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Time, Distance and Modern Technology in the Measurement of the Heavens

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The sky and the heavens have always been the subject of poetry, mythology, science and wonderment. People of all ages and all cultures have looked at the heavens and wondered about creation and the nature of things around us. Students at Vincent E. Mauro Elementary School are excited to participate in the inquiry of scientific discoveries in the heavens. This is a great opportunity for us to start an exploration of the heavens, and to incorporate the information of the seminar to fit the curriculum needs of the fifth grade. Language, math, science, art, and social studies are incorporated in a multidisciplinary approach addressing the needs of the student by aligning the material to the curriculum standards of the school and the district. Breakthroughs in modern technology have allowed us to have new vistas into the Universe by providing the tools, the methods and devices to measure the movements, relative distances and specific physical characteristics and composition of celestial bodies around us. Our intent in this curriculum unit is to bring this information into the classroom, explore the material with the students using models and manipulatives, and instill in them the need and want of scientific inquiry and an awareness of who we are as human beings in this wonderful Universe.

This seminar is of interest to us because it presents a variety of challenges for the student, the teacher and the administrator. It really demands a collective effort and the support of the administrator for us to embark on projects meaningful for the student. These challenges are encountered in the classroom and outside the classroom situations. For us, at Vincent E. Mauro, a challenge means an opportunity for all to enter into the path of learning. Let's think, for example, of the physical environment of the school when we plan to create a Solar System using manageable scales. Let's think of the challenge it represents to think, plan, design and execute a job of these dimensions at the school grounds. Students have to have a very clear idea and visualization of a model of the Solar System. The Solar System is a relatively large place, but it is very empty. Teachers have to develop a method or series of methods to facilitate the learning of the student. We have to be resourceful and inventive. The administrators have to be able to open up the space, provide resources, time and support for both students and teachers. A model of the Solar System to scale is not a little thing to toy with for a fifth grader. Neither it is for an administrator. Therefore, we have to devise ways to accommodate the learning styles of the students, and to keep a level of comfort with all the people in the building. Astronomy is basically a science of observation. Students have been observing models of the Solar System that do not really represent the true dimensions and relative distances of the celestial bodies that are part of it. New models will have to be proposed and built up in order for the student to dispel the traditional models. The problem of scaling the heavens become more acute when we talk about galaxies and other celestial bodies separated by extreme distances and time.

We have a set of curriculum objectives and some strategies to implement these objectives. The seminar, “Outstanding Problems in Contemporary Astronomy and Cosmology.” has afforded us the opportunity to reinforce the scientific method as a tool of investigation, scientific inquiry and discovery. Language, mathematics, art, social studies and science will be integrated in an effort to bring Astronomy and Cosmology to fruition in the classroom. Students will be able to conduct research in their field of interest and reinforce this scholarship with the construction of models. These models will be a bit different than the conventional models by the fact that they will be made to scale. We will concentrate in our home environment: the Earth, the Moon, the rest of the planets, our Galaxy, but we will visit and revisit the vast array of fascinating information about other worlds and creations in the Universe. Students will nurture cooperative and team teaching-learning. Dialogue about Astronomy will be established in the school at different levels: students with students, teachers with teachers and students, and the administration with everyone else. This is also a great opportunity to bring to practice applications of measurement of space and time with scientific notation with all the new array of information opened in the last few years by modern technology. We will use pre-algebra materials and applications, estimation of astronomical distances and numbers, and the realization that waves, now-a-days, allow us to make reliable calculations of the heavens [1]. Finally we will implement these objectives with strategies suitable to the school environment and resources.

One of these strategies is the conceptualization and the construction of manageable astronomical models. Another is the binding of language, math and science together when we apply a hands-on procedure to the inquiry method. This is to say that students in the classroom and outside of the classroom become critical thinkers, always going one step further with a fervor for discovery and scientific inquiry. The scientific method is a guide to answering questions postulated in this path of discovery. In this context, teachers and students have to keep on formulating question such as:

What would happen if . . . ? Are these the same . . . ?

How are they different. .?

Could we try this way, or that way . . . ?

Have you noticed . . . ?

How many . . . ?

Why do you think . . . ?

