectives, want to understand what works, why it works, and what might work better. Each group has its own job, and each group needs the other.

It Has to Make Sense

Abigail Baird, assistant professor at Vassar College, talks about neuroscience and suggests a simple way for teachers to distinguish between good and bad ideas from...

View video
Section 4: Teachers and neuroscientists at the same table

Teachers bring with them years of training and real experiences with real students in real settings—classrooms, hallways, cafeterias, recital halls, soccer fields, and basketball courts. No one cares more deeply about the success of students than teachers. They constantly observe students and draw conclusions in order to work on new strategies. They wake up at 4:00 a.m. agonizing about George, who seems to hate reading, or Mary, who still can't write, or Seth, who still can't solve a quadratic equation. They spend years confronting a wide range of learning problems. Not only do they develop deep insight into those problems, but they are also endlessly imaginative in addressing them. They are experts on student behavior, and are artists in the classroom.

Neuroscientists bring new insights into the brain itself. They devote themselves to exploring how the brain learns, how we recruit our different mental capacities to solve problems, how we compensate for our weaknesses, and how we capitalize on our strengths. Neuroscientists wake up at 4:00 a.m. wondering how to design an experiment to understand how a boy who has had his right hemisphere removed manages to do things he couldn't be expected to do—paint pictures, understand tonal nuances of speech, and succeed intellectually and socially in school. One series of experiments to test a single hypothesis can take years to carry out, sort out, and write up. Neuroscientists are experts in the mind and brain, bringing science into the classroom.

(End of first column online)
element of truth—that the teacher was responsible for delivering content—it didn't take long before educators became disheartened. They discovered that while their students could pass exams, they could not transfer their learning outside of the context in which it was learned. The same skills required to complete an assignment in class would remain untapped in real-world settings like the workplace, or when deciding which savings account is preferable (understanding the concept of compound interest).

Beginning in the 1970s, in reaction to many such observations, educators began to reevaluate the metaphors they used to describe the process of teaching and learning. This prompted a major shift in how people thought about teaching and learning that was detailed in a number of Annenberg programs developed in the 1990s. These include A Private Universe, the Private Universe Project in Science, and the Private Universe Project in Math. These programs are famous for scenes showing that even graduates of Harvard and MIT often fail to explain seemingly simple concepts, such as why seasons occur, even after years of the best education in the sciences. If learning could be explained as filling up empty containers, then how could such drastic failures of learning be explained? In fact, the old metaphor of passive, teacher-directed learning could not compete with more encompassing explanations. New metaphors were introduced that recognized that learning is dynamic; that students themselves must build knowledge to own it; and that the teacher's role is to interact with the ideas that the students are forming and then scaffold the learning experience.

**Learning as a Process That Constructs Understanding**

Once the metaphor for teaching and learning was changed, teaching suddenly became more complicated. Not only were teachers now responsible for understanding the content to be delivered, but they also had to understand what their students were thinking about these concepts. Teachers needed to become diagnosticians, like psychologists, to probe their students' ideas and understand their thinking. The model of teaching and learning that emerged at that time was often referred to as "conceptual change" or "constructivism," words chosen to suggest that learners build understanding for themselves, starting with their own ideas and modifying their understanding as they learn more about how the world works. In order to understand the seasons, for example, students must face the shortcomings of the common assumption that they result from the distance between the Earth and the Sun. (If you are curious or confused, remember that the seasons are, in fact, the result of the tilt of the Earth on its axis.)

Though the constructivist approach was helpful in promoting meaningful understanding, some educators found that even this didn't adequately describe the teaching and learning process. Educators rightfully observed that not all students learn in the same way, so they looked for some other model to help describe the learning process. Among the more popular ideas was a notion called Multiple Intelligences. Here, the idea was that the mind could be thought of as having capabilities in different areas, such as linguistic, interpersonal, or kinesthetic, and that teaching at its best would encourage learning that matched the strengths of individual students. This new metaphor was a refinement on the delivery and constructivist metaphors and honored individual differences among
students. However, educators began to realize that even this metaphor fell short. The notion that intelligence could be broken apart into separate capabilities, though perhaps a useful idea, was difficult to prove with research and often misinterpreted in practice.

**Building a New Metaphor for Teaching and Learning**

It may never be practical, desirable, or even ethical to genetically categorize every student or put all children through scanners to observe their brains as they learn. Yet, insights from neuroscience can be helpful in thinking about how teaching interacts with learning. And these insights will lead to new metaphors that teachers can use to sharpen and think about their work. Still, the metaphors for teaching and learning that are useful for teaching are not likely to come from the neuroscience community, at least not without some help. Teachers, who have an intimate understanding of what transpires in classrooms, will need to closely examine the ideas neuroscience has to offer in order to construct teacher-developed metaphors that are useful to the profession.

