



ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

Do the epistemological bases of qualitative and quantitative paradigms in STEM education still hold today?

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A recent «critical examination» of quantitative and qualitative methods

Recently, there was two calls for paper on methods in Physics Education Research (PER):

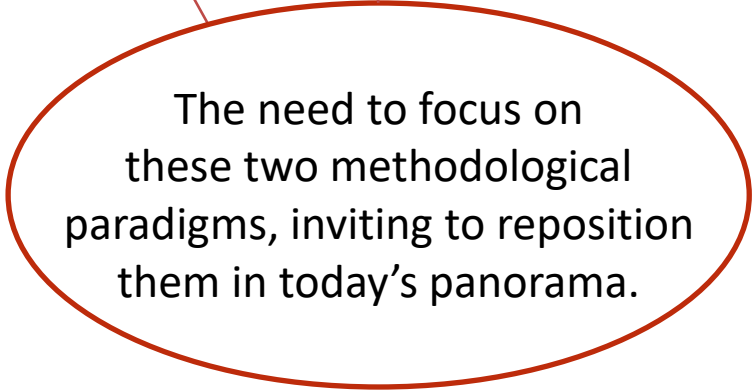
- Call for Papers Focused Collection of PRPER - Quantitative Methods in PER: A Critical Examination (June, 2017).
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The need to focus on these two methodological paradigms, inviting to reposition them in today's panorama.

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“We invite manuscripts that examine and challenge standard quantitative research methods in PER as well as those that use novel analysis techniques to provide new insights into data [...] to support researchers in making informed choices for their quantitative work.”

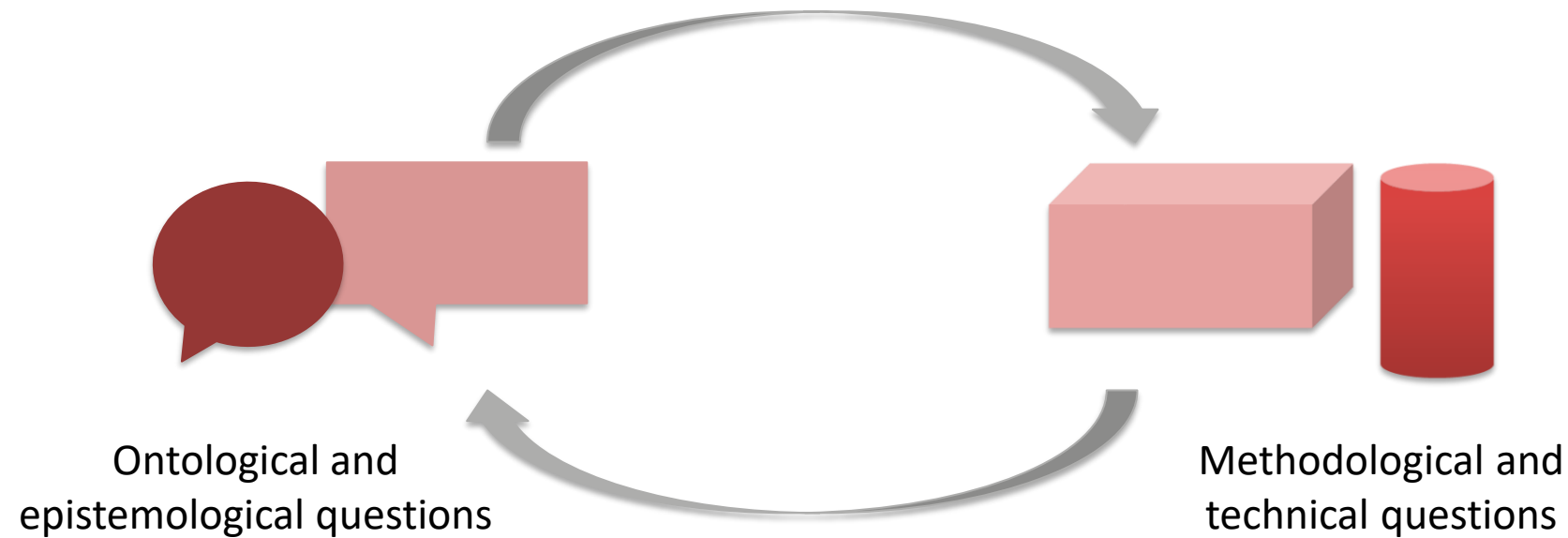
“This Focused Collection [...] aims to provide a space to examine and challenge current practices, learn how the qualitative landscape has changed over decades, and highlight the latest approaches in qualitative methods.”

