Regenerating disciplinary content knowledge to equip the young for the 21st Century challenges: results from the European projects IDENTITIES and FEDORA

DASERA, Vejle, Denmark

November 5th, 2023

Olivia Levrini

Department of Physics and Astronomy «A. Righi»

Aims of the talk

- To present the process that we followed to pursue the aim to develop a **interdisciplinary** model for science education – taking full account of the existing disciplines.

- To frame and discuss **approaches**, **tools** and **results** from interdisciplinary implementations to argue how designing learning environments as **boundary zones** can be a way to regenerate disciplinary knowledge for the 21st century.

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

The problem

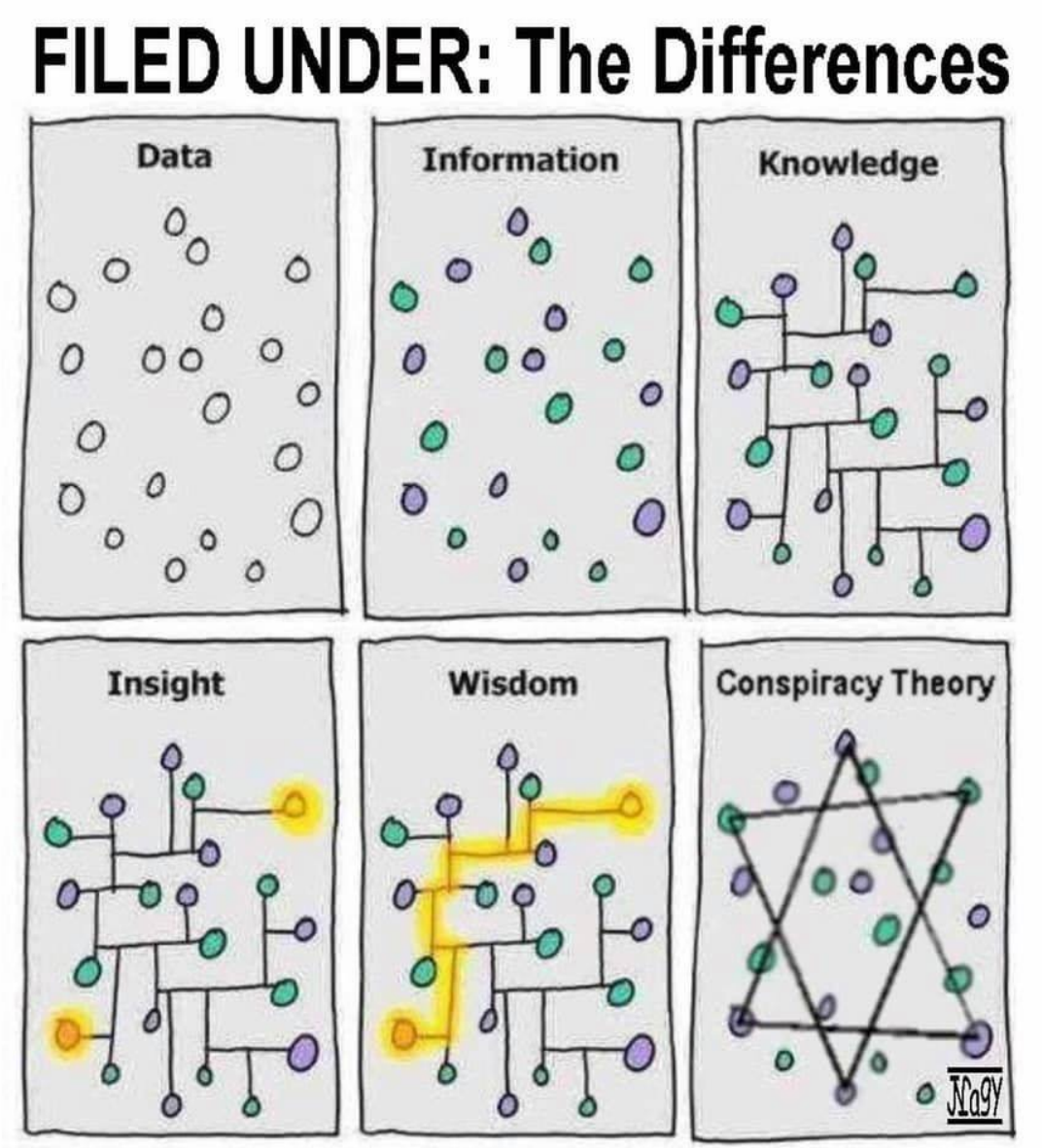
ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

The two great fears

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

…“Where is the wisdom we have lost in knowledge? Where is the knowledge we have lost in information?”

— **T.S. Eliot,** The Rock



QUESTIONS' formulation:

- *Can science (physics) teaching/learning still contribute to developing skills for navigating the complexity of the society of acceleration? If so how?*

- *In case, what thinking skills can be developed through science (physics) teaching/learning?*

Our basic hypotheses:

1 *Science (physics) teaching/learning CAN still contribute to developing skills PROVIDED THAT school science is regenerated and the epistemologies of the disciplines are seriously considered*

2. *Interdisciplinarity (and future thinking) is a way to regenerate Science (physics) knowledge and make it a fruitful source of thinking skills for turning data into knowledge (meaning making) and into wisdom (sense making also from a personal point of view)*

The approach:
theoretical frameworks to characterize disciplines and inter-disciplinarity

1.

The Family Resemblance Approach reconceptualized for the Nature of Science

2.

Akkerman and Bakker meta-theory on boundary zone

The term DISCIPLINE

"The term "**discipline**" contains the Latin root "discere", whose meaning is to learn. Disciplines are re-organizations of the knowledge with the scope of teaching it. In particular, disciplines ground their roots into the didactical necessity to re-organize knowledge in such a way that students, whilst building their knowledge, can also develop epistemic skills, like problem solving, modelling, representing, arguing, explaining, testing, sharing... Disciplines have been built to help student to make gradually sense of different categories of problems, approaches, tools and criteria to evaluate the correctness and efficiency of a procedure, a reasoning, an argument. From this perspective, disciplines can still play a relevant educational role, provided that they are explicitly pointed out as forms of knowledge organization historically developed and grounded on specific epistemologies" (Branchetti, Fantini, Levrini, 2019).

Family Resemblance Approach to Nature of Science

(introduced by Irzik and Nola and reconceptualised for science education by Erduran and Dagher)

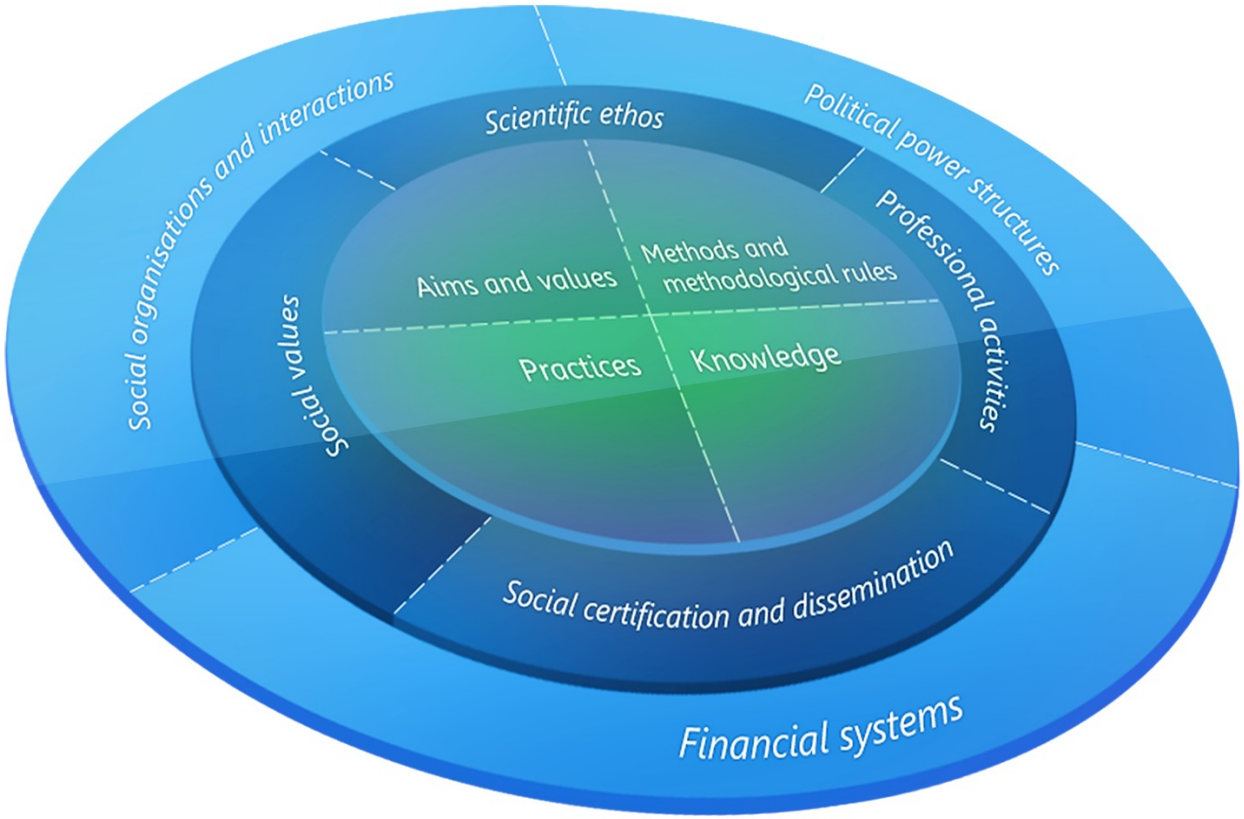


Figure 1. FRA wheel designed by Erduran and Dagher (2014, p. 28)

Family Resemblance Approach to Nature of Science

- framework theorised by Irzik and Nola (2011) and reconceptualised for science education by Erduran and Dagher (2014a);
- a specific stance with respect to the delicate methodological problem of defining science, accounting both for the diversity of the scientific disciplines and their reciprocal resemblances that create the "science family".
- the approach assumes that "there is no fixed set of necessary and sufficient conditions which determine the meaning of [science]" (Irzik & Nola, 2011, 59 p. 594). Yet, just like in a family, each member (out of the metaphor, each discipline) resembles some family members with respect to some aspects and other members with respect to other aspects.
- broad categories are set that can be both *domain-general* (i.e., with common and shared characteristics to all the sciences and the activities carried out within them) and *domain-specific* (i.e., characteristics that make the different disciplines unique).

Irzik, G., & Nola, R. (2011). A family resemblance approach to the nature of science. Science & Education, 20, 591–607

Erduran, S. & Dagher, Z. (2014a). Reconceptualizing the nature of science for science education: scientific knowledge, practices and other family categories. Dordrecht: Springer.

Cognitive-epistemic stystem aspects	Aims and values	The scientific enterprise is underpinned by adherence to a set of values that guide scientific practices. These aims and values are often implicit and they may include **accuracy, objectivity, consistency, scepticism, rationality, simplicity, empirical adequacy, prediction, testability, novelty, fruitfulness, commitment to logic, viability, and explanatory power**.
	Scientific Practices	The scientific enterprise encompasses a wide range of cognitive, epistemic, and discursive practices. Scientific [epistemic] practices such as **observation, classification**, and **experimentation** utilize a variety of methods to gather observational, historical, or experimental data. Cognitive practices, such as **explaining, modelling, and predicting**, are closely linked to discursive practices involving **argumentation** and **reasoning**.
	Methods and methodological rules	Scientists engage in disciplined inquiry by utilizing a variety of **observational**, **investigative**, and **analytical methods** to **generate reliable evidence and construct theories, laws, and models in a given science discipline**, which are guided by particular methodological rules. Scientific methods are revisionary in nature, with different methods producing different forms of evidence, leading to clearer understandings and more coherent explanations of scientific phenomena.
	Scientific knowledge	**Theories, laws, and models** (TLM) are interrelated products of the scientific enterprise that generate and/or validate scientific knowledge and provide logical and consistent explanations to develop scientific understanding. Scientific knowledge is holistic and relational, and TLM are conceptualized as a coherent network, not as discrete and disconnected fragments of knowledge.

