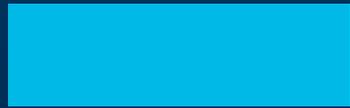




The Institution of  
Engineering and Technology



# STEM



# Superheroes

How children's love of  
superheroes can inspire the  
next generation of scientists  
and engineers.

By the Spectacular Dr Sarita Robinson,  
the Marvellous Dr Matt Dickinson and  
the Fantastic Dr Barry W. Fitzgerald



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# Introduction



Some of our best-loved superheroes are scientists and engineers. **Peter Parker (aka Spider-Man)** is a keen chemist; **Shuri**, the princess of Wakanda, is a talented innovator; and **Dr Helen Cho** is a gifted geneticist. This report explores how it could be possible to engender children's love of superhero scientists and engineers, inspiring the next generation into science, technology, engineering and maths (STEM) careers.

## Our love of superheroes

Heroic tales have been entertaining and inspiring children and adults throughout history. Today, the popularity of Marvel and DC's superheroes is reflected in everything from massive box office movie sales to the global appeal of superhero merchandising. Superhero fan bases are hugely diverse, from young children to older adults. Although comic book superheroes are firmly embedded in contemporary popular culture, can these superheroes achieve more than just entertain us?

Research suggests that superhero stories can inspire us to be the best versions of ourselves, as well as provide moral guidance<sup>1</sup>. Superheroes can also provide us with inspirational goals, encourage us to be more adventurous and learn new skills. So, what could be the important role that superheroes play in inspiring the next generation of scientists and engineers?

## Why do children have a greater affinity with superheroes than scientists?

A hero is described as someone who tries to help others or who will fight for a moral cause regardless of the risk, with no expectation of reward<sup>2</sup>. Scientists and engineers' critical role in keeping us safe in the 21st Century shows us that not all heroes wear capes. From Sir Tim Berners-Lee, father of the World Wide Web, to Professor Sarah Gilbert, who helped to create the Oxford Covid-19 vaccine, the fields of science and engineering are full of real-world STEM heroes. However, children seem to want to grow up to be superheroes, rather than STEM scientists and engineers.

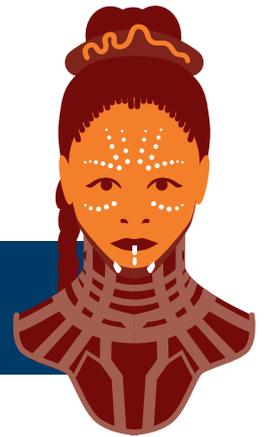
## Should we worry?

The answer is yes. Previous IET reports<sup>3,4</sup>, suggest children's interest in science, design and technology, and computing has fallen at least 10% among 9 to 12-year-olds in recent years. Meanwhile, the STEM skills shortages may lead to an estimated loss of £1.5bn per year to the UK economy, so inspiring the current school generation into STEM careers as scientists and engineers is critical, while they are still playing with their mud kitchens or building robots out of empty cereal boxes.



1 Kinsella Elaine L., Ritchie Timothy D., Igou Eric R. (2015). Lay perspectives on the social and psychological functions of heroes. *Frontiers in Psychology*, 6, 130 <https://www.frontiersin.org/article/10.3389/fpsyg.2015.00130>  
2 Psychologist Philip Zimbardo – What makes a Hero? – [https://www.youtube.com/watch?v=grMHztRm\\_8](https://www.youtube.com/watch?v=grMHztRm_8)  
3 <https://www.theiet.org/impact-society/factfiles/education-factfiles/addressing-the-stem-skills-shortage-challenge/>  
4 <https://eandt.theiet.org/content/articles/2019/08/children-s-love-for-stem-on-the-decline-iet-survey-finds/>

# Five reasons why children have a connection to superhero scientists and engineers but not to real-life STEM heroes



Children don't seem to have any issues engaging with science and engineering in superhero movies, but they often struggle to connect them with real-world STEM.

Superhero scientists and engineers, such as Shuri, Falcon or Kitty Pryde, are discussed in playgrounds around the world, with children embracing their complicated science-based storylines.

