Clash of the Titans: Aristotle meets Galileo

VAST values across space & time

HTTPS://WWW.VAST-PROJECT.EU/

Preface

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Project: VAST: Values Across Space & Time

https://www.vast-project.eu/

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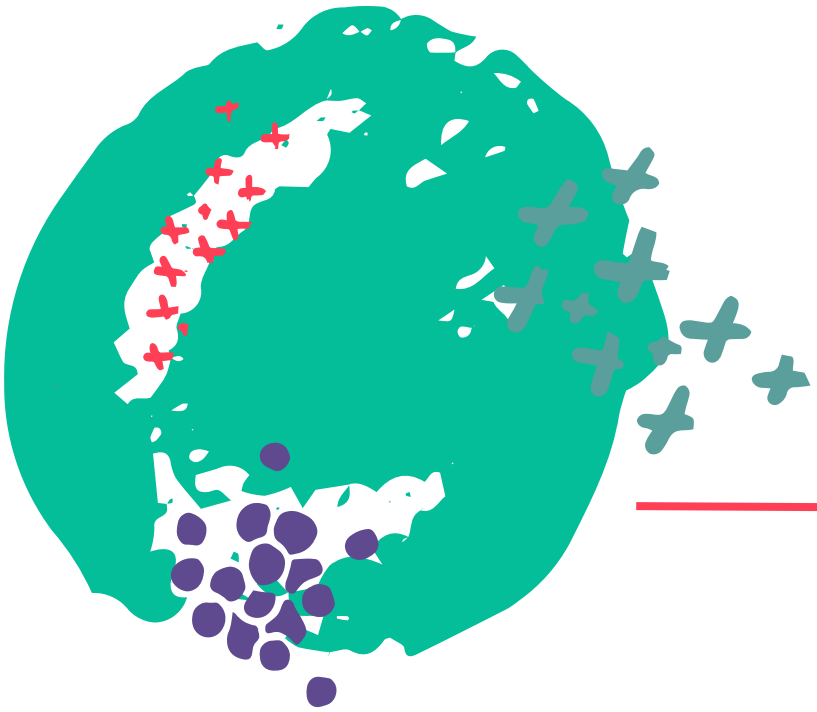


overview

The H2020 European research project VAST- Values Across Space & Time is a collaboration among the National Center for Scientific Research ‘Demokritos’ (Greece), National and Kapodistrian University of Athens (Greece), the Athens & Epidaurus Festival (Greece), Università degli Studi di Milano (Italy), Fairytale Museum (Cyprus), Museo Galileo (Italy), Universidade NOVA de Lisboa – NOVA (Portugal) and Semantika (Slovenia).

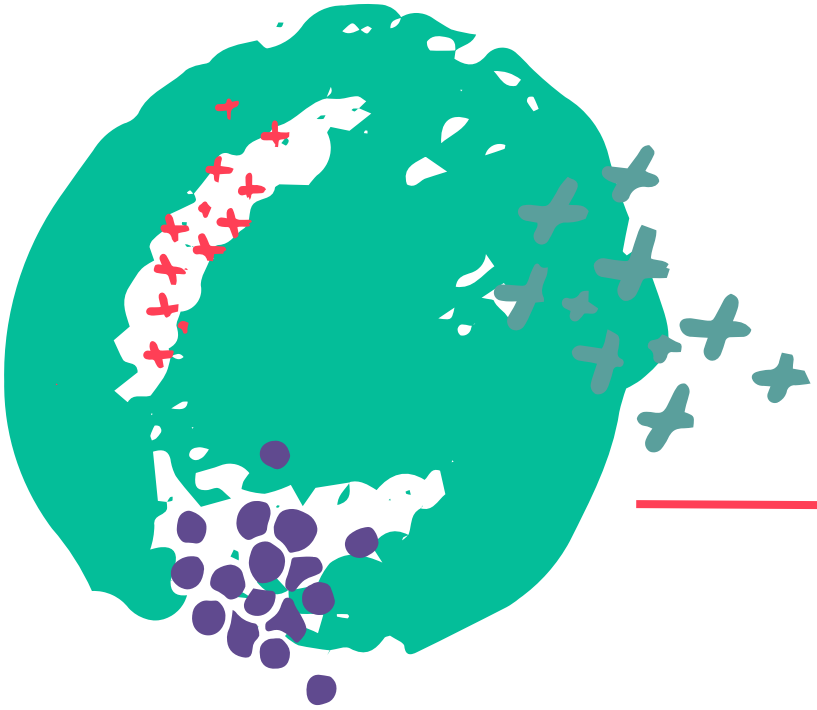
The project envisions to study the dissemination of the european values (such as freedom, democracy, equality, tolerance, dialogue, human dignity, the rule of law) in space and time through the use of digitised materials and intangible cultural artefacts as well as to explore the communication, reception and perception of these values in the modern era. For the purposes of this research, three pilots have been described concerning: 1. the theatre/ancient drama, 2. the scientific texts of the 17th century, 3. the fairy tales.