Table 1: FRA categories (from Erduran and Dagher 2014a) – adapted from Yeh *et al,* (2019, p295)

Social-Institutional system aspects	Professional activities	Scientists engage in a number of professional activities to enable them to communicate their research, including conference attendance and presentation, writing manuscripts for peer-reviewed journals, reviewing papers, developing grant proposals, and securing funding.
	Scientific ethos	Scientists are expected to abide by a set of norms both within their own work and during their interactions with colleagues and scientists from other institutions. These norms may include organized skepticism, universalism, communalism and disinterestedness, freedom and openness, intellectual honesty, respect for research subjects, and respect for the environment.
	Social certification and dissemination	By presenting their work at conferences and writing manuscripts for peer-reviewed journals, scientists' work is reviewed and critically evaluated by their peers. This form of social quality control aids in the validation of new scientific knowledge by the broader scientific community.
	Social values of science	The scientific enterprise embodies various social values including social utility, respecting the environment, freedom, decentralizing power, honesty, addressing human needs, and equality of intellectual authority.
	Social organizations and interactions	Science is socially organized in various institutions including universities and research centres. The nature of social interactions among members of a research team working on different projects is governed by an organizational hierarchy. In a wider organizational context, the institute of science has been linked to industry and the defence force.
	Political power structures	The scientific enterprise operates within a political environment that imposes its own values and interests. Science is not universal, and the outcomes of science are not always beneficial for individuals, groups, communities, or cultures.
	Financial systems	The scientific enterprise is mediated by economic factors. Scientists require funding in order to carry out their work, and state- and national-level governing bodies provide significant levels of funding to universities and research centers. As such, these organizations have an influence on the types of scientific research funded, and ultimately conducted.

The approach:
theoretical frameworks to characterize disciplines and inter-disciplinarity

1.

The Family Resemblance Approach reconceptualized for the Nature of Science

2.

Akkerman and Bakker meta-theory on boundary zone

The *boundary* metaphor for interdisciplinarity (Akkerman & Bakker, 2011)
The emphasis on its «paradoxical nature»: it both connects and separates

IDENTITIES
Enlightening Interdisciplinarity in **STEM** for Teaching

«Spaccanapoli» (Naples-splitter)

one of the most famous streets in Naples, a melting pot

Credits: Roberto Capone

The *boundary* metaphor for interdisciplinarity (Akkerman & Bakker, 2011)
The emphasis on its «paradoxical nature»: it both connects and separates

IDENTITIES
Enlightening Interdisciplinarity in **STEM** for Teaching

«Spaccanapoli» (Naples-splitter)
one of the most famous streets in Naples, a melting pot

Credits: Roberto Capone

The interdisciplinarity language is the language of the «boundary» (Akkerman & Bakker, 2011)

Boundary people
Boundary objects
Boundary mechanisms
(*coordination, identification, reflection, transformation*)

Boundary Objects

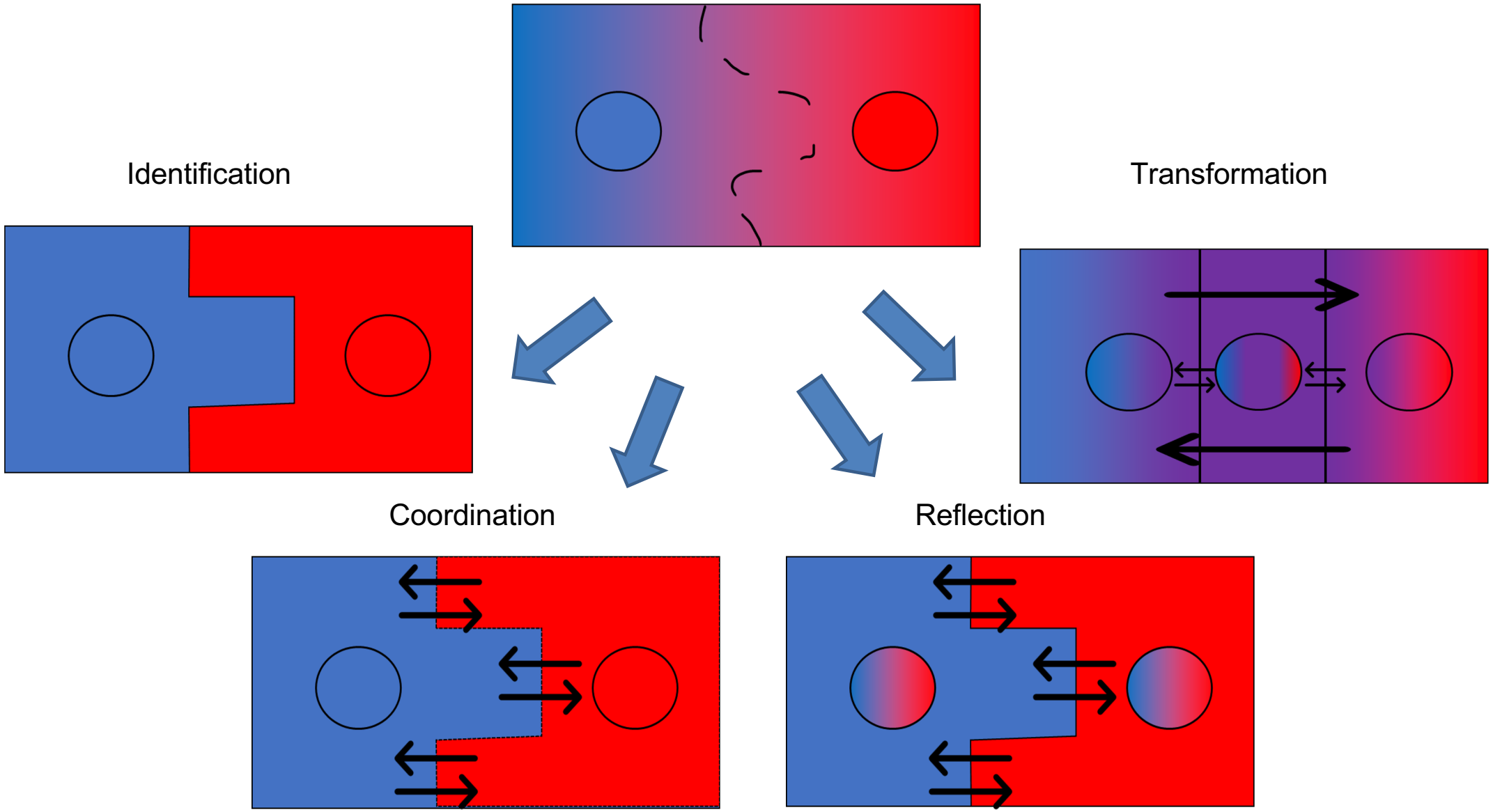
"In studies of boundary objects we also find the aforementioned **ambiguity**. On one hand, boundary objects are artifacts that articulate meaning and address multiple perspectives. As already indicated by the definition by Star and Griesemer (1989), boundary objects have different meanings in different social worlds but at the same time have a structure that is common enough to make them recognizable across these worlds. However, it is not only **interpretative flexibility** that turns objects into boundary objects; boundary objects are organic arrangements that allow different groups to work together, based on a back-and-forth movement between ill-structured use in cross-site work and well-structured use in local work (Star, 2010). […]

As an in-between or middle ground, the boundary belongs to ***both* one world *and* another**. It is precisely this feature that seems to explain how the boundary divides as well as connects sides (Kerosuo, 2001). However, **the boundary also reflects a nobody's land, belonging to *neither* one *nor* the other world**. […]

Boundary Learning Mechanisms

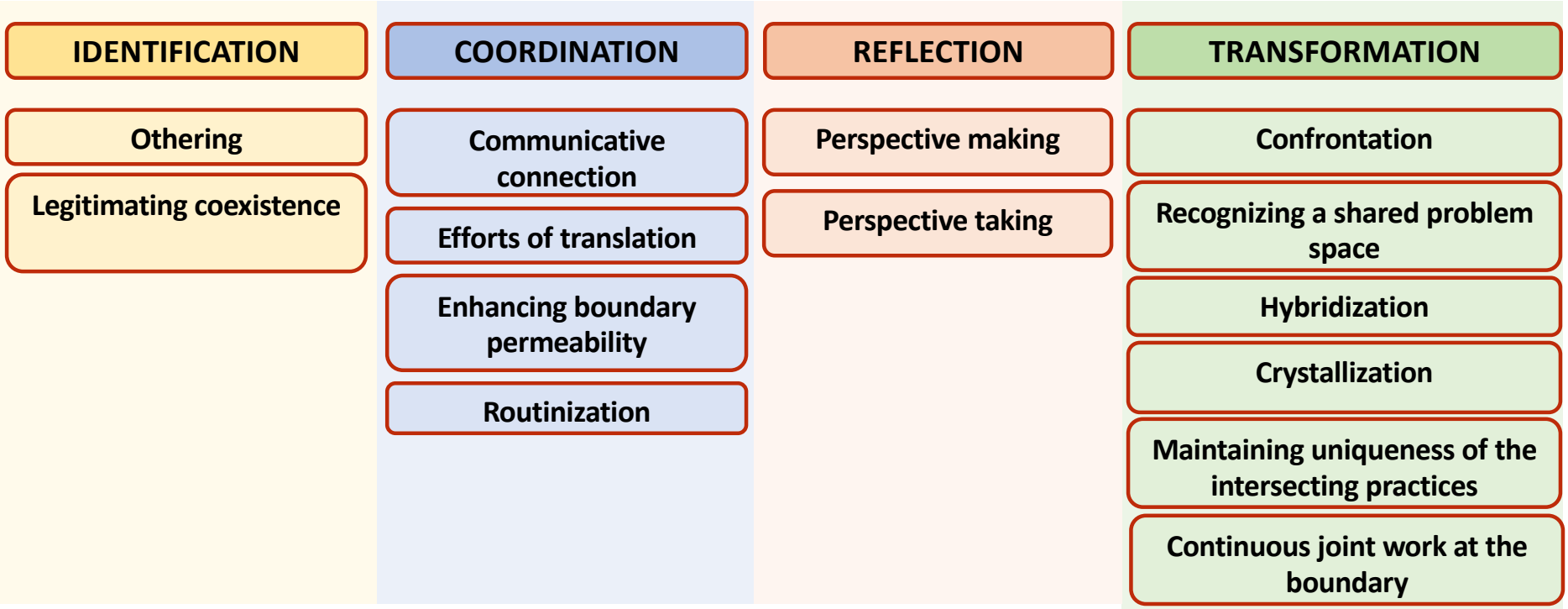
The result Akkerman & Bakker arrive at in their review is the identification of **four potential borderline learning mechanisms**: Identification, Coordination, Reflection and Transformation.

IDENTIFICATION	COORDINATION	REFLECTION	TRANSFORMATION
COMPARING DIFFERENCES BETWEEN PRACTICES	CREATING COOPERATIVE AND ROUTINIZED EXCHANGES BETWEEN PRACTICES	EXPANDING PERSPECTIVES ON AND BETWEEN PRACTICES	COLLABORATION AND CODEVELOPMENT OF (NEW) PRACTICES
The line between the two disciplines is not clear-cut, so the comparison leads to questions about the identities of the various sites participating in the exchange and to a renewed vision of the sites themselves and their respective practices.	Movement and dialogue between practices are encouraged in order to keep the flow of work between all participants in the joint work. The processes inside this mechanism use common instrumentalities, i.e., Boundary Objects, to connect and coordinate the different sites involved in the process	Expanding one's perspectives on the practices understanding the differences between them and discovering more about the practices involved. Through this mechanism people can look into the world in an enriched way and in doing so they can enrich the various identities involved in the process.	This mechanism unites all the others, as it represents a profound change that has taken place as a result of the sharing of practices and methods, which can lead to the creation of new, in-between practices, sometimes called boundary practices.


Identification
Transformation
Coordination
Reflection

Boundary Processes

Within each mechanism, the authors then identify processes, i.e. ways in which the mechanisms themselves can occur on different levels.