Diverse topics, such as bioengineering (e.g. X-Men and Hulk movies), artificial intelligence (e.g. J.A.R.V.I.S in *Marvel Avengers Assemble* (2012)) or advanced robotics (e.g. Vision in *Avengers: Age of Ultron* (2015)), are all debated with delight and interest. So why do children find topics such as astronomy and aeronautical engineering accessible in a superhero movie or comic but not in the classroom? And why is children's love of superhero scientists and engineers not transferred to real-life STEM heroes?

## 1 Lack of a window into the world of STEM

Getting access into the world of science and engineering can be challenging, with young people being less likely to have the opportunity to see people working in science research labs or an engineering workshop. However, in the world of superhero comics and movies, we have full access to our heroes' workplaces.

We can see Tony Stark working on his Iron Man suits or Jemma Simmons conducting experiments in her lab at S.H.I.E.L.D. headquarters.

## Top 10 favourite superheroes

1. Iron Man
2. Spider-Man
3. Batman
4. Wonder Woman
5. Superman
6. Thor
7. Incredible Hulk
8. Captain America
9. Black Panther
10. Black Widow

The top three superheroes are all engineers and scientists!

"It is really exciting to see Shuri's lab in *Black Panther*. I hope I can work in a lab like that one day."

Future scientist, 11.



## 2 Superheroes can be more relatable

It can be easier to make a personal connection and empathise with a fictional superhero, as they often share the same motivations and struggles as we do. For example, many teenagers feel socially awkward and can easily relate to a superhero like Peter Parker (Spider-Man).

Storylines give us access to our superheroes' lives, helping fans to find common ground with them. STEM heroes, by contrast, are harder to learn about and we rarely hear the full stories of their amazing achievements, making it more difficult for children to understand the struggles of, and relate to, real world scientists and engineers.



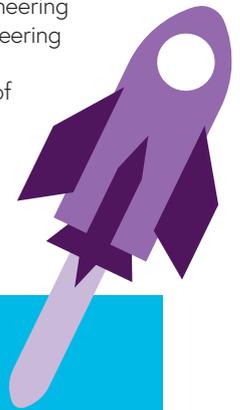
"I love how Peter Parker (aka Spider-Man) designed his web shooters, and he seems much nicer than the other Avengers."

Future engineer, 13

## 3 Superhero stories are simple

Fictional superheroes are more likely to give us a simplified version of real-life. Whereas a superhero might undertake a major engineering venture solo or perhaps race against time to create the antidote to a serious illness in a matter of hours, real-world STEM is more complex.

Science discoveries and technological breakthroughs can take years, with scientists and engineers normally working as part of a large and diverse team. Although real-world science and engineering can be just as amazing as in superhero movies, it may not offer as much 'wow factor' as when our favourite superhero finds out the answer on their own in just a few hours. In the real world, STEM applications can be more abstract, with children often not seeing the importance of these science and engineering projects. Superhero science and engineering can therefore help STEM seem more relevant, while making the outcomes of STEM research appear more concrete.



"Buzz Lightyear is my favourite. I want to build a spaceship for Buzz."

Girl, 2

## What children like most about superheroes

1. They're able to save the world
2. Having powers
3. The costume
4. They're good people that help the world to be a better place
5. They're brave

## 4 STEM is not always accessible

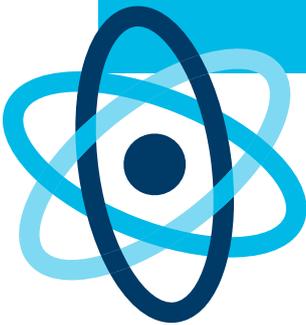
Science and engineering can be complicated and full of TLAs (three letter acronyms), often requiring a good deal of basic knowledge just to start talking about current scientific theories.

Superhero movies, however, can make science and engineering accessible, as they often have complicated STEM ideas at their core, and can also be connected to the real world, by clearly explaining the everyday applications of discoveries and inventions. This helps children engage with complicated ideas, such as what life at the quantum level looks like or what would happen if the Moon crashed into the Earth, without first doing science A levels. This makes what our superhero scientists and engineers are doing easier to understand and discuss, whereas it is much harder to discuss the work of real-world STEM heroes.



"I could not believe my son got interested in Quantum physics after watching the Ant-Man movie. We also had a really good discussion about the ethics of human experimentation."

