

Portable planetariums in the teaching of Māori astronomy

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Introduction

Using the night sky, environment and ecology that surrounded them as teaching aids, our tipuna, traditionally, taught Māori astronomical knowledge by observation and oral transmission. Today a variety of tools can be used to complement these traditional methods to facilitate the teaching and learning of Māori astronomy to present and subsequent generations. Our trust, called the Society for Māori Astronomy Research and Traditions (SMART) is at the forefront of revitalising Māori astronomical knowledge and is pioneering the use of digital technology in the teaching and dissemination of this knowledge. In this paper I discuss some of the avenues that have been used to transfer this knowledge back to our communities which consist of a variety of ages ranging from 5 years to kaumātua. Here we shall showcase our most recent programme, which utilised a portable planetarium to conduct outreach on Māori astronomy to communities and rangatahi. This programme had multiple project deliveries which received funding and support from the Ministry for Business, Innovation and Employment (MBIE) and Te Puni Kōkiri (TPK) for the English language delivery of the programme and Te Taura Whiri i te Reo Māori (the Māori language commission) for the te reo Māori component.

The SMART Trust

The Society for Māori Astronomy Research and Traditions ("SMART", 2017) is a group of experts in mātauranga Māori, science and education. The board members have expertise in different aspects of Māori astronomy. These members include:

- our voyaging community, Hekenukumai Busby, Hoturoa Kerr and Jack Thatcher, who carry with them significant expertise in celestial navigation;
- our specialists in the maramataka (Māori calendrical systems), Ockie Simmonds, Rereata Makiha and Liliana Clarke; and
- our academic arm including Professor Dr. Rangi Matamua who carries significant expertise in traditional narrative, the language and associated ceremony of Māori astronomy, Dr. Takirangi Smith a master carver, canoe builder and mātauranga Māori expert and, Dr. Pauline Harris an astrophysicist and the chair of SMART.

Local to SMART's geographical headquarters in Wellington are representatives from Ngāti Toa, Taku Parai and Toa Waka experts in local history and mātauranga Māori. The core objectives of SMART are:

- to preserve and revitalise Māori astronomical knowledge; and
- to bridge science and mātauranga Māori in order to create career pathways for

rangatahi Māori.

These objectives have led to the development of several significant research projects and outreach programmes including two Marsden funded research projects '*Te Mauria Whiritoi: Māori astronomy as a cultural resource*', and '*Ngā Takahuringa o te Ao: The effect of climate change on traditional Māori calendars*' as well as our education programmes '*Tūhono i te Ao: Connecting the worlds*' and the '*SMART planetarium Dome*' project.

Māori astronomy revitalisation

The breadth and depth of Māori astronomical knowledge spans a variety of topics such as cosmology, agriculture, architecture and calendrical systems (Harris, Matamua, Smith, Kerr & Waaka, 2013). The revitalisation of Māori astronomical knowledge is a core focus of SMART's aims and objectives. In order to effectively revitalise a body of knowledge it is imperative to combine both research and education to ensure succession of knowledge to younger generations and communities. SMART's research programmes have therefore led to the development of education programmes aimed to foster the knowledge development of communities and rangatahi in Māori astronomy. Programmes have been wide ranging from public and community talks, in-depth wānanga, to school and kura kaupapa Māori engagements. Due to the diversity of engagements, it is extremely important that both the method of and content of delivery is appropriate to the audience in order to obtain optimal uptake of knowledge transfer.

Pedagogy

Pedagogy plays an important role in determining the most effective delivery of astronomy programmes to different audiences. Effective teaching of such topics needs to consider how the audience will best learn and engage, whether they be younger, older, Māori, Pākehā or other peoples from the Pacific. In addition, if the schools are kura kaupapa Māori, their knowledge and language base differs greatly from mainstream education. Thus, fluency in te reo Māori is essential as well as a higher understanding of language and content knowledge. With this in mind a generic base plan of content for the introductory programme includes, the teaching of the origins of the celestial beings, how they were placed in the sky, basics on how the stars move across the sky, and an introduction on what or who the stars represent. In addition, introducing concepts around the calendrical system called the maramataka and also basic navigational techniques have proved popular in the delivery (see *Table 1*).