The language of interdisciplinarity as the language to create boundary zones and inhabit them as "epistemological nomad", where it is needed:

- to hybridize practices, negotiate meanings, rediscover one's own positioning of competence;
- to accept the ambiguity and interpretative flexibility of concepts and, at the same time, be able to recognize the specificities and different mechanisms of "disciplinary closure of meanings" (boundary making);
- to establish communication connections and build translation methods between one area of knowledge and another;
- to activate a dialogic process of "othering", defining one practice in the light of another, outlining analogies and differences between practices;
- to put oneself in perspective and to know how to put oneself in other perspectives (*perspective making and taking*)

IDENTITIES Enlightening Interdisciplinarity in STEM for Teaching

FEDORA

Freely taken from Akkerman & Bakker, 2011

IDENTITIES

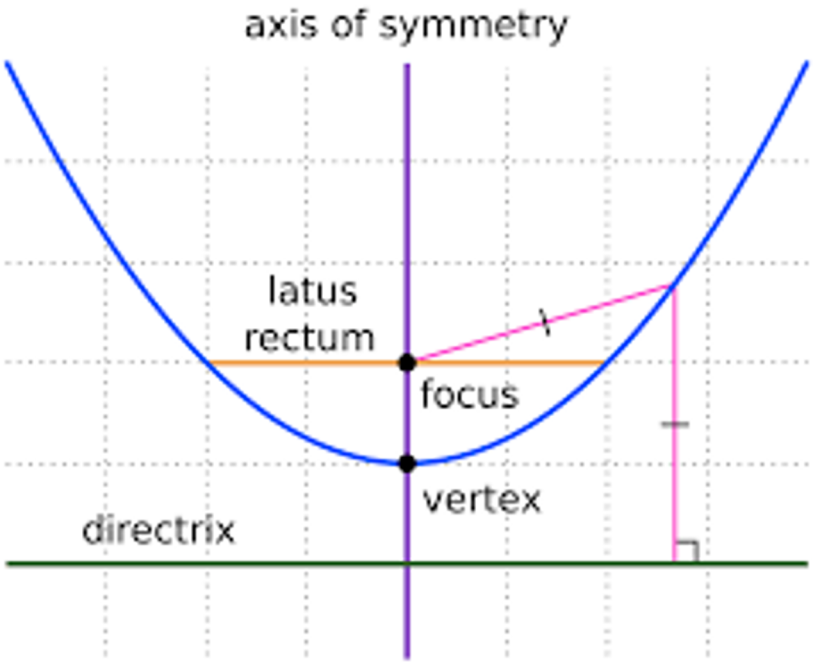
Enlightening
Interdisciplinarity
in STEM
for Teaching

The case of parabola and parabolic motion: co-designing a boundary zone for preservice teacher education and co-teaching

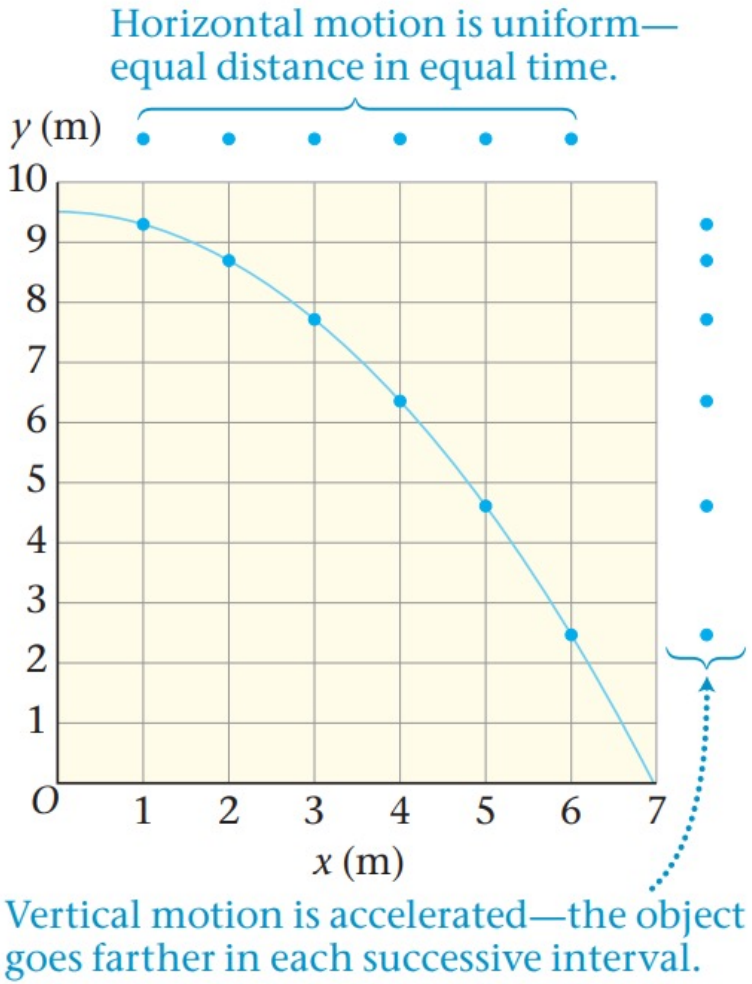
Laura Branchetti, Paola Fantini, Olivia Levrini, Sara Satanassi

Co-funded by the
Erasmus+ Programme
of the European Union

Grant Agreement n°2019-1-IT02-KA203-063184

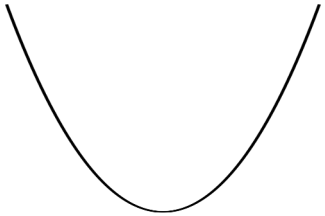


$$y = ax^2 + bx + c, \qquad a, b, c \in \mathbb{R}, a \neq 0;$$

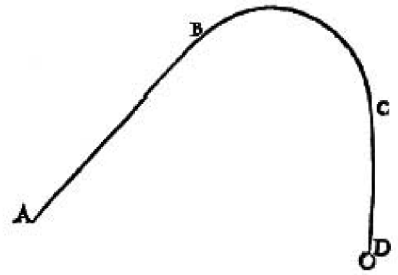


Choice of boundary objects: curve and proof

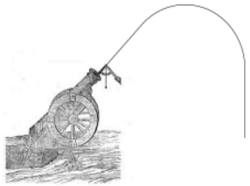
Enlightening Interdisciplinarity in STEM for Teaching

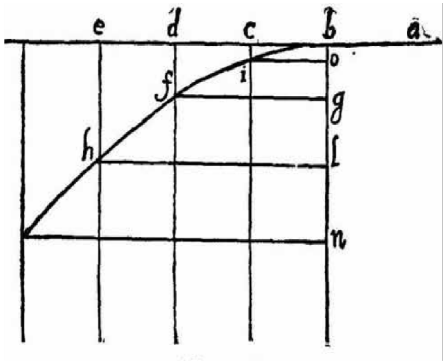


(1)

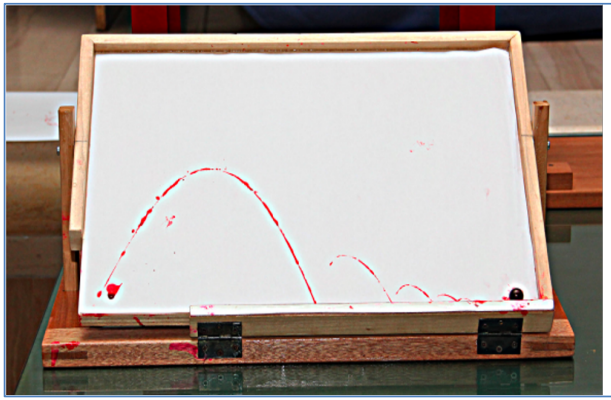


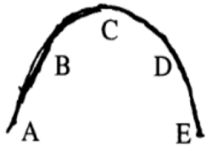
(2)

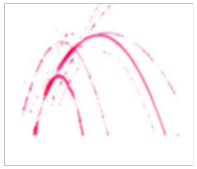




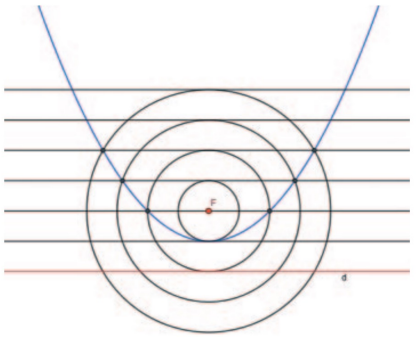
(3)



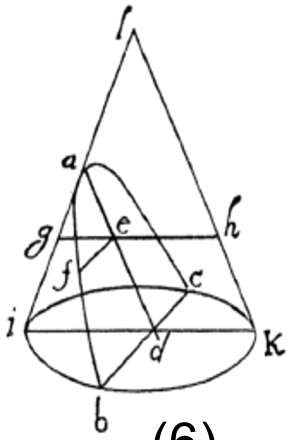




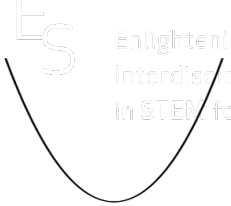
(4)



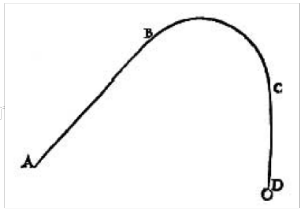
(5)



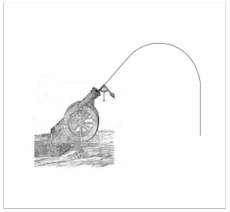
(6)

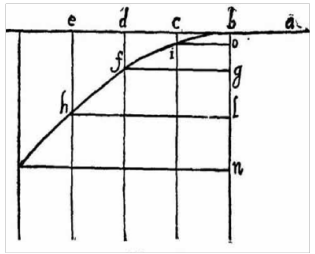


(1)

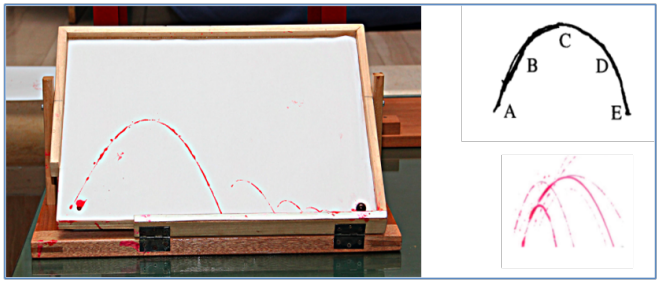


(2)

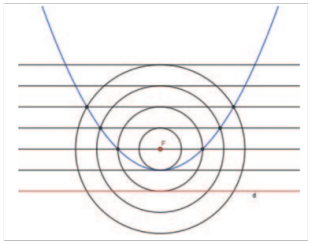




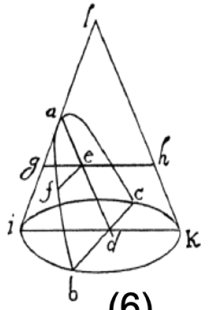
(3)



(4)



(5)



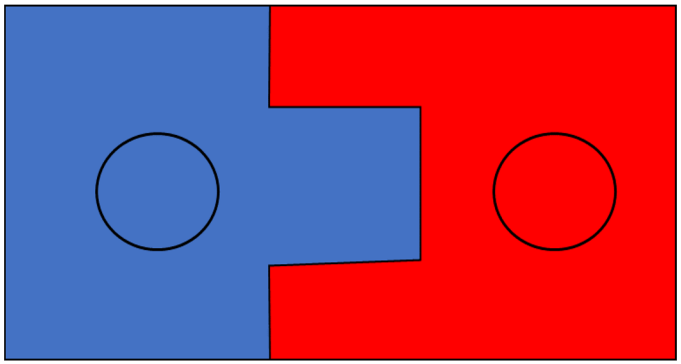
(6)

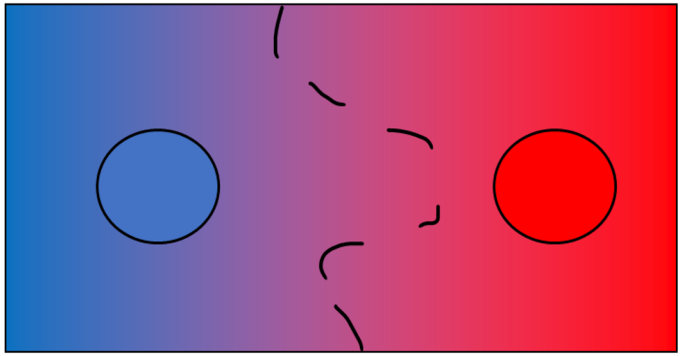
What curve is represented in the various images?

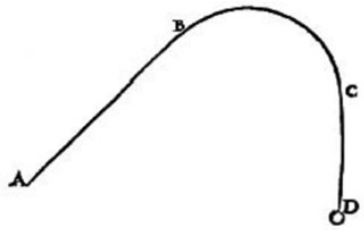
Are these curves mathematical, physical, philosophical, artistic, practical, mere drawing…? How can we tell that?

What is the embedded knowledge in the various pictures?

Identification

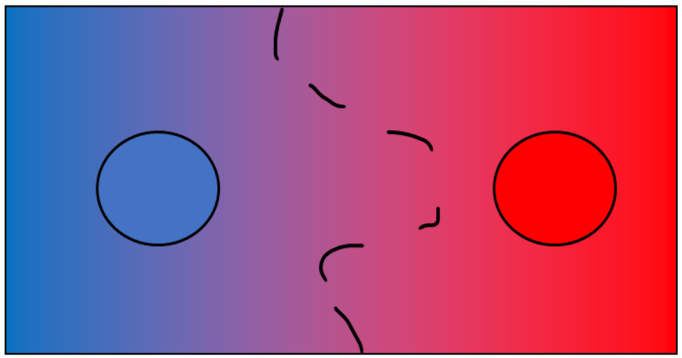




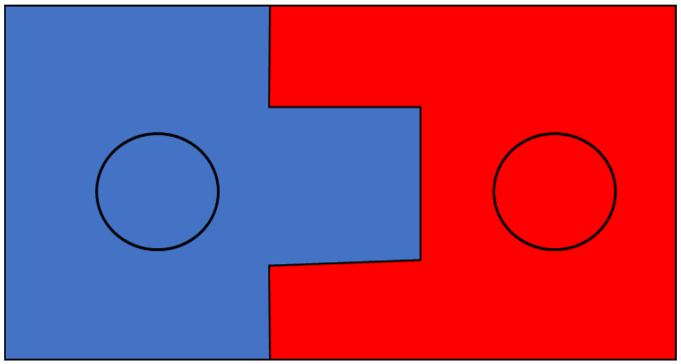


What does one ”physicist” see in the picture and what about a “mathematician”?