One goal of this course is to encourage teachers to work hand in hand with neuroscience researchers to develop new metaphors for teaching and learning that build on, sharpen, and refine those ideas previously developed. As you work through this course, either on your own or with your colleagues, think about how the ideas you see coming from neuroscience may refine or change the learning models you already have. Through this process, you will evolve a new set of powerful and useful metaphors for teaching and learning that are grounded in neuroscience. We hope that you will share these concepts with your colleagues and the neuroscience researcher community so that, together, teaching and learning can be made even more effective.

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**Mind, Brain, and Education**

Paul B. Yellin, associate professor at New York University School of Medicine and director of the Yellin Center for Mind, Brain, and Education, talks about the need for an equal partnership among...

[View video](http://www.learner.org)
Although they may not realize it, young people need teachers and neuroscientists to work together on their behalf. The collaboration between Jason Ablin, teacher and head of Milken Community High School in Los Angeles, CA, and Mary Helen Immordino-Yang, neuroscientist at the University of Southern California, illustrates the benefits of merging the two perspectives.

Immordino-Yang's research into the social and academic success of Nico and Brooke, two boys who had half of their brains removed to treat persistent seizures, led her to conclude that perhaps the way we perceive and solve problems is influenced by our particular cognitive strengths. We see the world and deal with it in personal ways that make sense in terms of prior experiences and a particular set of skills and abilities. It's not just that men are from Mars and women are from Venus. We all experience different realities in our minds.

In his book *Successful Intelligence*, Robert Sternberg illustrated this theory. As a child, he performed poorly on IQ tests and had very low spatial ability:

> By the time I was in high school, though, a strange thing had happened. My scores on tests of spatial ability improved radically. ...Or so it seemed. Had my spatial ability improved? Not really. It was no better than it had been years before. But I had come to realize that many spatial-ability problems on these tests can be solved verbally rather than visually. In other words, instead of trying to visualize what, say, a set of forms would look like in another spatial position, I tried to talk the problems through to myself. I would describe the figures verbally and then try to match that description with the answer options.

Sternberg had transformed a spatial problem into a verbal problem, a process similar to what Immordino-Yang observed in Nico and Brooke—a process that suits the problem to neural strengths and compensates for neural weaknesses.

Immordino-Yang's research and conclusions resonated with Jason Ablin's experiences in the classroom. Like most teachers, he knew that students often fail to understand homework and test problems as the teacher intended them to be understood. As a result, he saw that students might perform better in a classroom that actively engaged students in designing problems instead of wrestling with problems as
teachers conceived them. This sort of insight emerges when intuition built through practical experience—such as Ablin's experiences with students in the classroom—is reinforced by research into how the brain learns.

It's an exciting, creative moment when theory and practical observation come together and seem to reinforce each other. Of course, to complete the partnership, the teacher must then design the lesson and assess the validity of the new insight in practice. The teacher will likely discover new issues that challenge aspects of the theory and that suggest further research.

This dynamic partnership between teachers and researchers is the source of the goals for this online course.

"I think researchers tend to simplify things. Educators in the classroom see much more of the complexity. We need more of a discussion between educators and researchers, so we can form questions..."  – Dr. Tami Katzir

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Dr. Tami Katzir
INTRODUCTION: THE ART AND SCIENCE OF TEACHING

Section 6:
Beyond candy and smiley faces

People can be rather schizophrenic about emotion. While they may increasingly, though grudgingly, accept its importance to learning, it can be difficult to figure out how to integrate it into lessons and course goals. As a result, many continue to treat it as a nuisance that must be banished to the edge of the settlement. Rational thought—reason—remains dominant. When asked to discuss the connection between emotion and learning, most teachers mention a few popular notions:

- Negative emotions such as fear make learning impossible.
- Positive experiences enhance learning.
- Therefore, we need to create classrooms that are warm, welcoming, and supportive by smiling, shaking hands with students as they enter, getting to know them personally, making learning fun, and giving out rewards.

These ideas about positive and negative emotions are valid and important, but neuroscience is revealing a much deeper connection among emotion, thinking, and learning. For example, by studying patients who have sustained damage to the ventromedial prefrontal cortex, researchers are becoming increasingly convinced of the inseparable bond between emotion and thinking. Good thinking and good decision-making—"rational" thought—depend on emotional processes. In the words of Dr. Antonio Damasio, "Emotion is the rudder for thinking." We think in the service of emotional goals.

