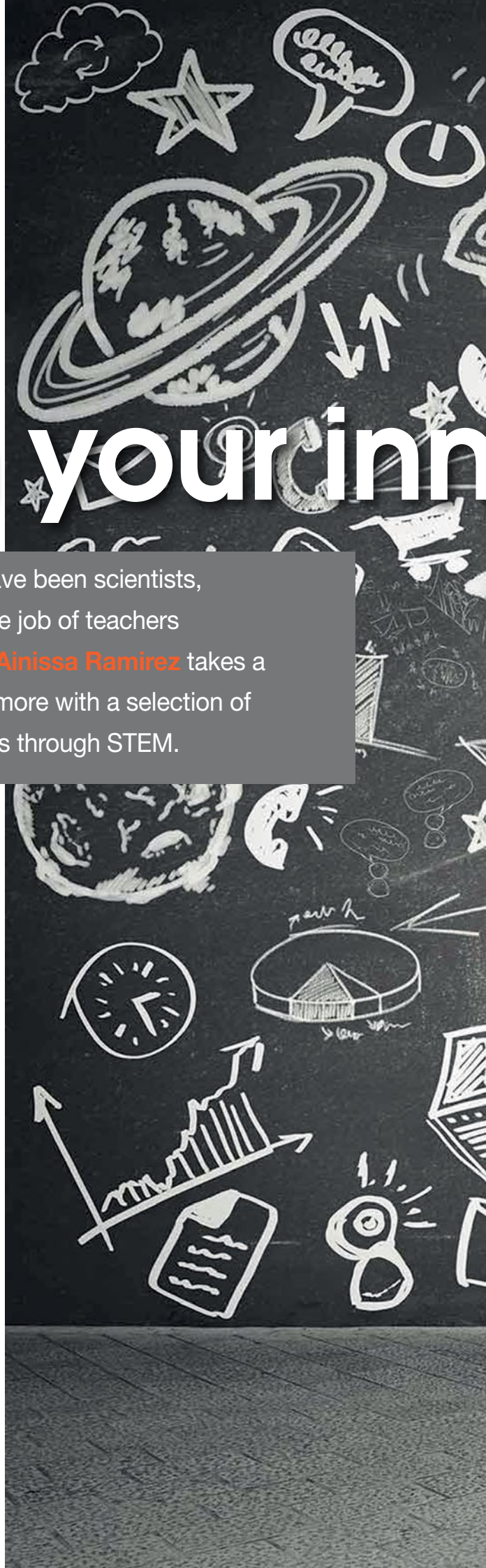
Unleash your inn



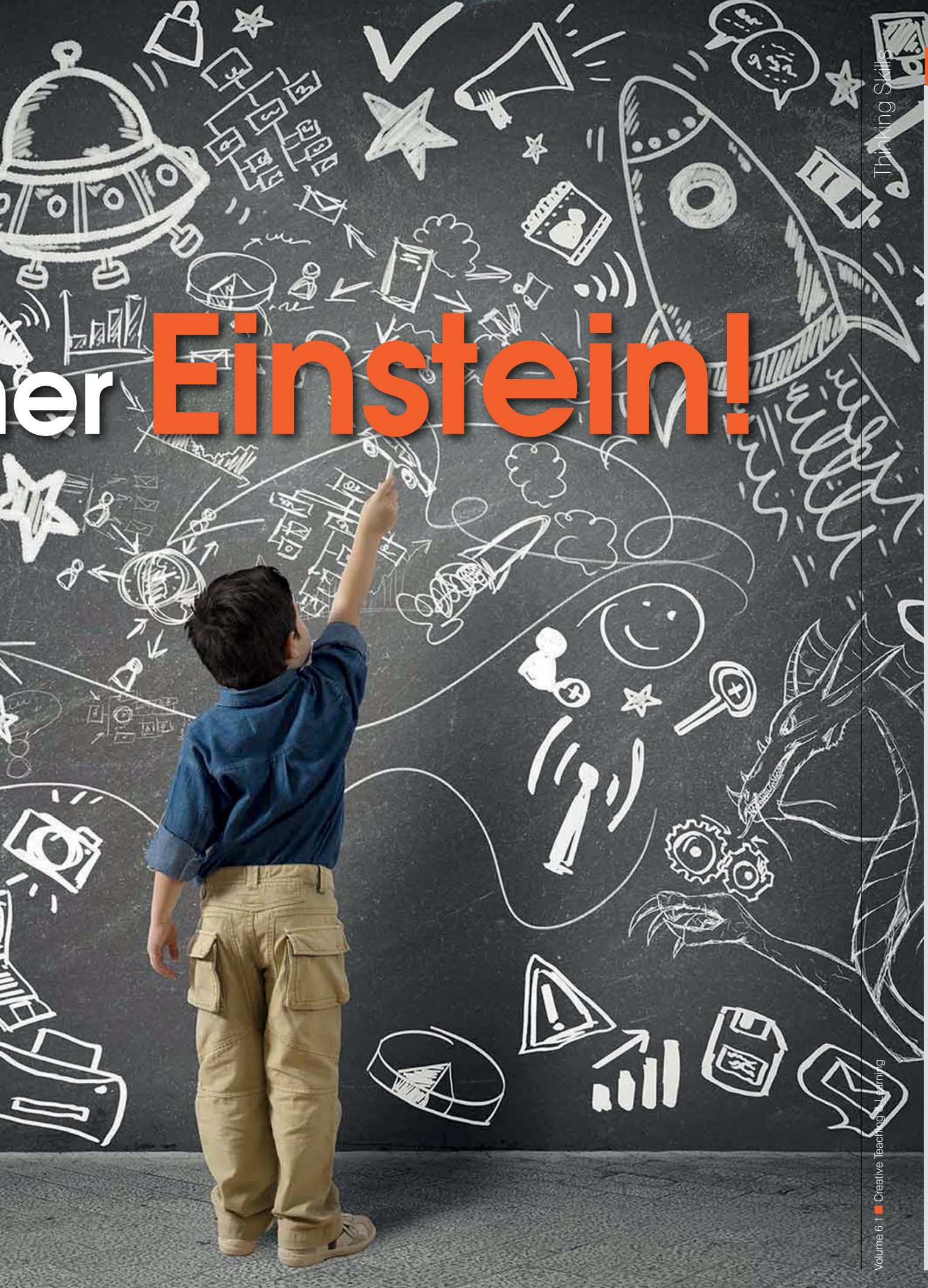
Some of history's most creative thinkers have been scientists, engineers and mathematicians – and it's the job of teachers everywhere to inspire the next generation. **Ainissa Ramirez** takes a lesson from Edison, Einstein, Newton and more with a selection of strategies to promote creative thinking skills through STEM.

Since ancient times, humans have found new and creative ways to put things together. Someone thought it would be a good idea to apply pigment to a wall, and did it, which is why we see prehistoric cave paintings. Someone thought it would be a good idea to make a contraption that cheats gravity, and did it, which is why we travel in aeroplanes. Someone thought it would be a good idea to submerge trans-Atlantic transmission lines, and did it, which is why we communicate rapidly over vast distances.

We in the 21st century face many global quandaries, which can only be solved through approaches not yet imagined. As Einstein said, 'We can't solve problems by using the same kind of thinking we used when we created them.' The next generation will therefore need to be willing, and able, to do things differently. In other words, they will need to be able to think creatively.

One pathway to developing children's creative thinking skills, especially those that will prepare them for their future as innovators, is through STEM.

There is a lot of talk in the news about STEM at the moment. STEM is the bridging of science, technology, engineering, and maths, but in actual fact, it is much more than that. The best way to think about STEM is to enumerate what it isn't. It's not about memorising facts – that's what your parents had to do. Neither is it about reciting trivia or doing problems with answers in the back of the book.


er Einstein!

What it is, however, is a mindset; it blends separate disciplines together and produces a new type of learner with a new set of skills. STEM helps children become creative problem solvers. And, this is what our century certainly needs.

Promoting divergent thinking

There are two schools of thought about creativity in problem solving. The first path is to have lots of ideas and see which works. This is the divergent thinking approach. Linus Pauling, who won the Nobel Prize in Chemistry in 1954, had such an approach. He said that his method for doing science was to have 'a lot of ideas, and throw the bad ones away'.

Pauling wasn't alone. The American inventor, Thomas Edison, was a master divergent thinker too. With over one thousand patents to his name, Edison believed in trying lots of ideas to find one that worked. When he was looking to create a long-lasting filament for the light bulb, he tried thousands of different materials—ranging from bamboo to platinum to hickory to human hair—before he reached the carbon filament.

Sometime later, a reporter interviewed Edison and asked if he felt like a failure for all those unsuccessful attempts. Edison replied: 'I found 9,999 ways how not to make one.' His response gives us another clue about the creative process. We need to rebrand failure as data. Trial and error, which is just a fancy way to say fail-a-lot, is part of a fact-finding mission. STEM activities can reduce the sting of failure by bringing children to understand that it is part of the creative process.