A digital platform has been developed, as part of the project, with open access to citizens. In this platform, values-related scientific and educational materials and research evidence/results will be posted, as well as various tools for scientific and research study.

Do not miss visiting!

The educational activity “Clash of the Titans: Aristotle meets Galileo” has been designed as part of the VAST project framework and is aimed at young people. This activity has been designed based on the principles of experiential learning and a collaborative teaching approach, where the active participation of students is encouraged through dialogue and practice, and has been piloted in the context of our collaboration with schools and museums.

According to the Council of Europe and the principles of democratic citizenship and human rights education, the educational process must, beyond imparting knowledge, aim at highlighting values, as well as cultivating attitudes and skills aimed at raising awareness and to motivate young people for further thought and reflection.
This educational guide was designed to present and distribute recommended educational material to educators/museum curators who wish to work towards this direction.
Enjoy reading!



activity

Institution

National Centre of Scientific Research "Demokritos"

Audience

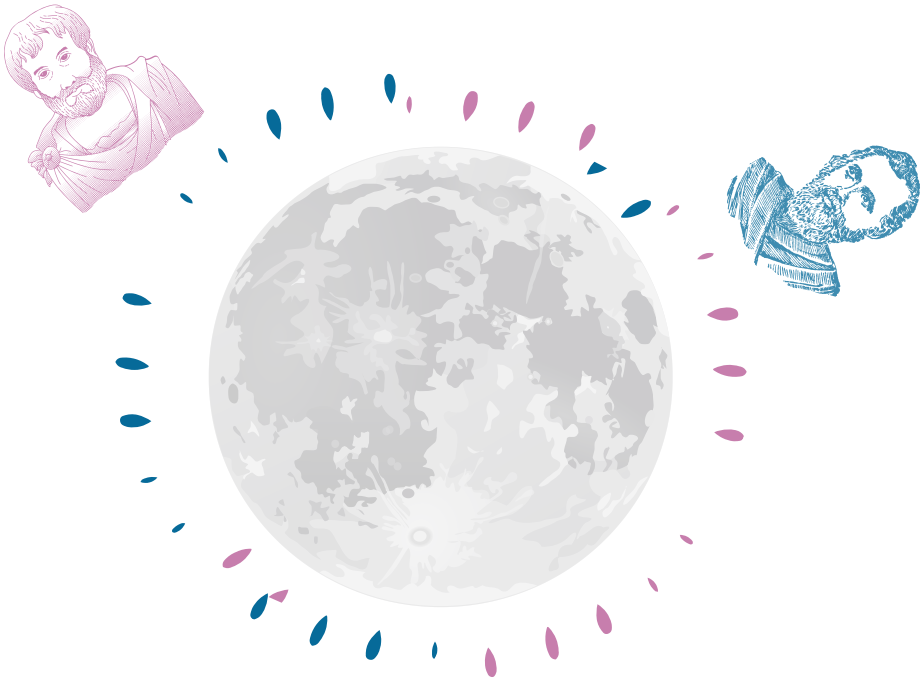
16 to 18 years old

Title

Clash of the Titans: Aristotle meets Galileo

Description

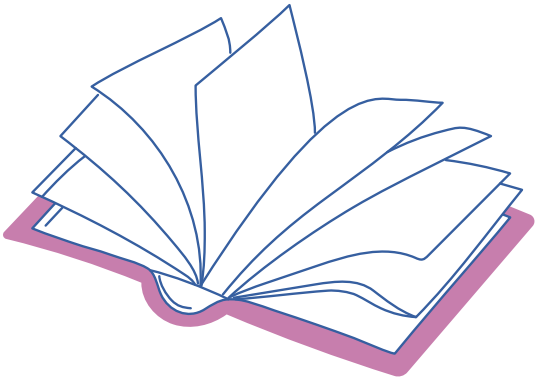
The Italian mathematician, astronomer and natural philosopher Galileo Galilei (1564 - 1642) is one of the most iconic figures in the history of science. Participants will get to know the man who strongly challenged the Aristotelian natural philosophy of his time and proposed a different way of explaining natural phenomena. Galileo clashed with the natural philosophers by introducing mathematics and experimentation into the investigation of nature. One of the consequences of this conflict was his condemnation by the Catholic Church. The aim of this activity is to highlight the differences between the methods of the Aristotelian philosophers and Galileo through discussion and activities. Also, participants will be able to reflect on the values embodied in the study of nature.



