Talkin' About the Resolution

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Abstract

How do astronomical images work? Astronomical images (and, actually, all the digital images we are used to) are representation of reality mediated by an instrument that has its own characterisation (resolution, sensitivity, etc.). We developed a series of new creative and fun educational hands-on activities to play with children aimed at communicating the science of digital images and understanding concepts like image resolution in a multidisciplinary, participative environment. The educational activities we are proposing have a learning by doing approach and use favorite children's toys (e.g. pegs and bricks) as a research tool in order to introduce forefront science concept in a playful and inclusive environment. The use of familiar objects and ludic equipment prevents gender barriers and encourages immediate commitment and engagement of all the participants.
The project we will present is carried out in the framework of Italian National Institute of Astrophysics (INAF) SKA related projects (e.g. "SKA-Genesis", "ESKApe-HI", "FORECaST"). SKA (Square Kilometer Array) is one of the most ambitious international science projects and so we think that for astronomers it is of crucial importance to communicate its science, starting from the fundamentals. It'll be the world's biggest (radio) telescope and it'll give us insight into the major open problems: formation and evolution of the first stars and galaxies, the role of magnetism, the nature of gravity, possibility of life beyond Earth.

Keywords: *Astronomy, Image Resolution, Participation, Inclusiveness, Hands-on;*

1. Introduction

1.1 The framework

The activities we are presenting are developed and being tested by the Italian National Institute of Astrophysics (INAF Istituto di Astrofisica) in the framework of SKA related projects ("SKA-Genesis", "ESKApe-HI", "Towards the SKA and CTA era: discovery, localization and physics of transient sources" e "FORmation and Evolution of Cosmic STructures with Future Radio Surveys).

SKA, Square Kilometer Array [1], is one of the most ambitious international science projects, it is currently under construction in Australia and South Africa and it will become the world's biggest telescope, tens of times more sensitive and hundreds of times faster at mapping the sky than today's best radio telescopes. Italy through INAF is strongly participating at its concept, design and operation and is playing a major role defining the scientific cases and building and infrastructure in preparation of the scientific exploitation. We believe that for astronomers it is of crucial importance to communicate the science of SKA, starting from the fundamentals. The SKA telescopes will give us insight into major open astronomical issues: formation and evolution of the first stars and galaxies, the role of magnetism, the nature of gravity, possibility of life beyond Earth… SKA will produce a data flow that is 100 times the global internet traffic: these data are not real pictures, but can actually be visualized as images: but what, in fact, these *images* are? In our hands-on activities, we introduce children to the science of (astronomical and radio-astronomical) imaging and data visualization, with a learning-through-play approach.

1.2 The approach

"Learning through play" describes a pedagogical and psychological approach according to which children make sense of the world through play. The concept is mainly based upon John Dewey's contribution [2] to the theory of constructivism [3] and Seymour Papert's theory of constructionism [4]. They basically suggest that "education is not an affair of 'telling' and being told, but an active and constructive process" ([2] Dewey, p.85) and that "the best learning takes place when the learner takes charge" ([4] Papert, p.25). Play-based learning programs are student-centered learning approaches,

focused on the fully autonomous development of children’s cognitive, social, experiential and creative potential through play (think also of the Montessori Method [5] and the Reggio Emilia Approach [6]).
Play-based approaches not necessarily employ toys as work equipment, nevertheless in this activity we take advantage of children's toys that use image sampling and make use of simple, very little structured playful stuff for reproducing images at different resolutions. Also, we build upon real children’s interest (such as bricks!) to let them build their understanding of complex characteristics and phenomena. The main aims of this activity are:
- to introduce basic concepts of astrophysical imaging, such as spatial and chromatic resolution and sampling through toys and playing;
- to create an inclusive and participative environment, leaving much space to personal intuition and autonomous discovery;
- to prevent literacy barriers and encourage all children’s commitment thanks to familiar objects as their toys.

2. Description of the activities

The activity mainly addresses elementary school students (8-10 years old) but has also been tested with middle school teachers. It includes at least two sessions of 2 hours each, involving the whole class divided in working teams of 5-6 children.

