**ANNEX 1 – HISTORICAL TEXT**

# How did the Earth become a globe?

When we go to the beach or an open field and look at the horizon in the distance, we can see a long path that resembles a straight line. We can look in any direction and all we see is a straight horizon line, surrounding a surface that appears to be flat. What's more, we don't feel any movement under our feet. The ground seems completely still. And when we look at the sky, we see the Sun, the Moon and the stars moving around us.

There's nothing more intuitive than thinking that the Earth must be a flat, still surface, and that the stars revolve around us. After all, this is the impression we have from our most concrete and non-systematic observation of the world.

However, many thinkers have long since realized that there are other elements, other observations, that challenge this model for planet Earth. For example, when we watch a ship move away in the distance, we can see that it disappears from the bottom up. If the Earth were flat, we would see the boat decreasing in size uniformly until it is no longer noticeable. This is one of the reasons why there are tall lighthouses on beaches. Being at a higher place, one can see further than if one were at beach level. In a flat Earth model, this would not make any sense. Even in ancient times, many thinkers had the notion that the Earth could not be flat, but rather have a shape similar to that of a sphere.

We cannot assume that all people have always accepted this throughout time. In fact, even today, there are people who try to resort to the flat Earth model. But does this make sense in the 21st century? Just to give one example, even in the 19th century (more specifically 1893), there are records of proposals for maps with a flat Earth model (Figure 1).

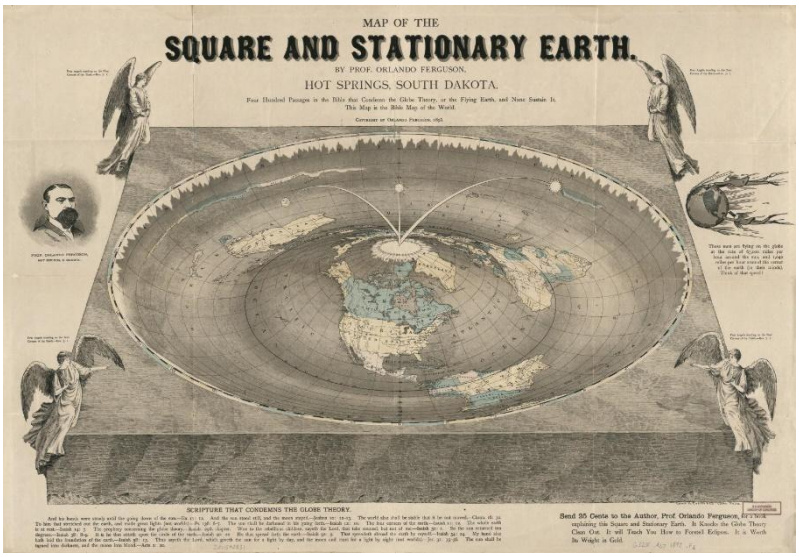



**Figure 1**. Flat Earth proposal in the 19th century (source: https://www.loc.gov/resource/g3201a.ct003543/?r=-0.364,0.246,1.831,0.767,0_).

In science, we can always be open to new propositions. The value of a proposal, however, is associated with the implications it brings. For example, if we consider that the Earth is round, what other information about the Universe can we obtain? And does the flat Earth model account for the same phenomena? Which of these models best explains Nature as we know it today?

To discuss especially the case of the shape of the Earth, we will discuss how we can, with observational data, draw even deeper and more precise conclusions about the Earth, such as its radius, for example. And, once we know the radius of the Earth, we can also find the radius of the Moon, the South, as well as the distance of these and other stars from the Earth!

**Calculating the radius of the Earth**

The first measurements of the radius of the Earth that we have recorded in ancient Greece date back to the second century BC. About this period in Greece, we have some notions about its great advance in knowledge about Nature.

> The period from the end of the 4th century to the end of the 2nd century BC witnessed, in Greek-speaking countries, an explosion of objective knowledge about the external world. While Greek culture had already reached great heights in art, literature, and philosophy in the preceding classical era, it is in the so-called Hellenistic period that we see for the first time anywhere in the world the emergence of science as we understand it today: not an accumulation of facts or speculations on a philosophical basis, but an organized effort to model nature and apply such models, or scientific theories in the sense that we shall make precise, to the

> solution of practical problems and to a growing understanding of nature. We owe this new approach to scientists such as Archimedes, Euclid, Eratosthenes, and many others less familiar today but no less remarkable. (Russo 2004, 2).

More specifically, it was in the city of Alexandria that there was a profound intellectual ferment:

> It was in Alexandria that Euclid worked and taught, towards the end of the fourth century B.C. Also there, in the first half of the following century, lived Ctesibius, creator of pneumatics and founder of the Alexandrian school of mechanics, and Herophilus of Chalcedon, founder of the sciences of anatomy and physiology. The activity of Aristarchus of Samos, famous above all for having introduced heliocentrism, dates from the same period. It was also probably in Alexandria that Archimedes studied and, even in Syracuse, he maintained constant communication with Alexandrian scientists. Among the scientists of the second half of the 3rd century was Eratosthenes, head of the Library of Alexandria, who, among other things, carried out the first true measurement of the size of the Earth (Russo 2004, 16).