There is a great need to engage Māori in education that is relevant to them in both content and delivery method. The inclusiveness of kaupapa Māori education has been a journey with many challenges (Pihama, Cram & Walker, 2002). Resistance by the mainstream can still be seen in the most recent issues around the inclusion of Māori history in mainstream education ("No Compulsory lessons", 2016) and compulsory teaching of te reo Māori ("Education Review", 2017; Ngawhare, 2017). These sorts of barriers have hindered the development of mātauranga Māori based content in schools. As a reaction

Māori have taken matters into their own hands, to develop programmes and schooling systems that are at its core, kaupapa Māori, that is (Smith, 2003) 'for Māori by Māori' (Durie, 1998).

The design of the Māori planetarium programme seeks to mitigate the lack of Māori science in the current education system and aims to create a transformative safe space whereby rangatahi and communities can learn and discuss Māori astronomy and related topics. This creates a space in which we hope to inspire communities, iwi and hapū in order to revitalise their own knowledge. In addition, we also hope to mitigate other key issues as well, such as the dearth of engagement of Māori in science education and careers. With relatively low numbers of Māori engaging in scientific studies and careers (Harris & Mercier, 2006), there are growing concerns that this lack of engagement puts Indigenous and Māori at a continued social and economic disadvantage (McKinley & Gan, 2014). SMART programmes seek to address this trend of disengagement whilst, more importantly, creating a meaningful engagement of sharing of ancient ancestral knowledge. In order to effectively design a programme tailored for Māori, and also our wider Pasifika whānau, we followed a kaupapa Māori methodology (Pihama, Cram & Walker, 2002; Smith, 1997).

Digital technology in Māori astronomy education

Over many years SMART has engaged in delivering Māori astronomy to a variety of groups from school children to kaumātua. The technology previous to 2016 was limited to hands on interactive activities, Powerpoint presentations and simply, but most effectively, going outside looking at the stars. This is an important fact that should be noted, that nothing can replace the true experience of simply going outside and looking up and around at your environment. Although technology is a powerful tool in teaching, true understanding of the sky, environment and ecology requires true engagement and experiential learning. In 2016, however, SMART obtained a planetarium dome and projection system. This system had been on the 'much desired wish list' for quite some time due to its great potential and 'wow factor' that would dramatically raise the level of engagement of rangatahi and communities with our programmes.

Portable planetariums

Portable planetariums are used worldwide to promote and educate communities about astronomy. Perhoneimi defines a planetarium as a circular dome shape which acts as a theatre and relies on a projection system to project a simulated view of the night sky onto the inside of the dome (as cited in Gillete, 2013). These planetariums can be a fixed structure or portable. Fixed structures are usually large theatres located within an environment such as a museum, which has accompanying displays and interactive activities. A portable planetarium is a dome that is collapsible, which is inflated using a fan system (Gillette, 2013). Portable planetariums are easily transportable with the small ones fitting into a large suitcase when folded. Early planetariums utilised an analog system that relied on a central light source with light rays exiting through pinholes in a covering

to mimic the stars and other objects in the night sky. Although effective in its time, new systems have highly sophisticated projectors, mirrors, lenses and sound equipment that are controlled by a central computer or multiple computers for larger systems. Accessibility to portable planetariums have more recently become more realistic with relatively inexpensive setups now existing. *Figure 1* shows a typical portable planetarium set up. The top figure is the outside of the dome with a fan used to inflate the dome and a double doored entrance way to ensure the dome stays inflated and dark upon entry. The bottom figure shows the interior of the dome with the projection system shown to the right.

