The Universe at the Fingertips of the Visually Impaired: Building a tactile planetarium

Cláudio Luiz Carvalho
Department of Physics and Chemistry
Universidade Estadual Paulista
Brazil
carvalho@dfq.feis.unesp.br

Hermes Adolfo de Aquino
Department of Physics and Chemistry
Universidade Estadual Paulista
Brazil

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Summary

In this work we describe a tactile planetarium made with the goal of teaching astronomy to visually impaired people, but which is accessible to all. The planetarium consists of two hemispheres representing both the northern and southern hemispheres, with around 72 constellations and more than 500 stars with different apparent magnitudes.

Introduction

Astronomy has been a major focus of attention for people since the most remote times, as can be seen from the many and varied records made by ancient civilisations (Verder, 1992; Marriott, 2004; Matsuura, 1996).

In Egypt the night sky was the vault of heaven. It was a place of the gods, which linked the sky with the body of the goddess Nut, the air god Chu (foot) and the earth god Geb (Figure 1; Marriott, 2004; Matsuura, 1996).

Historically observations of stellar objects had a practical use as the positions and movements of these objects were used to guide sustainable agriculture and production, but they were also associated with mysticism through astrology in the Sumerian–Babylonian (3000 BC), Mayan (300 BC) and other cultures (Kaufmann, 1998; Marriott, 2004; Matsuura, 1996).

Through observation and research many new questions about the Universe have arisen and many others have been answered. Today one can study the different branches of astronomy using a wide range of technologies (Matsuura, 1996; Arantes, 1995).

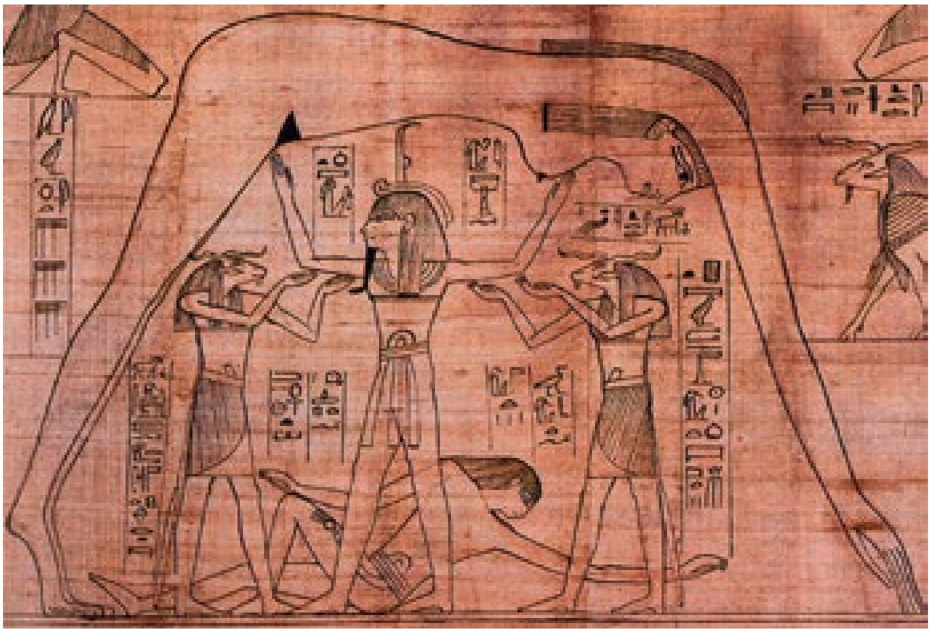

Figure 1. *Symbolic representation of the presence of gods and goddesses on Earth, in the sky and in the air made by the Egyptians. Credit: Photographed by the British Museum*

New technologies have advanced astronomy research, but although these technologies can be used for outreach, they can also present a barrier to those lay astronomers and members of the public who wish to learn about the Universe but do not have access to the appropriate technology.

Planetariums provide an interesting and versatile way for many people to view the arrangements of celestial bodies such as stars, clusters, constellations, galaxies and planets in the sky, and to observe planetary motion (Kaufmann, 1998; Marriott, 2004; Arantes, 1995; Puig, 1985).

In recent decades the design of planetarium technology has evolved significantly to become today's modern digital optical devices, with the capacity for almost unlimited presentation. However, this phenomenal equipment does not allow a visually impaired individual with no or only a small amount of sight to access astronomy.