But how is it possible for someone to know the radius of the Earth, especially in the 2nd century BC, if our eyes are not even capable of seeing a round Earth? This is a great capacity of the scientific enterprise, which we must pay attention to.

First, we realize that science does not necessarily agree with our most basic sensory data (such as the appearance of a flat Earth), but contradicts our experience. It must then be able to offer a more robust model (one that explains more phenomena) and one that is able to explain why our senses "deceive" us.

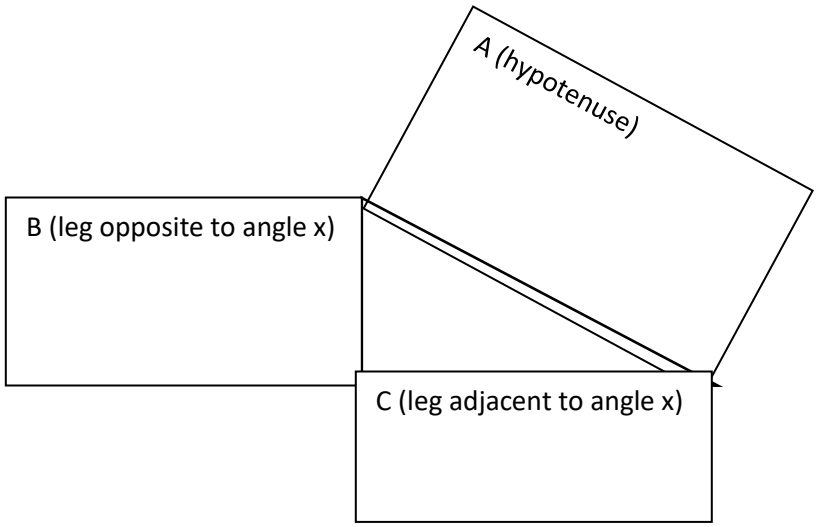
At this point, the question is to go a little further and understand how the combination of experimental or observational data and a theoretical model can be used together with a mathematical language to determine magnitudes of things that escape our senses.

The report we have today indicates that Eratosthenes knew that on June 21st the Sun was directly overhead at noon in the city of Syene, but not in the city of Alexandria. In other words, at noon, any object would not have a shadow in Syene, while in Alexandria it would (more specifically, an object one meter long would have a shadow of 12 cm). Eratosthenes knew that the distance between the two cities was approximately 800 km (using current units).

With only this data, Eratosthenes was able to estimate the radius of the Earth! This shows us another interesting aspect. Science often starts from a strangeness or a criticism of phenomena that seem very simple. Besides, what is interesting about a shadow? A shadow seems like something completely simple and uninteresting, but – as we will show – it allows us to not only indicate the shape of the Earth but also to know its radius. To understand Aretosthenes' method, we need to review some concepts of right-angled triangles.

**Right-angled triangles.**

A triangle is a flat figure, composed of three sides and three vertices. The sum of the internal angles of a triangle is always 180º. A right-angled triangle is a specific type of triangle in which one of the angles is 90º, and therefore the sum of the other two angles must also be 90º.




We remember that this type of triangle has an important property, given by the Pythagorean equation:

$$A^2 = B^2 + C^2$$

Additionally, we can define the cosine, sine, and tangent of angle X.

$$sen\ x = \frac{B}{A}$$

$$cos\ cos\ x = \frac{C}{A}$$

$$tan\ tan\ x\ = \frac{B}{C}$$

**Questions**

1- What was the Hellenistic period? What happened during this time? Was there any religious or philosophical conception in Greece at that time?
2- Access the link in figure 1. What did the proponent of this flat earth model think? What were his arguments.
3- Based on the studies of right triangles and the data provided in the text, calculate the radius of the Earth.
4- What should be the distance between a city that is on the 30ºS parallel and another on the 50ºS parallel, if both cities are on the same meridian?
5- If the distance between the cities were 1200km, considering that the Sun is directly overhead in one of them, what would be the shadow of a 1 meter object on the other?

## ANNEX 2 – INITIAL QUESTIONNAIRE

PART 1

1. What is the role of Physics classes in Basic Education?
2. How can Physics teachers contribute to the education of citizens?
3. How can Physics content help in the exercise of citizenship?

PART 2

1. Is there a controversy today about the shape of the Earth?
2. What is the shape of the Earth? How do you know that this is the shape? Present all the evidence you can.
3. When you go to the beach or an open field, what is the shape of the horizon line?
4. Is this in accordance with the expected shape of the Earth? Justify.
5. There are people today who defend a different conception than yours. Tell us what this conception is.
6. What arguments do you have to refute the arguments of this other group?
7. In your opinion, why do these people defend this conception and why has this movement grown recently?

