

# The NOVA Mobile Planetarium: Ten best practices for planetarium projects based on an astronomy education success story

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The Netherlands Research School for Astronomy (NOVA) has operated a Mobile Planetarium for over 14 years. Between 2009-2023, the project reached more than 400,000 learners and their teachers across the Netherlands. The project has been popular with schools since the beginning but continues to grow and reach increasing numbers of learners and schools each year. A project like the Mobile Planetarium does not continue growing this way without developing key ingredients or best practices. In this article, we describe the NOVA Mobile Planetarium project in detail and the challenges faced over the last 14 years. Reflection on the different aspects of the project has led to 10 best practices which have been critical to the continued success of this project. In this article, we aim to share our experiences to help other mobile planetarium projects around the world.

## Introduction

The NOVA Mobile Planetarium project has been visiting schools across the Netherlands since 2009. Between 2009-2023, the project reached more than 400,000 learners and their teachers, and the demand for school visits continues to grow. In this article, we reflect on the last 14 years to understand which ingredients have led to our success, even in the face of challenges such as the Covid-19 pandemic. After introducing NOVA, we describe in detail the project's key features, including the technical setup, the planetarium team, and our educational vision and approach. In the sections following, we convey practical aspects relating to a typical planetarium visit and how this is funded. We additionally reflect on the project's flexible ethos, particularly during challenging times. Finally, we discuss special projects, collaborations with other projects and our vision for the future.

We have synthesised these reflections and ingredients into 10 best practices, which provide a blueprint for a successful mobile planetarium project. These are presented separately from the main text to highlight this information further. To aid the reader, we have clearly linked each best practice, listed

at the end of this article, to one or more sections in the text.

## NOVA

NOVA is the partnership of four Dutch astronomy university institutes in Amsterdam, Groningen, Leiden, and Nijmegen. NOVA aims to bring together astronomers, foster collaborations and be the hub for projects on a national scale (e.g., building instruments for telescopes) and national memberships to large international organisations (e.g., the European Southern Observatory). In addition, NOVA facilitates national-level public engagement and school-level education projects through its dedicated Information Centre (NOVA-NIC).

In 2009, during the UN/IAU International Year of Astronomy, the NOVA-NIC began a mobile planetarium project for primary and secondary-level education. The project aims to give "every child in the Netherlands an unforgettable science experience during their school career" (NOVA, 2018).

The project has grown significantly in recent years. The planetarium now visits around three times as many schools per week compared to its first years of operation. The

project has also developed new, innovative content, including introducing real astronomical data into the dome. In the last few years, the planetarium has not only expanded within the Netherlands but has also been involved in developing new planetarium projects in Namibia (e.g. *Honsbein et al., 2023; Holt et al., 2020b*) and Chile (e.g., the 100 planetarium project led by former ESO Alma Director Thijs de Graauw).

## The NOVA Mobile Planetarium

The NOVA Mobile Planetarium operates three inflatable domes, the most recent addition in 2023. The domes have an internal diameter of 5.5 metres and accommodate around 30 visitors, approximately 1 school class. The NOVA-NIC coordinates all mobile planetarium visits to schools in 9 out of the 12 Dutch mainland provinces. Two further domes based in Groningen and St Eustatius cover the three northernmost provinces of the Netherlands and parts of the Dutch Caribbean, respectively. The Groningen and St Eustatius planetariums are coordinated separately, although NOVA provides software support and advice to both projects. Figure 1 shows an internal



**Figure 1:** Inside the dome of the NOVA Mobile Planetarium inflatable domes at a school in the Netherlands. The presenter is explaining the Moon's craters. The presenter and equipment sit in the middle of the dome; visitors sit on cushions around the dome's edge. Image Credit: J. Holt/NOVA.

view of one of the NOVA Mobile Planetarium domes.

The NOVA Mobile Planetarium runs state-of-the-art planetarium software with a customised dashboard that allows for full flexibility during shows and was designed according to our didactic approach. With just one or two mouse clicks, presenters can rapidly change the imagery to answer questions on topics as diverse as satellites, objects in our Solar System, other galaxies and black holes in quick succession.