The problem is clear when we look at astronomy's history, in which different views of the night sky and a large amount of imagination have played important roles in progressing our view of the Universe. For example the early people of Mesopotamia, now Iraq, imagined that the sky was composed of precious stones; the Mayans believed that the sky was formed in layers; and Aristotle and Empedocles thought that the Universe was a sphere (Friedlander, 1985; Filho et al., 2004; Verder, 1992;

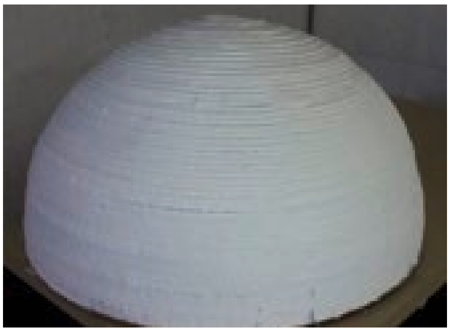

Figure 2. Photograph of a spherical surface made of Styrofoam stacking layers. Credit: Aquino, H. A.

Figure 3. Spherical surface coated with plaster to remove imperfections. Credit: Aquino, H. A.

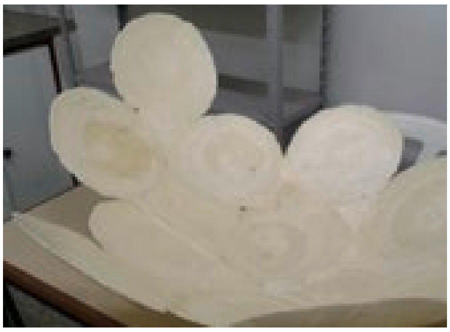

Figure 4. Gradual formation of a hemisphere by building up polymer plates 40 centimetres in diameter. Credit: Aquino, H. A.

Kaufmann, 1998; Marriott, 2004; Blum, 1990; Matsuura, 1996).

The aim of this project is to adapt the planetarium to include people with visual impairments in the study of astronomy. A planetarium that would enable disabled people to better understand some basic concepts of positional astronomy, whilst also providing a tool for fully sighted individuals to experience the Universe in a new way, was designed and built.

Methodology

In general, individuals with visual impairments have a more sensitive and accurate tactile sense as their ability to feel is very important, as when reading Braille for example. This sensitivity was used in the project by building hemispheres representing the southern and northern hemispheres of the sky that could be explored with the hands.

The hemispheres are constructed using polymer resin deposited on a plaster sphere one metre in diameter[1]. On the inside of each hemisphere constellations are defined by boundary lines and some of their respective stars. The stars were made from small plastic spheres whose size is associated with their apparent magnitudes, and varies from two to nine millimetres in diameter. A wire of 0.8 millimetres in diameter outlines the area covered by the constellations.

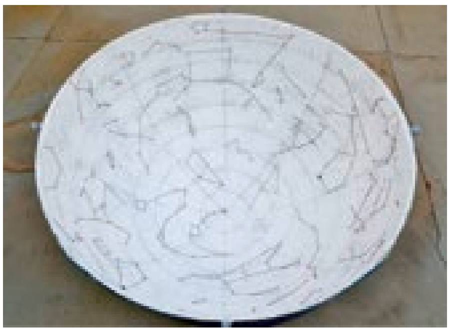

Figure 5. Celestial northern hemisphere with some of its main constellations represented by lines of metallic wire and plastic spheres. Credit: Carvalho, C. L.

The distribution of the stars in the hemispheres follows the system of equatorial coordinates used by astronomers and the Stellarium® software[2]. In addition, the constellations and the stars can be identified by their names written in Braille and in conventional print, making the installation accessible to both fully sighted and visually impaired individuals[3].

Construction

The use of styrofoam in building a spherical mould made the work much easier due to its malleability and lightness. Thin layers of Styrofoam with one centimetre thickness were cut with different diameters up to half a metre. The layers were stacked and bonded to form the object seen in Figure 2, which shows a sphere composed of several layers of Styrofoam with small irregularities on its surface.

The spherical surface of Figure 2 was covered in several layers of plaster to give it a very smooth surface, which was used as a template for the construction of the inner surface of the celestial hemisphere. Imperfections or irregularities presented in the object in Figure 2 were eliminated completely as can be seen in Figure 3.