“ [...] proposed manuscripts should include the strengths and weaknesses of the presented areas”.

The need to focus on these two methodological paradigms, inviting to reposition them in today’s panorama.

An epistemological reflection

**While the methods are changing,
can we say that the same paradigmatic bases still apply today?**



The aims of the presentation

To point out the epistemological assumptions that stay behind the traditional qualitative and quantitative methodological approaches.

Epistemological bases of quantitative and qualitative methods



To argue why the big data and technological revolution has been questioning the basic epistemological assumptions that justified the distinction in the past.

Do the bases hold?



To raise examples of foundational epistemological questions, that can motivate the need to overcome the traditional dichotomy, and ground the elaboration of new “mixed” methods.

Epistemological questions today



PART 1

Reconstruction of the historical debate on methods

Epistemology, ontology, and methodological implications
(from PhD dissertation of Paola Fantini)

Ontological and epistemological pillars of this part:

- The view of reality;
- The “normative or idiographic” nature of the laws studying a phenomenon;
- The different ontological and epistemological positions;
- The methodological implications.

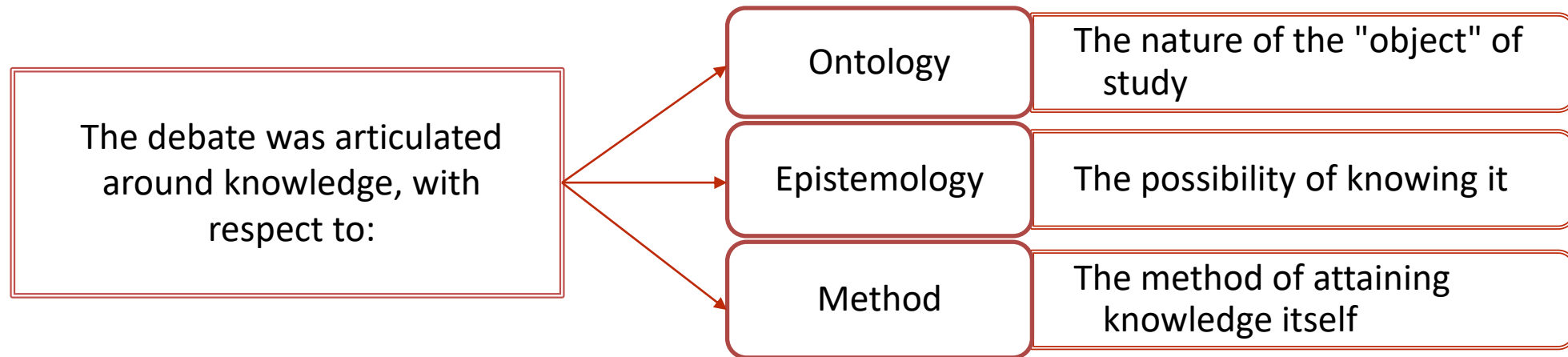


The origin of the debate on methods

The debate developed in Germany at the turn of the 19th and 20th centuries.

Its main exponents were:

- the German philosopher and psychologist Wilhelm Dilthey (1833-1911) of the post-Hegelian orientation;
- the German philosopher Wilhelm Windelband (1848-1915) of the neo-Kantian orientation.



"A wide, articulated and... difficult debate" - Paola Fantini, PhD dissertation



Why does this debate matter with Science Education?

Science education research is a particular research field.

It is in the middle between natural sciences and social sciences.

