Education and Heritage in the era of Big Data in Astronomy
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Research, innovation, scientific literacy and inclusion in astronomy

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Abstract. With this roundtable we wished to discuss about different topics related to research, innovation, scientific literacy and inclusion in Astronomy education, putting together the expertise of educators from all around the world. The present paper includes the introduction to the roundtable prepared by the chairs of the session as well as the contributions from several of the participants.

Keywords. research, innovation, scientific literacy, inclusion, Astronomy education

1. Introduction to the roundtable

To start the discussion and exchange of ideas, the chairs of the roundtable proposed some initial thoughts that we describe in this section.

1.1. *Research*

We wish to tackle the following questions: (1) Who conducts the investigation. (2) On what topics is research conducted in Education/Didactics of Astronomy. These questions are being addressed to:

- Teachers and professors in their own professional activity.
- Teachers and professors who work with researchers in didactics.
- Researchers in didactics who do experiments in critical mode.
- Astronomers who work with researchers in didactics to transform the knowledge they produce in Astronomy (new discoveries, formulation of new hypotheses, questions and doubts about previous theories) into knowledge for the teaching of Astronomy.

Research on Didactics/ Education is different from the outreach activities addressed to the general public, and dissemination. These researchers are interested in the thoughts, misconceptions, difficulties, and challenges that the learners face. This also includes their initial hypothesis, which can be locally true only, their questions and their partial answers.

But above all we need to focus on the processes that lead to the construction of knowledge: the tools, words, models and activities that help, or those that confound them or prevent them from learning. And this is not something that worries professional astronomers, disseminators or amateurs.

As researchers in didactics we have learnt that a crucial problem in Astronomy is to reconcile what we see, what we perceive and what we think is the truth.

We have learnt, from the research on Didactics of all the scientific disciplines conducted during the decades from 1970 to 1990 that the pre conceptions of the learners are crucial, be them children or adults. We study how to detect them but not only through tests or the use of words (oral registry) but also by means of iconic, gestural and symbolic registries, while remaining open to the ones we are not yet aware of and are brought in by the students. There is research about the conceptions that are already built but find obstacles, difficulties that can be epistemological, perceptual, conceptual, and research about the learning progression at different ages and at different levels of knowledge acquisition.

There is also research related to the history of sciences and to the different cultures in our planet, in different epochs and different places: the mistakes, hypothesis, discoveries, formulation of "laws"; the presence/absence of men and women; the existence sin antiquity of scientific communities – Alexandria's library and museum in Egypt, Bagdad's library-.

Other research focuses on the differences related to gender, social background – in particular between countries from the North and South hemispheres. One example is the Globolocal Project (www.globolocal.net).

1.2. *Innovation*

In the literature, most of the definitions of "Innovation" include two keywords: change and improvement through something new. But new does not mean necessarily better than what there was before, nor does it mean good in itself. New can be new locally, for specific people at a given time. Perhaps what one (teacher, researcher) thinks is new (because it is new for him, or because he has thought about it and found it) is not new for everyone, in all cultures and in all periods: but it is still an enrichment for your own activity.

Innovation is not the indiscriminate use of technological tools, either. as it can be done while still being attached to an obsolete pedagogical framework. This is particularly true during the current pandemic times when everybody is using IT resources (meeting platforms like ZOOM or MEET, electronic devices, virtual tools) at all education levels. Their use does not ensure an improvement from a pedagogical and didactical point of view, it depends on the use the teachers make of them. In fact, it might well be more innovative to learn by observing directly the natural world, our own surroundings or the night sky.

This leads us to consider which are the desirable characteristics that a particular educational innovation action must comply with. For example, it has to be sustainable: it should be applicable even after the initial funding has been spent, the experience published in a professional journal or the initial time scheduled for it. It should be transferrable: the action should be possible to use outside the context in which it has been developed. Finally, it must take into account the efficiency with which the learning is attained, like whether the learning goals are reached, and whether the students get better results thank previously. The goal of any innovation in education is to facilitate the adaptation to the societal changes regarding the knowledge, technology, information, new languages, communication and scientific research. But is should also help to include everybody: it must serve as an inclusion tool.

1.3. *Scientific literacy*

Astronomy is a scientific discipline whose activity is not directed nor its specificity is directed at education, or learning or teaching, or to link the construction of knowledge

that it generates in relation with the sky with the daily lives of people. It is a professional activity that does not require that connection. With regard to teaching-learning, there are two international currents, very different at the deepest level:

• A current based on information and content: a relationship is not sought between what is read, heard, known, and what is seen and experienced directly by looking at the sky, but using books or optical instruments and models instead. This modality of Astronomy teaching is widely spread, especially in the formal context of education, at all levels, including university and the training of specialists in Astronomy.

