

An Investigation on students' conceptual understanding about Cosmology through cluster analysis

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Introduction and research questions

Recent curriculum reforms in Italy have promoted the introduction at secondary school level of up-to-date physics topics, such as quantum mechanics, particles' standard model, the origin of the Universe and Cosmology

Students' beliefs and ideas about some aspects of Cosmology have been identified by prior works. (Prather, Slater & Offerdahl, 2002; Trouille et al., 2013; Wallace, Prather & Duncan, 2012)

A coherent picture of students' conceptual understanding in this content area is yet to be provided

Research questions

RQ1. What are the students' ideas about relevant conceptual aspects of Astrophysics and Cosmology?

RQ2. To what extent does cluster analysis allow to identify coherent patterns of understanding?

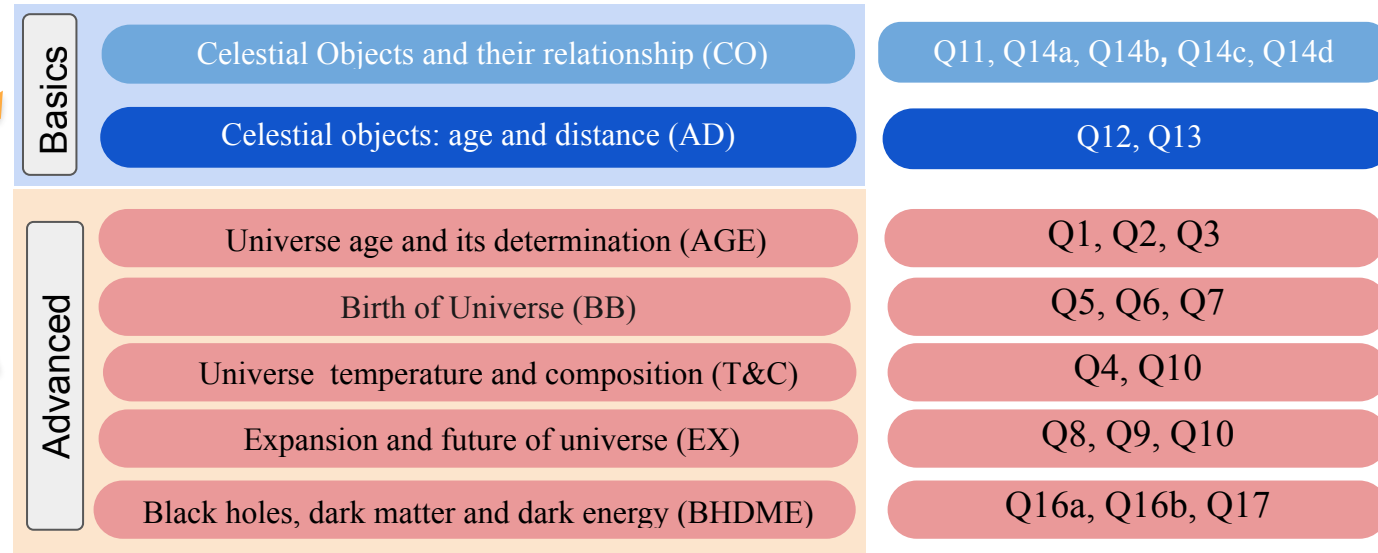
Instrument

Methods

We identified **seven conceptual dimensions** (Prather et al., 2003; Bailey et al., 2012; Wallace, 2011; Trouille et al., 2013; Wallace, 2012).