Educational Objectives

Through this activity the participants are expected to:

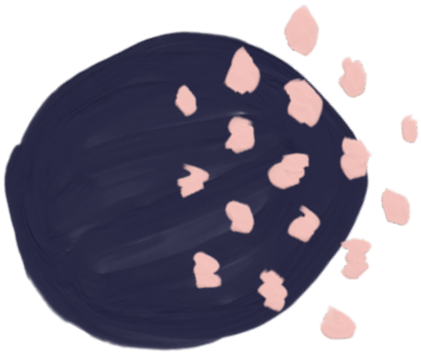
1. come into contact with Aristotle's reasoning and empirical method regarding the study of nature
2. understand the new methods used by Galileo (experiment and mathematization of nature)
3. take an interdisciplinary approach in order to understand how cultural and historical conditions are a constitutive factor in intellectual achievements
4. understand the shared values embodied in the work of both Aristotle and Galileo
5. learn the differences between different methods of studying nature
6. exercise their critical thinking about the differences between 'today' and 'yesterday'
7. understand concepts of the past in terms of their own time, beyond anachronistic commitments to 'right' and 'wrong' views or ideas



Expected outcomes

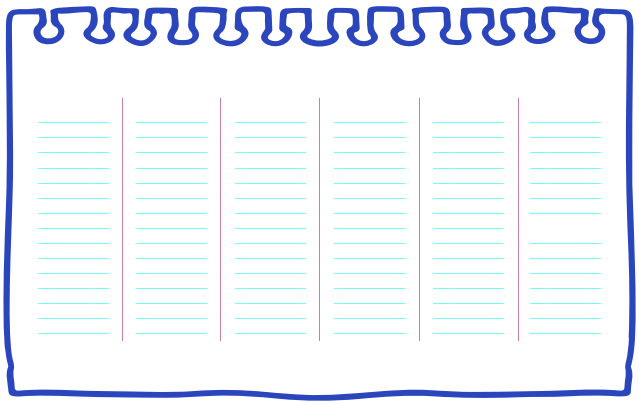
After completing the activity, the participants:

1. will have understood the methodological and conceptual changes brought about by Galileo's work
2. will have an overview of the historical relationships between philosophy, physics and mathematics
3. will have understood the sciences as achievements directly linked to their cultural and historical origins
4. will have constructed new knowledge based on their previous knowledge
5. have worked together to argue for a method of studying nature
6. will have realised that the work of different thinkers can be based on shared values (and how these values are transformed in time and place)



Structure

Duration	**70′ - 90′**
Educational materials/tools	• **Experimentation** • **Learning through action and inquiry learning** • **Discussion and reflection** • **A4 and a notebook**
Educator/facilitator	**1 educator/facilitator for each group of 10-15 students**
Target group	**Youth 16-18 years old/adults**



Modules/sections (design)

Welcome	Duration:	20'
	Materials/tools:	Paper & pen
	Described in pages:	10
1st part of the activity	Duration:	15'
	Materials/tools:	A page of paper or a lightweight object
	Described in pages:	11-13
2nd part of the activity	Duration:	25'
	Materials/tools:	A page of paper and a notebook or light book
	Described in pages:	14-16
3rd part of the activity	Duration:	30'
	Materials/tools:	-
	Described in pages:	17-19
Farewell - Activity evaluation	Described in pages:	20

Welcome

A. Introduction (5')

Welcome of the participants & information about the activity.

B. Ice breaker activity (15')

Game 1: brainstorming on values

Brainstorm, in which we start with two questions: What are values and what role do they play in our lives? Are there values that are important when we study nature and try to understand it?

Note: It is important to derive concepts such as the truth or validity of an argument and proof. The list can be compared towards the end with the values that appear in Galileo's letter to Duchess Christina.

Game 2: Things of the mind

Give the group members time to think, discuss and write down concepts which cannot be perceived with experience and the senses. That is, to record what they think exists independently of sensory experience.

Note: Within the answers we want the word mathematics to appear. The list can be compared with the previous list and see if there are values that can be referred to in the concepts on this list. For example, the value of truth has a close relationship to mathematics.