When I was a mechanical engineering professor at Yale University and teaching materials science courses to undergraduates, I tried to incorporate opportunities for divergent thinking. It was my intention to provide a safe space to think creatively. Divergent thinking thrives in an environment that allows pupils to express themselves in different and unique ways, take risks and fail.

Commonly, I found my students very reluctant to be creative in class. It wasn't their fault – they were trained that way. In addition to that training, materials science is often presented with what seems to be unconnected facts, so it is hard to be creative within this topic.

In my class, I would make an opportunity for creativity by stopping in the middle of my lecture, and asking: 'How can we use this material?'. There was often a long silence. I

could sense my students looking for the 'right' answer, and the brave ones would suggest a few answers that they thought I wanted to hear. So I'd make room for divergent thinking and say: 'This is a judgement-free zone. You've learned a few things about this material, so please share with your neighbour how we might use it.'

Once I said this, a transformation happened. Ideas would start to trickle in and after a few more moments, they started to pour. My class entered the creative zone. And, the next time I did this, the hesitation lessened. My students became more comfortable with spontaneously generating ideas. They became more comfortable with divergent thinking.

Strategies for thinking divergently

According to Diane Rees, there are four general guidelines for supporting divergent thinking:

- Defer judgement (this includes both criticism and praise).
- Collect and consider every possible idea.
- Strive for the unusual and encourage different perspectives.
- Look for combinations of ideas that might work together – i.e. building off the ideas of others.[1]

Brainstorming is a simple strategy, and can be done in groups or as a class. Brainwriting is sometimes used instead of brainstorming. Here people write down their ideas about a particular question or problem on a piece of paper, then after a few minutes, they pass it on to the next person, who reads the ideas already written and adds their own. This process repeats until after ten to 15 minutes the sheets are collected and posted for immediate discussion. This works well with quieter pupils who might be intimidated by other more confident members of their group and are afraid to share their ideas or speak out.

Edward de Bono's six thinking hats are also useful for promoting divergent thinking, as they allow pupils to view a problem from different perspectives depending on which hat they're 'wearing', helping groups to bounce off each other with positives, negatives, new ideas, questions and more.

Here is a very simple activity for you to try in your own classroom to nurture pupils' divergent thinking. Bring in a household item like a key, a can, a toothbrush or any other object. Now, have your students come up with a list of possible uses for this item. For example, a key can be used for opening doors, but also for opening boxes, carving wood, and opening a can. And that's not all. A key can also be a computer stylus, a scraper, jewellery, wind chimes and a fishing sinker. See what comes up. No answer is wrong. The goal of the activity is to come up with as many ideas as possible.

Linking the unlinked

The other type of creativity is the combination of things from different fields. This is the Janusian approach, named after the Roman god Janus, who was the god of opposites.

Many famous STEM innovators were supporters of this type of thinking – Newton paralleled a falling apple to gravity's pull on the moon, Kepler linked the workings of a clock to the motion of the planets, Bohr compared the planetary orbits to the structure of the atom. Even Einstein used railways to explain time in his special theory of relativity.

The best way to describe the Janusian approach in STEM is the use of analogies as a model to help grasp a concept. Analogies and metaphors are thought-mappings that help understanding. And, when we give children an opportunity to make such mappings, we prepare them to be more inventive. They'll be able to make unusual parallels between topics—they'll create. If metaphors are the tools used by the giants in science, then the art of using metaphors will benefit our children as well.

Einstein once said: 'You do not really understand something unless you can explain it to your grandmother.' This simple but profound statement holds for all of us. To be more creative, we need to feed our subconscious with simple interpretations so that we can generate new combinations of these ideas later. Making metaphors enables us to find the connective tissue between these ideas down the road.

Strategies for encouraging connections

To nurture Janusian creativity in children, use information from one domain to explain another. Use analogies. Ask how is blood circulation like traffic? How is a cell like a city? How are chemical bonds like human relationships? Such suggestions may sound a bit farfetched to pupils initially, but they do two things: First, they solidify understanding by entering the brain through another pathway. Second, students find it easier to understand when complex concepts are likened to familiar everyday scenarios.

To get children to encounter Janusian thinking, create ways to couple different ideas in new ways. Make a game out of it. List topics that fall under science or engineering and find new ways to describe these phenomena. Can you parallel a concept to music, a river or dance? These analogies allow students to see things more simply.