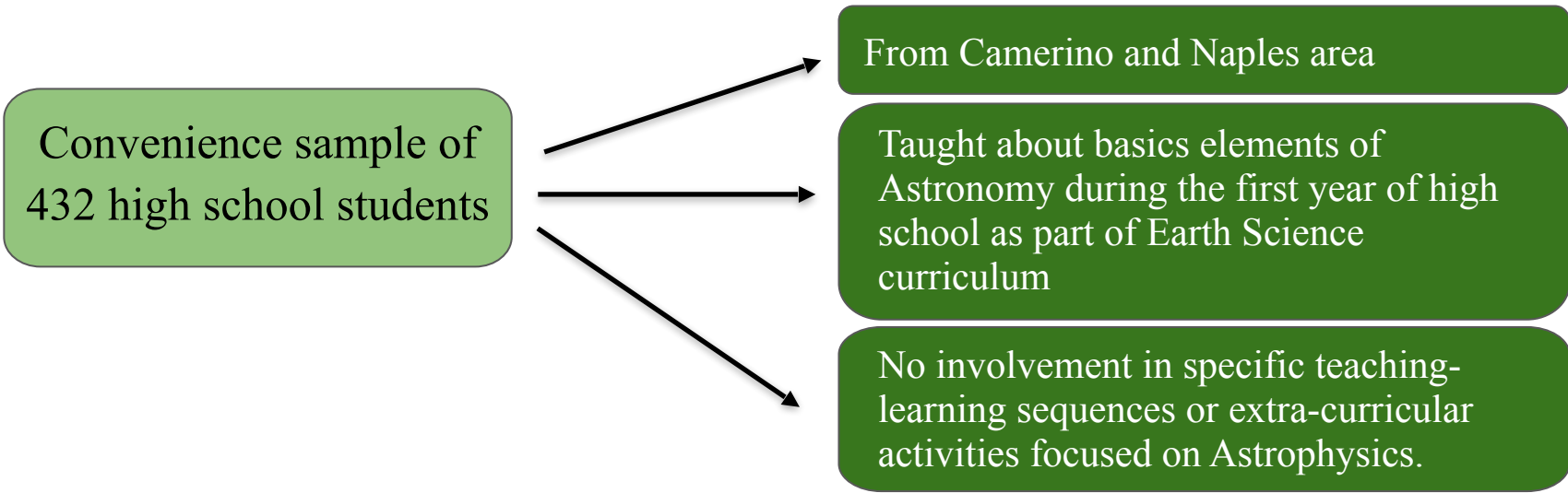
To investigate students' knowledge about these dimensions we design a questionnaire based on three types of tasks: 15 written text, 5 drawing and 2 ranking.