In addition, emotion is essential to good problem-solving. People constantly rely on intuition as they work on problems or seek answers to questions. We "feel" we are on the right or wrong track. We experience a sort of emotional jolt, often just prior to consciously recognizing a solution, whether to the problem of where we left our keys or to the problem of making sense of strings of numbers or pages of data. Intuition and what we call "rational thinking" may be different sides to the same coin called "emotional thought"—one side is more nonconscious and the other is more conscious, but both are minted in emotion.

It is these deeper aspects of emotion and learning that this course will cover. In fact, this deeper understanding will provide greater insight into the truths that teachers already understand about emotion—the reasons that learning is undermined by fear, and enhanced by fun and a balance of challenge and support.
ventromedial prefrontal cortex
An anatomical location in the brain. This region is in the lower half (ventro), deep between hemispheres (medial), in the front portion (prefrontal) of the brain.

Glossary

Dr. Antonio Damasio
"Emotion is the rudder for..."
– Dr. Antonio Damasio

View larger image

http://www.learner.org  Neuroscience & the Classroom
INTRODUCTION: THE ART AND SCIENCE OF TEACHING

Section 7:
Making meaning vs. getting answers

A learner is a learner is a learner. Regardless of whether learners are students in school or teachers engaged in professional development, the essence of learning is building new skills and new conceptual understanding. Learning is a process of internalizing new ideas so that they become personally meaningful (emotionally relevant) and useful. To solve problems, like how to help Sally learn to write an essay, means wrestling with ideas about learning, understanding Sally, and setting a path toward a solution.

Unfortunately, many educators continue to equate learning with "having" answers, as though knowledge is an object like an apple or a pencil, something that can be grasped or stuffed in a box, usually in one of the memory boxes—short-term memory, long-term memory, or working memory. However, accustomed as they are to an educational system built on correct answers, most teachers come to professional development seeking answers. This desire for answers is understandable, even inevitable, given the huge demands on teachers' time. They want a quick fix. "Don't bore me with a lot of theory or abstraction; give me the answers. How do I apply this stuff? What do I do on Monday morning?"

Although a quick fix would be nice, conditions and challenges vary too much from school to school and classroom to classroom and learner to learner. A solution that works in one classroom for one student might simply make matters worse in another classroom for a different student. Meaningful answers to the multitude of specific questions that teachers face tend to rely on the creativity, flexibility, and skills of the person asking the question. As a result, this online course takes a different approach. Rather than pretending we have answers that no one else has, our objective is to help you develop an understanding of new principles—new lenses for examining the teaching and learning problems you face. That way, you can create and test your own solutions. This course is designed to foster a discussion among a community of professionals interested in education.

As a young theater teacher, Sam recalls the panic of Monday morning. What could he do with 18 acting students? Oh, Viola Spolin has the answer. He grabbed her classic book, "Improvisation for the Theater," and led his students through mirror exercises, tug-of-war, and who-started-the-motion. They had a lot of fun, but Sam's laughter barely hid his growing dismay over how little the students were learning, and how meager their development was as actors. He had no clue how to assess the value of these exercises because, beyond some vague notions about spontaneity and reacting in the moment, Sam had not internalized the concepts on which this method of training was built. They were just exercises that occupied the students—diversions that kept order and created an illusion of purposefulness. They were Spolin's answer, not Sam's.

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So, he spent some time thinking more deeply about acting, about the principles embedded in his own education, and about his experiences with different acting teachers and theater directors. Slowly, Sam built an understanding of acting that was meaningful to him, one that felt true. Acting is living in public as though you are in private. Acting is believing. Based on these ideas, Sam built and borrowed new exercises that made sense, that emerged coherently from these principles, and that seemed appropriate for his 18 students. For example, instead of asking his students to play pantomime games that focused their attention outward on an audience, he had them engage in small tasks on stage—like threading a needle and sewing a button on a shirt. That way, they could begin to build a feeling of private concentration even as others watched.

These exercises, in turn, gave students experiences that led them to develop their own understanding of acting and invent their own ways to approach a scene or build a character. Eventually, Sam even found his way back to Spolin, whose approach now seemed, through the lens of the meaning he had constructed, more suitable for advanced rather than for beginner students. Finally, he was able to create his own solutions to the problem of transforming theory into practice, of understanding and inventing what to do on Monday morning.