The three NOVA mobile planetariums use different high-quality laser projectors to project onto the dome. All projectors have a high resolution (WUXGA 1920x1200 & 4K UHD), a high optical output (6500, 6000 & 5000 lumens) and a large contrast (ranging from 1:20,000-1:500,000). Two projectors use a fixed, custom-made optical block to project the image onto the dome. The other projector has interchangeable lenses and is, therefore, capable of flat-screen and dome projection.

Several additional small items complete the NOVA Mobile Planetarium setup, including a table, 32 cushions, and two 20-metre

extension cords (one of which is suitable for outdoor usage; though the planetarium dome is designed for indoor use, occasionally, the planetarium is used outside on a marquee with a floor). The full planetarium setup can be transported in a small car, with vulnerable components secured in custom-made flight cases.

### **The NOVA Mobile Planetarium: A team with specialised skills**

The NOVA Mobile Planetarium project and team are coordinated by the NOVA Education Manager based at NOVA-NIC. The Education Manager is supported by a Planetarium Expert. Planetarium shows are given by both the Education Manager and the Planetarium Expert, but predominantly by a team of 35 university astronomy students. The domes are transported by a pool of more than 10 drivers. Only the Education Manager and Planetarium Expert are NOVA staff; Planetarium Presenters and drivers work freelance. Our experience has been that having well-qualified individuals at all levels of the planetarium is integral to its success. In this section, we discuss in detail the individual skill sets of the team.

### **The Education Manager**

The NOVA Education Manager is a part-time role; the current Manager (an astrophysicist with more than a decade of experience in public engagement and education) combines this role with science education research at a separate institute. Historically and currently, the NOVA Education Managers have had the interest in astronomy and educational skills needed to give shows at schools regularly.

### **The Planetarium Expert**

The Planetarium Expert holds a joint master's degree in astrophysics and science communication. Over the last decade, the Planetarium Expert has become skilled in planetarium programming, developing custom content to facilitate fully live and interactive planetarium shows. The Planetarium Expert continues to give shows regularly.

### **The Planetarium Presenters**

Astronomy and astrophysics students are invited to work as Planetarium Presenters at any time from the start of their second year in university. Planetarium Presenters work freelance but are required to give a minimum commitment to give shows at least one day per month for at least one year. In general, Planetarium Presenters continue to work for the planetarium for much longer than this, typically until they finish their studies. Initially, most Planetarium Presenters were senior-year bachelor's or master's students. However, following a significant rise in bookings, the Planetarium Presenter Team now includes people from their second year in university to PhD students.

At the time of writing, the Planetarium Presenter Team is approximately 50 per cent male and female and includes presenters from different cultural and ethnic backgrounds. NOVA has chosen to work with a team of students to increase the accessibility of the role models – for upper-secondary school learners, the age difference between the Planetarium Presenter and the visitor can be as little as 1-2 years, meaning that learners can much more easily identify with the presenter and visualise themselves as an astronomy student (e.g., *van Gorp, 2022*). In addition, small inaccuracies in student explanations – which came across to learners as “astronomers don't have to be geniuses” – were cited as positive experiences that helped them to make the final choice to

apply for a university course in astronomy and (astro)physics (*van Gorp, 2022*).

**The Planetarium Transport Team**

The rising popularity of the mobile planetarium called for a larger team and efficiency in logistics. A pool of freelancers transports the planetarium, most of whom are students. The planetarium is typically collected at the end of the school day and immediately driven to the next location for the following school day in a continuous relay. This approach is not only efficient and cost-effective, but it is also much easier to arrange cover should a driver unexpectedly be unavailable at the last minute.

**Live and interactive planetarium shows**

The NOVA Mobile Planetarium shows are fully live and interactive. There is no script, and each show is tailored to the knowledge level and interests of the visiting group. For school visits, the contact teacher is asked in advance which age group(s) will visit the planetarium and whether certain