Initially, Science Education Research was influenced by the methods of research used in the natural sciences, for two main reasons:

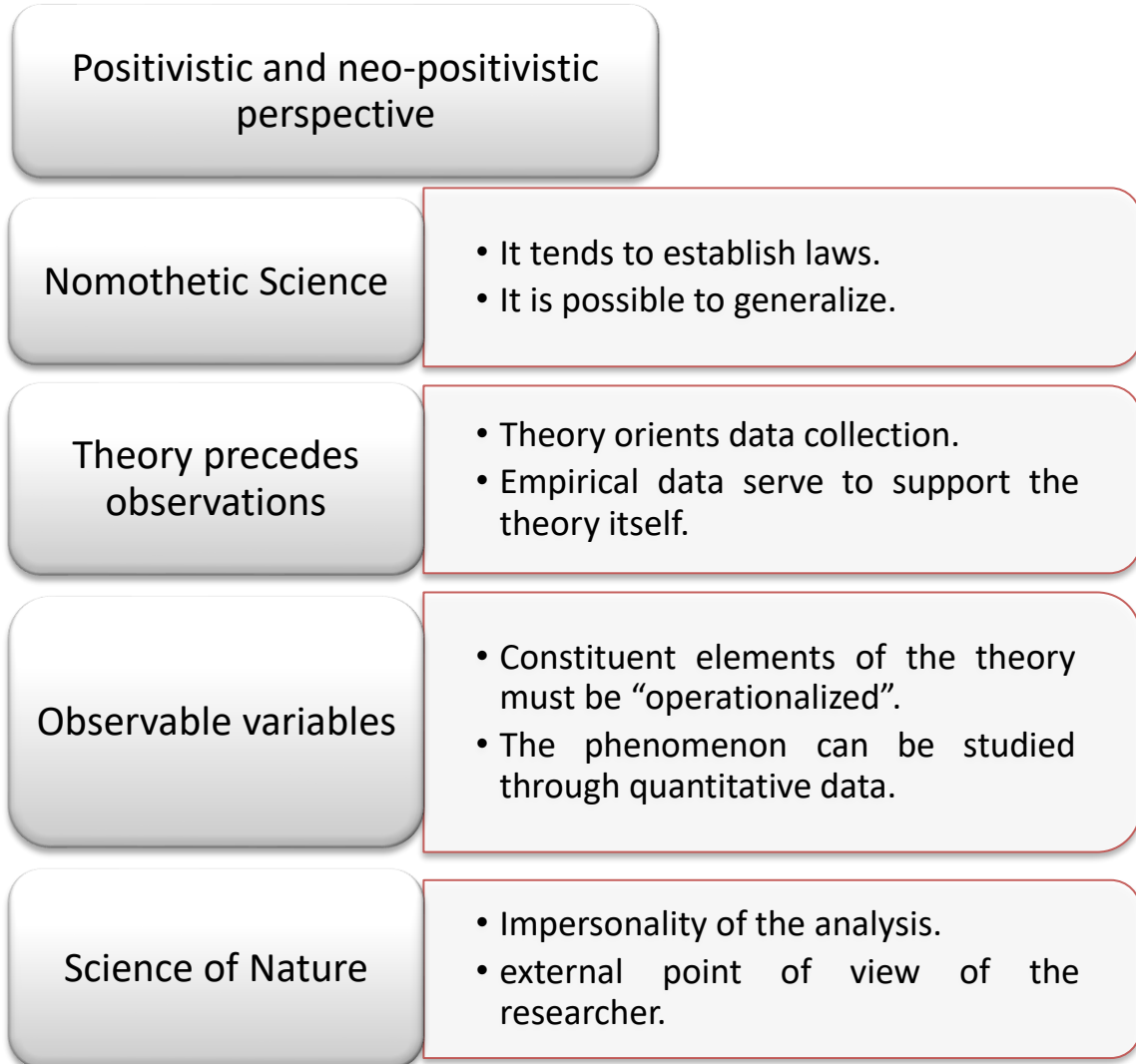
- 1) Temporal reason: As Dilthey writes, the *Science of Nature* (science of the natural sciences) was the first to elaborate their methods.
- 2) Philosophical reason: According to a positivist approach, applying the method of the natural sciences guarantees the validity of knowledge itself. According to this perspective, the sciences are sciences if they provide causal explanations (effects can be traced back to causes) and are therefore able to produce general laws and theories.