"Teachers have to mix it up and try varied ways of reaching students. If I am only saying something one way, it may make sense to me, but students may not have that same association. If the..." — Siri Fiske

"The tactics that are most productive center on a very old notion of project- or problem-based learning. It starts with students’ own interests in something that is important in their..." — Dr. Gary Scott
Glossary

**short-term memory**
A term used to describe the neurocognitive system that retains a finite amount of information for a short period of time.

**long-term memory**
A term used to describe the neurocognitive system that retains information, most typically described in two forms. Declarative memory includes subdivisions of episodic and semantic memory, referring to specific episodes or facts, respectively. Procedural memory includes knowledge about how to complete tasks or procedures.

**working memory**
A term used to describe the neurocognitive system that simultaneously stores and manipulates information for a short duration. Multiple models and definitions of working memory are actively being explored in research.
INTRODUCTION: THE ART AND SCIENCE OF TEACHING

Section 8:
The essence of learning and teaching

Building an understanding of concepts and then creating solutions and answers to problems are essential steps to successful learning and teaching. To paraphrase Kurt Fischer, director of the Mind, Brain, and Education Program at Harvard University, Graduate School of Education, Sam (Introduction, Section 7) needed to develop a new neural network for acting. That way, he could invent classroom exercises that emerged from his understanding—and that, in turn, helped his students build their own neural network for acting. Being given the answers short-circuits the process of understanding because people often fail to create the necessary connections between theory and practice. People fail to create a rich neural network. For Sam, using Viola Spolin's answers divorced from the principles that give them meaning was like a child using a screwdriver as a hammer. The more opportunities people have to work with concepts and to make them our own, the richer, more stable, and more complex the neural connections will be.

Teachers who rely on answers from someone else deny themselves the more engaging challenge and fun of creating their own exercises based on their own understanding of the research. And if teachers can't create their own exercises, they remain dependent on others to tell them what to do. They don't develop their skills as creative teachers, just as students who parrot the answers their teachers give them rarely become creative learners.

It really doesn't matter whether we are teachers or students. The slow process of making knowledge our own is ultimately more powerful, meaningful, and effective in producing learning.

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Yet, many teachers continue to seek answers, and there are plenty of hucksters ready to sell them the brain-based elixir of the day.

Like prospectors following a gold rush, snake-oil salespeople are cashing in on neuroscience, peddling "brain-based" teaching methods that will strengthen memory and stimulate comprehension. For only $29.99, you can buy a book of nifty classroom gimmicks guaranteed to work and backed by scientific studies, complete with standard deviations.

In the absence of sufficient counterclaims, many teachers are buying (see article, "Understanding..."
"Teachers need to know about neuroscience because there are myths out there. And these myths help us stereotype students into different kinds of learners. Consider this idea: There is a right..." — Siri Fiske

The Role of Neuroscience in Brain Based Products: A Guide for Educators and Consumers

The bottom drawers of teacher desks and filing cabinets, as well as gigabytes of CDs, are filled with free handouts and expensive books stuffed with answers for Monday morning. Most are rarely used, and many are used ineffectively as empty worksheets or busywork. They are as useless to the teacher as memorized formulas or abstract definitions are to students.

Successful professional development brings together a community of learners willing to take the risk of thinking together about insights into the connections among the mind, the brain, and learning, as well as their implications for schools. The major goal of this course is for you to share the experience of a colleague who said, "I expected more 'answers' and am glad I didn't get them. Too much professional development works to give answers and overlooks that the teacher is the skilled professional, acting in a nonduplicable context. This course helped me to THINK better."
INTRODUCTION: THE ART AND SCIENCE OF TEACHING

Section 9:
New lenses, eternal questions

Over the six units of this course, you will be encouraged to formulate and understand principles or hypotheses from research and use these to explore classroom and institutional issues. The course asks you to imagine implications of the research for how we teach and then to create lessons and design schools. While exploring the relationship between emotion and cognition, the course examines some specific biology and functions of the brain:

- How the brain recruits its many parts to accomplish different tasks (right-brain/left-brain facts and fiction)
- Developmental differences and individual profiles of cognitive strengths and weaknesses
- The interplay of emotion with the mind and body
- Mirror neurons, empathy, and the self
- The biology of social emotions like compassion and admiration
- The relationship between performance and context in learning
- Skill development via the construction of webs and neural networks
- The critical role of regression in learning

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All of which have significant implications for education:

- Motivation, attention, engagement, and memory
- How different students perceive and solve problems
- Learning differences and disabilities
- Policy and practice issues involving all aspects of school—such as homework, grading, course loads, and graduation requirements
"It's important for teachers to know about the research because it can support great intuitive teaching. It can also help us to understand how we can align our teaching to the ways in which..." — Eric Baylin

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Section 10:
Resources


