

## How Big is Earth

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### Description:

Using only the sunlight striking the Earth and a wooden dowel, students measured the circumference of the Earth. Eratosthenes did it over 2,000 years ago. In *Cosmos*, Carl Sagan shared the process by which Eratosthenes measured the angle of the shadow cast at local noon when sunlight strikes a stick positioned perpendicular to the grounds at two different North-South geographic locations. By comparing his measurement to another made a distance away, Eratosthenes was able to calculate the circumference of the earth.

We provided an online learning environment where students were able to do science the same way Eratosthenes did. A notable earlier project in which this was done was The Eratosthenes Project, conducted in 2005 as part of the World Year of Physics; in fact, we used elements of the teacher's guide (<http://www.physics2005.org/projects/eratosthenes/TeachersGuide.pdf>) developed by that project. The difference between that activity and How Big Is Earth? Is the online learning environment provided by the iCollaboratory where teachers and students collaborate, share data, and reflect on their learning of science and astronomy. We collected data on student learning from surveys pre and post activity. We had hoped that students in each school would collaborate with students around the world. Unfortunately this did not occur.

The poster I created for the my poster session at IAU 2015 in Hawaii can be found here:

The poster contains a list of activities, support materials and images of students.

### Results:

We were only able to collect fragmentary data from four schools because teachers who said, "Yes, they would participate in the project," did not realize that it was a "real learning project" that lasted two months. The students from Morocco, Sweden, and USA took measurements on cloudy days. Out of 68 enrolled students, only 10 students finished the project and that was because I really nagged the teacher to complete it.

I discovered that there are lots of Eratosthenes projects online. Most of them are designed to collect angles and lengths and compare measurements. Ideas for teachers to use are posted in these projects but they are not set up for student discussion of ideas and sharing.

The Pre-Activity Survey provides some insight on how well prepared in basic geographic, mathematical and scientific content the students were. It is interesting

that most students knew who Eratosthenes was and where he lived but only 20% of the students knew after watching the Cosmos video that Eratosthenes had calculated the Earth's circumference within 5% accuracy.

The data shows how many misconceptions of basic ideas these middle school students have. 29 out of 40 students correctly described a ratio; 25 out of 40 students correctly defined a kilometer; and 27 out of 40 students knew that 360 degrees is the number of degrees in a circle. However, what these researchers found disturbing was that 49% did not know what a circumference is. This was equally distributed across all the four schools. Although 74% knew what a ratio was only 45% knew how to solve the ratio problem.

By the end of fifth grade students should know the difference between latitude and longitude. However, in our survey, only 37.5% knew what longitude was and 30% knew what latitude was. 25% of the students mixed up latitude with longitude.

This lack of basic knowledge by so many of our middle school participants makes analysis of the Project problematic. The final survey contained the data for the two students who responded to the post activity survey. Although there is one wrong answer for the circumference of the earth, without knowing what these students responded in the pre activity survey does not allow us to determine if, even on a small scale, doing the project had an impact on students' content knowledge and science understanding.

Three students completed the survey of attitudes toward science post activity. Overall there is a positive science attitude but without having the data prior to the activity we cannot say for certain these attitudes toward science are a result of these students doing the How Big Is the Earth Activity.

We would like to comment on that fact true to form a small number of students responded with characteristic middle school humor. The four students who responded that a ratio is the amount of pie and ice cream you can eat in a day are not really all that wrong just totally out of context. We would like to meet the student who responded that a kilometer is a centipede with 100 legs. This student is truly gifted with a great sense of humor.

Considerations for the Future:

We think we need to get a firmer commitment from teachers that they will follow through and do the activity they signed up to do with their students. Granted that we had the date that many students were not in school, that does not excuse teachers from their commitments. We are unsure how to remedy this in the future. Perhaps we could have much more monitoring and conversations online between the researchers and teachers as the project proceeded.

The other important finding from our limited data is that many students were not prepared and had major misconceptions of the basic scientific, geographic and mathematical concepts that should have been mastered by middle school students.

In the future, the researchers should have shared with the teachers the results of the pre activity survey and asked them to “re-teach” some of the necessary content students MUST have in order to develop deeper understandings from using Eratosthenes’ method of measuring the circumference of the earth.