Once the mould was complete, polymer resin platelets were deposited on its surface to form the celestial hemisphere. Figure 4 shows the gradual formation of a hemisphere by building up polymer plates 40 centimetres in diameter.

The handling of the polymer resin allows easy moulding of such small plates and each joint was made with the polymer itself. Removal of excess polymer and refining of the inner surface of each hemisphere can be done with acrylic paste and sandpaper. The inner surface of the hemisphere should be very smooth as the tactile sensitivity of visually impaired people means that any irregularity can be misinterpreted.

The constellations and their brightest stars — those with apparent magnitude between 6 and −1 — were distributed on the inner surface of each hemisphere using equatorial coordinates and with the help of the Stellarium® software. In Figure 5, the lines

Figure 6. Photographs of the hemispheres and the constellation of Scorpius. Credit: Carvalho, C. L.

made with metallic copper wire and plastic beads represent the lines marking the constellations and stars, respectively.

Figure 6 shows how the northern and southern hemispheres of the sky look when ready, including a detailed picture of the constellation of Scorpius, indicating the names of the stars written in Braille and in conventional print.

Initially the planetarium was tested by individuals with a visual impairment, but not selecting for specific problems or types of disability. Figure 7 shows two visually impaired people interacting with the celestial hemispheres. On the left, the young person interacting with the inner part of hemisphere was able to read the names of the stars and constellations as well as to make out the shape of each constellation very easily. On the right, the individual interacts with the outside of the sphere, having explored the inner part of hemisphere.

In both cases some initial guidance was given, and there had been discussion on several questions that the subjects had related to astronomy, but both were free to explore in their interactions with the hemispheres.

According to users, this type of model can greatly help to clarify the ideas they have about the night sky and frequent interaction with it makes it easier to locate the stars in relation to the constellations. The users also emphasised that being able to control the height of the hemispheres makes it more comfortable and makes it easier to read the Braille writing and explore the objects in high relief, as shown in Figure 8.

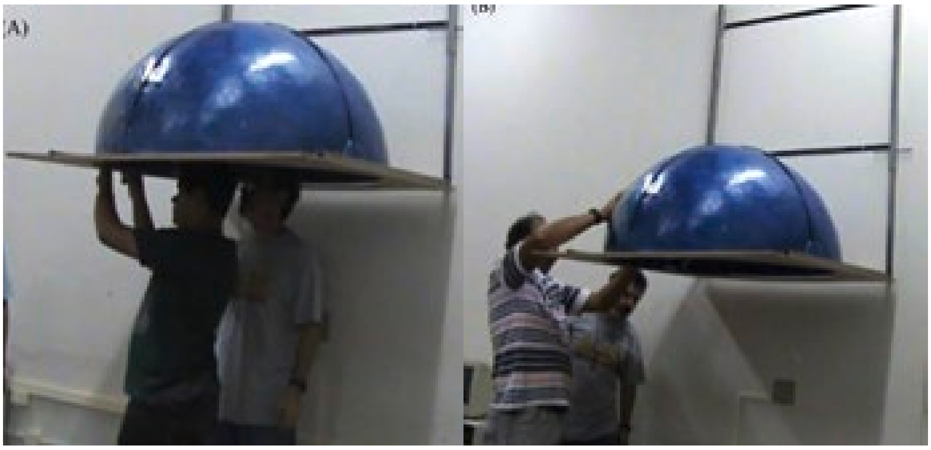

Figure 7. *Visually impaired individuals interact with the celestial hemispheres. Credit: Carvalho, C. L.*

Conclusion

We built two hemispheres representing the northern and southern hemispheres of the sky containing 72 constellations and over 500 stars. Both hemispheres were embossed and contained names in Braille and conventional alphabetic script, making the hemispheres accessible to both fully sighted and visually impaired people. Through experiments, we observed an easy interaction with and between visually impaired individuals using this teaching tool. New experiments are underway. So far, this type of instrument is completely new in Brazil.