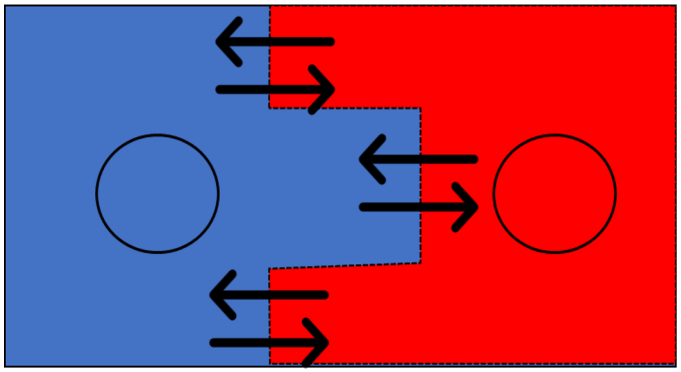
What are the roots and the contexts of the different “readout strategies?
(contextualization for identification)



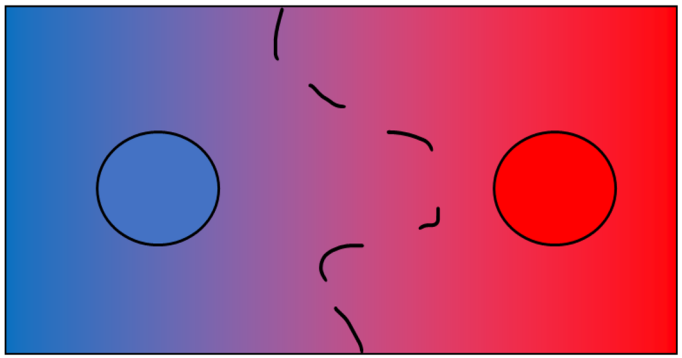
Identification



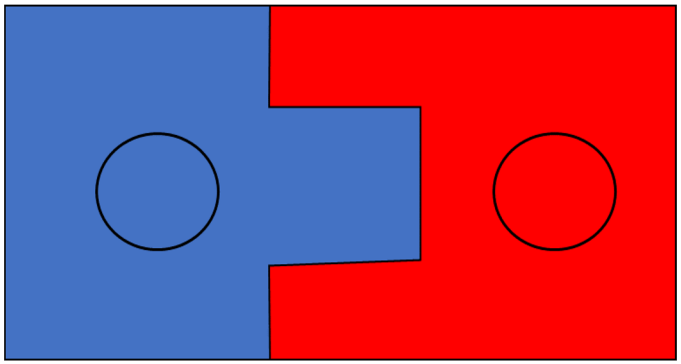
Coordination

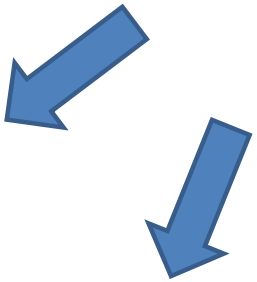


Why is it so difficult to communicate? What implicit assumptions, knowledge, aspects of linguistic and cognitive ambiguity can made our communication difficult?
(*Enhancing boundary permeability and effort of translation to communicate effectively*)

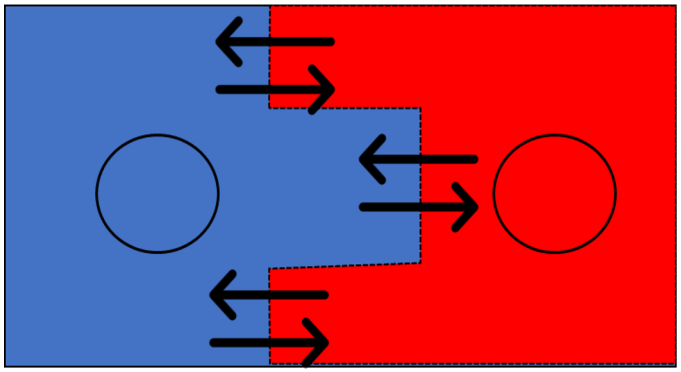


Identification

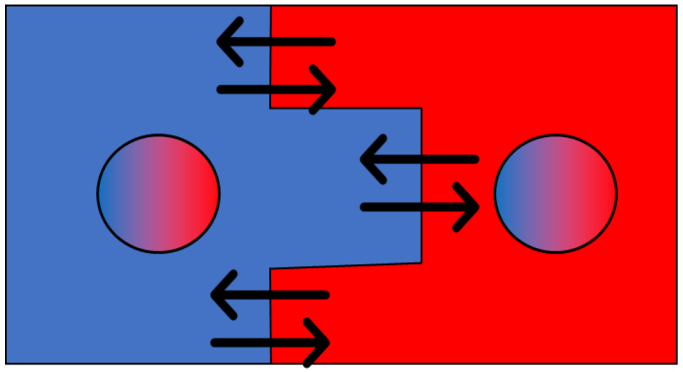


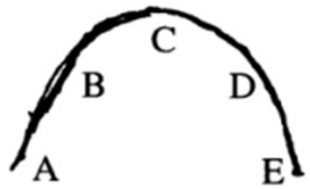


Coordination



Reflection

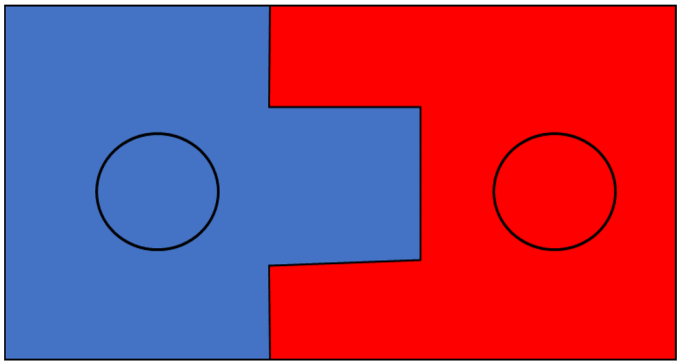




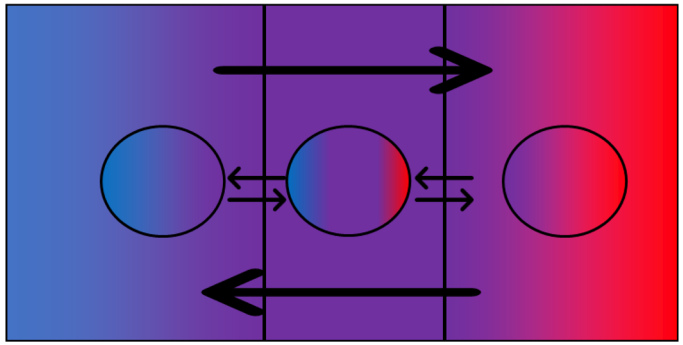
"What would Laura see, say or argue"? "What would Olivia/Paola/Sara see, say or argue?" What are we learning from and of the other discipline? (*learning by perspective making and taking*)

Do we see new “disciplinary areas or knowledge” built by transgressing the boundaries?

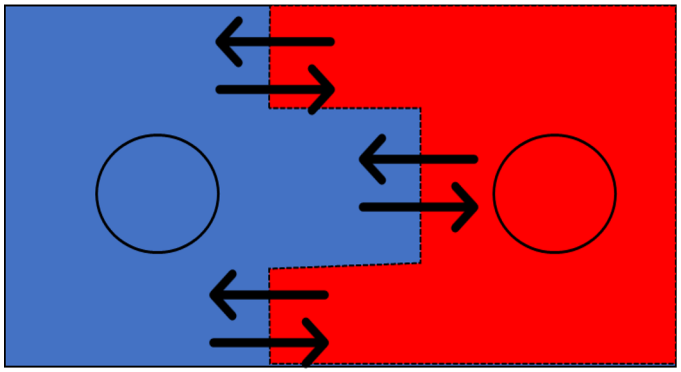
Identification



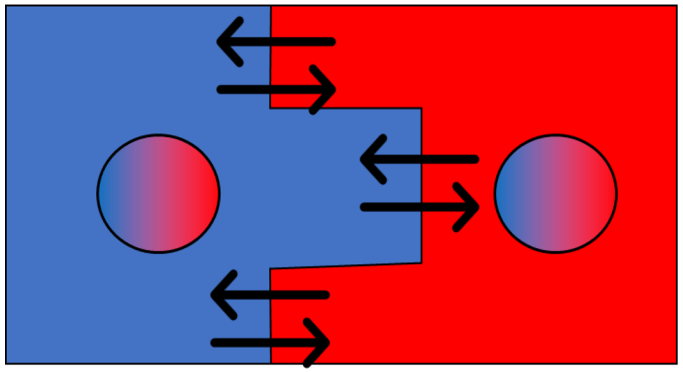
Transformation



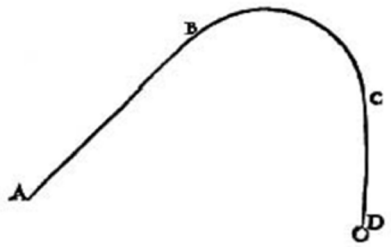
Coordination



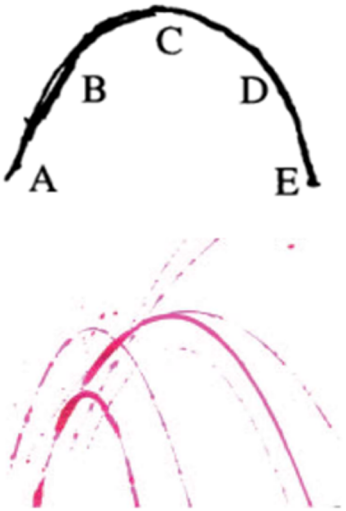
Reflection



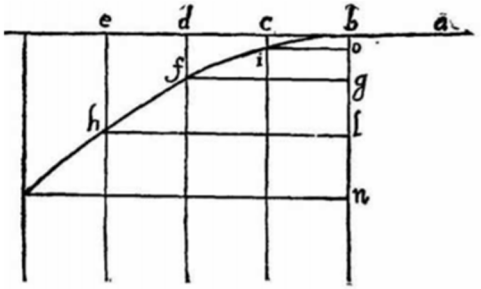
Parabolic motion and the establishment of physics as a discipline



Tartaglia (1537)

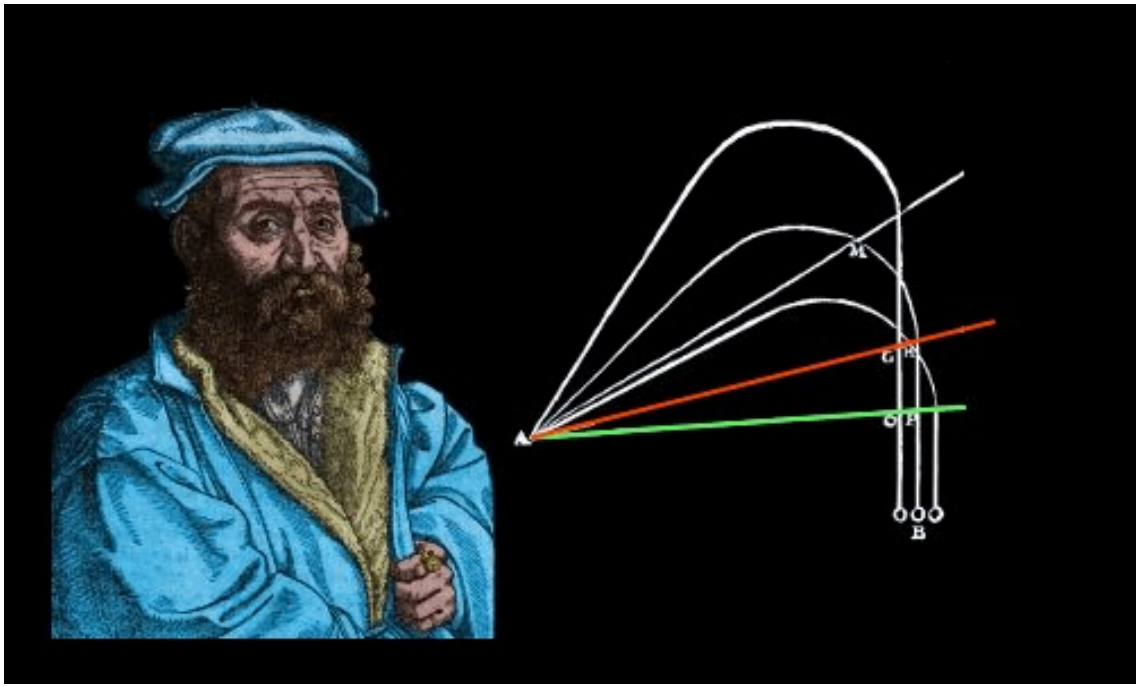


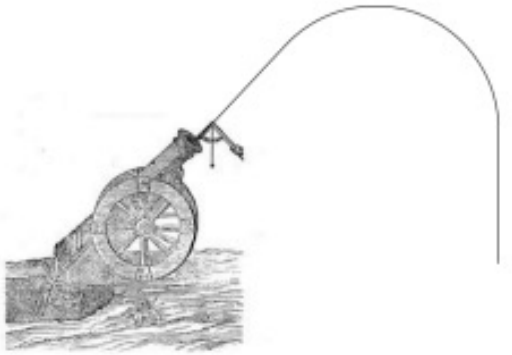
Guidobaldo (1592)