Conceptual dimensions



Sample

Methods



Age

(17.9 ± 0.7) yrs

Gender

43,7% Female
56,3% Male

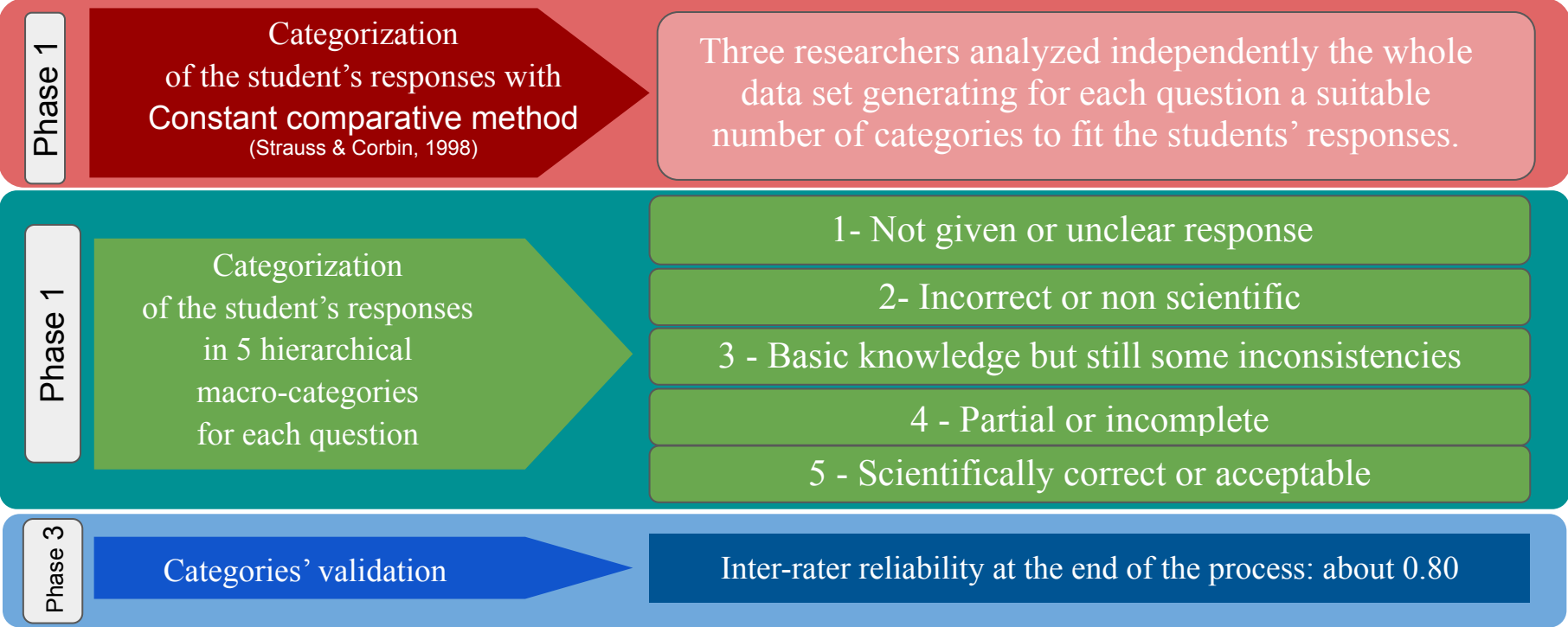
High School

78,7 % Scientific
14,4 % Humanities
6,9 % Vocational

Data Analysis process

Methods

Students' responses categorization



Data Analysis process

Methods

Cluster analysis

We performed a non hierarchical cluster analysis using SPSS k-means algorithm.

Clustering procedure

Repeated K-means routine
for number of cluster from 2
to 10

Validation
of
cluster number

Cluster interpretation:

- identify understanding patterns
- classifying the clusters according to increasing level of knowledge

Clustering phases

Phase 1

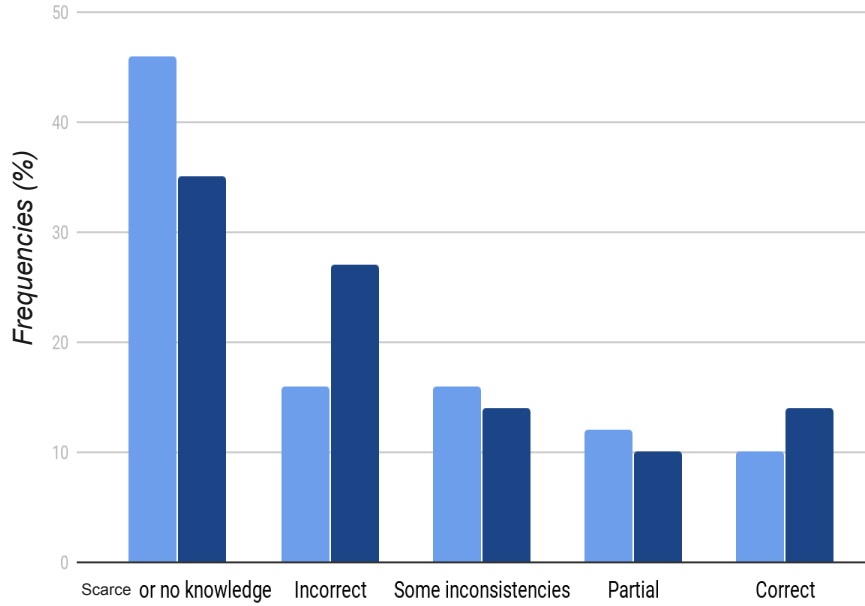
Separated clustering of questions
related to each conceptual
dimensions

Phase 2

- Two separated clustering for
- basics conceptual dimensions
 - advanced conceptual dimensions