1st part of the activity: *Acquaintance with the thought of Aristotle.*

Introduction to Aristotle's Thought. In this part, the group will learn about Aristotle's method and how he handled the concept of motion.

Game 3

Ask the group members whether they think that mathematics is a safe guide in the search for truth or whether it is safer to rely primarily on our experience and the reasoning that comes from our experience. The members who defend mathematics as a guide to the search for truth are on the Plato side, while the rest are on the Aristotle side.

Discussion

Explain the differences between Aristotle and Plato in terms of mathematics. For Aristotle, mathematics was extremely beneficial and a practice that led to certain knowledge but was not independent of the world of experience. He believed that they were abstractions of real objects and that without real objects we could not have mathematics. On the contrary, Plato held that mathematics was part of the world of Ideas and existed independently of the world of experience. For this reason, Plato believed that mathematics should be our guide to finding the truth about nature. These differences will help the group understand Aristotle's method, which was based on reasoning from the experiences we have. Also, we will make it clear that Aristotle's arguments were dominating the study of nature for about twenty centuries. His arguments emerged from the everyday experience.

Game 4

Here are three questions, with which we try to explain how Aristotle treated the concept of motion. These questions can either be posed as questions for discussion and exploration or as quizzes, where we can put correct and incorrect answers. They can also be explored interactively. For example, we can take an object and push or drop it from a certain height.

1. When we push an object, why does it move? (In this question we can push a body with our hand.)

2. When we let a body fall from a height, why does it fall if we do not move it? (In this question we can take a crumpled paper or a light object and let it fall.)

3. Why does an arrow continue its motion and not fall instantaneously as soon as it leaves the bow? (To answer to this question we can throw the crumpled paper to one of the group members to catch it in the air.)

Discussion

The answers to the above questions reveal Aristotle's thinking about motion, as well as concepts such as weight and lightness. Ask group members if mathematical or experimental methods appear in the Aristotelian interpretation of motion. The fact that they do not appear simply suggests a different way of studying nature. We point out, however, that Aristotle was primarily interested in the search for truth and correct method. His methods were highly sophisticated and he developed an equally sophisticated conceptual framework to support them. Importantly, as far as the concept of motion is concerned, he provided explanations that did not require mathematical formulations nor experimental ones. It was based on everyday experience.

Here it is quite important to point out that the experimental process is distinct from everyday experience, even though it is based on empirical evidence. An experiment is not merely an observation of a natural phenomenon but a designed process of intervention in nature.

Game 5

We end this section with the question: *Why did the spherical Earth, according to Aristotle and all the ancient philosophers, stand still at the center of the world?* And here it can be posed in quiz form for more interaction. The answer we want is that the motion of the Earth would cause the bodies on it to be thrown off its surface because of the high velocity it would theoretically have.

Discussion

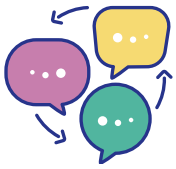
Note that in ancient times they knew that the Earth was very large in size and understood that if it was capable of completing one rotation in a day, this would mean that its speed was frighteningly high (which is indeed true). It is critical to point out that this argument was perfectly reasonable given the data and methods they had.

2nd part of the activity: *Introduction to Galileo's thought.*

In this unit, the group will be introduced to Galileo's thought and the aim is to understand the differences between the Galilean and Aristotelian methods.

Discussion

A brief description of Copernican theory and the new position the Earth occupies in the heliocentric system.



Discussion

We refer to Galileo as one of the early proponents of Copernican astronomy. We describe his five important observations with the telescope, which seemed to confirm Copernicus' claims. We also discuss Galileo's mental experiment (the famous ship mind experiment), which shows why we do not perceive the motion of the Earth.

Game 6

Galileo's theory of the concept of motion. At this point, we demonstrate with a short activity, involving two members of the group, the differences between Aristotelian philosophy and Galilean thought regarding the free fall of material bodies. One member has the role of Aristotle and the other of Galileo.

We give "Aristotle" two sheets of paper and tell him to let them fall from the same height at the same time. We ask him why they fell together. The answer we want is: “Because they have the same weight”. Then we ask "Aristotle" if he can find a way to make the second paper fall faster than the first. What we want is for him to crumple it. We ask what it is that has changed, since the weight has stayed the same. The answer we want is “the shape”. Weight and shape were the two main reasons, according to Aristotle, why bodies fell at different speeds.