Father of a teenager, 58



## 5 Lack of representation

We are more likely to form a connection to people who look like us. If we see scientists and engineers who look familiar, we are more likely to adopt them as role models, believing that we can also have a STEM career. Yet, although things are improving, a lack of diversity remains in those who choose to work in STEM, and can lead children to look to the world of fiction for STEM role models who represent a cross section of heritages and life experiences.

Superheroes come from a range of different backgrounds, and must often overcome barriers to success, so superheroes who are also scientists and engineers offer a set of diverse STEM role models for children. For example, Charles Xavier (Professor X, leader of the X-Men) is a scientific genius who also requires a wheelchair for mobility; Matt Murdock is a blind superhero who fights villains as the iconic superhero Daredevil; and Maya Lopez (Echo) is a Native American, deaf superhero who appears in the Disney+ TV series Hawkeye. Children growing up today may find it hard to find a real-life scientist who looks like them, so for children who do not see themselves reflected in the current world of STEM, superhero stories can inspire them.

"As a biracial woman growing up in the 1980s I knew I wanted to be a scientist, but all the scientists on TV shows like "The Great Egg Race" did not look like me. I had to look into the world of fiction to find women working in STEM. I loved Lieutenant Uhura from Star Trek and Nyssa from Doctor Who. The next generation of children will be inspired by superhero scientists and engineers such as Shuri, the scientist from Wakanda (Black Panther) or Jodie Whittaker's portrayal of Doctor Who."

Scientist, 46

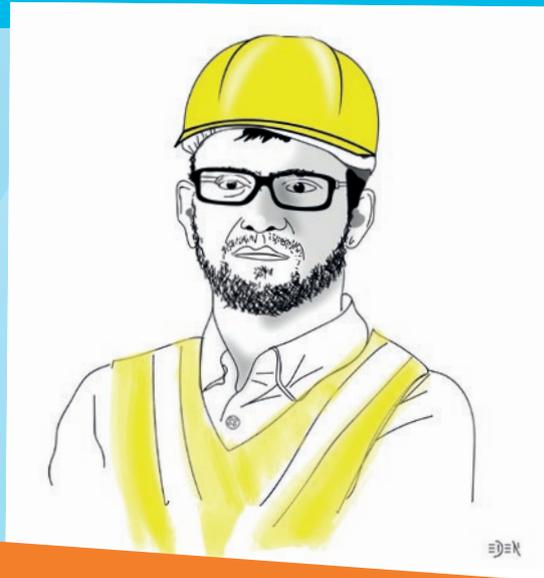


# Science and engineering are for everyone

The "Draw-a-Scientist Test"<sup>5,6</sup>, is a great way to gain insight into how children perceive scientists and engineers.

If the children in your life draw the stereotypical image of a scientist or engineer (an unkempt, small, elderly or middle-aged man, wearing a white coat, glasses and with a beard), it might be worth asking them to reflect on how this matches up with the scientists and engineers that they know from the world of superheroes.

For example, superhero engineers from the Marvel Cinematic Universe, such as Shuri (Princess of Wakanda), Sam Wilson (Falcon) and Hope van Dyne (the Wasp), highlight the current diversity of superhero role models.



**Over 90%**  
of children think  
superheroes  
are "cool"

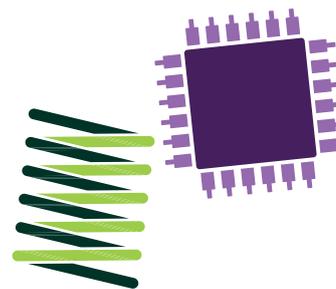
**60% of children**  
didn't realise Peter Parker (Spider-Man),  
Tony Stark (Iron Man) and Bruce Banner  
(Hulk) are scientists or engineers

**63% of  
children**  
would prefer to be  
a superhero than a  
scientist or engineer  
when they're older

5 Mead, M., & Metraux, R. (1957). Image of the scientist among high-school students. *Science*, 126(3270), 384-390.

6 Chambers, D. W. (1983). Stereotypic images of the scientist: The draw-a-scientist test. *Science education*, 67(2), 255-265.

# Real-life STEM heroes case studies



So much of what we love about superheroes is based on technology and innovations that already exist or are being developed by real-life scientists and engineers.