PART 3

1. Why did you decide to become a teacher?
2. Why did you specifically decide to pursue a degree in Physics (and not another subject)?
3. Where do you imagine working after you graduate? What do you imagine your career path to be like today?
4. What was your experience with Physics like in high school?
5. Did you enjoy Physics (give a score from 0 to 10 to determine how much you enjoyed it)?
6. Did you get good grades (what was your average in Physics)?
7. How many hours per week did you study Physics at home?
8. What were your main difficulties with Physics?

## ANNEX 3 – TRANSCRIPTION OF THE FLAT EARTH VS. ROUND EARTH DISCUSSION

Student 2: We know that to talk to people, to have direct communication with flat-earthers, we need to speak their language. So, we take their own arguments based on religion, which they take as a basis for the flat-earth argument, which is based on religion in a way. We took their own arguments from religion to say that the earth also has a spherical shape.

Student 7: In Isaiah, chapter 40, verse 22, “he is the one who sits above the circle of the earth.”

Student 2: Clearer than that?

Student 7: This verse, originally in Hebrew, uses the word a … which translates to dome, which literally translates to globe or circle.

Student 7: And there is also Amos chapter 9 verse 6 “God is the one who builds his chambers in the heavens and has founded his vault on the earth”

Student 2: In other words, the very argument in the Bible that you are basing yourselves on talks about the round earth. From this, we can stop joking around and move on to the real arguments. [...]

Student 2: The first argument, obviously, is our beloved gravity. Gravity, it… Bodies governed by gravity in a size like the Earth and in an age like the Earth, only have the tendency to attract everything to their center. Gravity has the tendency, due to its weight, to assume a spherical shape, so there would be no other explanation for the shape of the Earth if we consider gravity. If the Earth were flat, gravity would be at its ends and edges, which we know does not happen. So nothing is attracted to Antarctica. …. If we think of it as a disk like you said or as a square or any other shape, none of these arguments are based on the fact that gravity cannot be considered without the spherical format. We mentioned the law of universal gravitation and Keppler's second law by Newton. That all bodies have mass and are attracted in principle. In other words, with the mass of the Earth, it would obviously be spherical.

Student 7: We also have the Foucault pendulum experiment, which demonstrated that the Earth rotates around its own axis with centripetal acceleration.

Teacher: She explained that there is an experiment called the Foucault pendulum. Have you seen it? It's a pendulum that you put very high. The first time it was done in Paris at the Pantheon, you make the pendulum spin, but let's suppose that it is scratching in the sand, it forms a rosette. In the end, it will form a super complex shape. You can explain this by the non-inertial effects of the Earth's rotation. How do you explain this feat on a flat Earth?

[laughter]

Student 2: Argument 2 that we put forward, in a flat Earth model where it would obviously be flat, we would be able to see practically any object at a certain distance. Mount Everest would be visible in the flat Earth model. Only with the Earth as curvature can we explain why we cannot see it [...] it would be possible to see Mount Everest from anywhere, regardless of where we are. For example, on a spherical Earth like ours we cannot see it... A very empirical experiment is that we see the stars, even if it is a tiny point of light, we see it and it would be at an absurdly greater distance than Mount Everest or any, I don't know, the tallest building in Dubai. We could practically see them easily if the Earth were flat.

Student 3: The stars are in the dome.

Student 9: Exactly.

Estudante 3: Tu esqueceu disso.

Estudante 9: Estão grudadinhas lá. São furos no domo.

Student 2: We even calculated in the last physics test that wasn't worth a grade, we calculated the distance at which we would see a 1 meter object with the capacity of the human eye - which was 3km, in other words, a 5 m object would be an absurd distance.

Student 9: That's based on the Earth being round.

Student 2: No, that's based on trigonometry and how far the human eye can see.

[laughter]

Student 2: And the end, the lunar eclipse, right? Explain the lunar eclipse to us if the Earth isn't round.

Student 9: It's all invented by NASA.

Student 2: Oh yes, invented by NASA, something that you see right in front of your face.

Student 9: Yeah, NASA literally controls everything.

Student 3: NASA controls the dome.

Student 6: Guys, the arguments are later.

Student 3: Come on guys, let them have fun there.

Student 2: It can only be explained by the spherical Earth model where the Sun revolves around the... the Earth revolves around the Sun and the Moon revolves around the Earth.

Student 8: And the sunset...

Student 2: And the sunset too. If it weren't a spherical Earth and had two suns and a dome, we would see the sun disappearing and fading on the horizon and not setting like we do. And then there are the ships that we see on the horizon that disappear from the bottom to the top because of the curvature. And we can also measure this curvature with certain optical instruments, which has already been proven several times.

Student 3: I liked their arguments, they were worse...

Student 9: Don't clap your hands...

Student 2: And there were the great voyages too.

FLAT EARTH GROUP

Student 3: Let's start by clarifying that we are scientists here and therefore only science, only science. And some arguments that we are bringing to talk about why the Earth is not spherical.

Student 2: It is a geoid.

Student 3: Of course it is a geoid, geoid means the shape of the Earth

Student 9: [teacher's name suppressed] said that in the other class.