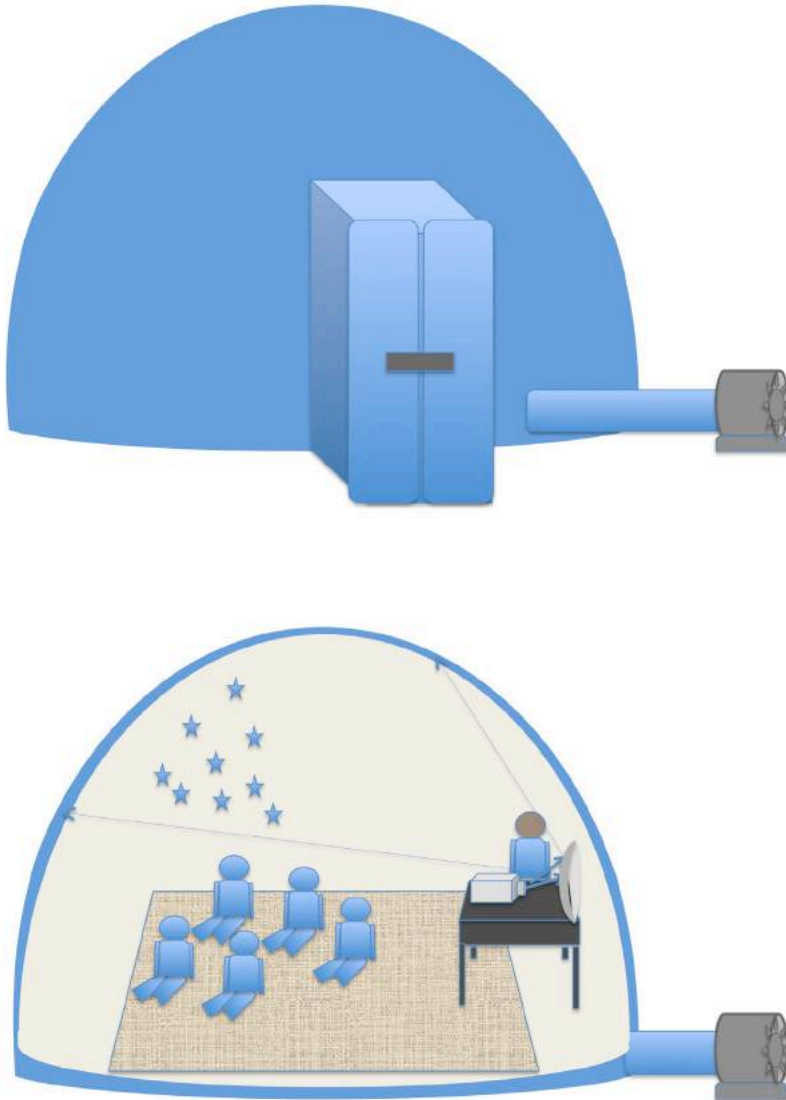


Figure 1: The inside and outside setup of a portable planetarium dome.

Planetarium system

Today a variety of methods are available whereby projection systems can range from simple systems using a high definition projector and convex mirror to more advanced systems using fish eye lens projectors. The former projects an image onto a convex mirror that is then bounced onto the inner surface of the dome whilst the latter system (fish eye) projects directly to the inner surface. Fish eye lenses are better quality with 360 degree image capability as opposed to the projected image via a convex mirror onto the dome which covers around 70% before distortion becomes an issue towards the back of the projector. Another major difference between the two systems is the cost which differs significantly, with fish eye lens system being much more expensive. The projectors for planetarium domes need to be high resolution and depending on the size of the dome, of high luminosity.

Mirrors

Normal mirrors have a reflective coating deposited on the backside of a substrate; this could be glass or plastic with a protective layer covering the coating. These types of mirrors are called second surface mirrors and are robust for general usage. First surface mirrors that are used in projecting images, such as that in planetariums, have a reflective coating deposited on the front of the substrate. There is no protective layer usually placed on the front of a first surface mirror. The main reason for using first surface mirrors instead of second is due to the fact that second surface mirrors have two reflections of the images (one from the reflective surface and then one from the substrate (glass or plastic) at the front), which produces a slighted distorted image. However, first surface mirrors only have one reflection, which results in a high quality undistorted image.



Figure 2: Planetarium Dome equipment setup for inside the dome, from left to right mirror, computer and projector.



Figure 3 Inside the dome, Captain Tawhana Chadwick delivering a talk to an audience, behind Mary Tipoki watching the show.

Full setup

The full setup of the dome includes one projector placed on a table at a distance from a convex first surface mirror; a good quality laptop that is capable of high definition video play if required; a blow up planetarium dome; and an external fan. The mirror is mounted for stability, with extreme care taken when putting it in place, bearing in mind that first surface mirrors cannot be touched or it will get damaged. The placement of the table-projector-computer system depends on your preference. However, after several iterations of the delivery, the current setup is about 70 degrees from the door, which minimises risk of audience participants touching the mirror.