The potential to use superheroes as a teaching tool has long been recognised<sup>7</sup>. As far back as 1944, Professor Sones of the University of Pittsburgh undertook research examining the use of comics in education. Teachers involved in the study reported using language workbooks that included Superman was a success but "presented the annoying difficulty of causing the youngsters to complete a whole week's work in one evening!"<sup>8</sup>

Today's superheroes have been used to engage children and young adults in STEM subjects, in publications such as "*Unmasked: The Science of Superheroes*"<sup>9</sup> and "*Secrets of Superhero Science*"<sup>10</sup>. However, using Superheroes to promote STEM may achieve more than just capturing a young person's interest in a topic. Superheroes who are scientists and engineers also act as inspirational role models, showing children that STEM is for everyone.

Here are a few examples of STEM in (superhero) action:

## Super(hero) applications of exoskeletons

Exoskeletons are designed to protect us (as the Iron Man suit protects Tony Stark when it's hit by Thor's hammer) or even to hold or carry extra weight.

Could we engineer a suit like Iron Man's in real-life? In part, yes. However, compared to what the Iron Man suit does without recharging, our exoskeletons will never operate for as long – or at least, not yet! Will we ever have an exoskeleton suit that looks like skin? Definitely in the future. With the development of soft material exoskeletons, such as the Exosuit, we are well on our way to creating the technologies needed to make this happen.

What about Batman? Well, he can fly by gliding, then land on the ground and spring into action. As he lands, a huge force will be travelling across his spine and shoulders, so he could easily be injured to the point where his arms are no longer usable. Could science and engineering fix that? The answer, of course, is yes. By creating a passive exoskeleton that absorbs the force of the landing, Batman can be confident he will always make a great entrance to the party!

The current challenge with all these super-complex systems is they need frequent recharging. In future, developers hope to find lower power consumption solutions that don't compromise people's ability to do more and move better.

**90% of children**  
want to solve world problems  
and help the planet when  
they're older

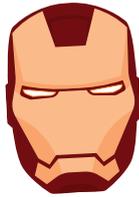
**75% of children**  
say they are more inspired by Spider-Man than science  
graduate Peter Parker, despite them being the same person

7 Fitzgerald, B.W. (2018). Using superheroes such as Hawkeye, Wonder Woman and the Invisible Woman in the physics classroom. *Physics Education*, 53, 035032, doi: 10.1088/1361-6552/aab442.

8 Sones, W. W. (1944). The comics and instructional method. *The Journal of Educational Sociology*, 18(4), 232-240. (Quote from page 233).

9 Walsh, R. et al (2020). *Unmasked: the Science of Superheroes: Science Behind Superheroes*. UCLan Publishing. <https://unmaskedscience.uclan.ac.uk/>.

10 Fitzgerald, B.W. (2016). *Secrets of Superhero Science*. BW Science. [www.bwscience.com](http://www.bwscience.com).



## Prosthetics and Exoskeletons

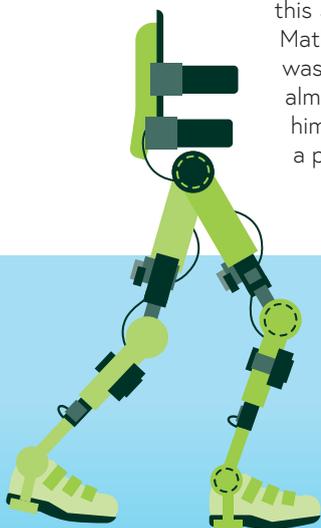
For over 100 years, scientists and engineers have been fascinated by the world of insects. One thing that has always sparked interest is the outer shell attached to their bodies. Through research into these fascinating creatures, scientists were able to establish that these shells, seen on crabs, cockroaches or mites, are in fact an external skeleton, hence the term "Exo", which means outside, and "Skeleton", meaning hardened structure to support motion. By taking inspiration from these animalia, and using electronic and mechanical engineering methods, scientists and engineers are aiming to mimic this structure for humans.

Exoskeletons are used in various aspects of society, one key area of which is to aid recovery from injury (rehabilitate) or even help people walk again – the "ReWalk" exoskeleton and the "Homcoma" exoskeleton are two amazing examples of this pioneering technology in action.