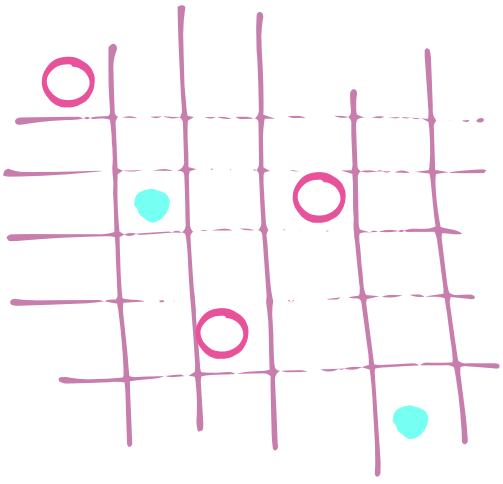
Next, we tell "Galileo" to take a page and a notebook and drop them from the same height at the same time. What he notices is that, because of weight, the notebook falls faster. We ask him if he can find a way to make them fall at the same time, but he is not allowed to change the shape of the paper, as "Aristotle" did before. What we want is for him to put the page of paper on the notebook and let it fall. He will then see that they fall at the same time. With this simple experiment, we see that the speed of a body in free fall does not depend on weight and shape but on distance and time. We see, in other words, a conceptual reinvention of motion by Galileo.

Discussion

Next, we show a video from the internet of the inclined plane experiment (https://www.youtube.com/watch?v=eghdN-GFuqo) and explain the relationship between time and distance. We point out that Galileo is the first to take into account the concept of time and make it part of the velocity of a body. We ask, however, the members of the group: How do you think he measured time?

After all possible answers have been heard, we refer to the ways in which Galileo measured time (bells at specific distances, musical intervals, volumes of water, geometric proof). Especially in the experimentation with the bucket, we could without exaggeration say that Galileo is the first person to "collect" time in a bucket. The bucket didn't just have water, it "had time itself trapped in it".

We conclude that Galileo introduced mathematization and experimentation into the study of nature. With the help of geometry he studied motion in idealized conditions (surfaces without friction), and with the help of experiment he shifted the study of nature from mere observation to intervention. With Galileo, the concept of motion changed in meaning and content.



3rd part of the activity *Clash of Titans.*

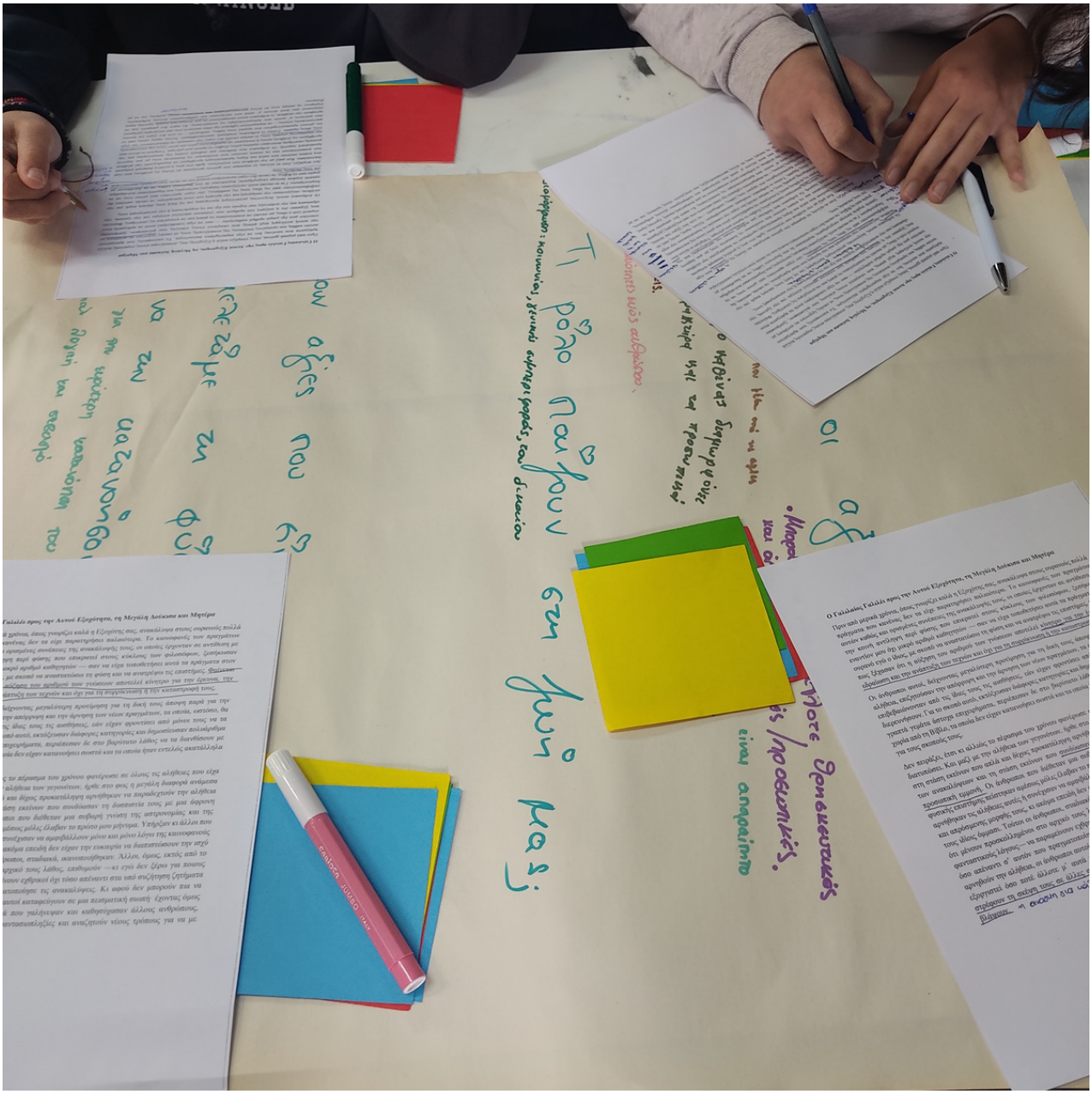
In this unit, the group will discuss the values present in the "Letter to Lady Christina of Lorraine, Grand Duchess of Tuscany". We will then discuss Galileo's controversies and his famous trial.

