Space+: Pathways for All Abilities

A VISION TO CHANGE THE WORLD

ONE TACTILE MODEL AT A TIME

An interview with Nicolas Boone
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Born three months premature, Boone had underdeveloped eyes at that stage. The oxygen that kept him alive also damaged his eyes, causing permanent vision impairment. Nevertheless, that did not stop him from star gazing. Growing up in Bendigo, in the Southeast of Australia, Boone was able to venture to the countryside where the deep, dark skies await. Even though he could not see a lot, he received support from his parents and brothers, who would describe what they could see and help him spot some of the brighter objects like the moon or planets.

This childhood experience motivated him to pursue STEM subjects in primary and secondary school and eventually to complete a bachelor's degree at Monash University in Melbourne, majoring in astrophysics, with minors in maths and physics. However, the path to a PhD was tumultuous. Boone's first attempt at a PhD failed due to a combination of factors such as inaccessible education materials and anxiety and depression due to a fear of inconveniencing others. However. Boone bounced back stronger after learning how to advocate for himself and eventually earned a PhD in his second attempt.

He earned a PhD after experiencing challenges, a break from studying and a journey of self-discovery.

In this interview, Boone shares his journey of self-discovery and his passion for science education and outreach. As the lead of the award-winning Tactile Universe public engagement project, Boone is considered a trailblazer in his field. He believes his vision impairment offers a unique perspective and understanding of astronomy and our universe. With each new tactile model and outreach workshop, Boone works towards his dream of championing for accessibility in space science education for all.

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UNOOSA: Tell us about how you became interested in space.

Boone: I developed an interest in space and science at an early age. In fact, my first memory was watching a documentary on TV about the Voyager probes. The Voyager 2 pictures of Neptune got my attention and inspired me. I had my face pressed right up against the TV screen, and I could see that Neptune was this beautiful deep blue colour. I could also tell that behind Neptune, there was just darkness and emptiness, and I remember being amazed that it had taken 12 years for Voyager to travel to Neptune.

For 5-year-old me, that was a revelation. This idea that everything, even in our solar system, was so far away and far apart, really got me thinking about the many unknowns of the universe. I also remember being inspired by science communicators like Carl Sagan at that time and being drawn to their passion for astronomy.

A student comparing a tactile image of galaxy Messier 51 to a full colour image of the same galaxy.
Credit: Glenn Harris

After my initial interest as a child, my family continued to cultivate my curiosity in science and astronomy. I was never told, "But you are blind, so you can't do this or that." My family and teachers were always willing to sit down with me and find ways to make my interests accessible.

This included creating a unique way of describing something that made more sense to me or modifying a school science activity so that I could participate and learn. We all became proficient in problem solving and thinking outside the box to develop solutions. Thanks to those experiences, I have developed the ability to problem solve. This is something that still serves me well today, particularly in my current job.

Astronomy relies heavily on visual representation, which may present challenges for persons with vision impairments. What difficulties did you encounter and how did you overcome them?

I'm not totally blind, though, and I can see a little to read and use computers, as long as text is magnified and high contrast.

When I was younger, there were fewer resources available to allow me or other people with vision impairment to study astronomy and science easily.

Most of the media that was available were pictures used for education. These media are produced by somebody who has a good level of vision and can look at a detailed picture of something in space and provide detailed descriptions.

So, I must either rely on somebody else's description, which of course, contains their own biases and interpretations or spend a lot of time looking at that picture carefully and thoroughly myself. Despite those challenges and setbacks, I think what really kept my attention and enthusiasm was a the facts, figures, and information that I was able to absorb.

Also, I was surrounded by teachers, friends and family members who were willing to share my interest, encourage me when things got difficult and spend time collaborating with me to understand the more visual aspects of astronomy. Finding the best way to describe images or processes really helped.

Can you tell us why you left astronomy during your first PhD attempt and what made you return?

During my first PhD attempt, I struggled to speak up when things were not accessible or adapted for my needs.

One of the major problems was keeping up with reading material. Also, the accessibility of the coding was difficult. Astronomical observation was another challenge. I struggled running the observation —optical observing was challenging, but the radio observing wasn't bad.