Harvard Biodesign Lab in the United States has been working on a new approach to exoskeletons, which has been renamed the Exosuit. Typically, we think of the exoskeleton as a solid structure designed to help the human move their joints with the aid of small electric motors.

The Exosuit uses fabric to imitate the contraction of muscles. The hope is that such assistive technology could one day be worn to help us where we may need it – for example in space.

Currently, robotic prosthetic arms are available but tend to be programmed to do multiple, pre-defined actions. However, researchers at Johns Hopkins Applied Physics Lab in the United States have been working on a new type of prosthetic that doesn't read signals from the muscles but straight from the brain itself. The first person to use this \$120 million arm was Johnny Matheny who, in a live demonstration, was able to move a prosthetic arm almost as well as a human, showing him move all his robotic fingers like a person with a healthy hand.



## Biosensors

Numerous superhero characters wear suits that enhance their abilities beyond the everyday experience. The Ironheart suit allows Riri Williams to fly; the Ant-Man suit allows Scott Lang or Hank Pym to shrink to the size of an ant or smaller; and the Black Panther suit protects the wearer and increases their strength and endurance. However, in the coming years, exoskeleton suits will be commonplace in many aspects of modern life, from construction to healthcare.

The aforementioned suits allow the wearer to do the extraordinary and, as technology advances, scientists will be able to monitor and guard the well-being of the wearer with an array of medical sensors.

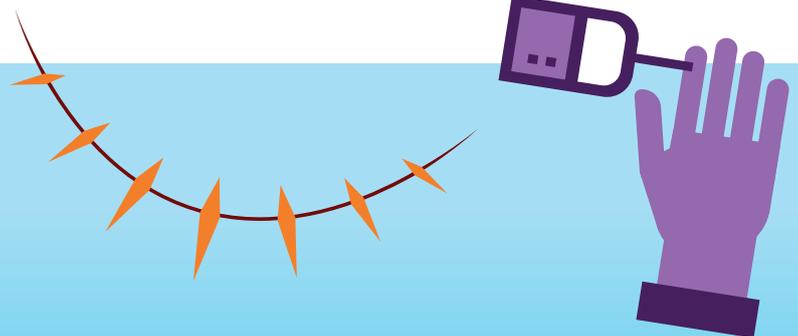
We already use medical sensors every day: an ear thermometer to measure body temperature, a heart rate monitor in a sports watch and a blood pressure cuff are all examples of medical sensors.

So why would an exoskeleton suit like the Iron Man or Ironheart suit need biosensors? Well, biomarkers can act as indicators for injuries or abnormal biological responses in the body; an innovation that our superheroes can certainly benefit from. If Tony Stark, for example, suffered bruising, internal bleeding or even a concussion, specific biomarkers would appear in the blood after the injury. Biosensors in the suit could continually check for these biomarkers and, if detected, the suit could quickly administer suitable medical treatment – all without the wearer having to take off the suit.

Advanced biosensors that can monitor biomarkers in the body are in fact being used now, but the prospect of the suit providing the wearer with advanced medical treatments is something different altogether.

Believe it or not, numerous researchers are working on the development of miniscule nanobots that could help the body to heal faster, seal wounds quicker, and eliminate infections in the blink of an eye!

While this sounds like something from the fictional laboratories of Tony Stark, in the healthcare and exoskeletons of the future, these healing nanobots may become run-of-the-mill.



## Let's visit the Quantum World!

In recent years, the superhero genre has been exploring an even smaller world than that of biomarkers in the human body. That smaller world is the quantum world. In the 2015 film *Ant-Man*, Scott Lang accidentally enters the quantum realm – a world so small that even our most powerful microscopes can't see it.

When Scott Lang enters this miniscule world, he somehow shrinks to a size smaller than an atom, a proton and a quark. In the real world, scientists and engineers are fascinated by the quantum world, but they don't plan to visit it; instead, they want to use atoms and sub-atomic particles to build the fastest computers imaginable: quantum computers!

Today's computing technologies are an integral part of our lives. Most jobs involve using computers in one way or another; then there's the small, but extremely fast, computers in our smart devices, such as smartphones and tablets.