Subsequently, Science Education Research was largely influenced by social sciences, in which there is the use of ethnographic and qualitative analyses, and a vision given by the interpretative paradigm.

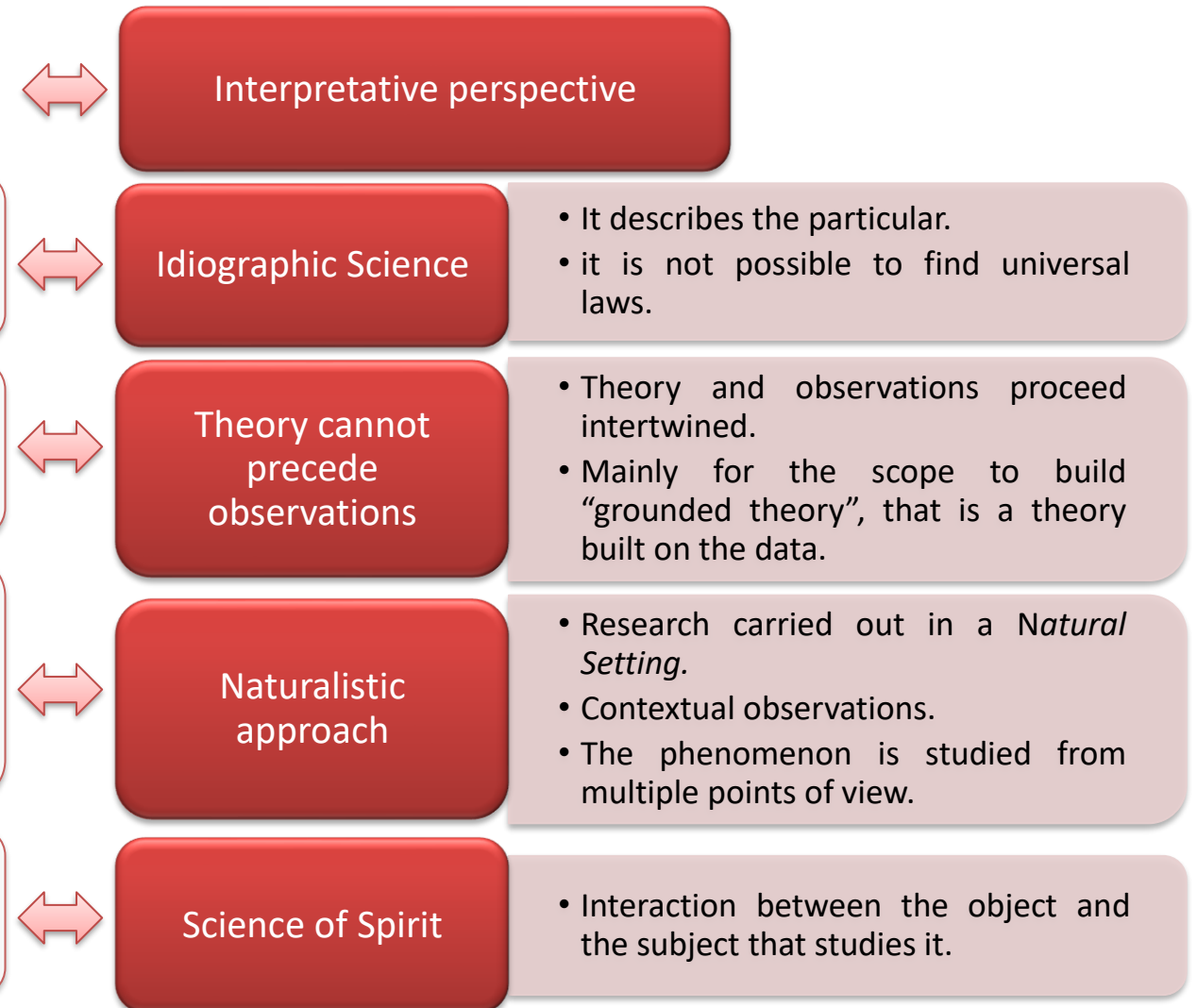


The historical debate: the main paradigmatic bases

As for quantitative methods



As for qualitative methods



PART 2

Sometimes, the paradigmatic bases of methods do not hold

Examples in Science and STEM education

We discuss some examples taken from current research in the way of science education of how sometimes this dualism doesn't seem to hold, or at least doesn't differentiate to make sense.