In addition, I was also dealing with undiagnosed anxiety and depression. This is because I was not speaking up when I needed things to change, and I thought I was inconveniencing other people.

So, for at least a couple of years after this, I thought that I was not going to go back to doing what I love. I thought I was done with astronomy and that I needed to find another dream to chase. At the time, it was heartbreaking. But when I started working on myself, I really started thinking about having another go at a PhD.

> *"If we can show people how to make a subject like astronomy accessible, we might be able to inspire other communicators and educators to do the same with their own resources and projects."*

Finally, I moved back to Melbourne from Canberra. One of my old lecturers from my time as an undergraduate at Monash offered me some work running undergraduate astronomy labs and tutorials. Working with the undergraduate students, teaching them about astronomy and seeing their enthusiasm really helped me recapture my love and passion for the subject.

By the time I had decided to start my second attempt at a PhD, I had also put a lot of work into understanding myself and my limitations. This includes understanding how my mental health could impact me. This helped me to become more confident in my ability to ask for help when I needed to and to advocate for myself in terms of accessibility. During my second attempt at a PhD, I was much quicker to jump on problems before they got bad. I also started doing things to make my own life a little easier, such as using text-to-speech software.

What motivated you to start the Tactile Universe project? How do you think this project will change the future of astronomy in terms of attracting young people from diverse backgrounds and creating an inclusive environment for persons with disabilities?

The original idea for the Tactile Universe came from a conversation I had with a colleague at the University of Portsmouth, where I was asked the question, "What would have made your PhD research easier for you as a visually impaired person?"

My response was, "Seeing the galaxy images," and my solution was to make those images tactile! My colleague was inspired by this idea, and we quickly created our first prototype tactile image. When I was able to touch the 3D print of that prototype image for the first time, I knew that we had something special with the potential to inspire people.

Nic Bonne working with vision impaired pupils from Toynbee School to develop accessible workshops around the Tactile Universe resources.

For young people using our resources, I really hope that we can use our project to demonstrate that subjects like astronomy can be accessible and that they just might need to do things in slightly unusual ways to succeed. We want to inspire these young people to chase their dreams and pursue interests or even careers in STEM subjects, if that is something that they want to do.

For educators, science communicators and researchers, I think that the project can act as a good example to others. If we can show people how to make a subject like astronomy accessible, we might be able to inspire other communicators and educators to do the same with their own resources and projects.

For me personally, being able to act as a positive role model for young people with vision impairments is a big part of things as well. If I can show that it was possible to achieve my dreams but also be very honest about the difficulties I have encountered along the way, I can really help people.

By making the educational resources free to download and 3D print, and by training others to deliver them to their own communities, the Tactile Universe has reached audiences across the UK and internationally.

How do you make the models as realistic as possible so that the students with visual impairment can better understand the images?

When it comes to disability, there is no "one size fits all," and everyone has unique needs and requirements for accessibility and adaptability. To address this, we included feedback from different people who have diverse types of vision impairments.

This helped us to set the size, models and tactile features. In addition, we have used different types of materials to enhance the feeling. The 3D-printed models represent a happy medium. They're very durable, have a good level of detail and are pleasant to touch.

This will also allow the user to explore the images and the 3D printed models in depth without being overwhelmed. We wanted to leave in features like foreground stars and background noise. All those extra details help users explore the images and can generate lots of interesting questions.

Also, to include those who have good vision, we added the image that we used to make each tactile surface to the back of the model, allowing users to look at this while feeling the corresponding tactile surface on the other side.

To get inspired, we used familiar objects such as footballs and rugby balls to talk about the shapes of elliptical galaxies, and models of spiral galaxies are made from CDs and sculpted putty or Play-Doh.

How do you think future science communication and inclusivity can be improved? Do you think this will change the way we see disability and perceive it as a whole — visual and non-visual people using the same object to understand the universe?

Multi-modal approaches are going to be important in improving inclusivity, as these will benefit everybody, not just people with visual impairment.

