Proceedings for the
3rd Shaw-IAU Workshop
on Astronomy for Education

What Everybody Should Know about Astronomy Education

12 – 15 October, 2021

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The following is a summary of the 3rd Shaw-IAU workshop on Astronomy for Education held 12 – 15 October, 2021 as a virtual event. The workshop was organised by the IAU Office of Astronomy for Education. More details can be found on: https://astro4edu.org/shaw-iau/3rd-shaw-iau-workshop/.

The Office of Astronomy for Education (OAE) is hosted by the Haus der Astronomie on the campus of the Max Planck Institute for Astronomy in Heidelberg. The OAE's mission is to support and coordinate astronomy education by astronomy researchers and educators, aimed at primary or secondary schools worldwide. The OAE is an office of the International Astronomical Union, with substantial funding from the Klaus Tschira Foundation and the Carl Zeiss Foundation. The Shaw-IAU Workshops on Astronomy for Education are funded by the Shaw Prize Foundation.

Foreword

3rd Shaw-IAU Workshop on Astronomy for Education

Teaching astronomy takes both solid knowledge of the subject itself as well as educational skills, such as knowing appropriate methods and techniques for teaching. To this, specific sub-fields of astronomy education add their own specialized skill sets: knowing how to operate remote telescopes, for instance, or the ins and outs of daytime observations. Last but not least, there are the skills needed in order to make our teaching fair, equitable, and inclusive.

In practice, most of us who are active in astronomy education have only been taught a subset of those skills in our academic training. Those who come from professional astronomy and have branched out into education and outreach typically have advanced training in astronomy, but not in the relevant areas of pedagogy. Most teachers, on the other hand, have pedagogical training as well as training in the subjects their teach, but often that does not include formal training in astronomy and astronomy education.

If this description includes you, and if in consequence you have ever felt motivated to expand your astronomy education skill set, then this workshop was, and is, meant for you. It is the third in a series organised as a collaborative venture between the Shaw Prize Foundation and the International Astronomical Union, and with 89 talks and 50 posters in a total of 18 sessions, it provides a fairly comprehensive "Astronomy Education 101".

For those who were unable to attend, or did not manage to attend all of the sessions they were interested in, we present these proceedings, and the associated talk videos from the workshop. While they lack the interactivity that the 580 workshop participants enjoyed as they posed their questions to the speakers, or interacted in the chat, we do believe that they are valuable in their own right — and we asked speakers to include in their write-ups helpful pointers to additional resources, so you have the opportunity to delve deeper. If you find these resources useful, and I hope they will be useful to many, please share them widely.

The workshop was made possible by funding from the Shaw Prize Foundation, for which we are very grateful. You can find the names of the individuals and institutions who organised the workshop on p. 6 — a big "Thank you!" to all of you!

For us at the International Astronomical Union's Office of Astronomy for Education (IAU OAE), this is just the start. Helping those who are active in astronomy education to grow their skills, and to become more professional in their activities, is one of our main objectives. Stay in touch if you want to make sure not to miss what is next — from additional events to more resources. On the web, you can find us at http://astro4edu.org, and on that page, you can also find your country's National Astronomy Education Coordinator Team. We are also on Twitter and on Facebook as @astro4edu.

Markus Pössel
Director, IAU Office of Astronomy for Education
Heidelberg, November 16, 2021

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In addition to the efforts from the OAE office in Heidelberg, Germany, the following OAE Centers and Node made key contributions to organizing this event:

OAE Center Italy

OAE Center Cyprus

OAE Node Nepal

The OAE Center India was not formally established at the time of this workshop but also made significant contributions.

Teaching about Indigenous Astronomy

Session organiser: Sivuyile Manxoyi, South African Astronomical Observatory, South Africa

Session overview

Astronomy is the most ancient discipline of science and one of its unique features is its multicultural roots. This stems from the fact that every person in the world has a profound relationship with the sky and the stars. This session explored the relationship between astronomy, culture and society; appraised the value, relevance and significance of indigenous astronomy. This predates western academic astronomy by thousands of years. This session concludes by revisiting challenges experienced in the teaching of indigenous astronomy and appropriate pedagogical approaches were shared.

Some of the challenges noted are the absence of indigenous astronomy content in school curricula in many countries, inaccurate representation, constant description of this knowledge and practices as irrational and absence of training and support for teachers. Reflexivity, recognition of epistemological diversity and willingness to engage in intercultural dialogues are imperative for the successful teaching of indigenous knowledge.