Student 3: First I would like to ask you that you said some things, but you did not prove anything. You did not prove that God created a round Earth, no, because God created the Earth flat, it is written in the Bible, you just don't know how to read.

Student 9: It even talks about the four corners of the Earth.

Student 3: And pumpkin, what is the shape of a pumpkin?

Student 9: dome, it's dome.

[laughter]

Student 3: Here's the dome, oh the dome. Pumpkin-shaped, dome. You never proved gravity to us, you kept talking about Kepler, who's Kepler in the bread line?

[some student showed something falling and said "cry", but it was not possible to identify who it was]

Student 9: That's density.

Student 9: Can you feel us moving now?

Student 3: You also talked about the attraction of bodies, how come my body isn't attracting itself? Where's the attraction of bodies here? There isn't, right, all bodies attract each other. We explained density, right. You have to create mathematics from beyond to explain this theory of yours. Did you know that Newton had to invent calculus just to prove that the Earth is round? And as you know from our other class that we have on Monday and Wednesday, calculus makes no sense. It's pure invention. It makes no sense. It's pure invention.

[laughter]

Student 3: Now I'd like to talk about some arguments in favor of a flat Earth, right, not just against a round Earth. And the first one is about how our vision, the horizon, proves it to us. The first one is that when we see it, right, we see that the horizon is always straight, right. No matter how much, even a friend of mine who is 2.05 m tall, I ask him "ah, so can you see the curvature?" He can't, even though he's 2 meters tall, he won't see the curve. (impossibility of seeing the curvature)

Student 9: even if he climbs to the top of the building. In other words, it has nothing to do with our height.

Student 3: there's also the super camera. What's the super camera like? Explain this one, I didn't understand

Student 5: The flat-earther's super camera is capable of seeing objects at a certain distance that if the Earth were spherical you wouldn't be able to see them. Because they would be below the line of sight.

Student 3: We also have the super famous case, right, of a priest

[laughter]

Student 9: The priest who caught a balloon, several balloons

Student 3: Just like in the movie Up

Student 9: And he left the dome and didn't come back. That's why he wasn't found, because God pulled him. Because nothing can leave the dome, except what God wants. That's also why we don't have footage of a rocket leaving the Earth, because God didn't want it to.

Student 3: Because then it would prove God, you know. If you saw the image of the person leaving...

Student 9: But the priest, since he was divine, he was pulled by God.

Student 3: And we also have Hawaii, right? There are some videos on the internet, right? You can see guys on an island in Hawaii who can see another island in Hawaii on the other side of the ocean. [possibility of seeing objects below the horizon line]

Student 9: Which, according to your calculations, round-earthers, there would be no way to see.

Student 3: So what is the most logical explanation? That there is a round earth here, right, and your vision is curving, 360º here... or that the earth is flat?

Student 9: Much simpler.

Student 3: Much simpler, much more logical.

Student 9: After all, I can't see down there. Can you see down there?

Student 3: It's impossible. Oh, what the…

Student 2: Talk about the government, talk about the government

[laughter]

Student 3: And all this information is manipulated, right? The government, NASA, Lula, communists, they control the information. Look it up, when you search on the internet, on Wikipedia, type: wikipedia.com, .com why? Because it's from the United States.

Student 9: communists.

Student 3: .org because it's an organization… .gov government, right… There's even the NASA website backwards..

Student 9: Exactly. If you type flat earth in English backwards you'll get to the NASA website. How can you prove to me that the Earth is not flat?

Student 3: It's like Xuxa's CD backwards.

Student 9: This is clearly a pact with the devil.

Student 3: We can't go back in time to see it either...

[laughter]

Student 2: That's a good argument, but not about the flat Earth.

[laughter]

Student 3: If we can't go back in time, then how can we see these stars 4 billion years ago?

Student 9: Exactly.

Student 3: Everything, right? So here we have our best argument, which is the meme about the round Earth guy who has nothing in his head and the flat Earth guy who is Chad(?). Is there any other argument that we forgot? Oh yeah, there's the other picture.

Student 9: First, the Earth, as you said...

Student 2: What does it say there? Monkey?

Student 9: No. It's because, how do you explain the existence of monkeys, there are monkeys here at UFRGS, how do you explain that if we evolved from monkeys?

Student 2: But what does that have to do with the Earth?

[laughter]

Student 9: It's all a lie.

Student 5: It has everything to do with government control.

Student 9: NASA lies to us, NASA and Lula.

Student 5: It has everything to do with information control.

Student 9: Another thing, the Earth is not flat, it's convex. And that's why the boats are going down.

Student 6: Or even relief.

Student 9: That's why we can't see Mount Everest. It's convex.

Student 9: How do you explain to me, on an Earth without gravity, the water being around the Earth. If I put water on a ping-pong ball, it will fall.

Student 2: Actually…

Student 9: Atlas, in Greek mythology…

[laughter]

Student 9: He holds up the sky. How do you explain why he holds up the sky on a round Earth? And he obviously holds up the dome that is above us.