If we just focus on sight, or just on touch, or just on sound, we are always going to be excluding somebody. We can include as many of those modes as possible in anything we create to engage people with astronomy. This will ensure that people can access what we've created in whichever way they feel the most comfortable with.

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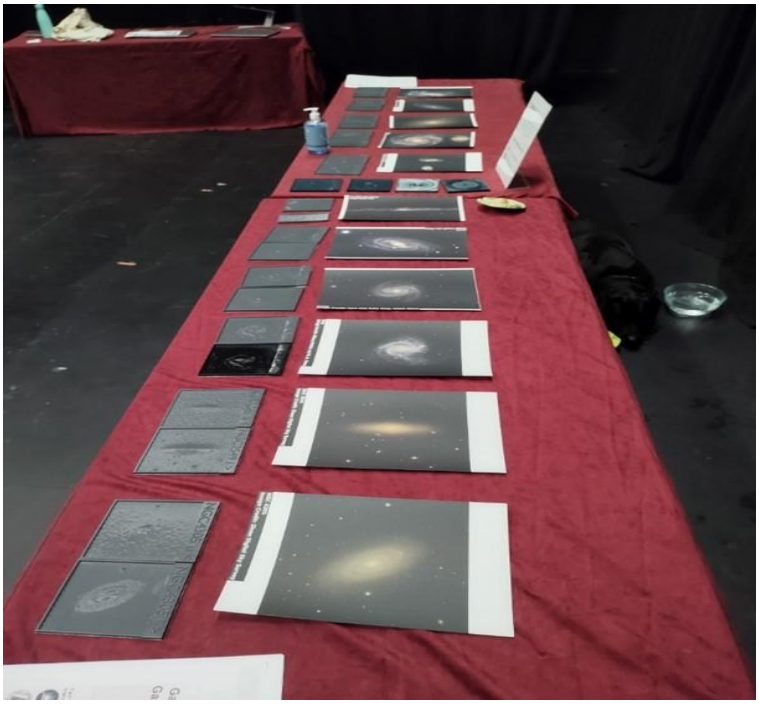
For slightly higher technology alternatives for the future, the use of haptics represents an exciting leap forward, though it's expensive. In the future, being able to feel the 3D shapes of objects in virtual spaces or interpret data sets through haptics has a lot of potential.



The Tactile Universe models set up at a public outreach evening held during the National Astronomical Meeting 2022
Credit: Nicolas Bonne

I think thanks to the Tactile Universe project, now people with visual impairment are able to feel things that they cannot see. I have had several astronomers tell me that this has made them think about elliptical galaxies in diverse ways. For example, when we work in classrooms with students in mainstream schools, there may be only one or two students with visual impairments and the rest are fully sighted. In these environments, we always run our workshops with everybody involved, using all the same resources, regardless of how much they can see. We have found that this helps the students in the classrooms understand one another better and work to gather.

You worked on the Audio Universe project. How is the use of sound different from the use of tactile models?

The Audio Universe project has been a lot of fun to work on. The advantage of audio over tactile is that audio is much cheaper and easier to produce. The Audio Universe planetarium show uses sound effectively to describe objects in motion (the planets in our solar system orbiting around the Sun). The sound that we chose to represent each planet was important, as producing audio that sounds nice helps engage a wider audience.

The project involves identifying each planet using a different musical instrument (with deeper, brassier instruments representing the gas giants and higher instruments representing the rocky planets). This made the sounds much more relatable for our audience.

Sound can be a powerful way of communicating space education; this includes listening to signals, spectra, etc. Our ears are good at picking up on this. Sonification can be a good way to communicate science as it can be interactive. By using tools, people can scan an image with their finger or a mouse pointer and get audio feedback.

What are the barriers to disability inclusion in the astronomy field in general? What are the challenges to fostering disability inclusion in astronomy and STEM education?

Disability can be a personal thing, and there's no "one size fits all" solution when it comes to access. Everybody has unique needs and reasonable adjustments.