Soon, students find themselves creating charts and tables and models full with legends and exciting information. Our inquisitive nature is set free. This strategy allows students to find a “natural” path to tackle a problem. Groups are formed. Teams are tested and the variety of talents and dispositions come to surface with very surprising results. We enjoy watching and helping in these negotiations. Victor Leger, the art teacher of the school, and I have tested this process. Students participated in this type of set up throughout the duration of the seminar during the school year. They built teams of the Milky Way Galaxy, The Planetary System, Tenochtitlan and the Stars, Butterflies—all projects stemming out of the Astronomy seminar. Each student put out his or her best. They enjoyed working together, video taping, recording, writing, drawing, and reading their work. They learn a myriad of skills, techniques, tricks, styles, and more important of all, they learn how to learn. They learn to stop and reflect on their own mental and physiological processes to be able to construct and re-construct, and in their own way—in the best way possible for them. In this process, arduous sometimes, but extremely rewarding most of the time, we utilize language, and impart the necessary tools for its materialization without losing track of our intent. [2]

This is why the "they" that we just mentioned should be a "we." Students, teachers and whatever support group that we might have in the classroom, learn together in a community of learners. In other words, the teachers have to show and model and get involved in an active way to bring into the classroom the needed atmosphere for learning to take place. "We learn how to learn together; and we learn to learn reflecting on ourselves." This is a truth that sometimes we don't want to reveal. We are not even aware of it most of the time. A realization of this truth brings wonders to the classroom. Students feel more confident because they contribute just like any one else in the class. They feel the truth in our eyes and thus they learn that it is fine not to know everything. Nothing is farfetched. They are free to think and act. Many times pictures and charts will lead the way for the beginning of the construction of models of celestial objects and related material that will help us visualize better vistas of the Universe. Models also get people together. Models require the efforts and the involvement of volunteers and students from other classrooms. Students cannot help themselves, but lend a hand right there, where is most needed. Soon we find that everyone wants to help to build the Sun. Students and teachers want to know how we did it. They want to be part of the planets and galaxies. It is important to genuinely empower the students; they take possession of their toil—there is ownership. All this is possible when students have access to the media center to find materials and research on a given theme. It is equally important to have teachers prepared with guidance and information. Our library media center specialist, Ms. Castiglione, has been able to meet the needs of the students without hesitation. Encouraging as this is, the New Haven Public Library became the next comfortable environment to continue in their learning trek.

Now, when we are dealing with a subject like Astronomy students of the fifth grade get really excited since the mysteries of the heavens are so fascinating to everybody's eyes. The language of Astronomy is very exciting also. Let's think for example of objects (language) such as supernovas, quasars, black holes, asteroids, shooting stars, meteors and meteoroids, galaxies, planets and rings, moons, chunks of ice, nebulas and many other sounds and concepts that get the student automatically hooked on learning. Go one step further and bring into the classroom a film, a scientific film on black holes, for example, and see what would happen to your fifth grade class [3] Students get into the subject matter very easily like this. The next step is to build the mathematical foundation to handle astronomical numbers. In order for us to understand a black hole, as much as we could, we have to understand the magnitude of the task. When there is interest students demonstrate an affinity to numbers. Number sense is a challenge for a fifth grader; astronomical numbers are a challenge for all of us. Under these circumstances, it is imperative to devise some kind of hands-on activity that would facilitate the conceptualization of great distances, speeds and long periods of time. We used strings and color yarn. We stretched the yarn in the classroom, in the hallways, outside of the building in the playground and all around the school. Field trips are also a good idea. When we start measuring long distances, time comes automatically into the picture. It takes light one second to travel 300,000 kilometers. It takes Sun light about 8 minutes to reach the Earth. From here on we tie up the four dimensions necessary to travel anywhere in space to these places of wonderment. No place can be visited without the consideration of time.

We have to use illustrations and examples to make the student grasp a Universe of four dimensions. The example of a balloon with the three dimensions collapsed into two on the surface and time expanding in the interior of the balloon catches their imagination. This is a Universe with no center; an expanding Universe where the most distant bodies, quasars, and some galaxies, are expanding faster than the ones closest to us. [4] The farther they are, the younger the Universe is. We are watching the beginning of the formation of these bodies billions of years back. In accordance with the *Doppler effect* , motion of a source of light, a star, a galaxy, "is relative to the observer and causes its spectrum to be shifted toward the red (going away) or toward the blue (coming towards) end of the spectrum." [5]