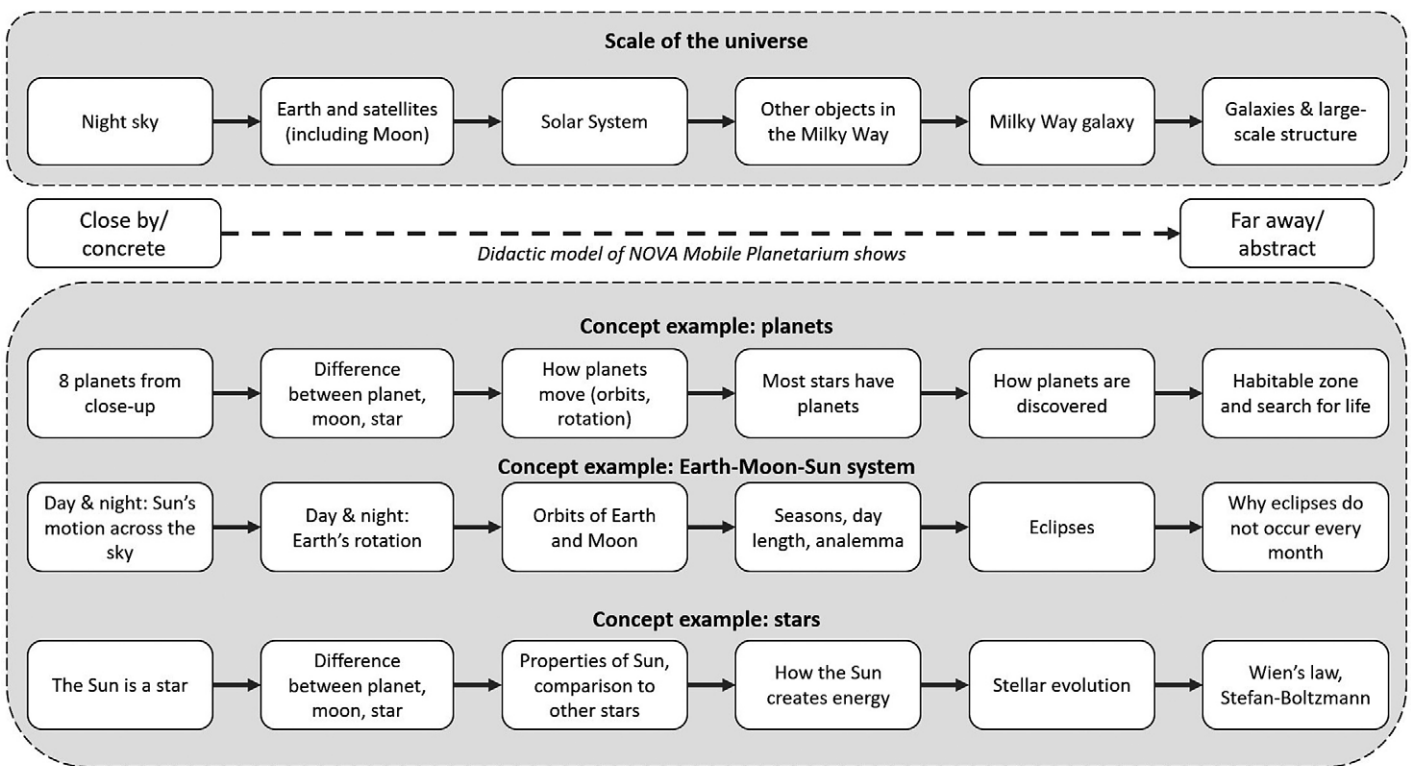
topics should be covered in the shows to align with the classroom curriculum. In addition, Planetarium Presenters are trained to encourage planetarium visitors to ask questions, usually by asking the audience questions.

A typical show has a standard story build-up or learning pathway: shows start close by and move slowly further away, literally and figuratively. For example, the planetarium software is set to the location and start time of the physical show, which moves forward in time to explore what is visible during the coming night and then progresses through the Solar System to other parts of the Milky Way and beyond. In addition, concepts discussed can slowly become more complex and abstract, the precise level of which is determined by the age group and knowledge level of those in the planetarium. This didactic model is illustrated with a few examples of learning pathways in the planetarium in Figure 2.