Student 6: And another thing, another thing, the fact that it appears in different cultures, not just in Christianity, shows…

Student 9: How real it is. And in Norse mythology too, there are nine worlds. And they are all flat worlds that are stuck to the tree.

Student 3: Atlas is a pizza delivery guy.

[laughter]

Student 6: Many of the things you say about the shape of the Earth are because you look at the stars. But what's the point of looking at the stars? We want to know the shape of the Earth, we have to look at the Earth. Why aren't you talking about the Earth and are you talking about the Sun and the Moon?

Student 9: Who cares about them?

Student 6: That's complicated, huh.

Student 9: The Earth belongs to God, the other stars don't. That's why we are flat and the other stars are round.

Student 6: The director of the Planetarium, in the video, said that there is no scientific proof. So what?

Student 3: Tests are what they have in school. To pass the year.

Student 6: So what? If there is no scientific proof, what can you tell us to convince us that the Earth is not flat?

Student 7: I don't think there is anything..

Student 8: The same goes for you.

Student 6: No, we didn't say that there is no proof. We're saying that there is proof in the Bible.

Student 8: Oh yeah, the Bible is science.

Student 9: You said that there is no proof. So how are you going to prove anything if there is no proof?

Student: Who said that science exists?

[laughter]

Student 6: I think the last thing here is the issue of Newton's Laws, Keppler's Laws. They are laws, they are things imposed on us. You can't say that it was discovered, it was imposed on us. It was invented.

Teacher: Just one question to finish. Why do you think people adhere to... there are people who may have bad intentions and propose this and such wanting to deceive, have power, or make money. But why do you think there are people who adhere to these discourses?

Student 8: Identitarianism, ignorance,

Student 2: Lack of information

Student 6: I think it's easier to believe

Teacher: Easier than scientific information?

Student 6: Yeah

Student 9: I think they're very bored, so it's a lack of...

Student 2: They could be socially excluded people who find a niche in which they fit in.

Student 3: I mentioned it in my work, right, like, I think, I put the phrase I saw in the documentary, right, that they... people are not flat-earthers because they believe in the flat earth. They are flat-earthers because if the flat earth is true, the other things they believe will be too. So, the other things they believe, like, in a literal interpretation of the bible, in a government conspiracy, all things will be true. So, like, the flat earth is just a... a step to prove their other beliefs.

Teacher: Yes.

Student 7: Complementing what [student's name suppressed] said, this thing about proving their faith. Because normally, those who have this type of faith have a faith that is very fragile, so just by thinking that maybe what they believe is wrong, their faith will also fall. If they believe that we are not alone in the universe, like, that the universe is very, very big, then by thinking about that, they will..., their faith may end up falling because it will fall. Everything they believe will fall to the ground. Like, God didn't create only us, or God has eyes for other things.

Student 2: There's no way they can believe only in the flat earth without connecting it to several other thing.

Student 8: Just like Carl Sagan, who said that a fanatic doesn't need to prove anything, he needs to believe in something. So no matter what comes his way, he'll stick to his beliefs, because otherwise he'll have no reason to live.

Student 2: At some point they'll say, "Oh, it's because I believe."

Teacher: The interesting thing is that you're bringing up issues of identity, religious issues, and social acceptance. You see, all of this is beyond science. So my question is, how can science education somehow engage in dialogue or transform this... What is the role of scientific knowledge, for example, what we have been working on - trigonometry, the history of Eratosthenes - how can this or cannot help these...

Student 14: I saw a video, now speaking of education, where some flat-earthers went to sea and put a laser below where you could see it and then they turned it on and saw that you couldn't see it. And then they were like "my god".

Student 3: Then in the video they raise the laser up to where you could see it

Student 14: And then they look and then they lower it. And you see them realizing that they are wrong. And I think that is what we have to do, not just say that someone did it. Like, we have to show and tell the person how to do it. Because, if not, the person will not believe it. Not everyone believes blindly like that, and I don't even think we should believe blindly in things. But we have to teach people to learn.

Student 2: Show the applicability of science too. Because if we could... if we based it on the concept of a flat Earth, we wouldn't be... Like, people who take, for example, international flights, they consider the theory of a spherical Earth. They calculate that the world has to curve in order to travel, they don't consider a flat Earth. So only this kind of thing, for example, of lighthouses being built in much higher places, because they consider the curvature of the Earth. So these are practical elements that the government and certain companies accept because imagine if, I don't know, Elon Musk considers the Earth to be flat to launch a rocket.

Teacher: That's interesting, right... so just to wrap up today, right? Scientific knowledge doesn't exhaust the problem, it will touch on a series of other issues. But it is a path that we have to problematize this. [...] And maybe there will be groups that we will never convince, but there is a considerable portion of the population that will soon see an argument and be convinced, "Oh, the horizon really is flat." So, first, I think, we have to reach this portion of the population that is not ill-intentioned and that is open to dialogue. And I think the second point is this, to create these spaces, as you said, to stop having this emptiness, right, that happened on the internet, right. We need to occupy spaces at school, on the internet, to talk about this kind of thing.