In this expanding Universe we need to consider time for whatever activity we choose to pursue. A complexity is rendered in the classroom and we could make it work to our advantage. These new visualizations and discoveries of the environment around us lend themselves to a myriad of commentary. Language and math are the most logical channels. It is important to keep in mind, all along our project, that the activities in the classroom and in the school have to align with the curriculum guides of the New Haven Public School System. Issues of language math and science have to meet the standards on a local, state and national levels. [6] For instance, let's take the problem of the conceptualization of time and space to a configuration of four dimensions. The curriculum and the standards of science and mathematics are being addressed here. The objectives of the Connecticut Mastery Test are addressed also. The most obvious objectives are estimation, rounding, geometry and measurement. Hands-on tasks measured and assessed by task assessment lists are also indicators of alignment with curricula. Moreover, many of the mathematical problems are open-ended questions requiring of the student some measure of reflection, critical thinking, problem solving and writing. Many times the "answers" are not important, but the process in which we have engaged ourselves to find solutions is the answer. [7]

Students get engaged in meaningful tasks, and are assessed based on the instructional material presented in the classroom. For this they have to become communicators and understand their role as communicators. They have to be able to make observations and to read supporting materials. They have to learn how to take notes in a clear and organized manner. Research, or rather, the spirit of research, is akin to growth and sacrifice. Students have to develop a sense of what material or lead is pertinent to follow in their research. Many times we all have to sacrifice material in the name of balance and clarity of our work. We show the students that many times in our work "less is more."

We have referred to waves as a means of communication and of arriving at answers to vexing questions about the Cosmos. The waves used to gather information and to gain knowledge on the Universe are a metaphor of how we could actually travel in the Universe and have it at our reach. As far as we know today, it is practically impossible for us to travel outside of our Solar System towards our neighboring stars. They are too far away, and really, there is no point in going too far away trying to find information that could be found by means of waves. It is known that the next star is about 3 light years away from the Earth. Then, we would need at least 6 years to go and come back to tell the story. This is at the speed of light. [8] According to the theory of relativity theory, it would take a tremendous amount of energy to accelerate our spacecraft to the speed of light. Let's remember also that some astronauts who have ventured into the heavens in the name of science, have come back not feeling their best; decalcification takes place after 200 days of flight. I imagine there would be little to do out there in space during those long and marvelous days (years) of decalcification. Modern technology has opened for us the way through the Universe. Not too long ago, scientists were still arguing about life on Venus and Mars. Today we could actually visit far away places that would defy the imagination by means of waves. Waves are one of the ways to travel in space, and a fast and reliable way to gather data about the cosmos. This piece of information alone has helped to raise questions about set conceptions and ideas about the Universe in our students of the fifth grade. They are really discovering the world. They are excited and curious to know more about the Earth, the other planets and the Solar System. Students are fascinated with their new discoveries in textbooks in different libraries. They are becoming a community of independent learners and teachers. Indeed, these students have taken one step forward to teach each other about their discoveries. One of the most immediate results of this attitude is that the word gets around and students from different grades and teachers from different grades are coming forward wanting to participate and to be part of this community of learners. In reality, they are very curious to find out more about the things that kids are talking about in the lunch room, in the bus or at home.

Furthermore, this kind of resource and information has helped to dispel a cloud of misconceptions about the worlds beyond the Solar System. We must keep in mind that we cannot travel for too long in a spaceship out of the Earth. We don't have any indication that there is some intelligent civilization in the group of the local stars. The local galaxies are just too far away to think about traveling there. All this brings to mind the unique and solitary position that we are in our Solar System, and, perhaps, even beyond it. Everything is just too far away from us. It also reveals the astonishing fact that aliens cannot be around on Earth, and clarifies a culture of fiction and opportunism that feeds on the fears and fantasies of people. [9] The way things are in the present day, science just cannot unlock the door for traveling great distances at great speeds. We could travel far, very far with waves. We could reach billions of years into the Universe and find through waves fascinating worlds of rays, atoms, stars, galaxies and quasars. We don't need to spend resources in vain to no end or benefit. "Virtually everything astronomers have learned about the Universe beyond Earth depends on the information contained in the electromagnetic radiation that has traveled to Earth." [10] Modern technology has the machines and equipment to gather, read, interpret, map and organize this information coming from the heavens.