The advent of online learning platforms and the extensive use of technologies in classrooms (e.g. sensors) led us to reflect on:

- 1) Learning traces as data and Data Mining.
- 2) Virtual learning platforms and what can be considered as “Natural Setting”



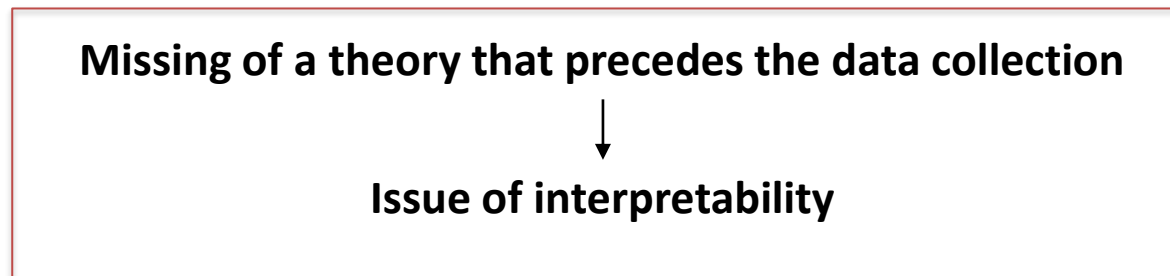
Example 1: Data Mining

Data Mining is classified as the third genre of quantification in quantitative methods (Ding, L., 2019).

«Of the three genres of quantification, data mining is the newest line of work; [...] data mining can be used to explore quantitative relationships between different constructs. However, it differs from the previous in that investigators in this tradition often have little control of data collection. In fact, the data being examined often have been previously collected»

Ontological feature:

- *“Data mining assumes an additive nature of human attributes and environmental features”*
- *“It is also assumed that human conduct in aggregate follows quantitative patterns.”*
- *“Data mining have little or no control of data collection”*

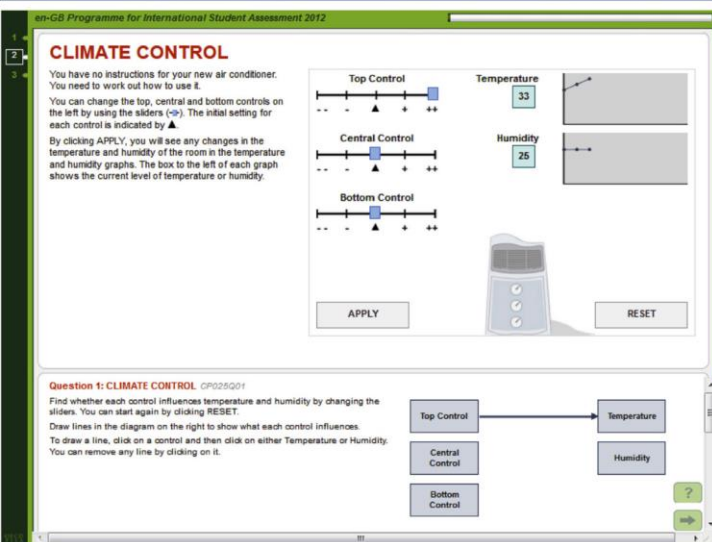
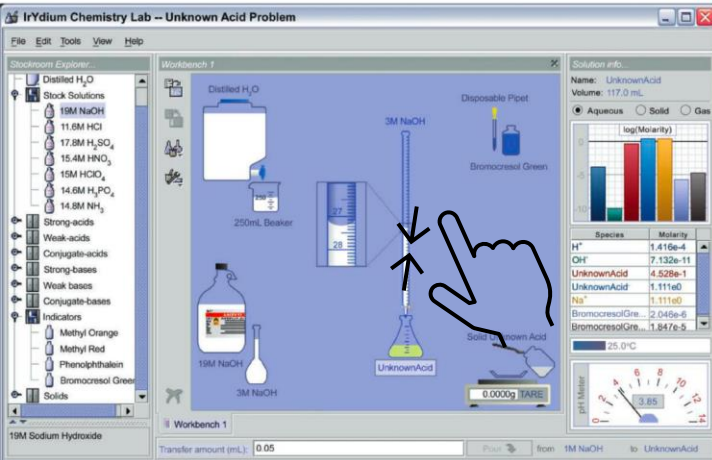
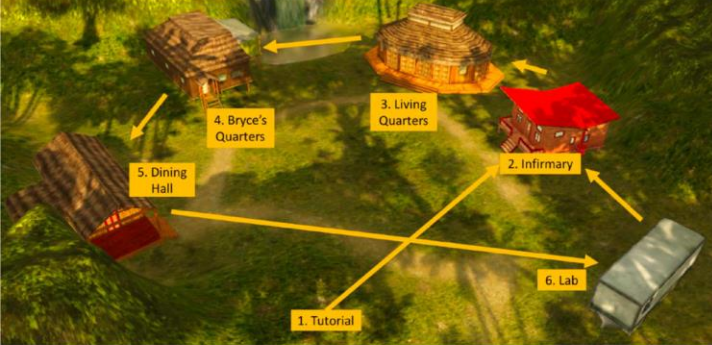