2.1 First part: the pegs

In each team, two of the students acting as “*operators*” are given a pegboard with a colour image under it: the image is only visible to them, whereas the other team members will have to guess the subject. The “*operators*” will use the board as a colour sampler, inserting in the holes pegs of the colours corresponding to the image they see under the board, in order to make the image recognizable to their fellow team members (Fig.1). They start with a limited set of the biggest available pegs of different colours. The other group members will try to guess the subject being reproduced; meanwhile they also help the *operators* by winning more pegs for the representation. The additional pegs are obtained by drawing and guessing astronomical subjects and kids can choose, in collaboration with the *operators,* what colour they need and also among 3 different peg size. During this phase, facilitators provide the additional pegs and the paper sheets indicating what subject to draw, but also provide the language necessary to help children articulate what they see happening and if needed ask questions, in order to expand and enhance play. Kids soon understand that smaller pegs (good resolution) are useful where the image details need to be defined, nevertheless they take much longer to be put in place; whereas when they want to represent large one-colour areas, no details are needed, and bigger pegs could provide a quicker solution (Fig. 2) …

Figure 1 Children starting to put pegs in the pegboard

Figure 2 Different peg sizes, different resolution of the image!

2.2 Second part: pixelization

In the second part of the activity, each group is given a colour image and a transparent baseplate for Lego-type bricks. The plate has to be transparent, so that the image under it is well visible. The kids will also have different sized and colour bricks (4x4, 2x2 and 1 button) and will try and reproduce the image using the different sized bricks as pixels, choosing the colour that best represents each image portion. First, they will use the 4x4 bricks, so to realise that the image resolution they get is too poor to even understand what it is about; then they will try the 2x2 and finally the 1x1. Also student can try this activity individually, using images and sheets with grids of different sizes (resolutions), colouring each cell of the grid with a single colour, chosen in order to be the most representative of the "overall" colour of the box (in this case the range of possible colours is given by the ones already owned by the students). This can add an occasion of re-thinking and different perspective to the team work with bricks (Fig. 3).

Figure 3 – Example of an image "pixelated" by the children

At the end of each phase, we took some time to discuss with children. We recap the main concepts arisen during play, discussing different ideas about the concept of resolution and also highlighting the limitation of our materials. We played the game "what if?" (e.g. if we had more pegs, smaller pegs, more shades of colour, different subject to pixelize). Through discussion, we relate this experience with familiar experience for kids (e.g. streaming file on *you-tube* with low connection). Finally, we connect the activity with the work of an astrophysicist again through a sort of play. We visualize an astronomical object such as a galaxy and we let them decide how to measure it fixing a certain amount of time for the overall observation (a certain amount of pegs). In the test class, thanks to their experience, they immediately suggested it will be better to cover the object with a lower sample and then focus on the more "interesting areas" that they point out.

3. Results

The main results of the activity are:

- the simplicity of the used materials, together with their friendly and "interesting" nature, favoured an extremely positive attitude of the students;

- basic scientific concept seems to be deeply rooted thanks to various “eureka moment” that actually occurred and we observed the children really experiencing spontaneous learning;
- the lab encouraged a deep personal involvement and a proficient team work.

In this phase, when the activities were tested in a few different situations, we just carried out some qualitative evaluation, mainly related to observation, self reflection and documentation. We are planning a deeper evaluation, which in our view will necessarily have to deal with an assessment of the approach and the methodology (other than knowledge or content learning) as we are interested in the spontaneous learning that occurs in this situations.

4. Conclusions

This lab clearly proved as “the true value of play is not that it can teach children facts, but that it can help them acquire important procedural knowledge, which is beneficial in acquiring declarative knowledge” ([8] Pinkam, p.31) We have literally seen the idea of images as data carriers rising in these children’s minds, while they experimented the limits of the medium and tried to overtake them.
Next step will be to create a consistent, repeatable activity, with standard equipment, such as arranged kit or a list of material. Already we made an agreement with the peg producer, in order to have useful kits at a special affordable price for schools and educators (please contact us if you are interested!) and part of the activities has already been carried out in other countries (Ireland) and different situation (e.g. science fairs)
We have also discussed a possible third phase, which could include the digital elaboration of the images, with dedicated graphic software or educational software such scratch [9], to dig dip on the concept of quantity of information in an image. We are also working on turning this lab multidisciplinary, in particular in connection with art experts and teachers, creating an art gallery of deconstructed images with less and less information and relating with the work of e.g. Piet Mondrian and also contemporary artists that are using pixelization as a distinctive signature of their work.
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