One of the most important features of the application of the materials of the seminar in the school environment is the work done in teams of teachers and students. Teachers model team work for the students. In fact, we started to work together at different levels right from the beginning of the school year. We used structures, already in place, developed in previous years by teachers and administrators for the implementation of the standards and the objectives of the curriculum. One of these structures is the Council of Science and Mathematics. Through this Council, teachers, the community, parents and administrators, together, decide about ways to integrate the curriculum and to work together in teams, supporting and motivating each other. The Council also organized all aspects of our science fair. New teachers coming to Mauro find these structures encouraging and adapt to them very conformably. Mr. Leger, for instance, worked with the fifth grade bilingual class in a project on the Solar System. We work in our classroom the mathematical calculations, language and history of the problem. We applied the objectives that we set out in the beginning of this curriculum unit. We formed teams of teachers and students; we started integrating the curriculum applying mathematical models whereby students would have the opportunity to grasp the content and the concepts through the visualization of models. Another very important structure is the organization of the media center, and the help and guidance of our media center specialist. Workshops for teachers, parents and administrators have also been very beneficial for all the people involved. Many times teams of teachers got together to give workshop on science for parents. Other times teachers trained teachers.

The results are always positive, and the information and attitudes always filter down to the classroom. It is clear that regardless of the audience, the use of manipulatives with the recording of information through experimentation and observation, are tools of discovery and learning. Inevitably, writing always comes into the picture, and students teachers or parents get engaged in a complex, but rewarding process of inquiry. In this vain of thought, the first model that we constructed was a model of a total lunar eclipse. This was before we started the model of the Solar System with Mr. Leger and the help of the media center specialist. The materials were simple and the procedure was an imitation of the movement of the Moon in front of the Sun. We used a blackboard, a flashlight an orange and a large marble. The results were dramatic. Students got hooked on Astronomy. The idea is very simple. We flashed the "Sun" (light) on "Earth" (orange). In front of the

Earth was the “Moon” (marble). The room was completely dark. We made sure that all little bits of light got eliminated from the classroom. Students were a little bit scare and noisy, but it was fun. The umbra and the penumbra were projected on the board, and, as we rotated the Moon around the Earth, the shadow of the Moon disappeared as the Earth blocked the light coming from the Sun. Students understood this simple exercise and wanted to do more of this neat stuff. All of them got a chance to test it and try it.

TOTAL LUNAR ECLIPSE

(figure available in print form)

Another of the models that we devised to instill the concepts necessary to grasp the physical aspect of the Solar System was a model to scale. The Sun is about 4 meter in diameter, and the planets are scaled accordingly, the distances of the planets to the Sun are scaled and it extends to about 16.5 kilometers from the Sun to Pluto (see table below). Students worked in two different classes to achieve their objectives. They worked building the model itself in the art class. They did the math, the language and the organization in the regular class. Later on, as the project began to take form, and students felt very confident, the math and the language was developed and produced everywhere. Students used extra time after school with teachers to set the display up, hanging from the ceiling in from of the main office of the school. This kind of display has snowballed. Now teachers who usually keep to themselves are coming out asking questions about the work in progress. Students of all levels pass by this Solar System looking in complete wonderment. Other teachers want to have students presentations in their classrooms. We have done this. We have gone to other classes to share information about the Solar System and about “our” Solar System. We have found that students in other classes are ready to listen and to ask questions of great value. Teachers want to have a follow-up of the first presentation. Students feel very important and are more motivated to pursue further research. Also the Solar System looks overpowering and beautiful. Students realized that this particular scale was sort of hard to keep in its place. So they devised other scales that would be more manageable. We came up with a scale where the Solar System will be 300 meter in length. This was done outside of the school. in the gardens. Pluto in this scale was no bigger than a tip of a needle (.15 mm). the Sun was 69.5 mm, and their distances 300 meters.

Distance of the Planets to the Sun

(Kilometers)

(figure available in print form)

Using this scale of the Solar System we could have a very clear idea of the emptiness of it. Let’s remember that the Sun has .004 kilometer in diameter on this scale.

For a more manageable scale of the Solar System we have used in the classroom the scale 20,000 kilometers = 1mm. This is what we get for the Solar System.

Distance of the Planets to the Sun and Diameters

(Scale: 20,000 Km. = 1 mm)

(figure available in print form)

One of the activities that will stem from this Solar System in the grounds of the school is the actual scaling of the relative distances of the planets to the Sun. If the Sun is 4 meters in diameter, then, if the rest of the planets are to scale, the sizes of them, the distances to scale will cover about 16.5 kilometers. In order to accomplish this mathematical estimation we are planning a field trip where we would measure the relative distances of the planets in the Solar System and will place them at the scaled distance in relation to the Sun in our lobby in the school grounds, our 4 meter Sun. We have chosen to take Route # 63 and we figured that we might approach Naugatuck, Connecticut. Pluto will be placed 16.57 kilometers away. Mercury will be 160 meters away from the Sun in the lobby of the school.