Appreciating multiple facets of different astronomies allows us to better understand how human ideas and models of the sky are generated. The teaching of indigenous astronomy presents us with an excellent opportunity to rehumanize science and society.

TALK CONTRIBUTIONS

Astronomies, Cultures and Education

Speaker: Alejandro Martín López, CONICET, Sección Etnología, Instituto de Ciencias Antropológicas, Universidad de Buenos Aires, Argentina

Some people talk about "astronomy" (the academic Western one) and "cultural astronomies" (the astronomies of "particular" cultures). This is a profound misunderstanding of the legacy of three decades of cultural astronomy studies. In this presentation we aim to discuss this confusion and to point out the contributions of cultural astronomy studies in thinking about astronomical education from an intercultural perspective. The sky and their phenomena have been an area of great interest for many cultures throughout the planet over time. In "Western culture", since the Copernican revolution, astronomy has become a model for all science. Due to the colonial expansion of the Western society their academic astronomy is taught today in the most diverse places on Earth. However, cultural astronomy has shown us that every astronomy is the result of a history and a society. "Western academic astronomy" is not "the" astronomy, and it is grounded – like all the others – on a series of implicit cultural assumptions. A truly inclusive and decolonial scientific education for our present and future world, supposes the possibility for the students and teachers of a critical appropriation of "Western academic astronomy", and the chance of putting it in dialogue with the astronomical knowledge systems of their own societies.

Talk link: https://youtu.be/qn8a_mzAeCM

Some people talk about "astronomy" (the academic Western one) and "cultural astronomies" (the astronomies of "particular" cultures). This is a profound misunderstanding of the legacy of three decades of studies in cultural astronomy. Cultural astronomy is an interdisciplinary academic field, not an adjective to identify some kind of "strange" astronomy.

Cultural astronomy is the study of all astronomical systems as social facts; not a search for fragments of "our" astronomy in distant cultures. This interdisciplinary field includes as some of their sub-fields: ethnoastronomy, archaeoastronomy, and a social history of Astronomy. In this presentation we aim to point out the contributions of cultural astronomy, especially ethno astronomy, in thinking of astronomical education from an intercultural perspective, transforming it from the point of view of cultural astronomy.

Ethnoastronomy is a perspective, a way of approaching ethnographically, ethnologically and

anthropologically the knowledge and practices about the sky of any contemporary social unit (such as an ethnic group, a social class, a family, a professional group, or an institution; both "Western" as "non-Western"), understanding them as an integral part of their social and cultural life. It seeks to place that knowledge and practices in their regional and global context, as well as in their historical development. It is interested in generally shared and largely implicit knowledges and practices (logics of practice, lebenswelt, worldviews/cosmovisions) and also, those more explicitly formulated and frequently associated with specialists (cosmologies, ontologies); understanding all of them as articulated, but always unfinished and under construction. Among the notes that characterize the ethno astronomical view, we can mention: a) the interest focused on giving an account of the perspective of the group studied; b) the question about the meaning of practices, discourses and their complex links; c) the holistic intention (any aspect of social life must be seen in connection with the whole); d) the centrality of the direct presence of the researcher and his / her interpersonal links with the members of the group studied; e) the "estrangement", as an effort to denature one's own common sense and that of the group studied; f) "reflexivity" or conscious analysis about our own position and influence in the construction of knowledge; g) a dominantly inductive character that includes comparison, models and general theories; h) the application of many combined techniques (such as interviews – especially informal – archives, life stories, elicitations, network analysis, images, videos, audios, surveys, statistical data, etc.) but articulated with participant observation; i) commitment, involvement and reciprocity with the studied community and local circumstances.

From ethnoastronomy we can learn that astronomical knowledge – as all human knowledge – is a socio-cultural construction, an important part of our adaptation to the world we inhabit: a physical, biological, but also social environment. Our world is a universe full of meanings, schemes of perception and metaphors in which we are introduced by other members of our society, essentially by primary socialization, imitation, and day-to-day life. The experience of the senses limits the possibilities of any human world view, but not to the point of generating a single compatible option. Also the social character of this knowledge and the need to legitimize that knowledge and comply with accepted truth regimes imposes limits on the possible world views in a given society at a given time, but they are not absolute either and they do not unequivocally determine only one possibility. From these socially shared ideas, or world views, grows the explicit systems of knowledge about the world that we call cosmologies. World views and cosmologies are poles of a continuum. Every system of ideas and practices about the sky has a constitutively unfinished and changing character, and is connected to general ideas about body, person, space, time, causality, etc. Also, knowledge systems are always involved in the general social field, with varying degrees of autonomy with respect to it and this implies that they are strongly traversed by power and social institutions.

