

Six Keys to Learning: Excerpts from *Limitless Mind* (Jo Boaler, 2019)

Studies in brain science present a very clear case for the importance of self-beliefs and the role of teachers and parents in influencing them. (10)

Key #1: Every time we learn, our brains form, strengthen, or connect neural pathways. We need to replace the idea that learning ability is fixed, with the recognition that we are all on a growth journey. (13)

- Every single day when we wake up in the morning, our brains are different than they were from the day before. (17)
- International studies of achievement in different countries across the world show that countries that use tracking the latest and the least are the most successful. (26)
- It is time to recognize that we cannot label children and have low expectations for them... As we ourselves are learning in these pages, the most notable quality of our brains is their adaptability and potential for changing and growing. (31)
- Struggle is the very best process for brain growth and that she could grow the neural pathways she needed to learn more mathematics. If she had known that, Susannah would probably have persisted and graduated with a math major. This is the damage that is caused by fixed-ability thinking. (41)
- Anders Ericsson has studied IQ and hard work for decades and concludes that the people regarded as geniuses — people like Einstein, Mozart, and Newton — “are made not born,” and their success comes from extraordinary hard work. (42)
- Many of us have grown up feeling judged for everything, often feeling “not good enough” and worrying about being found out. When people let go of fixed-brain ideas, they become unlocked, especially when they combine this knowledge with other findings from neuroscience. (45)

Key #2: The times when we are struggling and making mistakes are the best time for brain growth. (47)

- Researchers found that when people made mistakes, brains were more active, producing strengthening and growth, than when people got work correct. (48-49)
- The common belief is that getting most answers correct will motivate students toward greater success. Here’s the problem, though. Getting questions right is not good brain exercise. For students to experience growth, they need to be working on questions that challenge them, questions that are at the edge of their understanding. And they need to be working on them in an environment that encourages mistakes and makes students aware of the benefits of mistakes. This point is critical. Not only should the work be challenging to foster mistakes; the environment must also be encouraging so that students do not experience challenge or struggle as a deterrent. Both components need to work together to create an ideal learning experience. (49)
- Even when the message is phrased more powerfully — that mistakes are good not only for learning but for brain growth and connectivity — it is hard for teachers to send it in a system in which they are made to give students tests that penalize them every time they make a mistake. (56)

- In the moments when they turned to us, looking forlorn or despondent and sad things like, “This is too hard,” we would say “These are the greatest moments of brain growth — that feeling of it being too hard is the feeling of your brain growing. Keep going. It is really important and valuable.” And they would turn back to their work. (62)
- It is in the handling of failure that the quality of being limitless really shines... It is easy to feel open and free when things are going well; it is when things are going badly and challenges or aggression stand in our way that it is most important to be limitless. (72-73)

Key #3: When we change our beliefs, our bodies and brains physically change as well. (77)

- Part of the process of change and of becoming limitless involves letting go of the idea that your past failures came because there was something wrong with you. (91)
- One of the obstacles to a positive change in our beliefs is our own self-doubt... a natural part of our lives. What is not natural is a “true, dead-stop obstacle, one that is impossible to get around, over, or through.” In all of his years of research studies, Ericsson has found it surprisingly rare to find any real limit on performance — instead he sees people become limited because they give up and stop trying. (93)
- Teachers and others should praise the learning process, and if students are not making progress, help them find other strategies and different approaches. Crucially, praise should be linked to effort that leads to something important... Teachers hold an incredible amount of influence. They can change the pathways of students... when they communicate to students that they believe in them, that they will value times of struggle and mistakes, and that they will honor different types of thinking and ways of approaching life. (98)

Key #4: Neural pathways and learning are optimized when considering ideas with a multidimensional approach. (101)

- For students to develop a growth mindset, teachers need to teach with a growth perspective, opening content to the multiple ways students can learn, so that students can see the potential for growth inside it. It is challenging for students to develop a growth mindset when subjects are presented in a fixed way — as a series of questions with one answer and one method to get it. (102)
- Such multi-modal thinking creates the opportunity for brain communication and development. Fluid and flexible brains neuroscientists conclude, come from the synchrony that occurs when multiple brain areas come about together. (111)
- A creative and multidimensional approach — the invitation to see in different ways — can be enacted in any content area... What do you see? How do you make sense of it? This values visual thinking and the multiple different ideas students will come up with, both of which are to be celebrated and encouraged at all times. (116)
- The idea that it might not be okay to struggle or to think differently is tragic, and yet these are ideas believed by millions of students, particularly about math. When the children changed their ideas about the value of struggle and learned to see math differently, the increase in their self-confidence was noticeable to the teachers. (119)
- *What do you see? What don't you see? What might you see? What could be the next thing?* These different ideas are not complex, but they are at their heart all about multiple paths to

learning. They encourage students thinking to strike out in directions far different from “the usual.” Teachers who make these changes in their methods are playing with content and experiencing the freedom that comes with this approach — instead of following textbooks, they experiment with ideas and invite students to experiment with them. We now know that teaching through a multidimensional approach also increases a brain’s connectedness which will help students develop into powerful and possibly “trailblazing” adults (121)