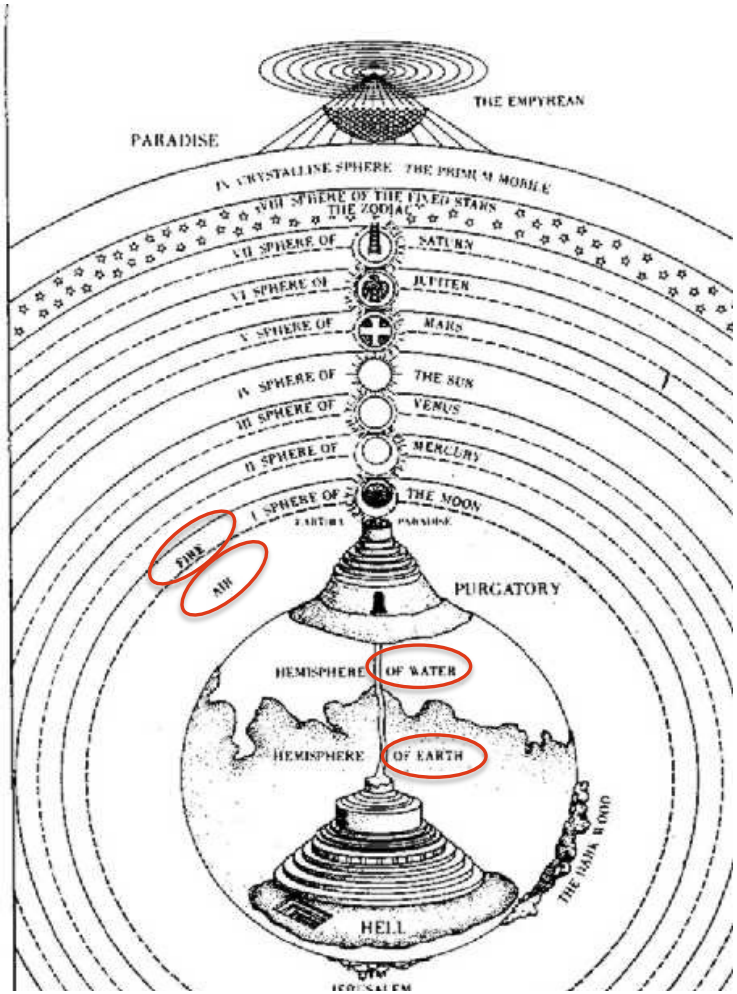


Galileo (1638)

Tartaglia's representation of the projectile motion in his *Nova Scientia* (1537).







The Aristotelian two-sphere universe: the sublunary region“

„The sublunary region was filled with the four Aristotelian elements: earth, water, air and fire. At every point of this universe some sort of substance was present. Matter and space were inseparably linked, with the result that the very notion of a vacuum was absurd. Motion was considered differently with regard to the celestial and sublunary regions. In the former, which was eternal and changeless, motion was supposed to be perfect, that is, uniform, circular and perpetual. Terrestrial or sublunary motion, in its turn, was divided into natural and violent.“

Gilbert, J. K., & Zylbersztajn∗, A. (1985). A conceptual framework for science education: The case study of force and movement. The European Journal of Science Education, 7(2), 107-120., pp.110-111)

The interpretative schemes were represented by the straight line and the circular line.

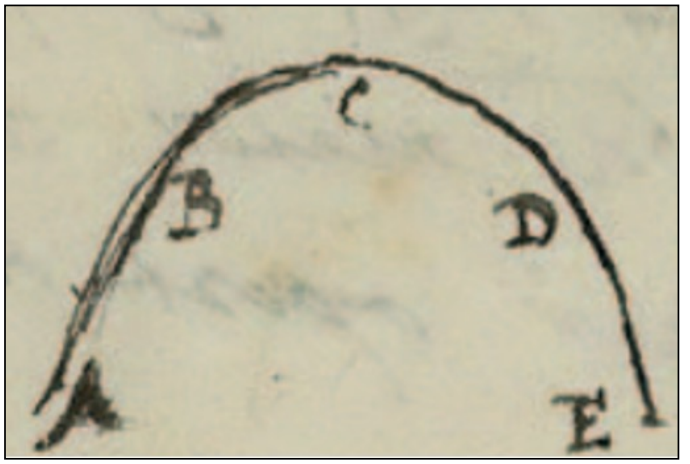
"Local motion, which is what we call 'translation', is always either straight, or circular, or a mixture of these two: because these two alone are simple. And the reason is that there are also only two simple quantities, the straight line and the circular one ".

(Aristotle)

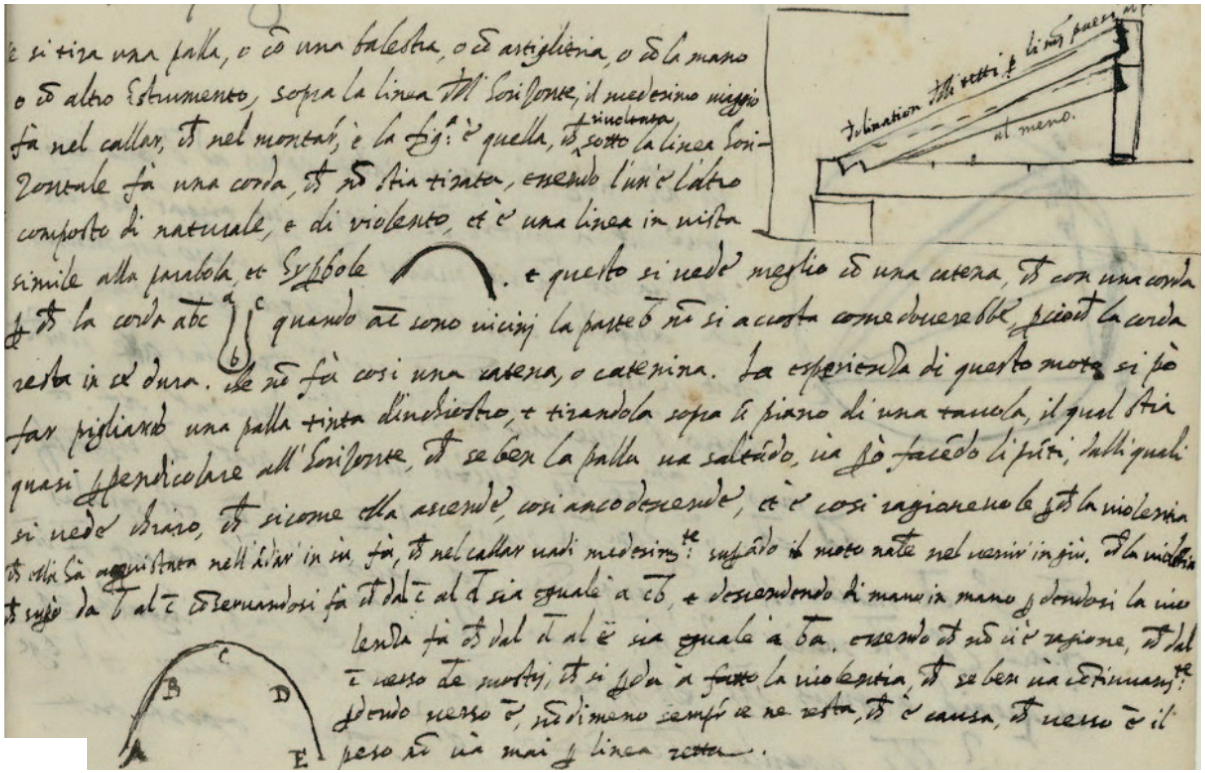
Parabola was not
among the interpretative schemes!!

IDENTITIES
Enlightening Interdisciplinarity in STEM for Teaching

Guidobaldo del Monte
Pesaro, 1545 – Montebaroccio, 1607



From Guidobaldo notes, 1592



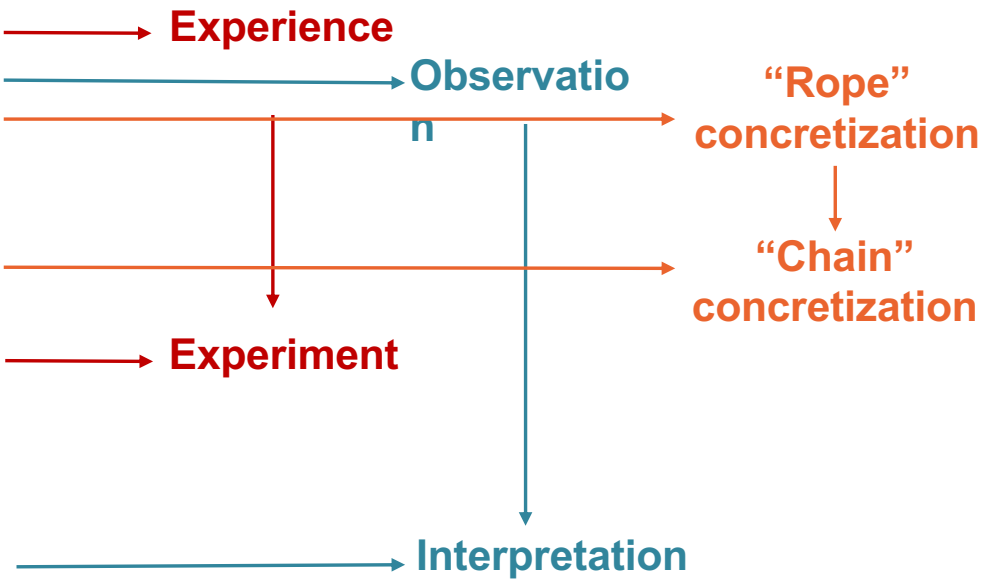
Guidobaldo del Monte

Pesaro, 1545 – Montebaroccio, 1607

From Guidobaldo notes, 1592

If one throws a ball with a catapult or with artillery or by hand or by some other instrument above the horizontal line, it will take the same path in falling as in rising, and the shape is that which, when inverted under the horizon, a rope makes which is not pulled, both being composed of the natural and the forced, and it is a line which in appearance is similar to a parabola and hyperbola. And this can be seen better with a chain than with a rope, since [in the case of] the rope *abc*, when *ac* are close to each other, the part *b* does not approach as it should because the rope remains hard in itself, while a chain or a little chain does not behave in this way. The experiment of this movement can be made by taking a ball colored with ink and throwing it over a plane of a table which is almost perpendicular to the horizontal.