The choice for live and interactive planetarium shows that build up from familiar experiences (e.g., phases of the

Moon, the seasons or the tides) to more abstract ones (e.g., stars and planets outside our Solar System and galaxies beyond the Milky Way) is based on several science education principles:

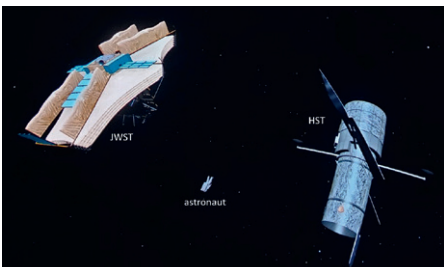
- The level of the planetarium show should be appropriate for the knowledge level and curriculum of the age group. For example, from the middle of primary school in the Netherlands, it is possible to show the Universe to the largest scales (e.g. with the Bright Galaxy catalogue) when the focus is on the number and different types of galaxies. Asking questions and encouraging learners to ask their own questions allows the Planetarium Presenter to better judge the level of the group, in addition to the information already received from the school. The group will lose interest if the content is too difficult or easy (*Vygotsky, 1978*).
- (2) The group's interests should (at least partially) influence the precise topics in the planetarium. This increases motivation and interest and boosts learning (e.g., *Marell & De Vaan, 2020*).



**Figure 2:** The NOVA Mobile Planetarium shows are not scripted. Shows follow a standard story build-up or learning pathway, from close-by the learner to far away, both in terms of physical distance and level of conceptual abstraction. Here, these two ideas are illustrated with several examples. Note that the physical and conceptual scales are not linear and do not necessarily correspond.

- Research has shown that the immersive environment of the planetarium plays a significant role in visitor experience, particularly in knowledge retention (e.g., *Zimmerman et al., 2014*). Another powerful visualisation tool within the planetarium is the ability to compare in real time various properties of different astrophysical objects (e.g., differences in size between various planets, moons or stars). Figure 3 illustrates this with a specific example from the NOVA customised dashboard.
- The three-dimensional space in a planetarium dome is particularly effective in teaching three-dimensional concepts (e.g., *Sumners et al., 2008; Plummer, 2009*) compared to how astronomy and astrophysics are conventionally taught. It is, therefore, crucial to schedule sufficient time inside the planetarium, allowing time to answer learners' questions within the planetarium environment. It is also crucial to compare and link astrophysical facts and concepts to experiences the planetarium visitors will relate to. For example, it can be much more meaningful to inform learners that the *International Space Station (ISS)* is approximately the size of a football field instead of giving the precise size in metres.

Whilst many planetariums in the Netherlands offer films and pre-scripted planetarium shows, some also offer live shows. However, these typically follow a pre-scripted show read aloud by a live planetarium guide. The NOVA Mobile Planetarium approach of fully live and interactive planetarium shows is employed by only a relatively small number of planetariums in the Netherlands. This approach is only possible because all



**Figure 3:** Size comparison between the James Webb Space Telescope (JWST), Hubble Space Telescope (HST) and an astronaut. The visual comparison of the telescope sizes to tangible objects, such as a person, is more meaningful than quoting the precise size in metres. Image Credit: J. Holt/NOVA.

planetarium presenters have a strong background in astronomy and astrophysics. This approach, combined with the focus on full lessons rather than short experiences, allows planetarium presenters to use the dome environment to answer visitor questions.

### A typical planetarium visit

The NOVA Mobile Planetarium currently visits more than eight schools across the Netherlands each school week. One Planetarium Presenter attends a school for each visit and gives all planetarium lessons that day.

### The day of the visit

A school visit typically begins between 07:30 – 08:00, with lessons beginning at around 08:30. Schools provide a draft timetable, including a minimum of two breaks. A school visit ends no later than a typical day at primary school (15:00), after which the planetarium is disassembled and transported to the next location.

### Maximum number of lessons per day

The maximum number of lessons is 6-7 (45-50 minutes) at secondary schools. At primary schools, 6-8 lessons are typically given with a mix of shorter and longer lessons. This is because the attention span of the average child increases dramatically between the ages of 4 and 11 years (e.g. *Betts et al., 2006*). The number of lessons is restricted to ensure each group spends enough time in the planetarium, and as such, only one Planetarium Presenter is required. Research shows that the immersive environment of the planetarium itself, plus the ability to visualise three-dimensional concepts, is key to the impact of a planetarium visit (e.g., *Sumners et al., 2008; Plummer, 2009; Zimmermann et al., 2014*). Many shorter lessons without breaks are untenable for one Planetarium Presenter alone and often lead to a double programme, consisting of a short planetarium experience followed by classical mini-explanations outside the planetarium. We typically avoid this type of programming because it requires more personnel to make the day workable. Exceptions are only made for special events, such as teacher conferences (where the goal is to give as many teachers as possible an idea of what the project can offer) or an event such as an eclipse (with a custom-made short presentation).

