

Misconceptions in astronomy

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Abstract

In the present study performed by the Astronomical Observatory of Brera (Italy) and the Astronomical Observatory of the University of Valencia (Spain), we analyse some common misconceptions in astronomy. In particular we explored the evolution of these misconceptions (if any) depending on age and socio-educational factors, from a cognitive structures point of view. Cognitive structures interact with learnt contents and produce resistant conceptual schemes that are almost completely unknown and ignored by teachers and educators. We carried out an extensive survey (more than 2000 tests in the two countries) and we studied the spontaneous schemes and concepts used by youngsters when facing some basic astronomical ideas, in order to focus efforts on helping to change the above schemes by inducing a “clash of ideas” for the students. In that way, students could acquire a dynamic mental model consistent with the scientific model.

Introduction

At the last *Communicating Astronomy with the Public* conference in Munich in 2005, F. Cavallotti, S. Romaniello and S. Sandrelli presented a very interesting work called *Astronomical Pills*: one-shot questions about the Universe, in which they explored the evolution (if any) of some misconceptions in astronomy depending on age and educational factors, of students of different age ranges (13-19 years old) and from different types of school. They found that the use of formal or informal language in a given framework significantly affects the subjects' answers, by introducing socio-educational and emotional factors. In particular, their results highlighted the fact that scientific and non-scientific knowledge is not combined together in our cognitive structures and that age and school grade do not modify pre-existing ways of reasoning.

The school visit programmes at the Astronomical Observatory of Brera (Italy) and the Astronomical Observatory of the University of Valencia (Spain) are very similar. At both centres students are taught some concepts about astronomy, for example, with themes related to the Solar System or gravity, by means of hands-on activities, talks, etc. for approximately three hours.

We decided to perform some research about these misconceptions in Spain. As with the Italian group, we did not aim to investigate the students' knowledge of science, but the spontaneous schemes and concepts used by youngsters when facing some basic astronomical ideas, mainly focusing on their perception of the Universe, on distance and size and how gravity works. We tried to use these schemes to rebuild the image of the Universe developed by youngsters over time.

We started from the same ideas about the origins of misconceptions and modern theories about cognitive structures of Cavallotti et al. (2005). Our work follows the line of the Italian researchers. We collected almost 800 tests comparable with the Italian ones, consisting of 9 questions on astronomical topics, concerning the perception of the Universe, distance and size, properties of light and how gravity works.

Our test sampled students of different age ranges (see Figure 1):

- 11-13 years old (last years of primary school);
- 14-16 years old (secondary school);
- Over 16 years old (high school);

and from different types of school. We followed the procedure described by Cavallotti et al. (2005) to carry out the tests.

Different School Levels and Age Ranges

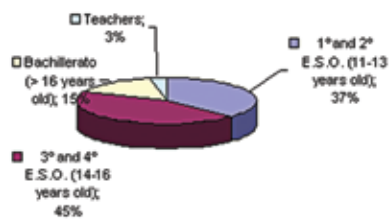


Figure 1

Draw the image of the Universe that you have in your mind.

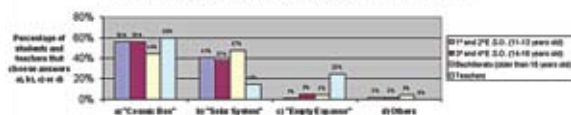


Figure 2

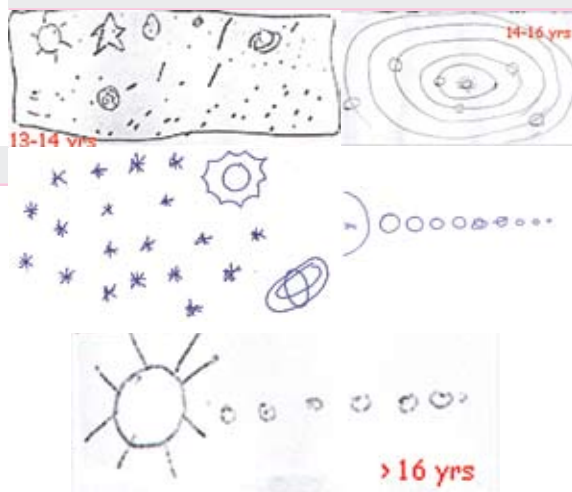


Figure 3

Data analysis

Perception of the Universe:

As in Italy, we collected drawings about the Universe representative of the subjects perception of the Universe. We found too three possible age-independent scenarios (see Figure 2):

- The so-called "Cosmic Box" in which the Universe is perceived as a box with stars, planets, galaxies in a space, sometimes encircled by an edge. It's worth noting that the Sun and stars seem to be perceived as two different types of objects.