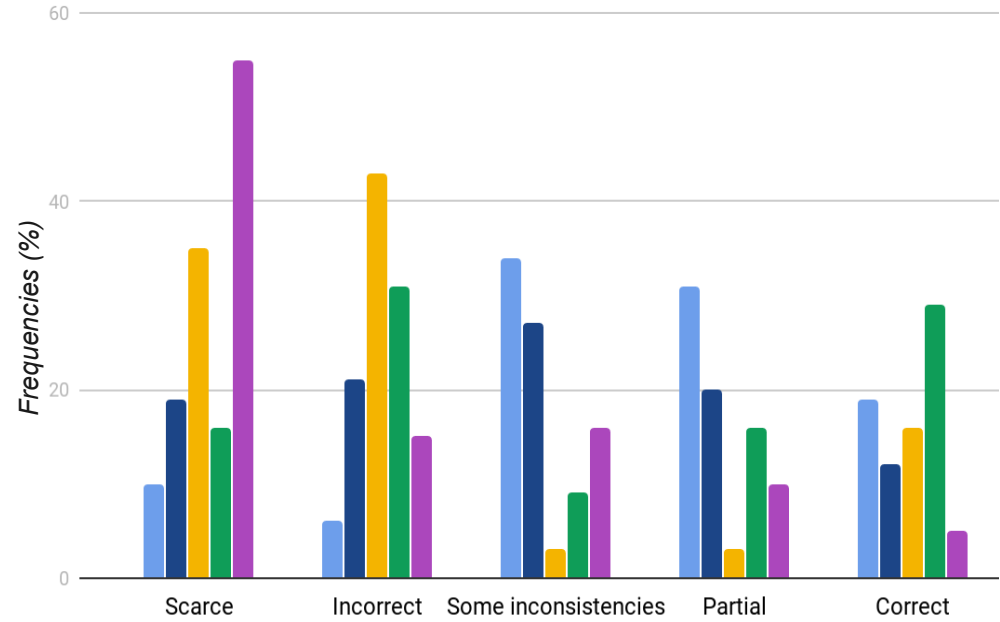
Phase 1. Clustering of questions related to each advanced conceptual dimension

Findings



Celestial Objects and their relationship

Celestial objects: age and distance



Birth of Universe

Universe age and its determination

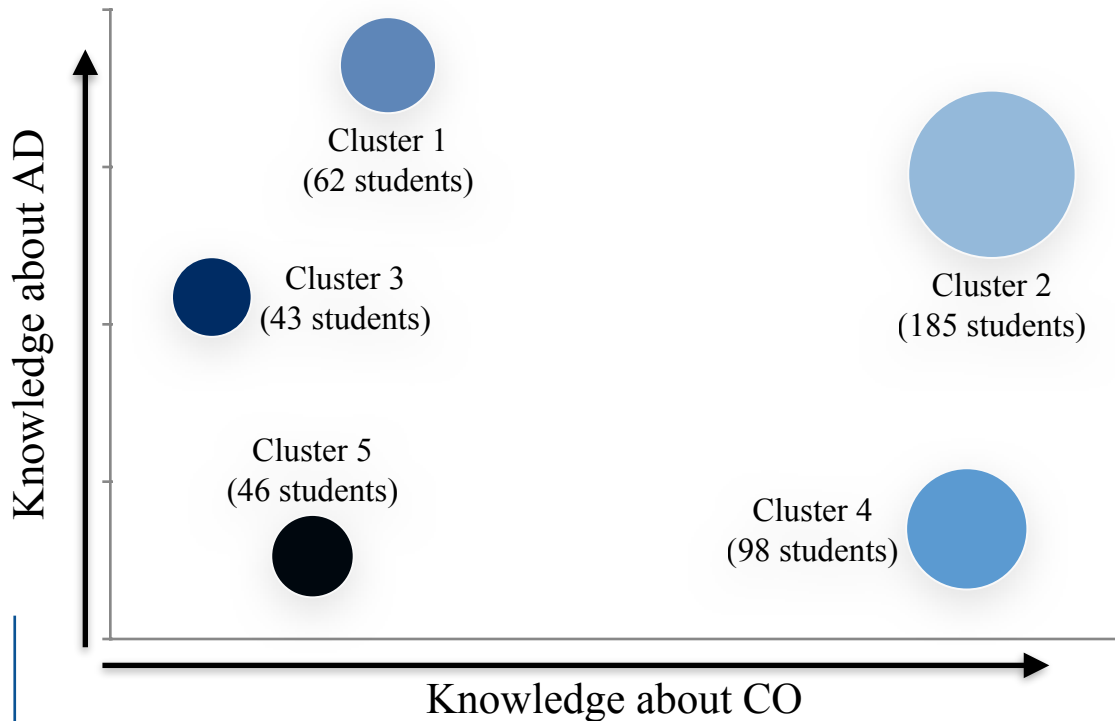
Expansion and future of universe

Universe temperature and composition

Black holes - dark matter - dark energy

Phase 2. Clustering of basics dimension

Findings



Cluster 1

- Correct knowledge of timeline and distances of celestial objects
- Scarce knowledge of celestial objects

Cluster 2

- Partially correct knowledge of timeline and near distance scale
- Correct knowledge of celestial objects