Activity

We give the group members some quotes from Galileo's text "Letter to Lady Christina of Lorraine, Grand Duchess of Tuscany" (pp. 1, 2, 3, 7, APPENDIX I). We ask them to find out what kind of values appear in this text. We discuss whether these values also meet in what we have discussed about Aristotle.

Discussion

Galileo's dispute with the Aristotelian philosophers was a socio-professional dispute between a mathematician and the philosophers. We refer to the clash of different methods and different conceptual frameworks. Galileo moves away from qualitative interpretations of natural phenomena and is guided by quantitative measurements. He attempts to delegitimise the methodology of Aristotelian natural philosophy by opting for a more technical approach.



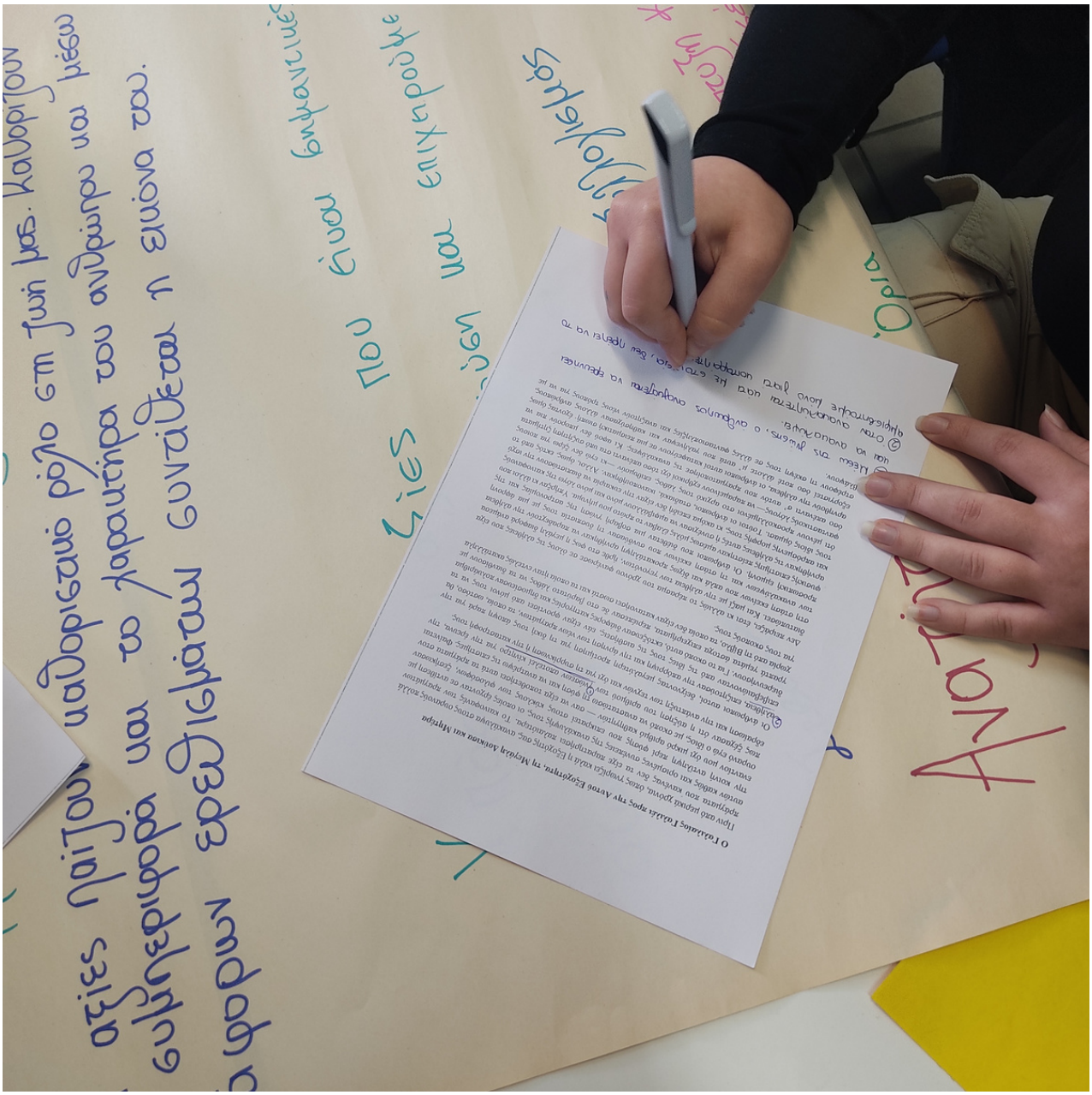
Discussion

Galileo and the Church: Galileo's controversy with the Aristotelian philosophers led to his trial and condemnation by the Catholic Church. A controversy over the study of nature became a controversy of intense theological interest. We refer to the historical context and discuss what kinds of values came into conflict.

Discussion

We pose the following questions: *Can we really be sure who is right in such complicated case? Can we assume that since the truth is revealed, everyone agrees in what they see? Is it possible that in a conflict opposite parties defend the same values?*

We ask the members of the group to submit their thoughts on the above questions briefly.



Farewell - Activity evaluation

We summarise the most important points. We point out that the study of nature is based on a constant search. Questioning is an inherent feature of the search for truth. Even conflicts are part of this dialectical relationship between world and humans. We also note that the study of nature is always based on languages we invent. These languages may be incompatible with each other and/or mutually exclusive. In these cases, linguistic incommensurability, that is, the impossibility of communication between two parties, inevitably leads to a state of conflict and also to a change in our view of the world.

We then ask students to complete an activity evaluation questionnaire (Appendix II).

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APPENDIX - I

Excerpts from Letter to Grand Duchess Christina, trans. by Maurice A. Finocchiaro, Finocchiaro, The Galileo Affair: a Documentary History, Berkeley-Los Angeles-London: University of California Press, 1989