From time immemorial humans have been looking at the sky and have created and recreated history in the language of metaphors, in the images of myths, and today, in the readings of waves and electronic icons brought to us by modern technology. At present, the ways to attain this information are based on the scientific method, and on observations and recordings from powerful optical telescopes on earth and in space. The detection and interpretation of radio waves have augmented intensely the capabilities of gaining knowledge of the Universe. We could actually measure the distance, the time that light travels in space to reach the Earth, and the material composition of the celestial object. A problem is solved when we test a hypothesis. This method is used at Vincent Mauro when we apply it for the elaboration of a science project. There is a purpose for an experiment. This purpose is closely related to a hypothesis. In order to test our hypothesis, and to go ahead with the experiment, we choose the necessary materials. Once this is accomplished, we follow the pertinent steps to get some results. Graphs, data, and illustrations are elements integrated in the process of this scientific inquiry. Student are urged to make close and accurate observations. They must measure with care and discipline and be able to record the information in an organized way. All along we have been writing and interpreting the information gathered in the process. Analyzing the data meticulously, within all the limitations that are present in an experiment, is an activity where we put to work a series of skills of a multidisciplinary nature. Our conclusions are based on a careful evaluation of the steps followed in the scientific process. Technology is served in the way that we apply this knowledge derived from our conclusions of the experiment. In this type of science experiment we have used content information and process information. Students generally are encouraged to work in teams and to share information whether they work in teams or individually.

Students of the fifth grade level are fascinated by the array of possibilities and questions posed by this kind of seminar. The Universe is a source of wonderment for all, particularly for young people who are beginning to formulate some sense of the world around them. It is of utmost importance to do justice to this natural curiosity in the student by introducing material that will make them more eager to go ahead to the next step, testing and re-testing, asking and answering questions, as part of a healthy trek into knowledge. The testing of the materials in the classroom already indicates the need for an integrated effort to make the student develop the essential step between descriptive writing and research and critical writing. Students will internalize skills enabling them to integrate several disciplines into unified patterns of learning. These patterns of learning will lead into more patterns of complex thinking in a healthy spiral process. We have already taken some very simple steps into the exploration of this process in the classroom. Our interest now is with the measurement of time and space in the Universe. In order to do this we have used our senses in spite of the limitations of such method. This is not a very reliable method when we deal with phenomena that are very distant from us, making testing an impractical, and really impossible undertaken. Modern technology has given us the opportunity and challenge to explore more realistically into the heavens. For this, first, we must know how to record information. Scientific notation is an indispensable tool to begin to record information about the time and distances in space. One of our students did an experiment with astronomical numbers. She wanted to know how to write astronomical numbers in a way that would be more manageable to write and to talk about. Calculators could not hold information. These numbers were just too big for our calculators. She tested different methods until she found the way to do it through research. She found out about scientific notation. This was a wonderful moment for all. She used this procedure for a science fair project. In this case, she worked with numbers, testing them again and again, until she found solutions in her research. She read a book that gave her the idea.

Students have been watching the skies at all times of the day. They were fascinated by the presence of a comet in the northern skies. They have been keeping track of articles in the newspapers. One special treat was the lunar eclipse in the beginning of April. In that occasion we had the opportunity to demonstrate a lunar eclipse in the classroom. Students really learned by means of illustrating with manipulatives a natural phenomenon in the heavens. At night they were able to see the eclipse for themselves. They tested our little experiment in the classroom. One was the mirror of the other.

We have already measured the distances in our Solar System. We have built the planets to scale, and plan to continue focusing in our immediate reality of the heavens. There are plenty of opportunities in the sky to learn and to grow. Students are beginning to realize this fact in every step that we take into our travels in the classroom and in our backyards. In the classroom we use books, films, video tapes and experiments with light (eclipse), color, temperature and the behavior of gases, solids and liquids. The laws of the Universe are the same all over its vast space and time. At this point of the game, we don't have to visit and revisit the theory of relativity. Einstein was trying to find a path, a solution, to the behavior of matter in space when it approaches the speed of light , and the laws of matter otherwise. We have not found it yet. In the fifth grade environment, measuring the Solar System and its components has been a real challenge. Black holes are fascinating objects and students get all excited when they read and talk about them. They ask many questions about these mysterious objects. All we can do is read and find out more about this objects in books and printed materials. After all, we are people of books and readings and we have rediscovered that the sky is one of the most prolific texts of all. Its pages are interminable and they are for free for anyone who ventures into the awesome and overwhelming wheel of fire around us!