- The so-called “Solar System”, in which the Universe is perceived as equivalent to a Solar System with very small distances between same-sized planets.
- The so-called “Empty Expanse” in which the Universe is perceived as an empty space without any evidence of stars, planets or other features.

We must point out that drawings were very similar in all scenarios in both countries (see Figure 3).

Perception of distances and sizes:

We conclude that students seem to have the correct idea about the order of magnitude for the size and distances between the Sun and the Earth but not with respect to the other planets or distances between the Sun and other stars. This is consistent with the “Solar System” scenario. (See Figures 4 and 5)

Gravity:

If using formal textbook language, students seem to have assimilated the concept of gravity. But using a different kind of question, formulated in informal language, we obtained the opposite result. So it seems necessary to conclude that the use of formal and informal language in a given framework causes differences in the resulting answers. As in Cavallotti et al. (2005), our results show that language formalism significantly affects the subjects’ answers irrespective of school grade.

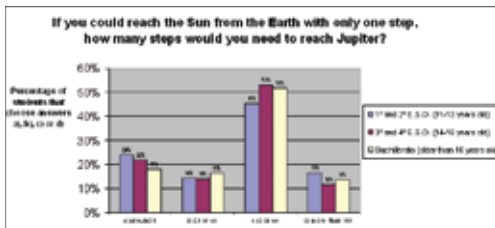


Figure 4

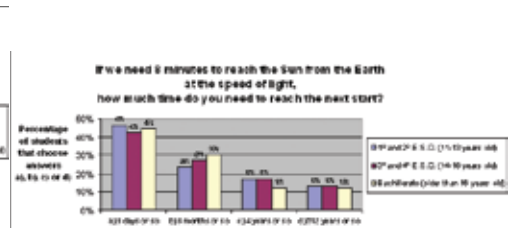


Figure 5

Conclusions

The Italian-Spanish research results agree on the following:

- Results suggest that age and schooling do not modify the most basic ideas regarding the Universe.
- Some misconceptions were demonstrated to be difficult to eradicate, while others are affected by the use of a specific language form.
- Misconceptions are resistant to time: our results are very similar to surveys carried out ~15 years ago.
- We did not find any significant difference between boys and girls. (See Figures 6 to 8).

Performance

What can we do to eradicate misconceptions? We are focussing our efforts on helping to change these schemes by inducing a “clash of ideas” situation for the students. In that way students can acquire a dynamic mental model consistent with the scientific model.

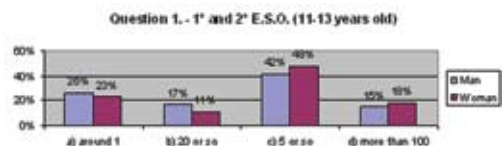


Figure 6

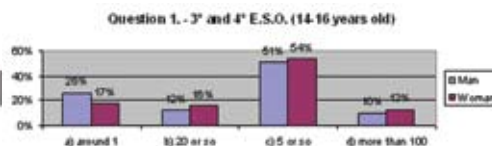


Figure 7

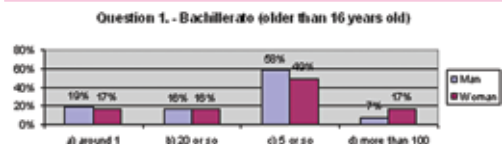


Figure 8

We have designed new hands-on activities to promote this “clash of ideas” that seem to be very effective because students realise the discrepancies between their cognitive structures (their representations of the environment in a common-sense framework) and the learnt contents (the representation from a scientific-sense point of view) for the first time.

Next steps

- Finish a new programme of activities following the above guidelines.
- Design an evaluation strategy about efficiency valid from an Experimental Sciences point of view (maybe a triangular scheme) (Rodríguez Fernández et al. (2005))
- Study lessons learnt to improve the activities for better efficiency.

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