> *"For a young person with a vision impairment to pursue an interest or a career in STEM, particularly astronomy, it is imperative to have teachers, lecturers or colleagues who are willing to work with them to find solutions for accessibility issues. Without this support, it can be challenging and isolating."*

But from my experience in astronomy and as a person with visual impairment, I can say the state of disability inclusion in STEM still isn't great. However, things are slowly improving with more awareness in the community and increased efforts targeting access and inclusion. Despite these positives, there is still lots and lots of room for improvement.

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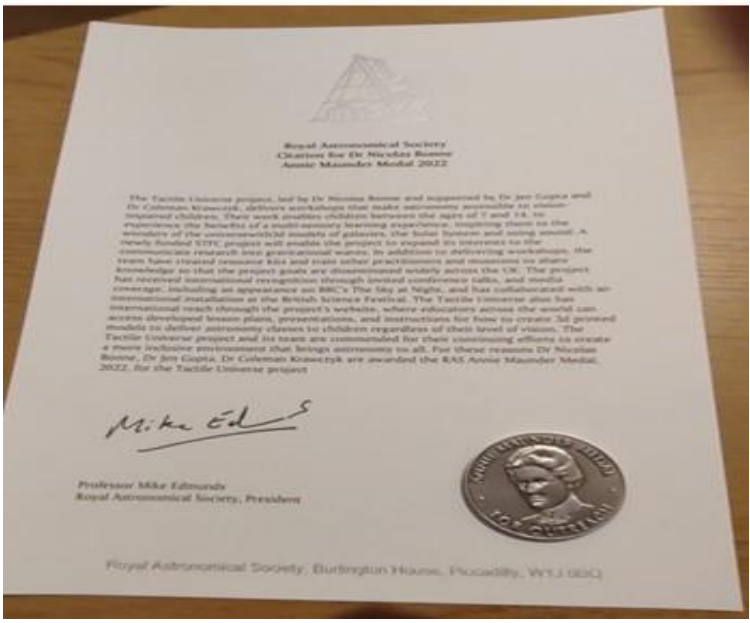
Most STEM subjects are taught traditionally and are inherently visual with a reliance on visual tools like figures, plots and diagrams. The visual concepts can be difficult to explain in words, equations and mathematical formulas to non-visual users. In addition, labs and experiments can be difficult as they require precise visual measurement, including using potentially hazardous equipment.

Teachers and lecturers are often unaware of alternative educational material for students with visual impairment, which presents another challenging aspect for studying STEM subjects. This impacts the attainment and retention levels in STEM subjects of young people with vision impairments around the world. Few students with vision impairment decide to study STEM, and of those who do, even fewer go on to study STEM in higher education or pursue careers in STEM fields. Those who make it this far often end up in workplaces that aren't prepared for them or their specific needs.

What challenges exist in your workplace? How can they be overcome?

I know of only a handful of professional astronomers working in the field right now who are blind or have severe vision impairment. These individuals have generally had to create their own toolkits (usually software) to do their research because those tools didn't exist.

Additionally, for people with vision impairments doing PhDs or working as researchers, accessibility of material in journals continues to be a significant barrier. This, including accessing mathematical and graphical content, is difficult.



Nic, along with colleagues Jen Gupta and Coleman Krawczyk received the Royal Astronomical Society's Annie Maunder Medal 2022 for their work on the Tactile Universe project.
Credit: Nicolas Bonne

However, some journals are starting to tackle this issue by adding suitable alt-text and descriptions associated with them. I hope in the future, there will be more accessible materials and there will be more and more people with disabilities in all levels of STEM education and careers. This will make STEM more accessible, and disability will be more normalized. There are still only small numbers of us; convincing other people that disability inclusion an important issue. This can be difficult to deal with.

Ultimately, building critical mass will be essential to gain access and acceptance that access is important and will benefit everybody.

Have you seen progress towards disability inclusion?

Despite the challenges and barriers, there are many groups with passionate people looking at ways to make astronomy and STEM more accessible. There has been a surge in this type of activity in the last few years, and there are also more efforts to collect and promote these resources and projects and to share them more widely. There is lots of positive momentum building behind disability inclusion, and I hope that this continues to grow over time.