Cluster 3

- Correct knowledge only of recent timeline
- Scarce knowledge of celestial objects

Cluster 4

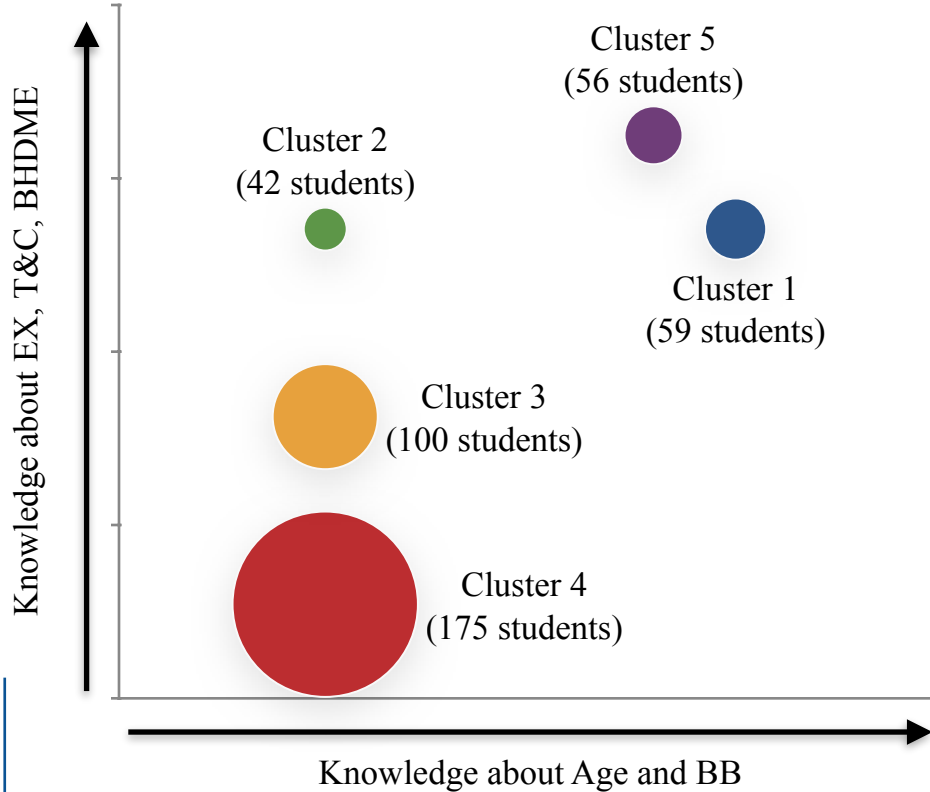
- Correct knowledge of recent timeline. Partial knowledge of distances
- No knowledge of celestial objects

Cluster 5

- Scarce knowledge about timeline and distances
- No knowledge of celestial objects

Phase 2. Clustering of advanced dimension

Findings



Cluster 1

- Correct knowledge about BB, AGE, EX. Partial knowledge about and T&C and BHDME.

Cluster 2

- Correct knowledge about EX, partial knowledge about EX and T&C.
- Generic knowledge about BB, AGE

Cluster 3

- Generic knowledge about BB, AGE, EX and T&C. No knowledge about BHDME

Cluster 4

- Generic knowledge about BB and AGE. Misconception about EX. No knowledge about T&C and BHDME

Cluster 5

- Partial knowledge about BB, Correct knowledge about BB, AGE, EX. Partial knowledge about and T&C and BHDME.

Conclusions

Discussion

- ◆ Most of students not recognize **the role of gravity** and other physical mechanisms
- ◆ **Curricular teaching seems to have a limited impact** on students' ideas also about astrophysics basic aspects and does not allow to integrate previous physical and chemical knowledge into new astrophysical topics
- ◆ a better understanding of Universe birth and age, expansion leads to a better understanding of EX, T&C and BHDME
- ◆ Overall, our results now provide a **wider and more coherent framework** about high school students conceptual understanding about astrophysical topics

Futures steps

- ◆ Compare different k-means algorithms with Multiple Correspondence Analysis
- ◆ Develop and validate a new concept inventory about advanced astrophysical topics for high school level
- ◆ Develop and validate a inquiry-based teaching-learning sequence for high school level
- ◆ Study of students' visual representation starting from the collected students' drawings