LESSON ONE: Understanding Astronomical Numbers

Goal of the Lesson

We want to make students understand the value of astronomical numbers and how we could use them.

Objectives
Students will be able to understand and use astronomical numbers and they should also be able to perform the most basic operations with them. Students will write explaining their answers.

Background Information
It is estimated that the Universe as we know it now is about 16 billion years old. It is also estimated that the Earth and the Solar System are about 4.6 billion years old. The explosion of a super nova created the Solar System, with the Sun, the planets, the asteroids, comets, moons and everything else in it. The Earth has been around for about 4.6 billion years. We have been part of these processes since the beginning of time. magnetic charges, atoms, molecules, simple life forms are our humble beginnings.

There is a time when we, as human beings, start to differentiate ourselves from other life forms. This is the time of culture. This is the time when we could say that the dust from the hypothetical explosion of the super nova begins to think about itself. The Universe thinks about itself. We are, in this sense, the consciousness of the Universe. This is one of the reasons why we have chosen to write and work with astronomical numbers.

Again, it is estimated that the history of humankind, the time that humans have been recording and scratching on rocks and bones events of the past, is about 200,000 years. If this is true, then, how could we visualize the difference between 4.6 billion years and 200,000 years? The use of astronomical numbers in the context of the historical statement of humans and the age of the Earth is of interest to the student. We want to make students understand the value of astronomical numbers and how we could use them to get to a higher understanding of ourselves.

Students will be able to distinguish the difference between a common number such as 200,000 and 4,600,000,000. If students are able to visualize this difference, then, they would be able to visualize the number 16,000.000.000. Further, students will conduct experiments of measurement of time with the help of manipulatives (color yarn).

200,000 vs. 4,600,000,000

How would students manage to understand these numbers and their relationships? Our answer is in the method: students actually have to see the difference visually in order for them to grasp what would otherwise be an incomprehensible number.

Materials

-yarn of various colors
-scissors
-calculator

Procedure

Teacher will ask students about their age. Students in the fifth grade are generally 10 to 11 years of age. What does it mean to be 50 years of age? 70? 100? 10,000?

What kind of numerical system do we use? Did we always use this system? The advantages of the use of the decimal system could be seen in the technology that we have been able to amass. One reflects the other. The decimal system allows us and afford us a tremendous flexibility in the construction of systems and in problem solving, in the production of food as well as in traveling. The decimal system is really the mathematics of one for all practical purposes. [11] Let's explain this realization. Students are going to use a piece of string the size of a thumb to be 200,000. All thumbs are about one inch (about 2.5 cm). We estimate this. We round it. Then they are going to measure 5 of these pieces to build 1,000,000. Now, with this piece they will measure ten times this 1,000,000 piece to get 10,000,000. These numbers are years. They represent years of life of the Earth. Going forward with our measuring we take this last piece and measure it ten times with the result of 100,000,000 years. The age of the Earth will be 46 times the length of this string. We actually did this exercise and students were going around the hallways in the school getting everyone's attention and curiosity.

I am sure that this is one of the ways to really make students grasp the difference between 200,000 and 4,600,000,000.

_____ ~ 200,000 years

_____ _____ _____ _____ _____ ~ 1,000,000 years

_____ _____ _____ _____ _____ x 10 ~ 10,000,000 years

(_____ _____ _____ _____ _____ x 10) 46 ~ 4.6 billion years.

The next step is the scaling of the Milky Way and the actual construction of a model of it. The structure in already in place. We built a model of the Milky Way with the help of our art teacher, Mr. Leger. Students and teachers worked together to place it in the lobby of the school, next to the Solar System. The Earth is less than a microscopic speck within another microscopic speck—the Solar System.

Because of the work that has been done during this year two teachers have been awarded with some money to actually construct a telescope in the school. The telescope is called The Cold Springs Telescope honoring the institution giving the resources for the telescope. [12]

LESSON TWO: The Milky Way

Goal of the Lesson

To teach students about the different kinds of galaxies in the heavens.

Objectives
Students will be able to describe the different kinds of galaxies. They will write about the different characteristics of our Galaxy.