Despite the strict maximum number of lessons for school visits, the NOVA Mobile Planetarium averages 200 learners per day with each of our planetariums.

### Further contact with the school

A planetarium visit begins several weeks or months before the actual visit. Promotion is through the NOVA website<sup>1</sup>, newsletter, social media accounts and attendance at teacher conferences. All bookings are made by the initiative of the school, and all schools are allowed to request topics to be included. After the visit, schools are asked for feedback. Any issues are discussed and fed back to the individual or team of presenters as appropriate. Positive feedback is always shared with the whole team to boost the team's feeling of achievement.

### Special Events

The planetarium is also available for educational events (e.g., University open days) and occasional private hires. All events are agreed on individually and can occur in the evenings or weekends. Planetarium shows at events typically last about 25-30 minutes. Events such as these usually have a full schedule, so it is common for more than one Planetarium Presenter to attend. At these events, the number of visitors can easily reach 400-500 per day per dome.

### The NOVA Mobile Planetarium budget

The NOVA Mobile Planetarium project is a low-budget, non-profit project. NOVA, its universities and other research organisations have sponsored some of the high costs, such as purchasing the planetariums and essential upgrades and repairs. NOVA also pays the salaries of the Education Manager and the Planetarium Expert. The schools and events visited cover day-to-day running costs (transport and presenter freelancer reimbursement). Schools in the Netherlands typically have a budget for activities through the educational budget (most common for secondary schools) or the annual voluntary parental contributions (most common for primary schools). Extra financial support also comes from contributions for private-hire events. Should any funds remain at the end of a financial year, these are used to cover maintenance costs or upgrades.

## Flexibility

Flexibility is a key pillar of the NOVA Planetarium team ethos, whether trying to squeeze in an extra last-minute booking or going the extra mile to ensure a visit can still go ahead when faced with unexpected obstacles. This has never been more true than during the Covid-19 pandemic. Whilst most planetariums worldwide were forced to close for an extended period, the NOVA team was determined to find a way to continue reaching learners across the Netherlands. In this section, we summarise a few key points and refer the readers to *Holt (2020a)*, *Holt & Hanse (2021)* and *Holt, Hanse & Baan (2021a)* for more details.

Instead of accepting a long closure, NOVA invested in a high-quality flat screen and made modifications to the software, reaching out to schools with the message that the planetarium team would think outside of the box and be flexible. Whilst most school activities were heavily restricted for most of the pandemic, those deemed essential for educational purposes were permitted access at the discretion of individual school management teams. Many schools identified the NOVA Mobile Planetarium programme as a key part of their science teaching and granted access, providing the basic mandatory Covid-19 measures were adhered to. As such, planetarium visits using a flat-screen commenced in early July 2020, just 3.5 months after the first lockdown, and continued throughout the pandemic, with

interruptions only during periods of full lockdown in the Netherlands.

This flexible approach has led to a rapid increase in the project's reach (Figure 4). Even before the end of all Covid-19 restrictions in the Netherlands in May 2022, planetarium bookings had increased to 1.5 times pre-pandemic levels, and growth has steadily continued, with bookings in mid-2023 at almost 3 times pre-pandemic levels. Furthermore, there has been a significant change in the types of bookings. Before the pandemic, approximately 80 per cent of bookings were for secondary schools. Currently, only 40 per cent of visits are to secondary schools, and more than 50 per cent are to primary schools. Bookings at other events have returned to pre-pandemic levels.

## Special projects and collaborations

The NOVA Mobile Planetarium project regularly works on special projects. These projects aim to increase the possibilities for the Planetarium Presenters during their shows and enable them to discuss and answer questions about topics currently in the public eye whilst still making use of the unique possibilities in the planetarium. Key areas of interest are:

- Developing content around current topics of interest, including a solar or lunar eclipse or the launch of new

space telescopes such as *JWST* and *Euclid* and their science.