The sky and their phenomena have been an area of great interest for many cultures throughout the planet over time. In "Western culture", since the Copernican revolution, astronomy has become a model for all science. Due to the colonial expansion of the Western society, their academic astronomy is taught today in the most diverse places on Earth. However, cultural astronomy has shown us that every astronomy is the result of a history and a society. "Western academic astronomy" is not "the" astronomy, and it is grounded – like all the others – on a series of implicit cultural assumptions. A truly inclusive and decolonized scientific education for our present and future world, supposes the possibility for the students and teachers of a critical appropriation of "Western academic astronomy", and the chance of putting it in dialogue with the astronomical knowledge systems of their own societies.

Cultural astronomy has an enormous potential to collaborate in a radical improvement of astronomical education. A deeper understanding of the astronomies of other cultures, which does not relegate diversity to a distant past, would be crucial to improve the teaching of astronomy in the world. But a huge amount of material about the astronomy of different cultures used in the teaching and popularization of astronomy, has no methodological rigor. Also, astronomies of other cultures are usually used in an "anecdotal" manner, as a kind of curious introduction to the strange things that were "thought" before the arrival of Western science. Hopefully, there are professionals in cultural astronomy and professional associations: Sociedad Interamericana de Astronomía en la Cultura (SIAC), Société Européenne pour l'Astronomie Dans la Culture (SEAC), International Society for Archaeoastronomy and Astronomy in Culture (ISAAC). They can help us to address the different ways of knowing the sky in greater depth, understanding its structure, allowing us to appreciate the way in which the ideas and models with which humans seek to know the world are generated. Also, they can help us to understand the logics, metaphors, interests and observations in which the Western Academic Astronomy rests, making it easier for educators to design strategies to approach the teaching of this kind of astronomy in diverse cultural contexts, and for the people to critically appropriate of Western Academic Astronomy. Also, we can learn a much wider variety of models, metaphors and approaches to the sky that can also be useful for Western Academic Astronomy.

Central and Mesoamerican skies: More than 4000 years of Astronomy

Speaker: Javier Mejuto, Archaeoastronomy and Cultural Astronomy Department, Space Sciences Faculty, National Autonomous University of Honduras (UNAH), Honduras

The archaeological record of the Meso and Central American peoples allows us to recognize, without a doubt, a methodical and continuous knowledge of the celestial space. Beyond this, indigenous peoples have perpetuated and are custodians of that knowledge in its most varied cultural expressions. This valuable astronomical knowledge brought to the classroom not only allows us to expand our knowledge of the universe and the human being, but also allows us to educate in a transversal way using ancestral astronomical knowledge to deconstruct ethnocentric discourses that support epistemological hegemonies, bringing the student closer to an explanation of the complex reality of our world.

Talk link: https://youtu.be/qYmm87cOUHY

The archaeological record of the Meso and Central American peoples allows us to recognize, without a doubt, a methodical and continuous knowledge of celestial space. The first thing

that we must take into consideration is that astronomical knowledge in other cultural contexts includes not only celestial space but also agriculture, weather forecasting, worldview, among others. That is, we must bear in mind that it is a knowledge system and not isolated knowledge.

In the Mesoamerican cultural context we can identify three types of structures for observing the sky, either directly or indirectly. The first type is the hemispherical, similar to the observatories of contemporary western astronomy. An example we have in the Caracol of Chichén Itzá, Mexico, from which specific moments in the apparent movement of Venus were observed. The second type is the horizontal observatory where the shadows of vertical elements, such as stelae, are used to know the time of year along with other ritual aspects. An example of this can be found in the Plaza de las Estelas de Copán Ruinas, in Honduras. Finally, the vertical observatories, used to know the days when the sun passes through the zenith (Aveni, 1981). Astronomical events typical of the intertropical zone and that in the case of the first passage of the sun through the zenith coincides with the beginning of the rainy season with the obvious agricultural implications for Mesoamerican communities. Examples of this type of observatories are in Xochicalco and the P structure in Monte Albán, both in Mexico.

We can also identify, through iconography, which celestial objects were mainly observed. The personification of the solar god K'inich Ajaw appears profusely in a variety of archaeological sites but perhaps the most profuse is in Kohunlich with its stuccoed masks (Velasquéz, 1995) or the Mayapán paintings located in the same country. This god also appears in the company of the moon goddess on the celestial bench of the Honduran site of Copán Ruinas. As we might expect, both the sun and the moon are the most represented celestial bodies but not the only ones, among them, the next in frequency of appearance in the archaeological record is the anthropomorphization of Venus. Although there are also many records on various supports, the paintings and representations in Cacaxtla are of relevance throughout the cultural area. Assumed as an omen of misfortune whose light was pernicious, it was related to the Haab civil calendar of 365 days through its synodic cycle and to the eclipses, well known in Mesoamerica. Of this we have written sources such as the so-called eclipse table of the Dresden Codex or the solar eclipse of 1531 that appears in the colonial section of the Telleriano-Remensis Codex (Códice Telleriano-Remensis, 1964).