> *"In the short term, the work that's already happening to make STEM more accessible needs to continue so that it becomes normalized in education and academic culture."*

Some examples of groups working towards accessibility include the International Astronomical Union's Astronomy for Equity, Diversity and Inclusion meeting series, the US-based SciAccess meetings, which focus on access in STEM, the Audible Universe meeting series which has focused specifically on bringing together groups working on sonification in astronomy. Additionally, there are experts in sound design, the psychology of sound etc. and the more regular Sonification World Chat monthly meeting series, which unites groups working on sonification in astronomy.

In my work with students in primary and secondary level education, I've met many young people with vision impairments, some of whom have already decided that they want to pursue careers in STEM subjects.

In recent years, my work has received overwhelming support from the University of Portsmouth, along with support from our project partners like the Royal Astronomical Society, the Ogden Trust, the Southeast Physics Network, and the Royal National Institute for Blind People. The fact that funding bodies like the Science and Technology Facilities Council have provided funding and support and that we've been able to inspire other groups in the UK to start their own accessibility-themed projects has shown me that this type of work really is important and is taken seriously.

In more public facing ways, it's also been fantastic to see high profile groups like NASA, and in particular, the Chandra X-ray Center, doing lots of great work on making their science communication more accessible. Recently they've been working with experts with vision impairment on audio descriptions to create some really wonderful image descriptions. They've also been collaborating with other groups in creating beautiful sonification of images and using the Tactile Universe code to create tactile versions of their image releases.

In the short term, the work that's already happening to make STEM more accessible needs to continue so that it becomes normalized in education and academic culture. This will take continued support from funding bodies, academic institutions, education networks and more.

In the long term, rather than reacting to accessibility as it becomes an issue for individuals, I'd really like to see more institutions build accessibility into the way that they operate from the very start. This will mean that when an individual with accessibility needs arrives, things will already be in place.

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What do you wish someone would have told you about disability and working in STEM? What advice would you give to those seeking to enter the field?

When it comes to someone with a disability, sometimes things will be challenging. However, self-advocacy and being your own disability champion are important, although this can be exhausting at times. As a person with a disability, you become your own expert. Only you can really know what you are capable of and what you might need to change so that you can achieve your goals and dreams. It is ok to ask for help or for something to change or to be adjusted when things are inaccessible or not working for you.

Unfortunately, it is not always going to be easy, and you may need to fight for change. Make sure you surround yourself with people who understand you and are willing to listen.

In terms of disability inclusion, I hope to see the field move away from being so overly visual and start to embrace modes like audio and tactile, which provide advantages for visual and non-visual people. A lot of this focus on the visual is now traditional rather than practical.

> *"Self-advocacy and being your own disability champion are important… Only you can really know what you are capable of and what you might need to change so that you can achieve your goals and dreams. It is ok to ask for help or for something to change or to be adjusted when things are inaccessible or not working for you… Make sure you surround yourself with people who understand you and are willing to listen."*

So much of the data we work with is in the form of signals or is in wavelengths that humans cannot even see, so why not consider alternative modes of accessing that information?

What difficulties did you face in finding employment after graduation?

I feel that through my outreach and passion for science communication, I fell into my current job. I was lucky in that I was in the right place at the right time with the right idea and the right people to talk to about it all.

> *"I think realizing that my disability meant that I had something unique to offer and give a unique perspective to the problems and coming up with new solutions was a big step for me".*

I think realizing that my disability meant that I had something unique to offer and give a unique perspective was a big step for me as well. This added value to the whole project.

In terms of job application, my initial search for postdocs in astronomy wasn't successful. I had applied for a few postdocs and fellowships but was unsuccessful. I do not think it was because of my disability, it was just that the astronomy job market wasn't the best at that time.