• By contrast, the other current is essentially concerned with the connection of people with the sky, mainly through observation from their own place, with strong ties to social, affective, cultural aspects (different according to latitude and longitude, the situation of the country, among other aspects), on what can be observed in a given moment, putting in relation the Earth and the sky. All this helps the autonomous and open construction of questions of those who learn, in many and diverse levels of understanding, and with great depth in the space-time dimension of phenomena, using especially the eyes and the body to observe and learn directly, in addition to the use of recording and measurement instruments, generally simple and inexpensive.

What makes the difference between both currents is how and for what purposes it is observed, since astronomy essentially requires observation. It is not the observation activity itself that characterizes each one, but the function it fulfils for the construction of knowledge in both streams.

1.4. *Inclusion*

Inclusion, in a broad sense, is a concern that is present at the IAU in all aspects of research, innovation and scientific literacy. With this theme, we intend to reflect on social inclusion of different people regardless of their wealth, the regions of the world where they live, the type of work they do, their mother tongue (specially in the case of non-English speakers who work in science), their gender, the technology to which they have access, their use of the physical senses, the possibility of using their body, their health, among many other possible factors that generate differences, exclusion, violence and discrimination in the world.

Therefore, research, innovation and scientific literature must be centred on each individual student to allow them to reveal their potentialities. One way to achieve this is through the Universal Design of Learning (UDL) framework which is based on the premise that everyone learns in a different way, has a specific personal style of learning. UDL proposes strategies and technologies that take into account these multiple styles.

2. Contributions from the participants in the round table

2.1. *Identifying the accessibility of educational resources, by Stefania Varano (INAF)*

We present here a study by the Inclusion Group of the National Institute for Astrophysics in Italy on a list of tags and keywords for the definition of specific inclusive features of educational activities, in order to identify the inclusive potential of activities available on several platforms for astronomy education. Tags, as icons, represent in brief the accessibility of specific resources. Such awareness allows to select what is most suitable to oneself and to build ones own customized path and experience.

These tags are indented to highlight characteristics of activities that are efficient in some contexts and with some specific needs. They have been identified on the one hand on the basis of the self-evaluation of our experience; on the other hand this list results from the advice of experts working with (or representing) disadvantaged groups and/or Special Educational Needs (SEN). Some examples:

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• "Short and simple texts": activities that make use of little text and simple language, also accessible to non-native speakers and people with some speech disorders.

• ÒSafe Materialsó: activities that make exclusive use of non-sharp, non-hazardous materials, which can also be used in prisons and with young children and some people with cognitive disabilities.

2.2. *Astronomy Heritage in Education, by Alessandra Zanazzi (INAF)*

This is a project that plans to involve students in the discovery of astronomical sites and the history of astronomy in the cities. It combines astronomy, history, art, history of science, philosophy, development of thought and technologies in a truly transversal way. It shows how astronomy and the relationship with the sky have always been part of culture, traditions and development of people being very much integrated in monuments, ancient churches and works of art in every historic city.

The project starts from the realization of astronomical walks in the city with students and from the detection of the success, collected even with young people, of initiatives such as the observation of the passage of the sun on monumental sundials at solstices or equinoxes, or the use of ancient instruments, armils and Zodiacs. We have also written a tourist-astronomical guide (for Padua, Florence and Palermo), easy to use, non-specialistic, with an attractive graphic; also the guide-book has a map and itineraries on different themes, which helps to explore the places with an astronomical perspective.

2.3. *Use of technology in teaching, by Sara Ricciardi (INAF – OAS)*

The idea I'd like to bring to this roundtable is about the use of technology in teaching. It is often superficially thought that bringing a robot or a device into the classroom is equivalent to doing an innovative teaching, as if bringing a pen into the classroom would make children become writers. Technology is a powerful, interesting and natural instrument to learn about science first of all because it is an instrument of science itself. Nonetheless the use of an instrument does not warrant a personal and significant learning. Technology could be a means of expression enabling creativity in the classroom but could be used as a dull and unexpressive tool: the same difference you can see between a free writing and a dictation. Pushing the example even further, should you keep from teaching children to write because you think they won't be writers or journalists when they grow up? That is why it is important to recognize technology as a means of expression able to transform children from users to creators in our societies where children are already soaked in technology.

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