Although the ball bounces along, yet it makes points as it goes, from which one can clearly see that as it rises so it descends, and it is reasonable this way, since the violence it has acquired in its ascent operates so that in falling it overcomes, in the same way, the natural movement in coming down so that the violence that overcame [the path] from *b* to *c*, conserving itself, operates so that from *c* to *d* [the path] is equal to *cb*, and the violence which is gradually lessening when descending operates so that from *d* to *e* [the path] is equal to *ba*, since there is no reason from *c* towards de that shows that the violence is lost at all, which, although it lessens continually towards *e*, yet there remains a sufficient amount of it, which is the cause that the weight never travels

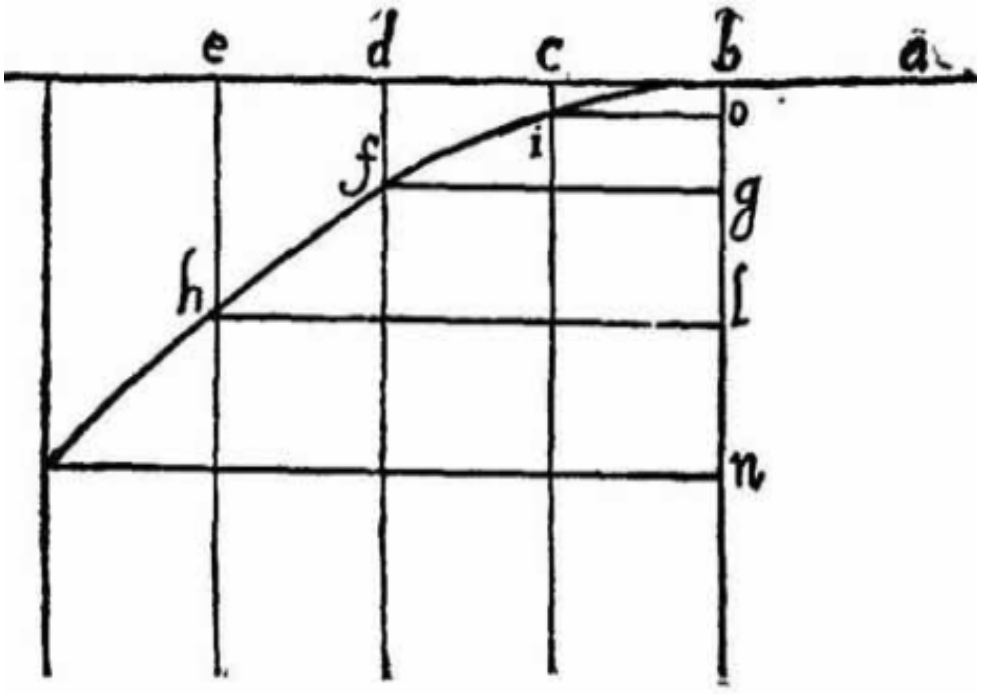


From Guidobaldo notes, 1592

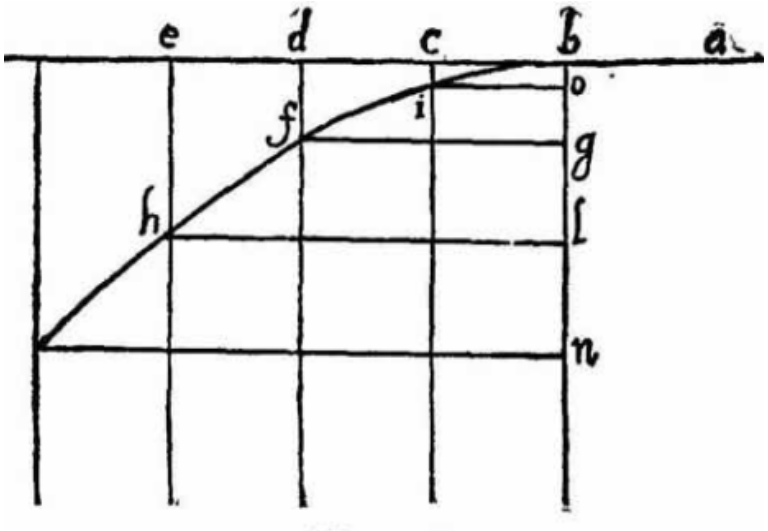
If one throws a ball with a catapult or with artillery or by hand or by some other instrument above the horizontal line, it will take the same path in falling as in rising, and the shape is that which, when inverted under the horizon, a rope makes which is not pulled, both being composed of the natural and the forced [motion], and it **is a line which in appearance is similar to a parabola and hyperbola. And this can be seen better with a chain** than with a rope, since [in the case of] the rope *abc*, when *ac* are close to each other, the part *b* does not approach as it should because the rope remains hard in itself, while a chain or a little chain does not behave in this way. The experiment of this movement can be made by taking a ball colored with ink, and throwing it over a plane of a table which is almost perpendicular to the horizontal.

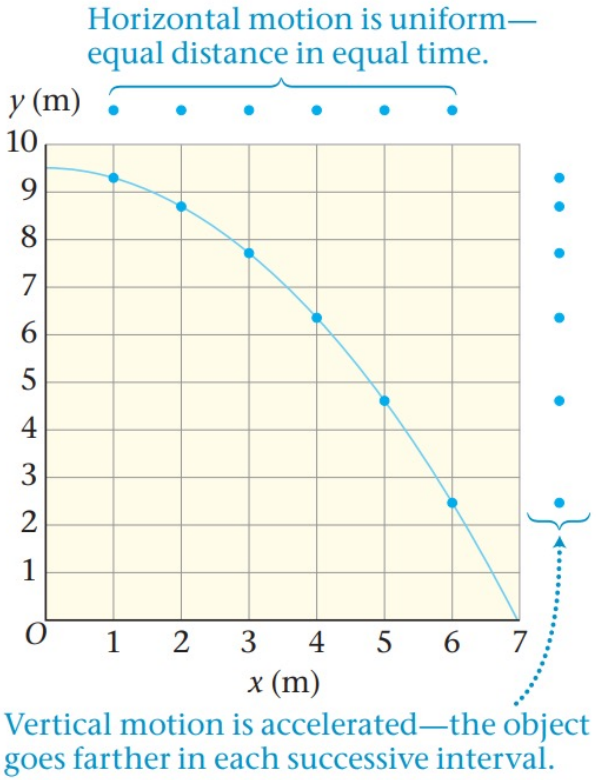
Although the ball bounces along, yet it makes points as it goes, from which one can clearly see that as it rises so it descends, and it is reasonable this way, since the violence it has acquired in its ascent operates so that in falling it overcomes, in the same way, the natural movement in coming down so that the violence that overcame [the path] from *b* to *c*, conserving itself, operates so that from *c* to *d* [the path] is equal to *cb*, and the violence which is gradually lessening when descending operates so that from *d* to *e* [the path] is equal to ba, since there is no reason from *c* towards de that shows that the violence is lost at all, which, although it lessens continually towards *e*, yet there remains a sufficient amount of it, which is the cause that the weight never travels in a straight line towards *e*.

Taken from the “Fourth day” of the *Discourses and Mathematical Demonstrations Relating to Two New Sciences* (1638), Galileo



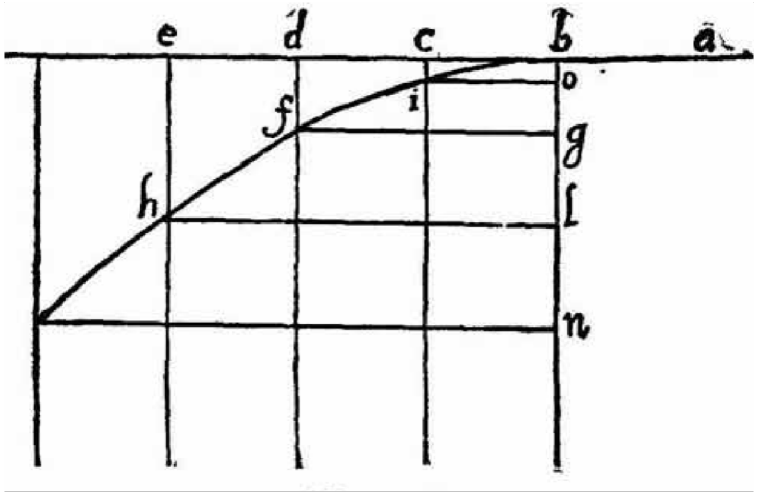
Taken from the “Fourth day” of the *Discourses and Mathematical Demonstrations Relating to Two New Sciences* (1638), Galileo





Taken from the Walker’ textbook

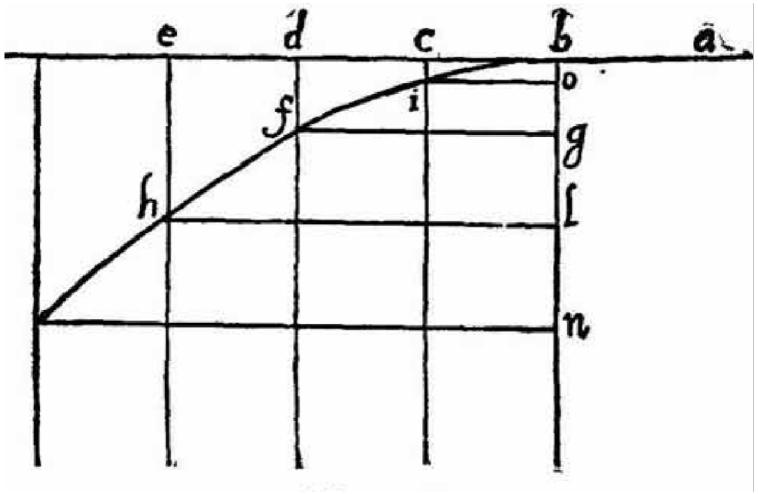
Galileo's proof



Theorem I, Proposition I

A projectile which is carried by a uniform horizontal motion compounded with a naturally accelerated vertical motion describes a path which is a semi-parabola.

Galileo's proof



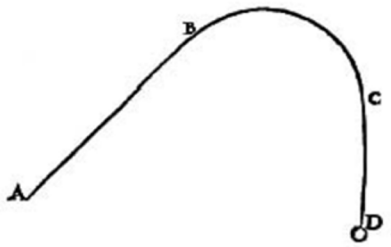
A theorem consists of (Mariotti et al., 1997)

- a statement
- the proof
- the theoretical framework of reference

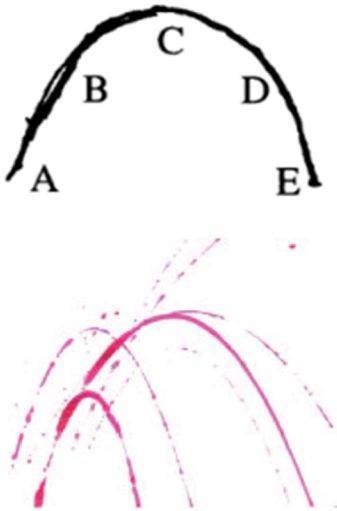
+

metatheory (i.e., the set of formal rules that allow to derive theorems from the starting group of axioms and definitions)

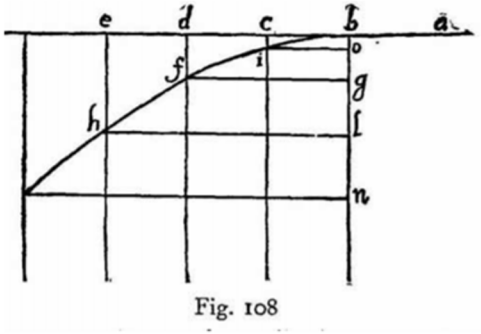
Parabolic motion and the establishment of physics as a discipline



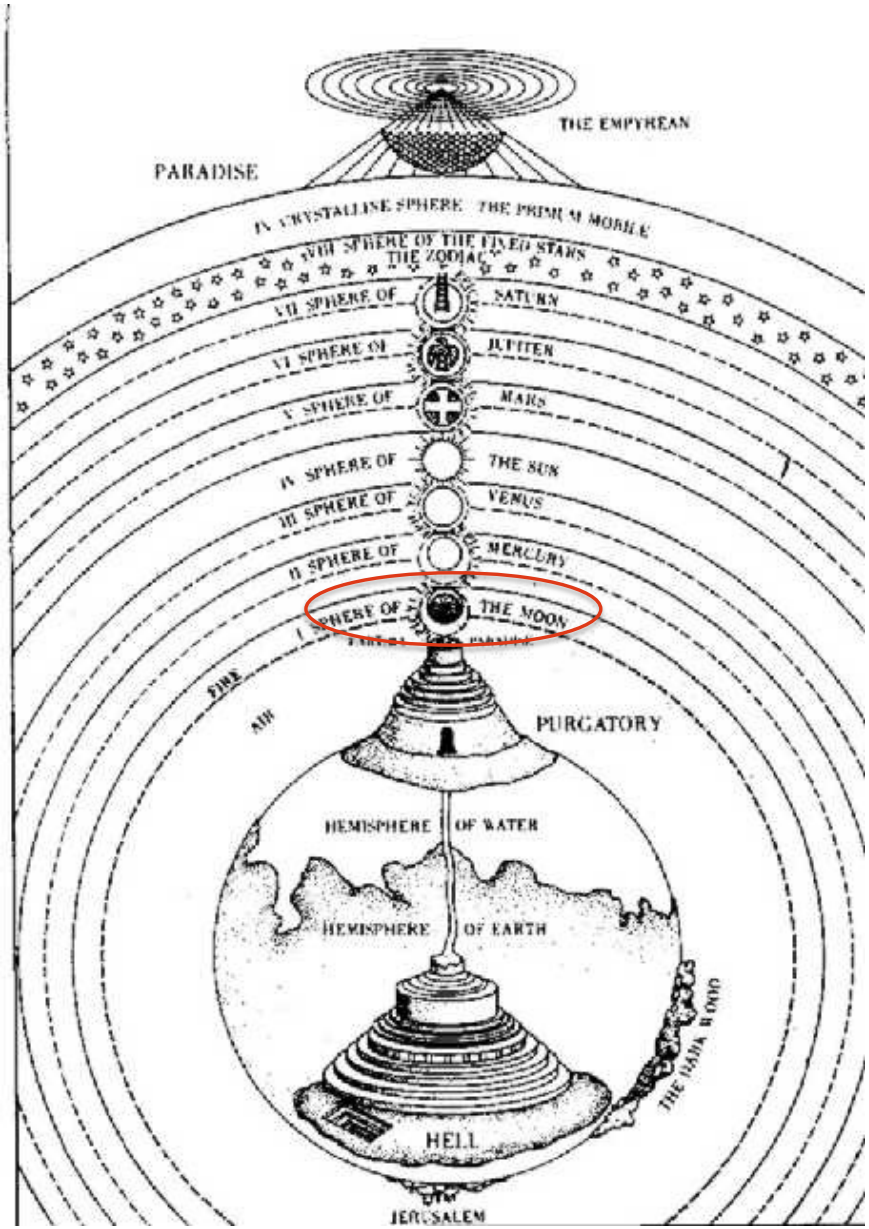
Tartaglia (1537)