As Your Most Serene Highness knows very well, a few years ago I discovered in the heavens many particulars which had been invisible until our time. Because of their novelty, and because of some consequences deriving from them which contradict certain physical propositions commonly accepted in philosophical schools, they roused against me no small number of such professors, as if I had placed these things in heaven with my hands in order to confound nature and the sciences. These people seemed to forget that a multitude of truths contribute to inquiry and to the growth and strength of disciplines rather than to their diminution or destruction, and at the same time they showed greater affection for their own opinions than for the true ones; thus they proceeded to deny and to try to nullify those novelties, about which the senses themselves could have rendered them certain, if they had wanted to look at those novelties carefully. To this end they produced various matters, and they published some writings full of useless discussions and sprinkled with quotations from the Holy Scripture, taken from passages which they do not properly understand and which they inappropriately adduce.

***

Then it developed that the passage of time disclosed to everyone the truths I had first pointed out, and, along with the truth of the matter, the difference in attitude between those who sincerely and without envy did not accept these discoveries as true and those who added emotional agitation to disbelief. Thus, just as those who were most competent in astronomical and in physical science were convinced by my first announcement, so gradually there has been a calming down of all the others whose denials and doubts were not sustained by anything other than the unexpected novelty and the lack of opportunity to see them and to experience them with the senses. However, there are those who are rendered ill-disposed, not so much toward the things as much as toward the author, by the love of their first error and by some interest which they imagine having but which escapes me. Unable to deny them any longer, these people became silent about them; but, embittered more than before by what has mellowed and quieted the others, they divert their thinking to other fictions and try to harm me in other ways.