Although it is only a brief brushstroke of the enormous knowledge of the celestial space that was developed in the Mesoamerican cultural region, we cannot ignore that it is not a petrified and forgotten knowledge but that it is still alive through the indigenous peoples that currently inhabit the region. This valuable astronomical knowledge brought to the classroom not only allows us to expand our knowledge of the universe and the human being, but also allows us to educate in a transversal way using ancestral astronomical knowledge to deconstruct ethnocentric discourses that support epistemological hegemonies, bringing the student closer to an explanation of the complex reality of our world.

Despite all this clear astronomical knowledge accumulated for more than 4000 years, we do not see it at all reflected in the curricula of the history of Astronomy subjects or in the associated degrees (as it happens with other cultural regions worldwide). This gives an idea of an unique course in the history of celestial space knowledge together with an evolutionary idea of it. Nothing could be further from reality. Astronomy, as a science, is a cultural product that has meaning and validity within the culture that has developed it, as is the case in past and contemporary cultures. With this we must motivate students to appreciate epistemological

diversity both in the past and in the present and its value for the present and the future of humankind. Expanding our understanding of other knowledge systems is not only important from an academic and pedagogical point of view, but it is an education in values that makes us stop looking only upwards, without a cultural or social context, to dream a future for all among the stars.

References:

- Aveni, A. and Hartung, H., (1981). "The Observation of the Sun at the Time of Passage through the Zenith in Mesoamerica", Journal for the History of Astronomy Supplement,12.

- Códice Telleriano-Remensis (1964) en "Antigüedades de México", based on Lord Kingsborough compilations.

- Velázquez Morlet, Adriana (1995), "Cosmogonía y vida cotidiana en Kohunlich", Arqueología Mexicana 14, pp. 32-36.

Astronomy Education at the Crossroads of Science and Indigenous Knowledge

Speaker: Duane Hamacher, School of Physics, University of Melbourne, Australia

The Knowledge Systems and cultural traditions of First Peoples around the globe contain layers of complex scientific knowledge derived from detailed observation, experimentation, collected wisdom and deduction through a priori and a posteriori systems of knowledge, which is passed down to successive generations through oral tradition. By learning from the teachings of Indigenous Elders, we can understand a great deal about the development of scientific information and how that can be used for a variety of applications. As Elders teach, everything in the sky is reflected on the land, a concept promoted by Annette Lee in the Lakota First Nation as Kapemni. As science educators, we also need to consider ways of assisting First Peoples who can approach scientific research and education through the lens of Etuaptmumk, "Two Eyed Seeing" - what Mi'kmaw elder Albert Marshall explains is seeing with one eye through the Indigenous world and the other through the Western academic world. This occurs at what Torres Strait Islander educationalist Martin Nakata calls the Cultural Interface. These theoretical frameworks provide a foundation for teaching Indigneous astronomy and science, and support the next generation of Indigneous scientists. This talk will focus on these frameworks and show examples from around the world about how Indigenous cultures developed scientific knowledge about the machinations of the cosmos and their relationships to events on the Earth.

Talk link: https://youtu.be/bsvEmuQorA0

Teaching Material of History of Astronomy Using Digital Archives in Japan

Speaker: Harufumi Tamazawa, Kyoto University, Kyoto City University of Arts, Tokyo, Japan

Digital archives make us learn the history of astronomy more effectively. Understanding the transition of the view of the universe is important in learning astronomy, but there are few teaching materials or workshops prepared compared to those who learn knowledge of astronomy. It is useful to touch on historical documents about astronomy. The promotion of digital archives in recent years provides this opportunity. In a class on the history of astronomy at the university, using digital archives, students searched for a diagram of the solar system drawn in historical documents about astronomy in Japan and conducted a task to consider how it differs from the real solar system. Using digital archives may make students understand how the heliocentric theory has flowed into Japan and the transition of the view of the universe deeper than simple lecture.