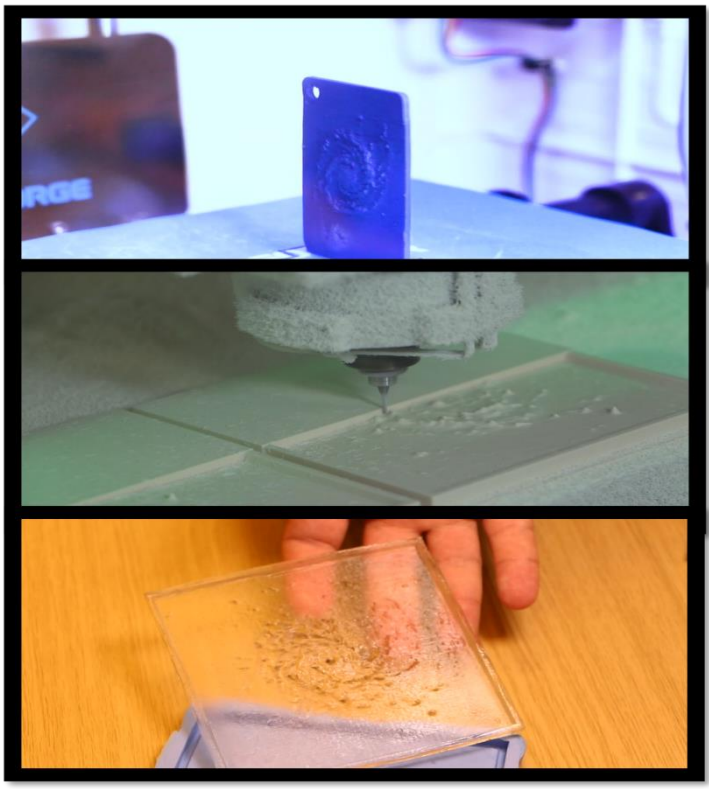
My challenge right now is that I am still employed on a short-term basis, which makes it difficult to plan long-term career goals and development.

What are your future plans?

My future goals are to continue doing the work that I am doing and love. Currently, my time is spent on the Tactile Universe project. This allowed me to move from research to science communication almost full-time. The Tactile Universe project has many aspects to manage, and this keeps me very busy.

In the future, though, I would be happy to collaborate with experts in other fields on improving access to STEM subjects in schools for students with visual impairment, as there are still issues in accessibility and reasonable adjustment for STEM and space science education.

My dream is to continue championing accessibility in STEM and space science education for visually impaired students. This will be a dream come true!!



(Above) 3D printing of a tactile model. (Middle) Wood milling machine making a high-quality version of a model. (Below) Liquid resin mould and tactile model. Credit: University of Portsmouth.

BIO

Originally from Australia, Dr Nic Bonne is a vision impaired astronomer with a background in galaxy research. He currently works in the UK as a Public Engagement and Outreach Fellow at the University of Portsmouth's Institute of Cosmology and Gravitation. Dr Bonne is a co-founder of, and currently leads the Tactile Universe public engagement project, which is developing resources and activities to help vision impaired students across the UK and internationally access current topics in astronomy. He also consults on several other vision impaired accessible projects both nationally and internationally. His current work and interests involve exploring multi-sensory techniques for communicating ideas in current astronomy research. Though this is aimed at helping blind and vision impaired people access topics in astronomy that are traditionally presented in visual formats, he firmly believes that improved accessibility helps everybody.

RESOURCES

- Tactile Universe (This includes lesson plans, 3D printable models, 3D printing guides and other supporting documentation).
- University of Portsmouth, The Tactile Universe video: [Link]
- The Audio Universe: [Link]
- Sonification World Chat community: [Link]
- The Data Sonification Archive can be a great place to discover projects using sonification for research, communication and education. Many of the projects relating to astronomy can be found here: [Link]
- The IAU Astronomy for Equity and Inclusion resource page links to lots of wonderful projects for a wide range of audiences: [Link]

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ABOUT

This article is part of the "Space+: Pathways for All Abilities" interview series under the United Nations Office for Outer Space Affairs Space for Persons with Disabilities project. The aim of this interview series is to raise awareness of the importance of disability inclusion and to advance inclusive and equitable development in the space sector through sharing the experiences of and lessons from disability advocates and persons with disabilities in space.

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