Student 3: Talking to your cousin at Christmas dinner...

Student 6: I think it is very important that we start to worry about explaining what science is, because otherwise people will think it is just a religion, that we believe in anything. But I think we should focus more on saying "oh, we have these parameters here; we are following a logical order of things to try to arrive at an answer, to try to find a model that can make predictions about the future".

Teacher: Yes, the area of science education is doing well in that direction. Teaching not only the concepts, but also how science works, why it is important and so on.

# ANNEX 4 – TRANSCRIPT OF FINAL DISCUSSION

Teacher: And the first question, which is perhaps one of the most fundamental questions that will accompany your entire career, is: why do we teach physics? This is what will determine the methods we use. If I have a certain vision of teaching, I will choose the methods that will achieve that objective. If I have another pedagogical proposal, I will have other methods. So, in my opinion, the most important thing, and we always have to ask ourselves this, is why are we teaching physics. So the first thing I wanted to hear is, in light of these discussions that we have been having, for you, for the pairs, what did the pairs arrive at: How important is Physics Teaching in Basic Education? [...] And I will add one more question: did you already have this perspective before? Was this how you taught physics in school, wasn't it... is it different from the teaching that you had, what we are discussing, or not? So, what was your experience like at school and, given what we're discussing, what do you think is good and what needs to be different when you become physics teachers?

Student 4: Regarding the question of how physics was taught to me, I think it was a more traditional teaching, we didn't necessarily deal with scientific arguments or issues to counter anti-science. But in the text's argument, I think that we bring these concepts, in this case, the purpose of teaching physics for me would be to make people understand how the world they inhabit works, how things happen around us so that you can have an insight, for example, so that you can understand the relationships between phenomena, or even between people. I think that having this curiosity, or awakening this curiosity for me, in people, would be the purpose of physics, right? And trying to use these tools to discover more and more aspects, no matter how distant or small they may be, to be able to learn more. I think that's the core of physics, trying to learn more and more about the world we live in.

Student 2: My physics education, because we had a lot of content in a very short time, ended up being very traditional, it was calculus, there wasn't much explanation of its applicability. Although physics is an explanation of the physical world, it was kind of like a drawing on paper. The teacher didn't talk much beyond that problem there, he didn't show its applicability in other places, or the replication of that problem in other places, or where that technology was attributed, or anything like that. And I came to the conclusion, with [student's name suppressed], we have the same argument that when teaching physics, if you understand its core, if you see its applicability in the world, in the technology where we live, you have greater confidence in the scientific methodology and the scientific methodology is there in all sciences. So, understanding this, you develop a greater critical sense for pseudosciences and that was kind of the conclusion we reached.

Student 12: The physics I studied in high school and elementary school was very good, it was only in the last year that we chose to study more things that would be on the entrance exam, so it was boring for me, there was a lot of content and, yeah, we couldn't see much. But the teacher gave us the option, right, of either studying what would be on the entrance exam or studying the concepts of physics and things that we could apply in our daily lives. We ended up in the worst side. Which is what we needed most. And then, I think that [student's name suppressed] and I see physics as a gateway to creating critical thinking in human beings, and that's basically what he said, that's what we wrote. That people use physics, it stimulates them to think, and understand things and that can be applied to all areas of life.

Student 6: We... basically everyone has already said... I think everyone kind of agrees with this, with the idea that we have to make an effort so that students don't see science as something abstract, but rather as a way of describing the world around them, and this is something that we should worry a little more about, perhaps, and this is an important point.

Student 1: I mentioned to [student's name suppressed] that in my high school, and also in elementary school, we had the science fair, but it was for the students there, right? If this science fair were open, could be expanded to the population, right, how interesting that would be..

Student 2: Just to comment on the science fair, on my campus there was a fair called Amostec, which was the campus science fair, and people from other campuses would come and do projects there, but it was very difficult to see physics-related things there. Basically, since the focus on my campus was either computer science or mechatronics, it was either that or the humanities. So I don't think I ever saw a physics project or one about physics.

Student 3: I think... In my high school, I think it was different because we saw things a little more experimentally, you know, we had a lot of classes with chalkboards, boards and pens, but we ended up having to do some experiments like that, for example, calculating ourselves with a little ball and everything, calculating what the value of gravity was, for example, and that kind of thing, so I think that was always more interesting. Not only for all the reasons already mentioned, but also because I think students lose interest if all they do is sit in a chair and watch a board being written on during the whole class. So, it was a break from the norm that was really good because we talked, we worked in groups, we discussed, we did the experiment as a group and it was much more fun, you know.

Student 7: In my high school, there were these very experimental things like that, but it was the teachers who tried to motivate the students, but the students weren't very interested either. We could do the OBA, we had the MobFog where we made a rocket to launch, we went to Ulbra to launch it, we also had our science exhibition where we could choose the theme since it was the last year of high school, so people did more about other things, but my friends and I did about James Webb, we did about string theory, things like that too. It was really cool. I think that at my school, at least, I think it was due to the students' lack of interest, because the teachers tried to push more scientific things on us.