A variety of research into planetariums has been conducted over the past several decades (Plummer, Schmoll, Yu & Ghent, 2015). Whilst some authors have investigated student learning experiences in planetariums from various perspectives including a focus on different delivery techniques such as kinesthetic delivery (Plummer, 2009), the effect of humour on learning in a planetarium (Fisher, 1997), and the experience of the planetarium delivers themselves (Croft, 2008), an in depth analysis of Māori planetarium delivery has yet to be conducted. Nonetheless, we intend to undertake future analysis to gather Māori experiences following the model provided by Gillette (2013) pertaining to cognitive theory of multimedia learning. However, modifications to the framework will need to be undertaken to incorporate a Māori pedagogical and philosophical approach to unearth the potential of a kaupapa Māori cognitive theoretical framework for enhanced learning

experiences for rangatahi Māori (Harris, in preparation, 2018).

Tūhono i te Ao

The first project designed by SMART was a collaboration called *Tūhono i te Ao*. This project was designed to close the widening gap between Māori/ Pasifika knowledge and 'western science'. The lack of an appropriate approach and delivery of our mātauranga in mainstream public schooling system contexts, as discussed above, has been a strong driving force to develop this programme. *Tūhono i te Ao* is a collaboration with Te Roopu Awhina at Victoria University. This programme was designed and developed to create activities that related traditional Māori/ Pasifika knowledge to western science to make it relevant, exciting and enticing to our Māori/ Pasifika rangatahi. The planetarium dome was a major component of the *Tūhono* programme and was largely experimental during the early stage of development of the project. *Figure 4* shows the programme being run in Auckland over a 3 day period with over 700 Māori / Pasifika rangatahi coming through the programme. Feedback from end users was overwhelmingly positive with very few negative responses. This was an extremely satisfactory result considering that this programme reached more than 3000 Māori and Pacific students over a 5-month period. The content for the planetarium component was developed and tested using base knowledge the team already had used in previous outreach presentations and the delivery method was largely developed through trial and error. After several iterations of the dome programme a more streamlined delivery was achieved.



Figure 4: Auckland expo for *Tūhono i te Ao*.

SMART Planetarium Dome

Our second project the SMART Planetarium te reo Māori project was designed to deliver a planetarium programme to kura kaupapa Māori and for the majority of programme to be in te reo Māori where possible. Very few programmes exist in the science outreach space that can go into the kura kaupapa Māori and deliver a programme on science in te reo Māori. Furthermore, there is also a lack of science teachers that can teach in te reo Māori which amplifies the need for such programmes. This innovative programme proved extremely successful delivering to over 2000 rangatahi Māori in kura kaupapa over a 4 month period. The success of the programme can be attributed to the strong fundamental design principles that underpinned the programme as a whole, the strengths and skills of the delivery team, their training and management during the programmes running. The content design underwent a more rigorous process for this second project, with training and delivery development conducted by senior members of the team. The content and process was underpinned by a kaupapa Māori framework to ensure that the desired knowledge was effectively delivered to rangatahi Māori and their connected communities. The goal here was to inspire and excite rangatahi Māori into learning about astronomy, science and mātauranga Māori and to motivate and excite the audience into pursuing further knowledge from their respective regions and iwi.

The delivery team was selected from voyagers whom are students of celestial navigation and whom are also fluent in te reo Māori. The team consisted of trainee navigators Te Ira Tohu (first trainee Māori female navigator) and Kawai Joe (trainee navigator), who are both crew of Ngahiraka Waka Hourua under the teachings of Pou navigator Jack Thatcher, and Pera Waaka of Haunui waka hourua. The team was trained by Dr. Pauline Harris and Captain Tawhana Chadwick. Content was developed by Harris and Chadwick with information on traditional astronomical knowledge provided by *Te Mauria Whiritoi* and *Ngā Takahuringa o te Ao*, the two Marsden funded projects. The content from these two projects included baseline information of where the celestial beings originated from, how they were placed in the sky and the maramataka. Given the navigational background of the dome presenters, knowledge on basic navigational techniques was also included into the programme. As the programme developed the team included a number of chants that they were taught during their navigation training. In addition, kinesthetic learning techniques were applied outside the dome with activities including actions and chanting of star names were incorporated. The software that was used was the freeware programme Stellarium, which has been modified to contain a list of stars in te reo Māori. Initial images to represent Māori constellations have been included, which is an ongoing process. An example of the constellation is shown in *Figure 5*.