- Incorporating real data into the planetarium. Examples include using cosmological simulations (e.g., from the EAGLE and Illustris collaborations), images of the supermassive black holes in the centres of M87 and our own Milky Way galaxy from the Event Horizon Telescope (EHT) consortium and actual exposures from the MeerLICHT and BlackGEM telescopes in the project Stargazing Live! (*Holt et al., 2022a, 2023b; Bredeweg et al., 2023a,b,c*). Planetarium content is available via NOVA (2023).
- Collaborating with science education researchers to create lessons linked to the planetarium project using smart education tools (e.g. *Bredeweg et al., 2023a,b,c; Holt et al., 2022a, 2023*). Schools regularly request lesson materials to expand on topics covered in the planetarium. Lesson content is available in English and Dutch (NOVA, 2023).

## Supporting others

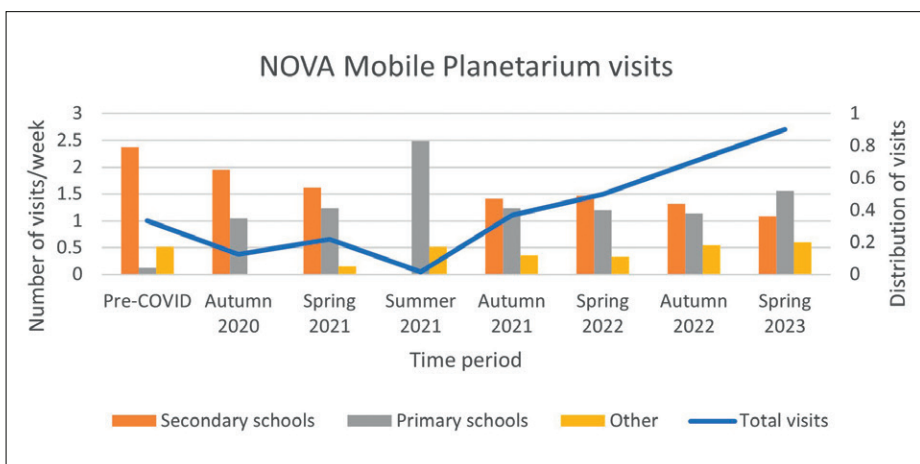
The NOVA Mobile Planetarium team is actively involved in supporting other planetarium projects across the world. It is important that established projects, such as the NOVA Mobile Planetarium, support other projects. This is not only beneficial to the other projects but also brings important learning opportunities for the NOVA planetarium. The following subsections describe the projects that are supported, to varying degrees, by NOVA.

### The Museon-Omniversum Planetarium in The Hague, The Netherlands

Museon-Omniversum is a museum with a large (300 pax) dome theatre. NOVA began collaborating with Museon-Omniversum in late 2020 and now runs all of its planetarium activities, including bi-monthly Star Parties for different levels, themed evenings (e.g. *JWST, Euclid*) with a guest speaker and school lessons.

### The mobile planetarium project in St Eustatius, Dutch Caribbean

This planetarium was set up in 2020 and is run by the former NOVA Education Manager. NOVA provides software support, and ideas are exchanged regularly.



**Figure 4:** The distribution of NOVA Mobile Planetarium visits. Line chart/left-hand y-axis: The total number of visits as a function of pre-Covid-19 levels (based on average visits per school week). Bar chart/right-hand y-axis: Distribution of visits per type (secondary school, primary school and other). This graph does not include planetarium shows given in the supported domes in Groningen and St Eustatius or the shows in Museon-Omniversum in The Hague.

### The mobile planetarium project of the Africa Millimetre Telescope (AMT) in Namibia

NOVA provides the AMT-planetarium project with the highest level of support. See, for example, *Holt (2020b)*, *Holt et al. (2022b)*, *Honsbein et al. (2023)* and The Africa Millimetre Telescope Project website<sup>2</sup> for more details.

### The 100-planetarium project (fixed domes) in Chile

Former ESO-ALMA Director Thijs de Graauw is embarking on an ambitious project to build 100 fixed planetariums across Chile. NOVA regularly provides advice for this project.