Example 2: The nature of reality under study and the «Natural setting»

Log data, produced by technology-based, open-ended learning environments, offer the possibility to reconstruct and study the students' learning behaviour from their digital learning traces.

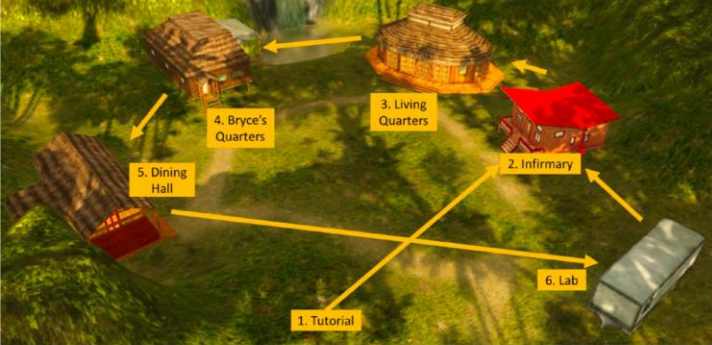
These data offer the possibility to look at the students' behaviour from several points of view:

- how much time the student spends on the learning platform.
- what the students looks at.
- what elements the students interacts more with.



Examples of technology-based, open-ended learning environments: 1) immersive world; 2) unconstrained lab Sim; 3) a constrained lab Sim. Picture taken from Wang, K. D., et al. (2022). *A systematic review of empirical studies using log data from open-ended learning environments to measure science and engineering practices.*