Background Information
The Milky way Galaxy is our home and our Solar System is in it. There are billions of other stars in the Milky Way. We are only one of them, and a very little and microscopic part in the middle of one of its arms. Our Milky Way is 100,000 light years in diameter. It would take us 100,000 years to travel from one end to the other 100,000 years at the speed of light. We have some neighboring galaxies visible in the southern skies. These are called the Magellanic clouds. The sky has millions of galaxies. In the northern skies we could see Andromeda, as a faint dot. It is the next large galaxy; a little bigger than our own Galaxy. It looks very much like the Milky Way. Looking at other galaxies in the heavens is a good way to learn about the Milky Way. Our Galaxy, the Milky Way Galaxy, is an example of a spiral galaxy. This type of galaxy has arms unwinding from its center. The letters a, b, or c are attached to the letter S (for spiral). The "a" is for a galaxy that has its arms very close together to the nucleus of the galaxy. The Milky Way is an Sb galaxy. [13]

There are other types of galaxies in the heavens. There are galaxies with a bar crossing its center. These are called bar galaxies. Other galaxies are elliptical in shape. The majority of galaxies are elliptical galaxies. Star are very old in elliptical galaxies. We also find irregular galaxies, with no particular shape. The local group of galaxies are millions of light years away from us. It is impossible to travel to these places. Waves tell us much information about these galaxies.

In the classroom we constructed a model of our Galaxy. We placed the Solar System in it.

Materials

- Wire
- Metal rods 1/4”
- pulleys
- sparkles
- rope

Students will give shape and form to the Milky Way Galaxy and will place it in the center of the school for all to admire. The structure is simple and lends itself for a good lesson of integrated material: math, science, language and a good portion of art and mechanics. The rods have to be shaped and tied with wires to hold them together. Its shape is that of a spiral galaxy. The center core is round like a ball. This is the place where most of the mass is. The arms of the spiral come out from the core. Here, on the arms, we tie more wires giving it shape, body and form. Students really enjoy doing this type of activity. Most of the activities that we have talked about in this unit were video taped. Students love to be video taped. In our experience students work with more concentration when they know that they are being video taped or recorded. They have a sense of importance. Watching them act is wonderful. Also, it is of great benefit for the student to allow them to watch these video tapes. We took many pictures of their activities and were very happy to get a copy of these unexpected vistas.

LESSON THREE: Tenochtitlan and the Heavens

Goal of the Lesson

To look at the heavens with the eyes of other cultures. Students will explore the idea that the heavens are a subject for myths and cultural interpretations. Different cultures will look at the heavens in different ways than our own.

Objectives
Students will be able to describe one of the meanings of the presence of two gods in the Major Temple in Tenochtitlan.

Background Information
Tenochtitlan was a great city. It was one of the largest and pretties cities in the world in 1519. The Spanish Conquistadores and the Tlaxcaltecas destroyed it after some brutal wars. What we have left of it now is only some archeological remains, some magnificent sculptures, codices and a myriad of stories and myths recorded by the Spanish themselves. Its people are a testimony of its great past.

Of the countless stories and myths that have come to us from the past, there is one that seems to befit our needs in this seminar of Astronomy. It is a story told by the Natives of Tenochtitlan to a Spanish priest, Fr. Bernardino de Sahagun. [14] It is said that Coatlicue, the mother of all the gods, was one day sweeping the floor of her abode. A ball of gentle and soft feathers fell from the sky, and she picked it up. She kept it close to her and this made her pregnant. [15] Mother Earth got pregnant. Coyolxauhqui, the Moon, was her daughter and the Centzonhuiznahua were her sons, the stars of the heavens. These sons and the daughter were extremely mad at Coatlicue because she had brought shame to the family with this pregnancy. They got together and planned to kill this shameless mother.

Mother Earth was very sad. She was also frighten to see these children planning to hurt her and her new child. Ah! Just at this moment of pain a voice came out of her womb.

> —Mother, mother, don't cry and don't despair about these bad people. . . . Whenever they try to do anything to hurt you, I will be there to help you!
>
> Coatlicue was happy to know that she was not alone anymore. This child was Huitzilopochtli, the Sun god. He'll protect her from all evils.

The day came when the Moon and the stars were ready to execute their plan to kill their mother. They came and tried to attack her. Huitzilopochtli, the Sun, came out of the womb of Coatlicue and stopped them with his might and power. His brothers the stars went away running from his fury and fire. Coyolxauhqui, the Moon, was cut to pieces by his rays. Coatlicue was once again free and alive. Huitzilopochtli had saved her.