Guidobaldo (1592)



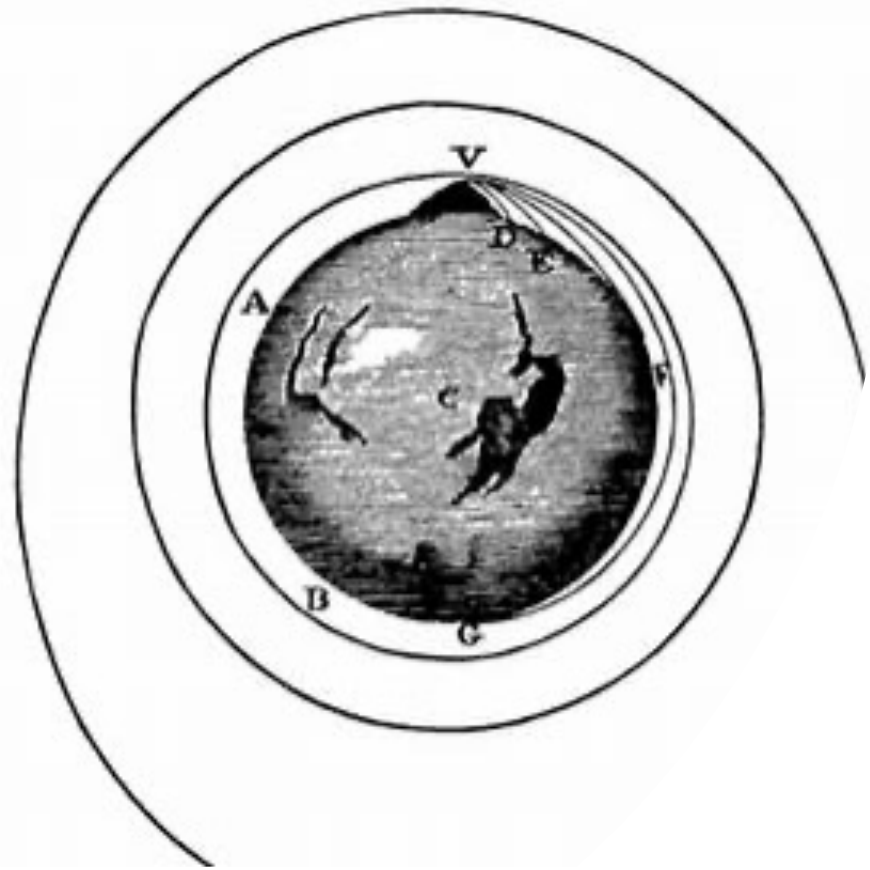
Galileo (1638)



The medieval view of the universe in a (incredible semplified) nutshell

The medieval view of the universe and its legacy from ancient greek philosophy (Plato and Aristotle):

- The distinction between the celestian and the sub-lunar world;
- The different role of mathematics in the two worlds;
- The classification of the «basic motions» of sublunar world was based on the distinction between natural and violent;
- Spheres and straight lines as the only «shapes» allowed to describe the world.

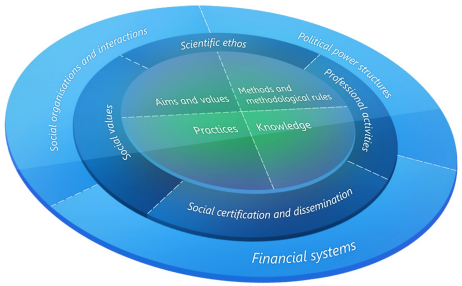


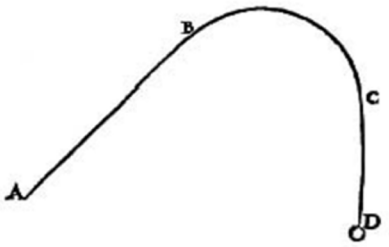
The modern view of the universe in a (incredible semplified) nutshell

The modern view of the universe:

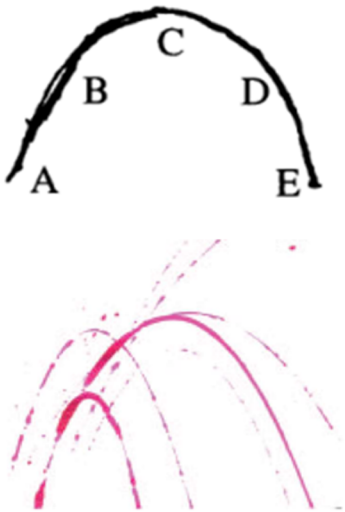
- The unification of the celestian and the sub-lunar world;
- The same structural role of mathematics in the two worlds;
- Spheres and straight lines as no longer the only «shapes» allowed to describe the world;
- The classification of the «fundamental motions» based on the distinction between uniform rectilinear motion and uniformly accelerated motion.

Parabolic motion and the establishment of physics as a discipline

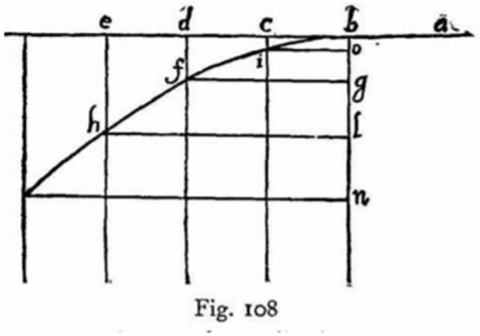




Tartaglia (1537)



Guidobaldo (1592)



Galileo (1638)

Work plan and module structure

1. «Living at the boundary: framing inter-disciplinarity through FRA and the boundary metaphor»

Interdisciplinary explorer

2. Parabolic motion and the establishment of physics as a discipline

3. The history of conics and the birth of projective geometry

Interdisciplinary student

4. The concepts of symmetry and proof as epistemological activators

5. Linguistic activators: text analysis

Interdisciplinary analyst

Interdisciplinary designer

6. Wrapping up

IDENTITIES

Enlightening
Interdisciplinarity
in **STEM**
for Teaching

Satanassi, S., Branchetti, L., Fantini, P., Casarotto, R., Caramaschi, M., Barelli. E., Levrini, O. (2023). Exploring the boundaries in an interdisciplinary context through the Family Resemblance Approach: the dialogue between physics and mathematics. *Science & Education*, https://doi.org/10.1007/s11191-023-00439-2.

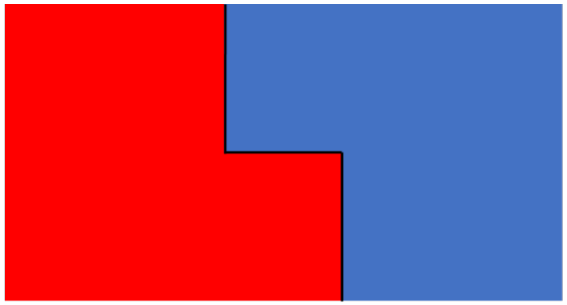
Co-funded by the
Erasmus+ Programme
of the European Union

Grant Agreement n°2019-1-IT02-KA203-063184

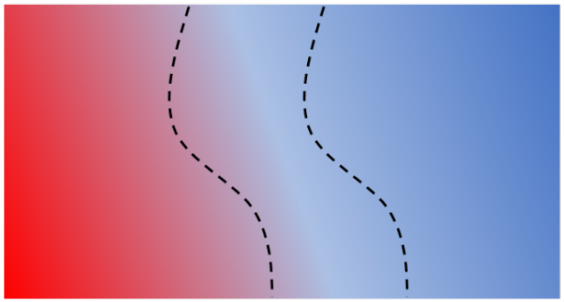
Enlightening
Interdisciplinarity
in **STEM** for Teaching

Three case studies on macro—attitudes toward knowledge and the boundaries

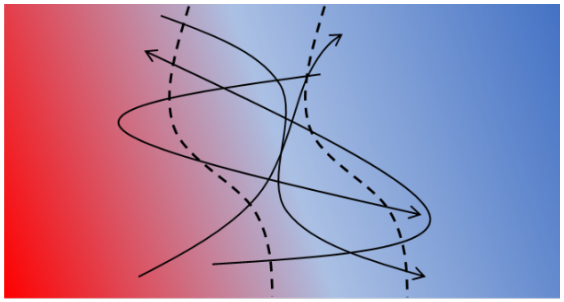
a)



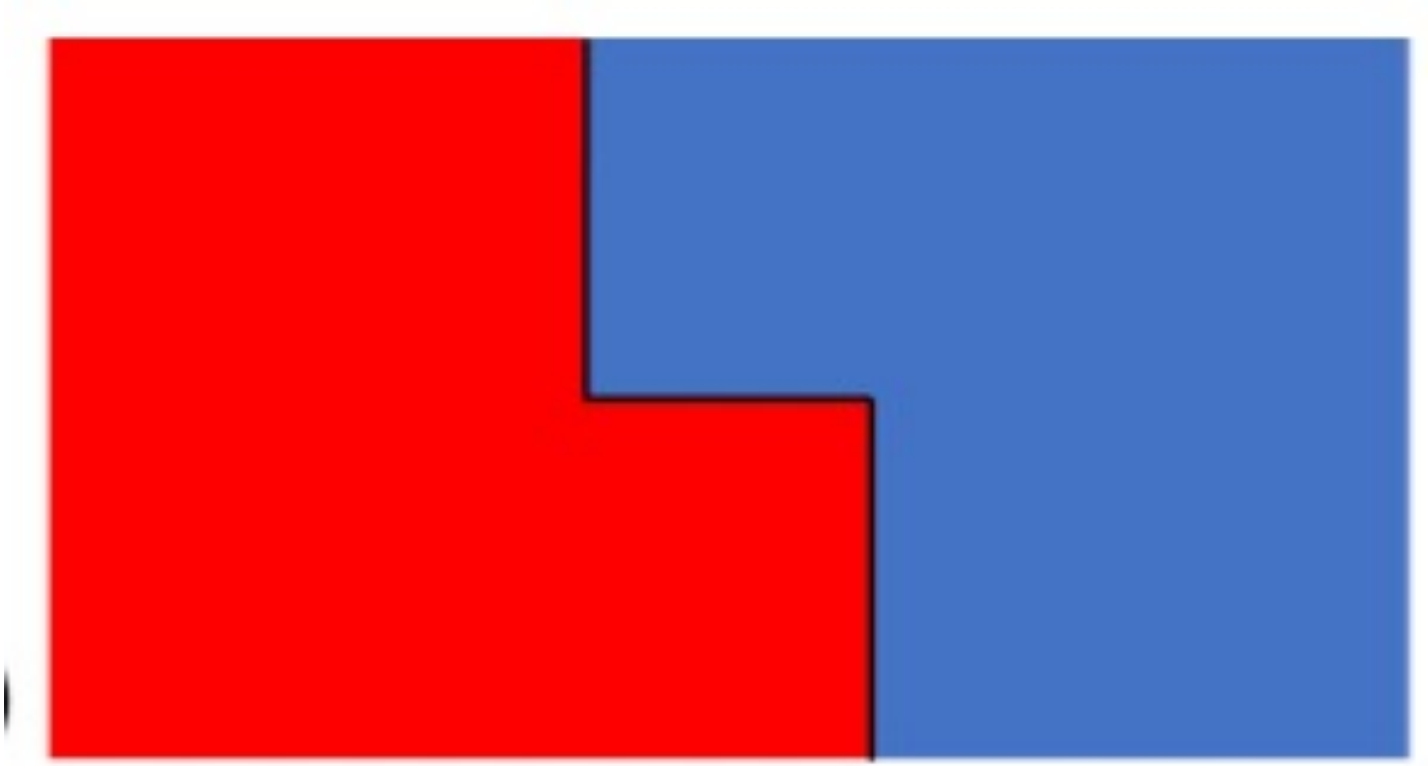
b)



c)



Case 1 - FRA domain-specificity for boundaty making



Placing parabolic motion in a historical context highlights how historically mathematics and physics were much more intertwined than they are today in textbooks, providing, with the work "Discourses and mathematical demonstrations around two new sciences" by Galilei, an example of interdisciplinarity. In fact, the text respects the characteristics of an interdisciplinary approach, highlighting the references to the disciplines, but at the same time explaining and motivating their intertwining.