Teacher: And why did you think there was this lack of interest? This is something you'll face all the time, right? The lack of interest. You'll get to class and the students... why does this happen? How do you deal with it?

Student 7: I think it's because of a stigma that exists about physics, because it's a very difficult subject, because it's hard to understand, and then when people have this idea in their heads, it really becomes harder for them to understand and try to get interested in these things. So... then it was in their heads, like, "oh no, I don't understand anything about physics, it's boring and I don't know what", but no, they kind of didn't give them a chance to try to open their minds a little and start getting interested in the subject.

Student 10: At least I studied physics at a state school, so the first year I was able to study with a teacher who studied mathematics, who had a degree in mathematics, and the second and third years were through distance learning, so it was difficult because our distance learning teacher, who had a degree in physics, didn't even know how to share the screen. So he would send us a PDF and talk about it, you know, so it was very boring and tedious. And we came to a conclusion, which is like [student's name suppressed] also said, like, we have to show a lot more experiments and everything so that the students can understand, but we also came to a conclusion that we have to show the student how to research, because many of the sources nowadays are TikTok, Wikipedia, and they are not reliable sources, you know...

Teacher: Yeah, interesting... I think you touch on some very good points, like. First, look, the things you are mentioning are things that the area has been discussing for a long time. First: a need for a methodological change, not just the lecture. But that is included in the assessment. It's no use now, I'm going to teach a bunch of active methods and then when the time comes, the test is the traditional test. A change in conception is necessary, right? Another proposal for Physics Teaching. What you are bringing up: I want my students to be able to interpret the world better, so our assessment has to say: are my students interpreting the world better? And the test can help with that. The test gives you a diagnosis of some things, but not only that, right. There are many other processes. And here comes an important point that you also touched on, which is what we have been working on here. We have gone through a revolution in the way we communicate in the world, especially after the pandemic. The material that people consume, where they look for sources, has changed drastically. And so I

ask, what is the role of physics teaching in this new scenario? What can we do as teachers to prepare students to move in this world full of information? Does it change anything?

Does it change anything in relation to the methodologies we already used? Because, for example, experimentation, I think it's great, it works, we're going to work a lot with experiments here in the discipline, but does it help in this aspect too or not? And if not, what else do we have to do?

Student 4: I think so, I see that in a way the internet helps in some aspects, especially because we have several channels that are about physics and deal with these subjects. So part of our initiative is to increasingly spread this content, thus, to also use this medium as a way to spread knowledge, let's say, in the correct way.

Teacher: You say, occupy these informal spaces, right? But what about inside the classroom? Because what you're bringing up, in the literature, is what we call informal spaces, you'll even have an internship that is the internship in informal spaces that can be, for example, in a museum, it can be in extension activities, it can be on the internet, but all of this, is part of education too. But what about in our class? What can we do? I don't know, that's an open question, there's no definitive answer.

Student 3: I think that, like, there are many times when we can try to integrate these things that we, right, these technologies and everything, like, more in the classroom, because, for example, many times when teachers use technology, right, it's just to, like, put on a boring PowerPoint presentation to watch or when the teacher doesn't want to teach, right, and puts on a movie for the students to watch, you know, so, like, there's a lot of that, right. So, like, integrate in a really consistent way, like how can I, for example, there are many websites, if you are teaching, right, to a very young class, like, to a very beginner class, about the solar system, it will be much better if, like, you have, there are several simulation programs, for example, right, or that kind of thing, if you, right, because it is much easier if you can see, and there are several programs for simulating space, from inside the earth, those things, right, which I think helps a lot in teaching.

Student 2: I think that like, for physics, for us to get interested in physics we have to instigate the student's curiosity. Like, make them curious about how it works and from there apply physics. But instigating someone's curiosity is very difficult. Like, in general, in a classroom, with so many students with so many different personalities. Maybe he's not curious to see how, I don't know, the light bulb works, so [name of university professor suppressed] said: oh, what motivated me to choose physics - which for him was mainly the curiosity to know how the world works. And for someone to like physics and be interested in it, we have to instigate curiosity. Maybe a method for that..., I can't think of a specific thing.

Student 3: I think that when you take a child, for example, 6, 7 years old, all they do is ask "why and why and why", you know, you don't need to instigate their curiosity. I think that, like, what happens is that over time, you know, what happens is that the child keeps asking "why does this happen, why does this happen" and the teachers and adults and parents too, right? They won't answer all these whys and the child becomes unmotivated to ask. If we had the motivation of the teachers, why does this happen? If someone was there really helping her understand, making her want to keep asking herself, I wonder if, like, she wouldn't continue with this "why why why" until she's older, you know?

Student 2: But like, this isn't a question of "oh the teacher influences this", it's kind of the parents' upbringing to instigate the child's curiosity from the beginning, but it starts at school.

Student 3: But I think it happens at school too, right? Like, the student comes there and asks "why why why" and the teacher says "no, we're not going to discuss this now because it's math class and shut up" you know?