Figure 5 Example of a constellation on left and Māori star names on the right. Planetarium deliverer Shane Warren seen here with the Māori star names on the right.

Table 1 shows an example of the planetarium content that is currently delivered. Delivery is able to be done in both English and te reo Māori.

Table 1: Example of a Planetarium session for ages 7-18

Content	Objective	Delivery description
Mōteatea (chant)	Engage the audience with traditional method of knowledge transfer through chant.	Dome presenter stands and introduces themselves followed by a chant about a large waka constellation in the sky. As they chant they move the skyview around and point out the stars they are referencing in the chant.
Finding south	Familiarise the audience with how the stars are used to navigate around the Pacific.	The Southern Cross and Achernar are used to show how to find south. A discussion about celestial navigation is described also.

Origins of the stars	To imbue ancestral knowledge of the origins of the sun, moon, planets and stars.	The first whare that existed and the parents of the celestial, Tangotango and Wainui are described followed by how Tāne journeyed with the help of Tamarereti to put the sun, moon, planets and stars in the sky.
The stars as a clock	To teach how the stars apparently move around during the day and night and how they can be used to tell time.	The Southern Cross is shown and time is fast forwarded, showing an accelerated movement of the stars. The Southern Cross rotates around the south celestial pole and shown to take 24 hours to rotate. Note the sun's brightness is removed from the programme. A story relating to being on the waka and telling the time is also included.
Waka of the Pacific video	Waka hourua video shown, that shows Te Mana o Te Moana journey.	Loud, large video shown of double hulled waka travelling across the ocean using celestial navigation. Video includes people known and in the delivery team. Other videos also available depending on length of dome session.

Discussion

There is no doubt that portable planetariums are indeed a powerful tool when coupled with solid content and an excellent delivery team. Previous to the obtaining of the planetarium dome we were limited to using PowerPoint presentations. However, although using static images and text on a two dimensional screen can yield good understanding on who and what the celestial bodies represent, this mechanism did little for understanding such as the daily and yearly movement of the sun, moon and stars which can be a very complex concept to understand. This was evident especially in the classroom setting running laboratory type classes in a computer lab using Stellarium where students found it challenging to understand concepts around star 'movement', sun rising and setting from different positions on the horizon and the concept of summer and winter solstices. In addition, even more difficult was the teaching of basic celestial navigation and viewing of the night sky from different locations on the earth using a two dimensional flat screen. Now, however, with the benefit of utilising a portable planetarium dome we are able to teach more complex concepts in a shorter amount of time. This is critical when delivering programmes to schools, as the time that one has with audiences is typically short (30 minutes), thus it is imperative to have a delivery system and team that can deliver the content in the most optimal and effective way.



Figure 7: The SMART planetarium team talking to rangatahi at a kura kaupapa Maori before they go in.



Figure 8: Some of the planetarium team, from left to right, Dr Pauline Harris, Te Ira Tohu, Pounamu Tipiwai Chambers, Pera Waaka, Captain Tawhana Chadwick, and in front Kawai Joe.

The SMART trust has been designing and delivering innovative programmes to schools and communities for many years with the 2016 and 2017 programmes seeing the use of more advanced digital technologies via the use of a planetarium dome. These programmes have been seen by more than 7500 Māori and Pasifika rangatahi and communities. These programmes have been designed using authenticated and well-researched content from leading researchers in the area of Māori astronomy and maramataka. SMART has also assisted the development of programmes run by Te Toki Voyaging Trust who recently obtained two planetarium domes. One dome has now a similar setup to the SMART dome and is delivering programmes on celestial navigation nation-wide.

With the growing amount of research being conducted on Māori astronomy and maramataka, it is indeed an exciting time to implement our collaborative research and knowledge in an education space. The use of digital technologies, such as planetarium domes, has been instrumental in allowing an effective and exciting delivery to mass numbers. Although this method differs greatly from how our tipuna taught and imbued their knowledge of the night sky, in the continuing effort to revitalise, preserve and pass on this knowledge, the SMART planetarium dome has proven to be a powerful tool for exciting and inspiring our youth and communities into learning and reclaiming our ancient knowledge of the stars.

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