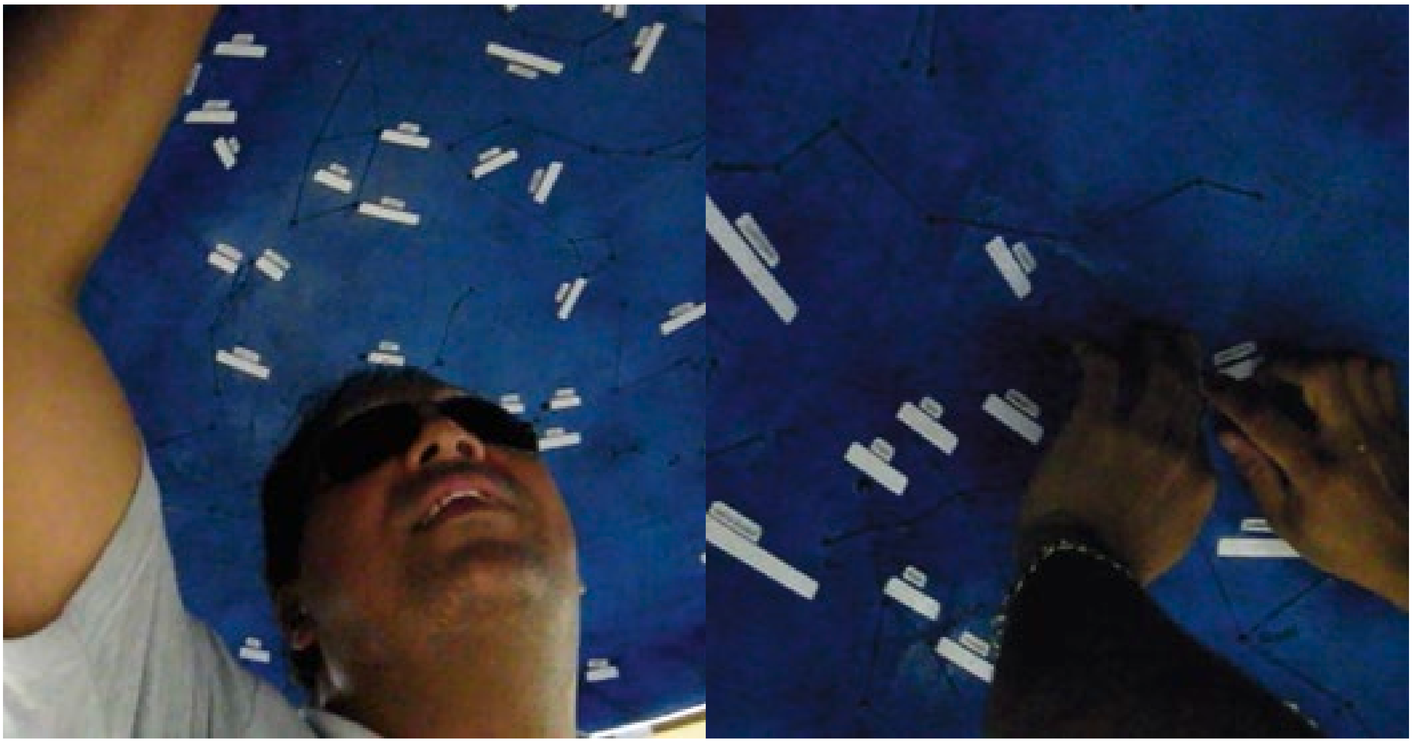

Figure 8. *Indicating the ideal position of the hemisphere for users.*

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Notes

1. Polymer resin http://www.moldflexmodelagem.com.br/r_poliuretano.html#produto01
2. Stellarium software http://www.stellarium.org/
3. Braille booklet http://www.lapeade.com.br/publicacoes/documentos/Apostila%20Braille.pdf

Biographies

Professor Hermes graduated in physics from the State University of Campinas (1979) and has a Masters in Physics from the University of São Paulo (1983) and a PhD in Materials Science and Engineering from the Federal University of São Carlos (1998). Currently, he is an assistant professor at the Universidade Estadual Paulista Júlio de Mesquita Filho. His experience in the area of physics, specialising in dielectric materials and dielectric properties, is used in the following subjects: activation energy, polymer materials, instrumentation for science education, teaching and learning of science and amateur astronomy.

Professor Carvalho has been doing research in the area of new materials for over 20 years. His current interests include superconductors, photovoltaic cells, optical glass, instrumentation and astronomy. He has presented his work at numerous conferences in several countries. He is a Fellow of the Brazilian Physics Society, Materials Research Society (USA) and currently Physics Professor at the Department of Physics and Chemistry, Coordinator of the Astronomy Group and Materials Development and Applications Group of the Engineering Faculty of Ilha Solteira, UNESP, Brazil. He also developed various projects at Argonne National Laboratory, Arizona State University and University of California-Davis.