An Introduction to Cosmology Problems at Classroom

Jan Novotný, Jindřiška Svobodová
Faculty of Education
Masaryk University, Brno, Czech Republic

Abstract
We present results that categorize and assess the quality of frequently asked cosmology questions within the didactic framework. The goal was to provide helpful hints for improving cosmology course for future science teachers and for evaluation the performance of individual students. This paper deals with the role of cosmology problems which help to develop various cognitive operations. Mainly the Bloom's taxonomy of educational objectives has been used for this purpose.

Keywords: students' questions, taxonomy levels, cosmology course, problems for development of various cognitive operations

Introduction

History gives evidence that visions of Universe played an important role in the life of man. It seems to be basic human needs to organize and integrate ideas into a meaningful system. We can consider that there are thousands cultures on the earth, many religious beliefs and worldviews exist.

Many traditional concepts how the Universe came into existence were based on religion myths and differed widely. Those cosmologies were scientifically unacceptable, but they provided a mental headstone that defined a shared reality for people. The challenge today is to take the new Universe picture and present it not only just as physics but as a reason for everyday thinking. Even if man will never calculate temperature of the star in life, it is important to know that many stars characteristics can be calculated, that it is nothing unpredictable or magic in it. If supernova occurs or comet will come it is not mythical wonder. Scientific theories about the Universe are refined as new evidence is discovered, but Universe events can be explained through natural processes.

Today, scientists can explore many cosmology questions about the origin and evolution of the Universe. Building on the results of other sciences, particularly physics and astrophysics, it has led to major new understandings about the nature and evolution of the matter around us. Recently, new observations have led to a revolution in our understanding of the structure of the Universe.

As the field of cosmology advances, it is of interest to study how teachers' and students' ideas relate to scientific understanding. In this paper, we show several questions and problems integrated in introductory level course of Cosmology at Masaryk University.
Our group is bringing new advances to cosmology course, we are developing new learning module for general education science students. The course is an integrated lecture and seminar, with approximately 10 students per semester. It covers the major cosmology topics typically taught. The class meets 1 hour per week for 15 weeks.
Course should equip science teachers with cosmology knowledge and skills they could meet at classroom. We have attempted to prepare the tutorial with common misconceptions at this field.

Questions and taxonomy levels

Specific education objectives closely related to the questions we ask students. In questions, we may express everything that we know, what we do not know and what we want to know at future. Questioning is a process which is direct linked to student learning "Learning begins when student begins to ask".

Bloom's Taxonomy of Educational Objectives (1956) provides useful way to think about when and how to use suitable questions in teaching. Bloom identified six types of cognitive processes and ordered these according to the level of complexity involved. His taxonomy provides a framework for categorizing question types and related activities.

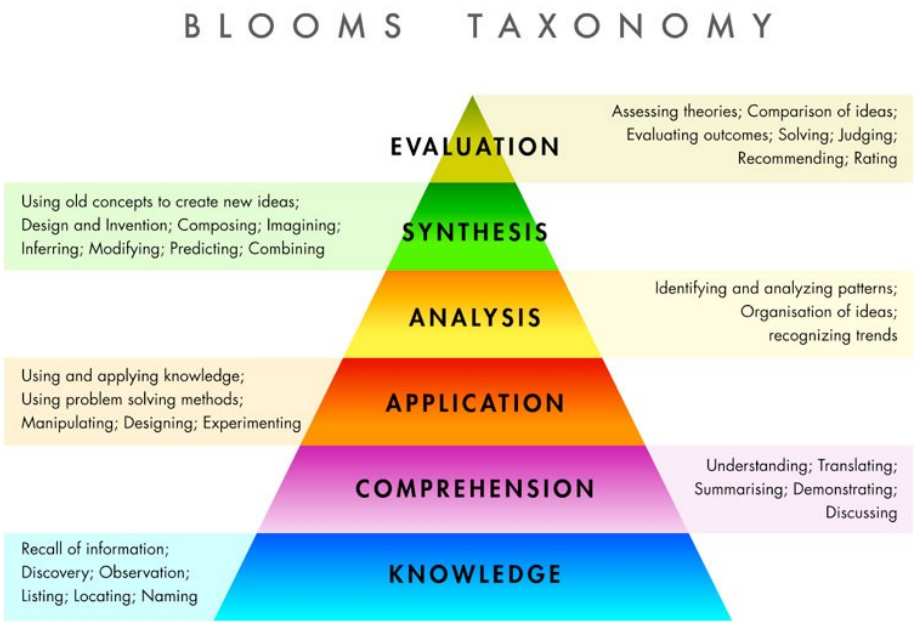

Figure 1 Bloom's Taxonomy pyramid

As shown in Figure 1, knowledge is the lowest level in the cognitive hierarchy. It refers to recall of knowledge and information.

In the next level in the hierarchical order is comprehension. In context of cosmology: students who comprehend cosmology knowledge should be able to process it into their own language and can summarize facts.

Application level requires ability to solve simple problems. In a cosmology context, student can apply suitable math and physical methods into a given problem.

Analysis level refers to the ability to break down the cosmology problem situation into parts, and detect the relationships of those parts.

Synthesis level represents the ability to put parts together, with emphasis on creating a new meaning or structure. Synthesis in a cosmology context is skill to apply multiple factors from different science disciplines.

Evaluation level refers to making judgments about the value of ideas. Evaluation skill in Cosmology context can be interpreted as skill to evaluate used methodology and solution plan.