### Future plans

The NOVA Mobile Planetarium project is successful and established. In the pre-pandemic period, the project was already reaching approximately 30,000 visitors per year and had been achieving this for many years. At the time of writing, the NOVA Mobile Planetarium project is running at capacity and cannot currently fulfil all booking requests. However, as discussed above, new situations, whether it is a global pandemic, supporting a new planetarium project in another country, or even the introduction of new team members, can give a change in perspective to transform a project to the next level.

The relative quiet of the pandemic period allowed several new projects and collaborations to start. In addition, the team reflected on the visits to the mobile planetarium in the Netherlands. By creating an interactive map of all visits since 2009, it became clear that there is a problem with the distribution of visits: under-resourced areas of the bigger cities and large rural areas of the Netherlands are structurally missed. The NOVA Mobile Planetarium needs to increase the diversity of the schools and learners it reaches.

The planetarium team is actively working towards finding a solution to this problem. NOVA has recently secured funding to purchase a new planetarium and undertake a small research project to understand why the project is not reaching certain areas of the country. This research will be done in late 2023 and will devise a plan to reach out to these areas. The team is currently

applying for more funding to implement this plan. One expected outcome is the need to fund partially subsidised visits, either for visits to schools that cannot pay the planetarium costs or special events for teachers to introduce them to the project. NOVA currently visits more than 300 schools per year with 2 domes. With the addition of the third dome, we aim to increase the number of visits by 50 per cent within the next 5 years to 450 schools per year, of which half of the new schools are drawn from underserved areas.

### Conclusion

We describe the NOVA Mobile Planetarium project run by the NOVA Information Centre in the Netherlands. Between 2009-2023, the mobile planetarium reached more than 400,000 learners and their teachers. Since the start of the pandemic, the project has entered a new phase, including new projects and collaborations both in the Netherlands and abroad. The planetarium visits have also rapidly expanded over the last eighteen months, with visits at almost three times pre-pandemic levels. In this article, we reflect on the last fourteen years and propose 10 best practices as a blueprint for a successful mobile planetarium project.

### 10 Best Practices for Mobile Planetarium Projects

#### BP1: Live and interactive planetarium shows

Give live and interactive planetarium shows. Tailor your shows to include recent events (e.g., an eclipse) and results (e.g., new data from *JWST* or *Euclid*) and allow questions from the audience to influence what you include in a show. This is a didactically strong and highly motivating approach, matching the show's content and level to the audience's interests and background.

See Sections: *The Nova Mobile Planetarium*; *Live and interactive planetarium shows*; and *Special projects and collaborations*.

#### BP2: Need for experts at all levels of the planetarium team

**BP1** requires that the planetarium presenters have a solid background in astronomy. Running a successful planetarium is a profession in its own right and requires experts with specific skills in

the management team. We argue that a successful planetarium requires a management team with experience and skills in astronomy, science communication, science education, science education research and planetarium programming. The management team should also be hands-on, regularly visiting schools and giving shows.

The correct skills and hands-on experience allow the management team to provide the right kind of training to the planetarium presenters and give insights into how best to develop the project in the future.

See Sections: *The NOVA Mobile Planetarium: A team with specialised skills*; *Live and interactive planetarium shows*; and *Special projects and collaborations*.

#### BP3: Work with a diverse group of astronomy students as accessible role models

Astronomy students have a solid background in astronomy (**BP2**). Working with a diverse group of students (e.g. good male/female mix and including team members with a variety of ethnic and cultural backgrounds) ensures learners see various role models. In addition, a small age gap between presenter and learner increases the likelihood that learners will see the presenters as role models. Interestingly, the fact that students sometimes make small mistakes and/or do not know the answer to questions has also been found to be inspiring to learners as they realise that an astronomer or scientist is not necessarily perfect. Further, the student presenters' humility to recognise and accept mistakes demonstrates a positive learning mindset for the young learners in the planetarium.

See Section *The NOVA Mobile Planetarium: A team with specialised skills*.

#### BP4: Create new content

Astronomy is a rapidly changing science. It is necessary to create new content to keep up-to-date, cover recent events and new results, or run special projects such as data-to-dome projects. Creating new content is also essential for live and interactive shows (**BP1**) in which the audience asks questions about what is covered in the planetarium show. Audience questions also lead to new ideas for further expanding the possibilities in the software. Creating new content is only possible with the right kind of expertise,

motivation, and flexibility in the team (**BP2**, **BP5**, **BP10**).