***

Therefore, I think that in disputes about natural phenomena one must begin not with the authority of scriptural passages but with sensory experience and necessary demonstrations. For the Holy Scripture and nature derive equally from the Godhead, the former as the dictation of the Holy Spirit and the latter as the most obedient executrix of God's orders; moreover, to accommodate the understanding of the common people it is appropriate for Scripture to say many things that are different (in appearance and in regard to the literal meaning of the words) from the absolute truth; on the other hand, nature is inexorable and immutable, never violates the terms of the laws imposed upon her, and does not care whether or not her recondite reasons and ways of operating are disclosed to human understanding; but not every scriptural assertion is bound to obligations as severe as every natural phenomenon; finally, God reveals Himself to us no less excellently in the effects of nature than in the sacred words of Scripture, as Tertullian perhaps meant when he said, "We postulate that God ought first to be known by nature, and afterward further known by doctrine—by nature through His works, by doctrine through official teaching" (Against Marcion, I.18); and so it seems that a natural phenomenon which is placed before our eyes by sensory experience or proved by necessary demonstrations should not be called into question, let alone condemned, on account of scriptural passages whose words appear to have a different meaning.

APPENDIX - II

Clash of the Titans Aristotle meets Galileo

Evaluation Questionnaire

1. Gender *

- ○ Male
- ○ Female
- ○ Other
- ○ Prefer not to answer

2. Age *

- ○ <13 years old
- ○ 13-15 years old
- ○ 15-18 years old
- ○ >18 years old

3. Where do you live; *

- ○ Big City/Capital (>100.000 residents)
- ○ Big city suburb
- ○ Small city (<100.000 residents)
- ○ Province (<30.000 κάτοικοι)

4. What is your mother language? *

5. What motivated you to participate in this particular educational activity? *

- ☐ curiosity
- ☐ interest of the topic
- ☐ obligation, as it was in class time
- ☐ other

6. How would you evaluate the activity, in terms of? *

	I didn't like at all	I didn't like	I don't know	I liked	I liked a lot
the content					
the structure					

	I didn’t like at all	I didn’t like	I don’t know	I liked	I liked a lot
the duration					

7. How would you evaluate the following parts/points of the activity? *

	I didn’t like at all	I didn’t like	I don’t know	I liked	I liked a lot
interactive activity (brainstorming - the things of the mind)					
Getting to know Aristotle's thought (game)					
Getting to know Aristotle's thought (discussion)					
Getting to know Galileo's thinking (game)					
Getting to know Galileo's thought (discussion)					
Clash of the Titans (highlighting values in the text)					
Clash of the Titans (discussion)					

I didn’t like at all	I didn’t like	I don’t know	I liked	I liked a lot

8. During your participation did you have the time to express your thoughts? *

- Yes
- No
- I don’t know

9. During your participation were you able to work with your classmates and exchange views? *

- Yes
- No
- I don’t know

10. Would you like to participate again in a similar activity? *

- Yes
- No

- ○ I don’t know

11. How often would you like to participate in similar educational activities with the school?*

- ○ 1 time per week
- ○ 1-2 times per month
- ○ >10 times during the school year
- ○ <10 times during the school year φορές

12. What was the conflict between Galileo and Aristotelian philosophers about in the 17th century? *

- o philosophy // mathematics
- o religion // science
- o tradition // new knowledge
- o modesty // arrogance
- o arbitrariness of power // law

13. What does 'value' mean to you? *

- ☐ personal rules
- ☐ way of thinking & behaviour
- ☐ ideally

- [ ] lifestyle
- [ ] ideology
- [ ] other

14. What values are projected through the text 'Galileo Galilei to His Excellency, the Grand Duchess and Mother'?*

- Truth
- Equality
- freedom (of speech/thought)
- democracy
- innovation
- obedience to the law
- progress
- obedience to science
- honor
- respect
- justice
- courage
- knowledge
- other

15. What values does Aristotle express?*

- Truth
- Equality
- freedom (of speech/thought)
- democracy

- innovation
- obedience to the law
- progress
- obedience to science
- honor
- respect
- justice
- courage
- knowledge
- other

16. What values does Galileo express? *

- Truth
- Equality
- freedom (of speech/thought)
- democracy
- innovation
- obedience to the law
- progress
- obedience to science
- honor
- respect
- justice
- courage
- knowledge
- other

Is there anything you would like to share?

Thank you so much for your time!

values
across
space
& time

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