Another activity you can try is to make two lists of random topics and ask your students to find connections between one word in each of the lists. Explore the linkages; they might be very entertaining, and again, there is no wrong answer.

Here is an example:

Water	Traffic
Bees	Crayon
Circle	Glass

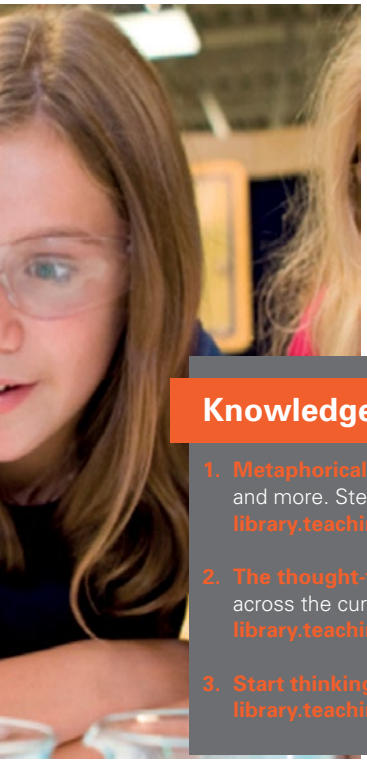
For a connection between water and glass, students might find that they both give a reflection. For bees and traffic, they might say they both behave like a swarm. And so on. Make it a game and have students share their connections.

Linking ideas in new ways and generating lots of ideas are certainly methods to improve creativity. We also need to give the brain a chance to incubate. Science shows that giving the brain downtime is a good idea. Let's explore why.

Reduce diversions, increase creativity

In our world today, every object around us is trying to get our attention. Things blink, beep or blast interesting ringtones. We are inundated with noise and occupied by diversions. As much as we are surrounded by a world full of distractions, science has shown that the removal of disturbances improves creativity. In fact, researchers have found that boredom increases creativity.

In a study from the University of Central Lancashire, scientists split subjects into two groups – one that did a boring task and another group that did not. Both groups were then asked to work on a task that would demonstrate their creativity. The 'bored' group performed better.[2] 'Boredom … has always been seen as something to be eliminated,' says Dr. Mann, a professor of psychology and one of the researchers of this study. 'But perhaps we should be embracing it in order to enhance our creativity.'[3] When you are not consumed by technology, your brain has space to breathe and to create.



Many great writers have echoed this. Agatha Christie once said: 'The time best to plan a book is while you are doing the dishes.' As unpopular as boredom may be, it is important for our children to make space for creativity by logging off, and a classroom is a great way to make such space. While in class, take a few moments and ask students to have their minds wander, and then have them report what they thought. Make this a fun activity to demonstrate the importance of making room for creativity. Their budding inventive minds will be grateful in the future.

Creativity is hard to define and even harder to teach, but there must be a willingness to do all that is possible to nurture it. STEM is one way to make our children become the creative problem solvers that are desperately needed in our peculiar century. So let's teach children to be creative and let's not be afraid to be creative about how we do it.

Ainissa Ramirez Ph.D. is a scientist, educator and STEM advocate, speaking internationally on the importance of making science fun. Find her on Twitter at @ainissaramirez.

References

1. Rees, D. (2010) Strategies and tools for divergent thinking. Instructional Design Fusions, [blog] 23 October. Available at: instructionaldesignfusions.wordpress.com/2010/10/23/strategies-and-tools-for-divergent-thinking [Accessed 5 June 2015].
2. Burkes, D (2014). The creative benefits of boredom. Harvard Business Review. [online] Available at: hbr.org/2014/09/the-creative-benefits-of-boredom [Accessed 5 June 2015].
3. British Psychological Society (2013). Being bored at work can make us more creative. ScienceDaily. [online] Available at: www.sciencedaily.com/releases/2013/01/130108201517.htm [Accessed 5 June 2015].

Knowledge trails

1. **Metaphorical thinking –** Metaphors and analogies are powerful tools for teaching and learning in science, English and more. Steve Williams explains why.
   library.teachingtimes.com/articles/metaphoricalthinking
2. **The thought-filled curriculum –** Arthur Costa shares five thoughts about developing children's ability to think across the curriculum.
   library.teachingtimes.com/articles/thethoughtfilledcurriculum
3. **Start thinking –** A selection of creative, open-ended starter activities to get children's brains buzzing.
   library.teachingtimes.com/articles/start-thinking