See Sections *NOVA* and *Special projects and collaborations*.

#### **BP5: Be flexible**

A successful planetarium is flexible in all areas. For example, flexibility in content allows the team to give interactive shows (**BP1**), create new content to discuss recent events and results and explore new ideas, such as incorporating real data into the dome (**BP4**). A flexible approach is inspiring and motivating for both the team and the visitors and can only be achieved with the right kind of team (**BP2**) that listens to and supports others (**BP7**, **BP8**) and strives to do better (**BP10**).

See Sections: *NOVA*; *The NOVA Mobile Planetarium: A team with specialised skills; Flexibility*; and *Special projects and collaborations*.

#### **BP6: Quality over quantity**

Though it may be tempting to think that you have twice the impact with twelve twenty-minute classes compared to six fifty-minute classes on one day, research shows that it is the immersive environment and 3D-learning space of the planetarium which have the biggest impact on learning (e.g., *Plummer, 2009; Sumners et al., 2008; Zimmermann et al., 2014*), not the volume of shows. Giving visitors the full immersive experience and answering their questions using the power of the planetarium may be more impactful than simply holding more shows (see also **BP1**, **BP2**, **BP4**, **BP5**, **BP10**).

See Sections *Live and interactive planetarium shows* and *A typical planetarium visit*.

#### **BP7: Seek out feedback**

For any project going into schools, it is important to engage with teachers. Make personal contact with teachers during the booking process, on the day of the visit and afterwards. Always ask for feedback and take it seriously. Discuss issues promptly with individuals or the whole team when necessary. Sharing positive feedback with the whole team is motivating and has many positive effects, including that team members may be more willing to be flexible and cover a visit at the last minute, or they

may discuss the planetarium amongst their peers, resulting in many new applicants wanting to work for the planetarium. Feedback does not necessarily need to be gathered by a formal evaluation tool to be important and useful either in the short or long term (**BP10**).

See Sections *A typical planetarium visit* and *Flexibility*.

#### **BP8: Supporting others**

Once a planetarium project and an expert team are well established (**BP2**), it is good to share that knowledge and expertise with other projects. This can be a mutually beneficial experience: different perspectives and support can lead to valuable feedback (**BP7**), new content (**BP4**), and increased visibility that will invariably extend both projects' reach (**BP10**).

See Sections *NOVA* and *Supporting others*.

#### **BP9: It doesn't have to be free**

Many astronomy education activities are free for participants and schools. If the project brings clear added value, there is no reason not to ask (at least some) schools and educational events to contribute to the basic costs, such as transport and support for the student presenter. Whilst the situation will vary per country, there will be some schools (e.g., private schools) and events that can afford to contribute towards a visit or potentially even sponsor a visit to schools that cannot afford it.

See Section *The NOVA Mobile Planetarium budget*.

#### **BP10: Do not be satisfied with the status quo**

A truly successful project will always actively look for ways to improve. Feedback (**BP7**), content development (**BP4**), and working to support other planetarium projects (**BP8**) will lead to small steps forward. Still, it is also important to look critically at what you do, reflect on the bigger picture and strive to improve. Sometimes, just one question can make the difference (e.g., How are the school visits distributed?).

See Sections: *NOVA*; *The NOVA Mobile Planetarium: A team with specialised skills; Flexibility*; *Special projects and collaborations*; and *Supporting others*.

## Notes

- <sup>1</sup> The NOVA website: [www.astronomie.nl](http://www.astronomie.nl)
- <sup>2</sup> The Africa Millimetre Telescope Project website: <https://www.blackholehunters.space/>

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## Biographies

**Joanna Holt** is the NOVA Education Manager based in the NOVA Information Centre. She is also an Associate Professor in the Science Education Group and Smart Education Lab at the Amsterdam University of Applied Sciences. She is the National Astronomy Education Coordinator (NAEC) for the IAU Office of Astronomy for Education and the current chair of PlaNED, the Association of Dutch-Speaking Planetariums. Joanna holds a PhD in astrophysics.

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