- Another core benefit of working and living with a multidimensional approach is that when roadblocks appear, you know there are alternate routes... there isn’t only one way to do anything; there are always multiple ways forward. (124)
- In many classrooms, students are given problems they do not know how to access — which causes them to think negatively about themselves and their learning. When problems are changed to become “low floor and high ceiling” — problems that are accessible by all but lead to more challenging work — everybody can access them and take them to different places. (125)
- When we let go of the idea that speed is important and approach learning as a space for deep and flexible thinking, it enables a breakthrough in the ways we encounter the world. (133)

Key #5: Speed of thinking is not a measure of aptitude. Learning is optimized when we approach ideas, and life, with creativity and flexibility. (134)

- When we are stressed or under pressure, our working memory is impeded. The students who are the most compromised are those with the most working memory. (135)
- Fields Medal Winner Laurent Schwartz: “It is true that I was, and still am, rather slow... Rapidity doesn’t have a precise relation to intelligence. What is important is to deeply understand things and their relations to each other. This is where intelligence lies.”(138-139)
- Easy come, easy go neural connections can be rapidly reversed. This is what is happening when we study for a test, and we go over something we have already learned. We cram information in and reproduce it in a day or so, but it does not last and is quickly forgotten. More permanent brain changes come from the formation of new structures in the brain — the sprouting of neural connections and synapses. This is always a slow process. (140)
- When people learn slowly and quickly, teachers often assume they have different potential, but they are actually involved in different brain activity, and the slow, deep activity is more important. (140-41)
- When we value memorization over depth of understanding, we harm the deep thinkers who turn away from the subject. We also harm the successful memorizers who would have been helped by an approach to knowledge that gave them access to deep understanding. (143)
- The researchers made an important point: the low-achieving students, who were not thinking flexibly, were learning a different mathematics, and the mathematics they were learning was more difficult. (146)
- They are underachieving because they have the wrong approach to mathematics, thinking they need to use memorized methods. They have memorized counting strategies that

they keep using, even when number sense would be much more helpful. They need, instead of being drilled, to engage with numbers flexibly and creatively. They need to approach numbers differently. (147)

- Fields Medal Winner William Thurston: “Once you really understand it and have the mental perspective to see it as a whole, there is often a tremendous mental compression. You can file it away, recall it quickly and completely when you need it, and use it as just one step in some other mental process. The insight that goes with this compression is one of the real joys of mathematics.” (149)
- The study showed, on an international level, that taking a memorization approach to learning does not lead to high achievement, whereas thinking about ideas and relationships does... Filling our minds with content that we can reproduce at speed is unlikely to help us solve the problems of the future; instead, training our minds to think deeply, creatively, and flexibly seems far more useful. (161, 163)

Key Idea #6: Connecting with people and ideas enhances neural pathways and learning. (166)

- Part of the reason students give up on learning is because they find it difficult and think they are alone in their struggle. An important change takes place when students work together and discover that everybody finds some or all of the work difficult. This is a critical moment for students, and one that helps them know that for everyone learning is a process and that obstacles are common. (168)
- Connecting with another person’s idea both requires and develops a higher level of understanding... When we collaborate, our brains are charged with the complex task of making sense of another’s thinking and learning to interact. (168, 171)
- In a world of online connectivity, genuine human connections are something that everybody needs and that changes people’s lives (186).
- To interact well, people need to have an open mind, and to develop it, they need to value difference. Students will start to appreciate and think positively about each other if teachers highlight the importance of different ways of thinking... When we change this perspective for children or adults, it changes how they interact with others, in classrooms and in life. (186)
- Relational equality — produce citizens who treat each other with respect, who value the contributions of others with whom they interact, irrespective of race, class, or gender, and who act with a sense of justice, considering the needs of others in society. (186-87)
- The connections that arise from more open beginnings lead to more worthwhile conversations and ultimately better relationships, thinking, and work. (192)
 - Becoming comfortable with uncertainty
 - Acknowledge that you don’t know (and want to explore it together)
 - Letting go of judgment
 - Knowing your worth
 - Becoming more resourceful when facing roadblocks
 - Not giving up on something
- Learning changes us as a people. When we learn new ideas, we see the world differently — we have a different way of thinking and a different way of interpreting every event in our lives. (203)