Quantum computers are the next stage in computing, where classical bits (which store information as ones and zeroes) are replaced by quantum bits, also known as qubits. Unlike classical bits, quantum bits can store both a one and a zero at the same time! This might sound confusing, but the quantum world and quantum physics are known to be confusing at times! This behaviour allows a group of qubits to store all possible values at the same time; in comparison, a group of classical bits can only store one value.

But what will we make qubits from? Well, atoms, of course, but more precisely the electrons that orbit the nucleus of the atoms. Electrons can spin, which can be spin-up or spin-down, and this is perfect for storing information in quantum computers. However, the qubit atoms need to be ultracold, otherwise they can't store information.

## The Quantum Future

Thanks to advancements in quantum technologies, and our understanding of quantum physics, quantum computers will become part of the fabric of society sooner rather than later.

This means new jobs: quantum computer engineers, quantum programmers, quantum software testers and quantum data scientists. Basically, any job associated with computers, then put quantum in front of it!

It might be some time before we have quantum computers in our homes, but they will play a key role in scientific research, particularly when it comes to doing calculations that classical computers would take far too long to complete.

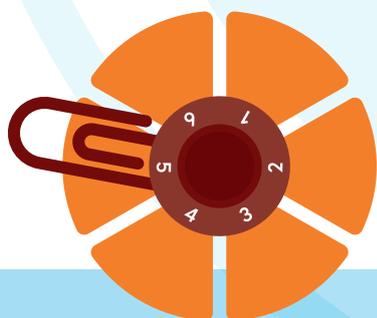
The Quantum Future is coming – even if we won't get to shrink to the size of atoms like Scott Lang (*Ant-Man*) or Janet van Dyne (the *Wasp*)!



### Conclusion

**It is possible that the person who could cure cancer or invent a physical matter transporter device has already been born.**

We now all have a role to play in inspiring and nurturing these bright sparks so that they turn into the next generation of inventive and creative scientists and engineers. Using superheroes from comic books, movies and television shows is a great way to capture a child's interest and get them started on a career in STEM – if we inspire them now, Iron Man, Ant Man and all of our other favourite superhero tech entering the real world may be closer than we think.



# Seven ways to use superheroes to inspire your children into STEM

## 1 Catalyst for conversation

Superhero movies and comics contain a wide variety of science-based storylines that can spark an interest.

Once you have read the superhero story or watched the movie, you can nurture children's interests by asking questions and researching answers together. Questions could include: "Is a super soldier serum possible?", "How can mutations to our DNA occur?" and "How could you design an advanced voice assistant like J.A.R.V.I.S?".

## 2 Superheroes as STEM role models

If you hear phrases like "girls can't be engineers", or if when you ask your children to draw someone working in STEM they draw an old, white-haired man with glasses, it is time to watch some superhero movies.

When watching superhero movies, caregivers should take the time to highlight potential superhero role models. For example, scientists from superhero stories, such as Shuri from Wakanda and Dr Margaret "Peggy" Carter (who works in the Strategic Scientific Reserve), can help to show children that STEM careers are open to everyone.

## 3 Spotlight on STEM careers

Children may not be aware of all the career options offered through STEM, however superhero movies and comics provide caregivers a perfect way to talk to children about breadth of STEM jobs they could consider.

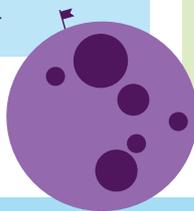
For example, talking about Doctor Jane Foster's field research into mysterious weather events (as in the 2011 *Thor* movie) is a good way to introduce children to the world of astrophysics

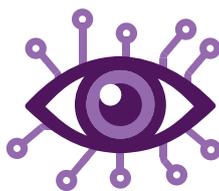
Discussing real-world scientists who have jobs in the same field as their favourite superhero will help fire their enthusiasm.

## 4 Real-world application of science

Caregivers can also use superhero movies and comic books to show children how STEM can have an impact on the world.

For example, it can be hard for children to understand what real-world impact mechanical engineering can have, but by discussing mechanical engineering in relation to the retractable wings of Sam Wilson's EXO-7 Falcon suit, it can be more meaningful. So, the next time you watch a superhero movie, it could be useful to ask how many times science or engineering saved the day.