We have collected appropriate questions for various cognitive levels for such special discipline as is cosmology. Questions at lower levels of Bloom's Taxonomy were prepared to show students' understanding of basic terminology and ideas, and questions at higher levels of their operating physical procedures used for given cosmology problems. We believe, if

students could answer the set of questions to which a cosmology gives answers, then they would have a good cosmology overview.

Realization

At first, we recorded student's own ideas about the universe and the meaning and relevancy of the ongoing human search for answers to cosmic questions. We have collected all questions and we have ordered questions according to the level of complexity involved. Students can see that simple question can has complicated answer. Answers for cosmology questions often lead to the next questions about general physics concepts.
Simultaneously we have attempted to prepare the tutorial with frequent cosmology problems, common misconceptions and discussion questions [1].

There is list of selected questions and problems:

- Are all the stars we can see like our Sun?
- Our knowledge about the universe is obtained by interpreting light gathered by telescopes. What is light?
- Is the speed of light the maximal speed in the universe? How is this possible and how we figured it out?
- Is it true that using known speed of light we can calculate the distance of star from Earth?
- How far could we see at the universe?
- Is it possible that some stars we see today may not even exist any more?
- How to determine the age of the Universe?
- Does the universe have a center?
- Is space flat or curved?
- Is the expansion of the Universe slowing down or accelerated up?
- What dangers we are threatened from space and what you consider to be the greatest?
- What is the evidence for the Beginning of the Universe?
- Is there intelligent life in the Universe?

Questions and associated sub-questions were categorized by the knowledge and comprehension levels of expected response. Most problems require a participation of multiple cognitive levels. Only the most relevant level for question (expected answer) was designated. Every item is expressed as brief task for student.

Level I: Knowledge
List the characteristics of celestial objects, stars, galaxies
List the characteristics of our Sun
List the characteristic of light

Level II: Understanding (comprehension - ability to think adequately with an idea)
Distinguish the sizes and distances of celestial objects.
Interpret cosmological constant.
Can you figure out what Hubble graph represents?

Level III: Application
Explore and define the Hubble Law.
Explain how astronomers can determine distance of celestial objects.
Construct a scale model of the solar system, galaxy, ... , time model.

Interpret image of cosmic microwave background radiation.

Level IV: Analysis
Which is older, the Sun or the galaxies?
How can scientists estimate the age of the universe?
What relationship is between a star's distance and its radiation?
How did scientists long ago learn about distant galaxies?

Level V: Synthesis
Demonstrate the role of light to human sight.
Why we suppose the laws of physics are the same everywhere and at every time in the observable universe?
What is the role of Doppler Effect in Cosmology?

Level VI: Evaluation
On which experimental results present standard model of Universe was developed?
What evidence would you need to show that the universe is expanding?
Write an essay arguing for or against manned missions to the Universe.
Describe the opinions of scientists on the formation and evolution of stars.

Discussion

Our study results suggest that questions in the lowest two taxonomic categories tend to be answered more frequently and with greater success. That answers mainly relate to terminology and cover basic ability to interpret presented material.
Higher level questions require complex application. Analysis questions or questions requiring synthesis are rather similar to problem tasks. Students have to build bridges between discrete science facts. Cosmology includes not only the macro world of galaxies but also the micro world of the atom and electrons and everything in between.
Evaluation questions ask students to make judgments and define the reasons for them. Cosmology question can include some hidden assumptions about time, space etc.

Cosmology questions above were categorized into levels. We have determined the frequency of each level cosmology question representation.
Frequency of questions at specified taxonomy varied as one can see at Figure 2.

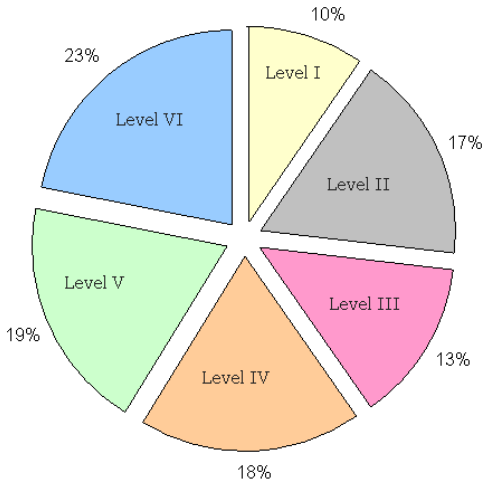

Figure 2 Procentual taxonomy representations of used questions

Conclusions

The main purpose of this study was to compare the cognitive levels of frequent cosmology questions. Most of the attractive cosmology questions fall into the categories - higher taxonomy level questions (IV,V,VI). Our observation is that during induced discussion students use a sequence of questions on lower levels to build depth cognition step by step - many brief closed questions. It is better than beginning with a single question that is too multilayered or complex. If students had the opportunity to operate at more than the lowest levels of Bloom's taxonomy they were more motivated and they have remembered more information.

Mix of different types of questions is also better for students attention, only one or two open questions can are the most effective in encouraging discussion and active learning.
Students should be encouraged to ask questions, they need time for questions. Teacher would be able to delicately intervene when student is not able to ask question or if the question is considered unclear. We hope the selected questions should help science teachers to communicate the facts, ideas, and ways of thinking that are important for science worldview.
We want students learn both cosmology facts and the processes of science. This includes formulating their questions in taxonomy order to gain better understanding science to everyday life.
The material was created to guide and simplify the selection and creation of cosmology and physics problems whose solution supports the development of cognitive operations. It may also help with student's motivation or the development of key competencies. In our opinion every science teacher should be able to respond to basic questions and facts about Universe.
Questioning provides interactivity during the process of teaching. Ideally, teacher combines questions that require lower-order thinking to assess basic students' understanding with questions that require higher-order thinking.

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