Although Galilei's text is a valid example of interdisciplinarity, the references to the disciplines are evident and appear in an epistemologically significant way. In particular, referring to the framework of the Family Resemblance Approach, and also considering the analysis of the textbooks, the following characteristic aspects of the two disciplines emerged.

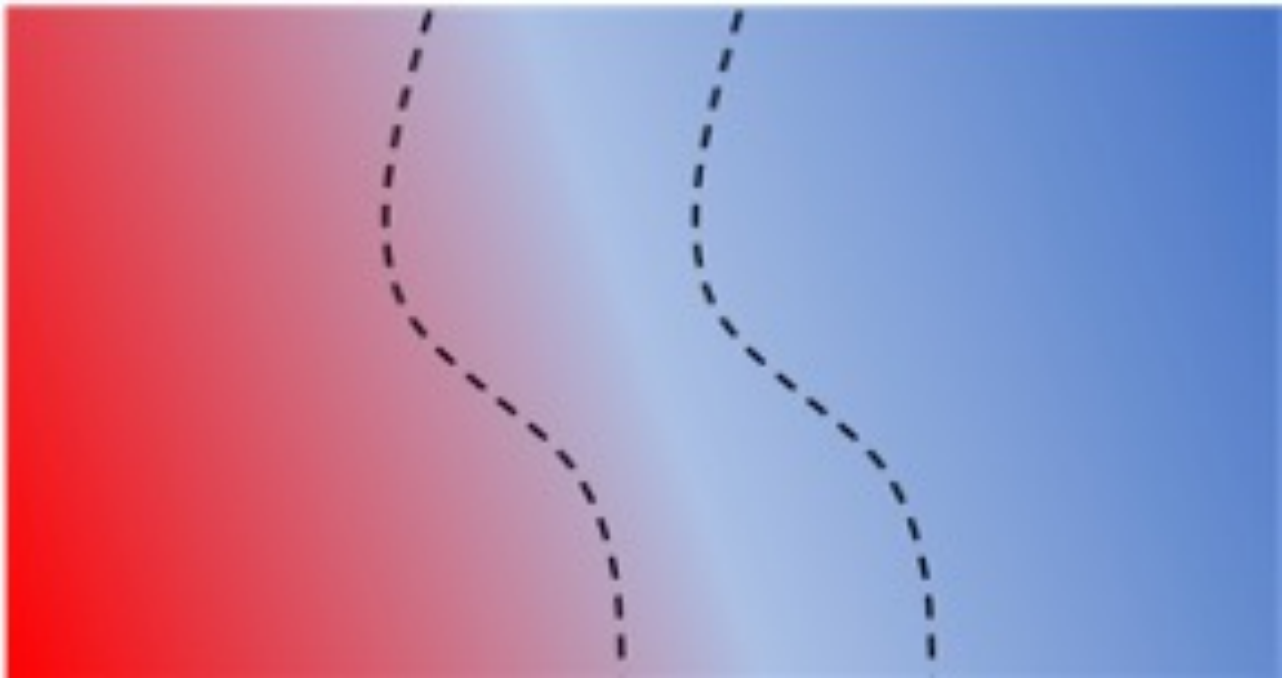
Physics:

- *Aims: Criterion of simplicity that manifests itself through the separation of the variables, that is, the independence of the motions; intelligibility, as we speak of common experiences.*
- *Practices: Experiment (epistemic practice) and dialogue (cognitive practice).*
- *Methodological rules: Construction of models starting from the observation of phenomena.*
- *Scientific knowledge: Mathematics provides logical and consistent explanations to develop understanding.*
- *Socio-institutional system: The dissemination of concepts that revolutionize the vision of the world inevitably leads to a cultural and social revolution.*

Mathematics:

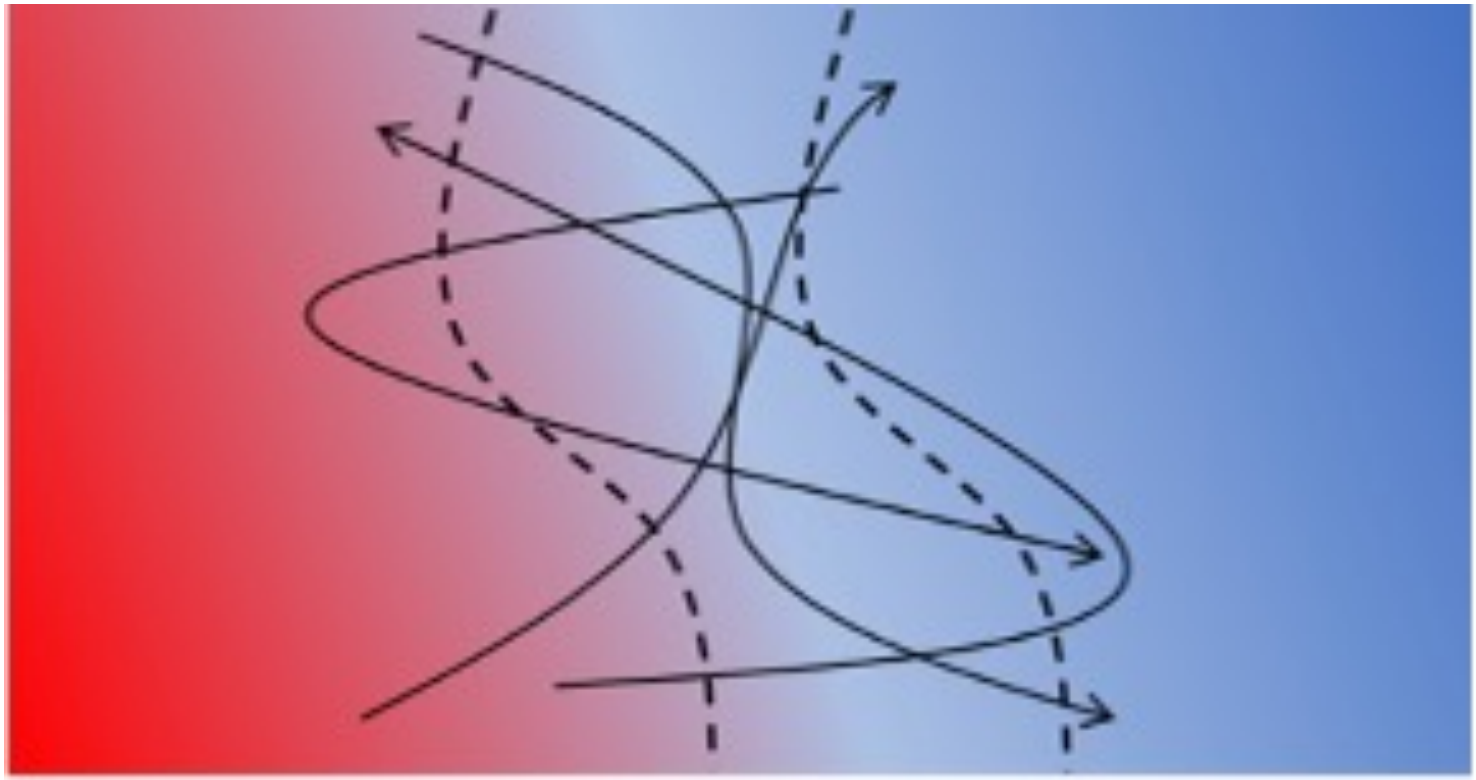
- *Aims: Rationality and consistency of axiomatic-deductive reasoning and objective value and truth of proof.*
- *Methodological rules: Model building with a solid logical argument.*
- *Socio-institutional system: A rationally structured argument has a social utility in that it produces responses to human needs and guarantees the equality of intellectual authority.*

Case 2 - FRA domain-specificity and domain-generality to enlarge and characterize the boundary



In the inseparability of the disciplines that have emerged in these historical cases, we find some of their constituent and most significant characteristics. If we put ourselves in a FRA perspective, we would immediately notice rigour as the basis of knowledge and value and an objective of mathematics, and mathematics itself as an element of knowledge for physics [...]. Again, in the physical field, various experimental practices are presented: sensory observation (e.g., the thrown ball seen by Guidobaldo) must generate hypotheses (e.g., the catenary as a curve) that allow other experiments (e.g., the ball soiled with ink) and lead to a model that must always maintain a logical and sensible structure (we can consider it as a value and aim shared by the disciplines) in order to explain its functioning. Another physical value is reproducibility, in this case, understood as validation of the method and the object of knowledge analysed (e.g., the "wondrous way" is actually wondrous for this reason). The [historical] evolution [...] shows us various common aspects of mathematics and physics: they outline a method of non-static hypothetical-deductive approach, both for the kind of activity to carry out one's studies, both with regard to work ethics and the certification/validation of one's work.

Case 3 – FRA ambiguity to reshape the boundary



The disciplinary division between mathematics and physics embodies one of the deepest and most deeply rooted dichotomies of our culture, namely [the dichotomy] between theory and experimentation, between abstract knowledge and real concrete knowledge of the world. It *brings with it, in this accelerated, complex, uncertain present, characterised by the fusion of knowledge, where disciplines are called to merge, intersect, and reflect each other (climatology, AI, big data science, ...), prejudices of form and thought which, perhaps, we no longer need.*

Enlightening
Interdisciplinarity
in **STEM** for Teaching

There are four mechanisms of boundary investigation and crossing identified by Akkerman and Bakker. The first is disciplinary identification (identification) with which the specificities of the disciplines are highlighted. For this purpose, the FRA wheel (Family Resemblance Approach) is chosen as the theoretical framework, a tool that helps and guides us in defining both the epistemic heart of the two disciplines divided into aims and values, practices, methods, and methodological rules and knowledge (core), and the relationship of the community of reference with society, their being part of society (first circle), and their more general relationships with citizenship and the economic and political decision-making powers that govern it (second circle).

Identification, supported by FRA (domain-specific) to describe «disciplinarization» and boundary making

"[We have realised] how much mathematics begins to characterise physics (reflection). We talk about proof and mathematical models in methods, we talk about identifying basic assumptions in practices (coordination), and we talk about the basic assumption in itself in knowledge. [...] Obviously, the methods and practices of generating proofs of agreement between theory and the world remain strong, translated into characterisation through the value of universality, Mathematics, with proof, with models, thus becomes an argumentative structure that keeps reasoning under control in a physical problem."

Reflection and coordination are used to problematize the boundaries and re-shape them…

Enlightening
Interdisciplinarity
in **STEM** for Teaching

“The placement of the study of motions and conics in the "great history of physics and mathematics" has certainly led to bringing the two disciplines closer together by breaking down the dichotomous prejudice from which we started: Therefore, a greater awareness has grown that mathematics and physics are close and that the aims and values of the one also guide the other.”

The recognition of the dichotomy as a prejudice and its overcoming by putting it in historical perspective

Enlightening
Interdisciplinarity
in **STEM** for Teaching

A safe and inclusive space

Room for very different epistemic demands of the prospective teachers: from who feels better within the identity cores of the disciplines, to who likes to inhabit the boundary zone, and to who likes to re-shape boundary spaces and move dynamically across them.

Boundary: FEAR or ATTRACTION?

«Boundaries are becoming more explicit because of increasing specialization; people, therefore, search for ways to connect and mobilize themselves across social and cultural practices to avoid fragmentation» (Hermans & Hermans-Konopka, 2010 in Akkerman & Bakker, 2011, p.132).

Videos on IDENTITIES choices on INTERDISCIPLINARITY:
https://identitiesproject.eu/videos/

Teaching materials on Videos on IDENTITIES choices on INTERDISCIPLINARITY:
https://identitiesproject.eu/videos/

INTERDISCIPLINARITY IN FEDORA:
https://www.fedora-project.eu/interdisciplinarity/

IDENTITIES
Enlightening
Interdisciplinarity
in STEM for Teaching

FEDORA

FEDORA - Future-oriented Science EDucation to enhance Responsibility and engagement in the society of Acceleration and uncertainty This project received funding from the European Union's Horizon 2020 Research and Innovation program under Grant Agreement n° 872941 www.fedora-project.eu

Credits: Emma D'Orto and formicablu

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

tak skal du have

Olivia Levrini

Dipartimento di Fisica e Astronomia «A. Righi»

olivia.levrini2@unibo.it

www.unibo.it