Student 4: But that's a point I was going to bring up, because, for example, in a school environment, maybe this child has this curiosity, but he or she also can't take up the entire space, let's say, of the

classroom with his or her curiosity. So he or she will have to understand that he or she will also have to share the teacher's space, let's say. I think, as … said, that it's important to instigate curiosity, but I think it's also important to instigate autonomy.

Teacher: And just one question along those lines - everyone is harping on about how important it is, in the end, for people to know science or be curious about science, but why would that be important for society in general? Just so we can close the argument like this... why do we value... because it could be like this, right, I like science, but not everyone is obliged to like science, there are people who like anything and I don't like it, and why would it be important for everyone who leaves school to like and understand a little bit about science?

Student 3: I think that, like, when we think about science, we're thinking a lot about the exact sciences, right? But I think that when we, like, learn how to investigate a physics problem, how to reach some result in physics, we're also learning, right? Or teaching is teaching, right? How to reach some truth for any field, you know, even for the social sciences and the human sciences, you know. So when we teach a child how to discover the shape of the earth, we're, like, indirectly, helping them to also be able to think about how to vote or how to act in society or how to do all these things. It's not just literally the exact sciences, so I think that, like, there's a lot of that. Even outside of the exact sciences, when you learn, you can also apply it to other sciences.

Teacher: What could be taken from this discussion that we had to this larger field, for example?

Student 3: I think that, for example, the biggest discussion we had was about how to find a reliable source, how to get reliable results and everything else, which also includes the whole fake news and politics thing and everything else.

Student 2: I believe that, for example, what makes science advance would be the creation of laws to encourage science, or encourage education, funding for people to be able to work with science. When you have people who pay taxes who know about science, who value science, they demand that the government invest more in science and also these people, if a society has knowledge of science, the government is a reflection of that society and will have this consensus that investment in science is necessary for us to evolve as a society. For us to discover, I don't know... how to stop global warming, it will be through investment and this investment will be given by people who are aware that science is important and I think that in the end this is the cycle.

Student 4: I think that, complementing what you said, it's about solving society's own problems, right? Because, whether you like it or not, you're going to have people there who have all the scientific basis to find various problems and end up, through these investments, solving them.

Student 2: If we don't have a government that values science, we can't have funds and work with science. And we can put government officials who know science, making more people have knowledge of science and vote for people who know they'll invest in science. [...] like investing in education and education is the basis for science.

Student 5: I think that science... we're driven by science, our whole lives. Everything around us is science. As he said... And the ways in which we can understand how to improve this. Environment, health, knowledge, so all of this is science itself.

Teacher: Okay, and one last question just to wrap up: Would greater investment in science necessarily imply a better society? Or could it be that more science could reinforce even more social inequalities?

Student 4: It depends on where you point this science. Because if you give all this knowledge to elite people, for example…

Student 3: Like artificial intelligence. Like, artificial intelligence isn't helping anyone. It's just taking people's jobs, you know?.

Teacher: Okay. Does anyone have a counter-point... does anyone have a different view? No? So, we are pointing out that science is important, right, but what precautions would need to be taken within what you are proposing? In addition to investing in science, what would be necessary in this social model that you are proposing?

Student 12: It has to reach everyone, that is the biggest difficulty. It is being able to reach all people from all social classes, so that everyone has the same level of knowledge, the same desire to change, the same... you know? I don't mean the same worldview, but the same... but that everyone has access. I think this part is the most difficult, so that only then can it be developed in a more balanced way.

Student 4: I have a good example on this issue, because in my opinion it is a very difficult issue to balance, let's say, whether more science means a good thing or a bad thing. There was a physicist at the time of the First World War, who was the first to isolate hydrogen, if I'm not mistaken... and... nitrogen, sorry. And this component was very important for you to be able to use it as fertilizer. So, during the First World War, Germany had large factories to isolate nitrogen for agribusiness, so to speak. However, this physicist, because he was also a patriotic person for his country, decided to use this knowledge, these advances, for example, to build weapons capacity in Germany during the First World War. So, he used this same knowledge of isolating nitrogen to make weapons. Later, he was one of those who managed to develop mustard gas, for example. Although he was a Nobel Prize winner, he was not known by the academic community because of the use of this knowledge. So, to this day, for example, we have an influence on our agriculture, for example, due to points of his discovery, but this knowledge, just like the knowledge of the atomic bomb itself, has to be used with great care. Student 6: I think that the Second World War is a good example of this, too, that in the concentration camps they were doing science in a certain way, but...what happened, happened.

Student 4: Yeah, right, the medical experiments.

Student 3: It's just like there's a huge poster right in front of the campus, now, with the cancellation of the quotas, you know, of the people who were with the... the temporary thing [temporary enrollment] that says: "without the people on campus, what kind of knowledge can be created?" you know... there's that too, literally right here in front, you know. So, like, if the only people who stay here are rich people, what kind of knowledge are we going to be bringing, you know?