## 5 Normalising failure

Some children can be put off STEM subjects because they can't grasp a concept immediately or they make mistakes with their learning.

Caregivers can use superheroes to show how everyone in STEM makes mistakes. For example, when Tony Stark was building the Iron Man suit in *Iron Man* (2008), he made countless mistakes during the process. This didn't stop him building the suit, and he continued to try new things, persevered and learned from his mistakes.

## 7 Dogged determination

When we learn about people working in STEM, the news stories are often focused on successes.

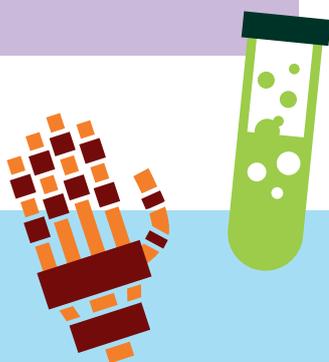
Less often do we hear about the hard work, heartache and failures which may happen before great achievements. However, superhero movies provide caregivers with the opportunity to explore the theme of determination and resilience in STEM. For example, caregivers can use scenes such as Peter Parker working on perfecting his web shooters in *The Amazing Spider-Man* (2012) as an example of how perseverance can pay off.

## 6 The importance of teamwork

Superhero stories give us the opportunity to talk about the softer skills needed to succeed in STEM. For example, children need to know it is OK to ask for help and that they need not face STEM challenges on their own.

Caregivers can use superhero stories to talk about the importance of teamwork and collaborating with people who might have different strengths to your own. For example, in *Avengers: Age of Ultron* (2015), Tony Stark works with Dr. Bruce Banner and Dr. Helen Cho because they are experts in fields where he lacks knowledge.

**So now it's time  
to suit up, to  
help children soar  
into the super-  
world of STEM!**





### About Dr Sarita Robinson

Sarita Robinson is passionate about inspiring the next generation into working in the STEM areas.

As the Deputy Head of School for Psychology and Computer Science at the University of Central Lancashire, Robinson works hard to promote STEM subjects to young people from a diverse range of backgrounds. Being a scientist, Robinson is keen to make science accessible to everyone, and has an extensive science communication profile, including many festival talks and media appearances. As well as publishing academic papers, Robinson has written several book chapters linking science and superheroes, most recently co-authoring the science book for young adults called "Unmasked – Science of Superheroes". You can check out her website – [www.drsvival.co.uk](http://www.drsvival.co.uk) for more information.



### About Dr Barry W. Fitzgerald

Barry W. Fitzgerald is a scientist, science communicator and a massive fan of the superhero genre.

A physicist by training, Fitzgerald has been combining his love for all things science and superheroes for several years. He is the author of three popular science books (including *Secrets of Superhero Science* and *How to Build an Iron Man Suit*), a podcaster and a YouTuber, with his channel "The Superhero Scientist", where he shares videos on the science and engineering of superheroes, Star Wars and other topics. Fitzgerald has spoken worldwide about science and superheroes at schools, universities and science festivals. In addition to publishing papers on fundamental and superhero science research, he is also the editor-in-chief of the Open Access journal *Superhero Science + Technology*. Fitzgerald currently works as a science communication officer at the Eindhoven University of Technology, in the Netherlands. He has seen the 2012 film *The Avengers* more than 80 times, and his superpower remains a closely guarded secret.

Photo by Bart van Overbeeke Fotografie ([www.bvof.nl](http://www.bvof.nl))



### About Dr Matt Dickinson

Matthew Dickinson is a mechatronics engineer who lectures in advanced design and simulation at the University of Central Lancashire.

He is also a researcher of exoskeleton technology predominantly aimed at rehabilitation for children. Along with one of his colleagues, Matthew is extremely passionate about STEM to inspire the next generation to believe in their ability. Over the past decade he has performed the show "Comic-Book Science" where the topic of a superhero or super villain is examined and then rebuilt to see if it would work in reality, such things as fully functioning Iron man helmets/plating, Dr Octavius working tentacle and a working "see with your ears" Daredevil cowl. This show was presented in schools and comi-cons all over the UK. He was turned into a superhero character in the comic book "Hero Lab". As well as publishing academic papers, He has co-authored the science book titled "Unmasked – Science of Superheroes."

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