Talk link: https://youtu.be/7EvkJ4pP8wc

When considering the relationship between education and history in astronomy, it is necessary to consider how to incorporate historical content as a teaching material in astronomy. In the case of archaeoastronomy, site, heritage, land/skyscape are research contents. In the ethno astronomical approach, records and memos of habits, narratives, movements such as songs and dances are research material. What does it take to convert these research content into educational content? Archive is useful to change research material to educational material.

NOJIRI Hoei（野尻抱影）(1885-1977) and KITAO Koichi（北尾浩一）(1953-) are pioneers of folklore studies of astronomy in Japan. They have asked people and collected star names in each region. Kitao has collected not only words but also folk songs about astronomy in Japan (for example , Kitao 2021). In some cases, however, the interview survey was not conducted on the premise that the archive will be released, so some material about research is not able to be used. In the field of paleoastronomy research, researchers use document archives to search for useful documents to detect astronomical events in history. For example, in Hayakawa et al. 2017, archive of Japanese historical documents in order to know how large the space weather event in 1770 was. There are two types of approaches to change research material to educational material about indigenous astronomy. In the case of Ethnoastronomy or Folklore studies of Astronomy, archiving of research material (recording data, memo, and so on) itself is education. On the contrary, in the case of the history of astronomy or paleoastronomy, archiving research material and using archives is also education.

How about the relation between archive and lecture? History of astronomy is usually taught

in "classroom type lectures". What are the teaching materials of the history of astronomy? After Covid 19 pandemic, lectures in university were changed to online, therefore lecturers should make online versions of teaching materials of the history of astronomy . What is the teaching material about the history of astronomy, especially the transition of the view of the universe? Examining papers on astronomy materials that include historical content reveals that they can be divided into three types; Reproduction of historical observation methods (including calculations), remake (creation of past observation instruments), and reuse (observation and consideration by visiting and using the real thing (Astronomical heritage, old telescope). To make material about the transition of the view of the universe, however, we should make another type because we should approach cultural Astronomy and Input science Studies, philosophy of science.

The author conducted the following tasks in a class on the history of astronomy as a test case. Students search "平天儀図解"（Heitengi-zukai） written by Zenbei Iwahashi (telescope craft worker with lens), using "Japan search", portarsite about japanese archives, and look at the figure, point out the points that are different from the current way of thinking of the solar system, and ask them to think about what causes them. Many students do not explain that it is a simple geocentric diagram, but they explain that the moon, the sun, Mars, Jupiter, and Saturn are rotating around the earth, and Venus and Mercury are rotating around the sun. About 10% of the students made comparisons with Tycho Brahe and others. There was a tendency for the amount of description to be larger than other lesson contents. It is presumed that many students were interested in the task.

To make teaching material of indigeneous astronomy, an archive of research material is important. Researchers should make a methodology of archiving research material of ethnoastronomy or folklore studies of astronomy(rule, ethics, privacy, skill, and so on). Using of archiving, and related studies (History of science, Science studies, and so on) is also important to make teaching material about ingigeneous astronomy.

References:

- Hayakawa, H., et al. (2018). The Astrophysical Journal, 862(1), 15.

- Kitao, K. (2021) Publications of the Japanese Society for Education and Popularization of Astronomy, 33, 5, pp.21-33 (in Japanese)

Discussion summary

The questions and discussion focused on the availability of material for teaching indigenous astronomy and readiness and preparedness of teachers to teach indigenous astronomy. So far, there is a growing movement of developing materials in the USA, Canada, Australia, and South Africa. However, the development and circulation of best practices in materials development for indigenous knowledge are needed as well as collaborations across the countries and continents.

Furthermore, some universities have begun including indigenous knowledge teaching in their education and science education courses and training programs. There are organisations dedicated to development and support of indigenous astronomy such ISAAC (International Society for Archeoastronomy and Astronomy in Culture) and host conferences annually.

All the speakers, without exception, emphasized that all knowledge is socially constructed including astronomical knowledge. Therefore, astronomy has to be viewed as a cultural product, even though every culture has its own version of astronomical knowledge. Western academic astronomy is one of the many versions of astronomical knowledge. Its dominance can be ascribed to colonial past and current western cultural imperialism. It is critical and imperative to acknowledge, recognize and respect astronomical knowledge of other cultures, Indigenous cultures in particular.

There were questions and an elaboration by Martin Alejandro Lopez on intercultural approach to the teaching of astronomy. He pointed out that it is empowering for learners to learn about how other astronomers of other cultures handle and understand the sky and the stars. Recognizing that cultures influence each other and have many commonalities may assist in addressing issues of domination, disrespect and powers. He argued that recognition of indigenous practices may assist and contribute to the decolonization of knowledge and science.

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