Every day in the morning, this battle takes place in the heavens between the Sun, the Moon and the stars. When the Sun comes out, the stars run away from sight and the Moon is seen cut up by the rays of the Sun. In the center of the city of Tenochtitlan, the Major Temple has these gods in constant battle. Hitzilopochtli is on top of the Temple with Coyolxauhqui at the bottom of the Temple, cut to pieces as a remainder of a great battle in the past.

Materials

- balsa wood
- paints
- maps of Tenochtitlan

Activities

Students will build the center of Tenochtitlan with details of the architectural characteristics depicting the story of the battle of the Sun, the Moon and the stars. Tlaloc, the god of rain and Huizilopochtli, the god of war and blood, have their abodes on top of the highest pyramid in the city. Huitzilopochtli was one of the gods that helped the Aztecs dominate the world. We don't want him to go away, We offer the Sun the most precious liquid of life so that we could see him again.

Students will write and do research about Mexico and Tenochtitlan. The next step is the decoding of the calendar of Tenochtitlan with its great Serpent of Fire—the Xiuhcoatl. This Xiuhcoatl is the wheel of fire in the heavens. These are the stars where all life begins and ends. In some ways this Mexican vision is akin to the vision of the great telescopes of our times. The stars are the ovens of life. It continues and goes on until the stars die. The Sun is just one little insignificant dust in the middle of all, but it means all to us.

Notes

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1. For a comprehensive discussion of this tool of the 20th century, see: *Space Based Astronomy: Teacher's Guide with Activities* (National Aeronautics and Space Administration, August 1994), pp.23Ð26.
2. Serendipities are also wonderful ways to discovery. We have to sensitize the student to their potential.
3. We brought a film about black holes to the classroom, and students never again stopped asking questions about these powerful objects. We learned many things because of this.
4. "Hubble's observations that the most distant galaxies are receding from us faster than closer galaxies can be explained if the universe were expanding in a way similar to the way a giant loaf of raisin bread rises." Donald H. Menzel/Jay Pasachoff, Stars and Planets (Boston: Houghton Mifflin Company, 1990), p. 125.
5. *Space-Based Astronomy: Teacher's Guide with Activities* , National Aeronautics and Space Administration, p. 41.
6. See the standards related to the solar system in: *National Science Education Standards* , 1996: 215Ð17.
7. Check , for example , standard 4 , "Tools for enhancing Discourse," in the Professional Standards for teaching Mathematics (Reston, Virginia: National Council of Teachers of mathematics, 1991), pp. 35Ð51.
8. The speed of light is 300,000 kilometers per second, or 186,000 miles per second. In this essay we prefer to use the metric system as a method of measurement.
9. Specially disturbing is the cultural accepted *chupacabras* in the Hispanic community and in particular in the Puerto Rican community. Word of mouth and the press have created an alien; an oppressive alien that, supposely, goes around sucking blood of innocent animals (goats, chickens, dogs, etc), and hovers around the boarderlines of human communities. For people this could be entertaining, but also damaging. " *La gente esta embobaa* ," they say (People are dizzy). What is interesting is that UFOs could easily exist, but aliens are out of the question. For our students this is important. It is learning our environment and the manipulation of information. It is critical thinking. It is seeing the world unmasked!
10. *Space-Based Astronomy* , 24.
11. Notice the mathematics of the number one. All we have to do is to keep on adding or subtracting zeros. The number one is also crucial in the solution of equations in the form of the multiplicative inverse. For Example, 6x + 5 = 23

    6x = 23—5

    6x = 18

    6x/6 = 18/6, where 6/6 = 1.

One is also used in the addition and subtraction of fractions:

1/2 + 2/3

1/2x 3/3 + 2/3 x 2/2 (again, 3/3 = 1; 2/2 = 1)

3/6 + 4/6 = 7/6 = 1 1/6 (again, 6/6 = 1).

12. We are interested in finding a telescope from a university. We want a good telescope that people don’t need anymore. We were thinking with Mr. Leger that paying for transportation will be a way to get anyone to donate our school, Vinvent Mauro, a telescope for our students to learn from the sky.

13. Menzel 1990: 120Ð24.

14. *Historia General de las Cosas de la Nueva Espana* .

15. Coatlicue is also Mother Earth. She is depicted in a monumental sculpture of snakes, hands, skulls and hearts.

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