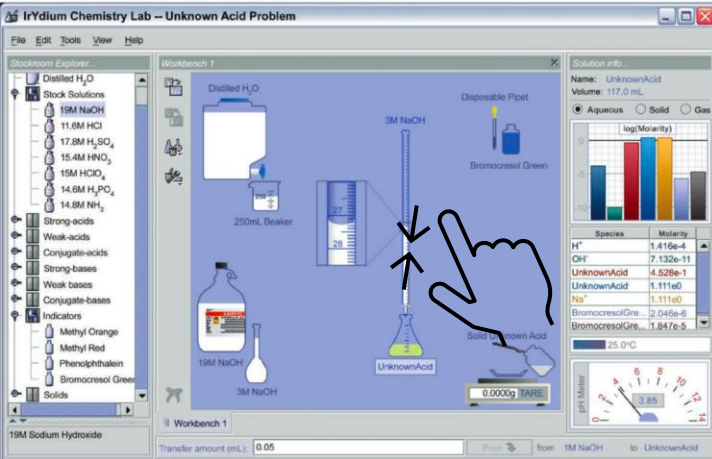


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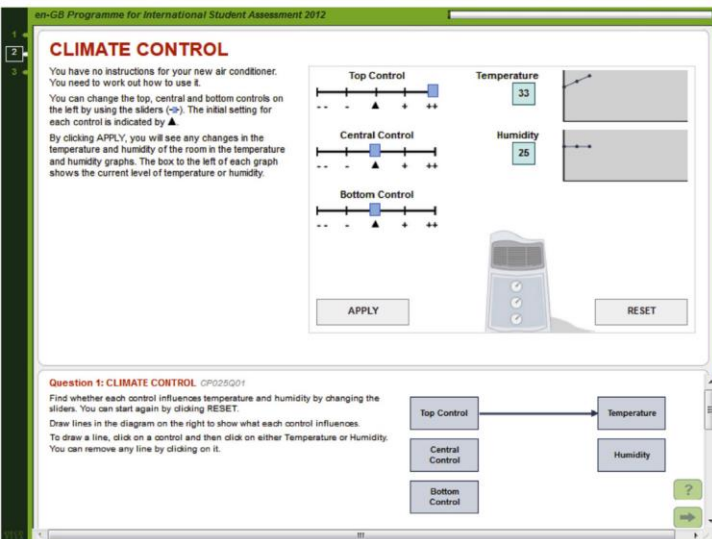
If we follow the traditional qualitative approach

The construction of a grounded theory requires:

1. An immersion of the analyst in the Natural Setting
2. A careful delimitation of the context.

Which are necessary conditions to:

- a) progressively refine the choice of the data and their contemporary analysis
- b) point out the limits of theory's applicability.



Digital environments are blurring the boundaries of a Natural Setting

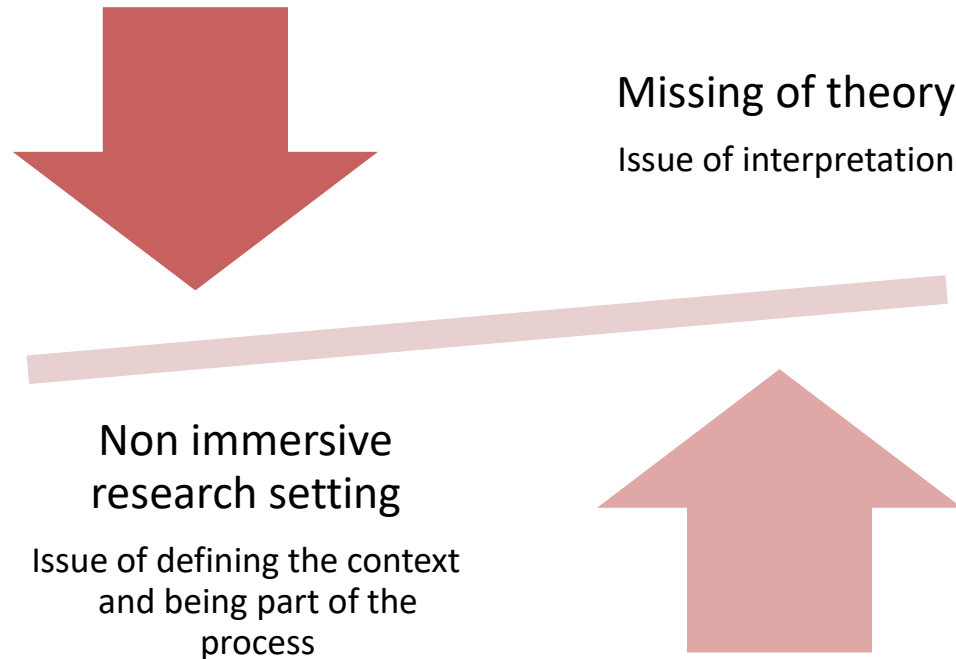
Issues in developing a grounded theory



PART 3

Re-thinking about methodological paradigms in STEM

Epistemological and ontological questions that can stimulate reflections



a) Is it possible to add an interpretative layer in data mining? If so, how, and where?

b) How can the basic assumptions of a grounded theory approach be redefined in order to consider also digital platform data?



References

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