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The Solar System and Space Technology

Curriculum Unit 96.06.10
by Eddie Rose

The goal I expect to accomplish with the Solar System and Space Technology curriculum is to develop modularized, individualized problem solving scientific mathematics packets. Contents of the packets will focus on space exploration, and its relationship to science and mathematics. The purpose of this curriculum is to develop student's ability to apply these skills in a realistic and interdisciplinary context. This curriculum unit was developed with the Connecticut Mastery and CAPT Test in mind.

The Connecticut Mastery Test is taken in the 4th, 6th and 8th Grade. The Fourth grad mathematics test assesses thirty (30) specific objectives in four general areas of: (1) Concepts; (2) Number Facts and Computation; (3) Problem Solving/Applications; and, (4) Measurement and Geometry. Emphasis is placed on both increased conceptual understanding and the application of skills. Test items evaluate a student's ability to: extend or complete patterns; identify alternative terms of expressing numbers; compute and estimate sums and differences; read and interpret tables, graphs, and charts; solve a broad range of problems' measure and estimate lengths and width' identify shapes; and, tell time. Student response formats include multiple-choice, grid-in and open-ended.

The Mathematics test assesses thirty-six (36) specific objectives in four general areas of: (1) Concepts; (2) Number Facts and Computation; (3) Problem solving/Applications; and, (4) Measurement and Geometry. Emphasis is placed on both increased conceptual understanding and the application of skills. Test items evaluate a student's ability to: order, rename and round whole numbers; identify numerical equivalents; extend patterns; compute with whole numbers, decimals and fractions; estimate with whole numbers and money amounts; interpret and create table, charts and graphs; solve problems involving whole numbers, money amounts and fractions; identify extraneous and needed information in problems; measure and estimate lengths and areas; and select appropriate measurement units. Student response formats include multiple-choice, grid-in and open-ended. Students are provided calculators for certain sections of the test.

The mathematics test assesses forty (40) specific objectives in four general areas of: (1) Concepts; (2) Number Facts and Computation; (3) Problem Solving/Applications; (4) Measurement and Geometry; and, (5) Algebra. Emphasis is placed on both increased conceptual understanding and the application of skills. Test items evaluate a student's ability to: order fractions and decimals; round whole numbers, fractions and decimals; make conversions among fractions, decimals, and percent; compute with whole numbers, decimals and fractions; estimate with whole numbers, decimals and fractions; solve 1-step and 2-step problems involving whole numbers, decimals, fractions, measurement and elementary probability (with a calculator available); estimate a reasonable answer to a problem; identify needed information in problem situations and solve problems with extraneous information; measure and/ or estimate lengths, areas, volumes and angle measurements; make measurement conversions; select appropriate measurements; interpret and create tables, charts and graphs; solve and interpret basic algebraic expressions. Students response formats include multiple-choice, grid-in and open-ended. Students are provided calculators for certain sections of the test.

The Connecticut Academic Performance Test (CAPT) is designed to establish high performance standards on a wide range of important skills and knowledge; ensure that students can apply their academic skills to realistic problems; and promote better instruction and curriculum by providing timely reports of student and program strengths and weaknesses. Thus, the CAPT is a tool that can help school districts assess and enhance their curricular and instructional programs in several important ways.

Because the CAPT focuses on the application of students' understandings in realistic, everyday contexts, student success on the test depends both on understanding of subject area content and on the ability to apply that content. Instructional program that strikes a balance between learning content and applying knowledge in a variety of problem-solving contexts will best ensure understanding of what is taught, thus preparing students for success in higher education and future careers.

Knowing discrete facts and mastering narrow skills are not ends unto themselves. The 21st century demands individuals who are adept at accessing and evaluating information, and applying that information to solve problems and make decisions. To successfully analyze, synthesize, evaluate and apply information, students need a strong foundation of knowledge and skills in the content areas.

The lines separating the traditional disciplines are becoming increasingly blurred as new applications are discovered for the rapidly increasing volume of knowledge. Students who understand the connections among knowledge and skills from different areas will prepare to make sense of and act on the range of information they will encounter in tomorrow's workplace.

Sound instruction is based on clear learning objectives and incorporates provisions for feedback on student understanding and progress. Assessment of student learning involves authentic tasks (tasks that model real-world problems in the curriculum. Assessment tasks often are embedded within instructional units, so that teachers use the assessments as leaning strategies as well as to gauge student learning.

The Solar System and Space Technology , is designed to help educators respond to the opportunities and the challenges by CAPT. *The Solar System and Space Technology* was developed to support the curricular frame work that provides the foundation upon which the CAPT was developed; suggest pedagogical strategies and techniques that are part of a sound instructional program; provide sample assessment items and tasks that can be used as part of the instructional program; present assessment and scoring information to help teachers integrate assessment with instruction.

The CAPT design and framework for the assessment of mathematics was developed by an advisory committee of Connecticut educators and is based on current research and theory about mathematics instruction and assessment. The CAPT mathematics framework that is presented integrates the skills, competencies and understanding delineated in Connecticut's Common Core of Learning (1987) with the vision described in the National Council of Teachers of Mathematics' Curriculum and Evaluation Standards for School Mathematics (1989).

According, the test assumes the acquisition of basic knowledge and skills and requires the application of that knowledge and those skills to the solution of realistic problems drawn from everyday experiences and the needs of the workplace. Using “real-world” scenarios, followed by clusters of either open-ended or constructed-response “grid-in” items, the CAPT assesses the mathematics that 10th grade students are expected to know and be able to do.

The CAPT Mathematics Test is based on the view that mathematical understanding is best assessed by doing mathematics, and that doing mathematics means using and discovering knowledge in the course of solving genuine problems.

This means that, instead of assessing long division skills directly, students apply division skills and might be asked to find the price per pound of 2.83 pounds of ground beef that has a total cost of $6.20, compare this price with the unit prices of other possible choices, and finally, justify their purchase decision. Students may use any type of calculator with which they are familiar and comfortable using, whether provided by school or brought from home.

Similarly, rather than factor trinomial expressions (a skill that is not part of the CAPT framework), students may be asked to sketch a distance vs. time graph and speed vs. time graph that represent a single circuit of a pictured roller-coaster ride, thereby applying critical algebraic understandings.

Thus the CAPT mathematics test assesses knowledge, skills and applications reasonable to expect of all students by the end of 10th grade. The mathematical content areas that constitute the CAPT mathematics framework upon which the test has been constructed.

Problem Solving and Reasoning

Formulate problems from situations and given data
Develop and apply a variety of strategies to solve problems—particularly multistep and non-routine problems
Make and evaluate conjectures and arguments
Verify, validate and interpret results and claims and generalize solutions

Communicating

Model situations using written, concrete, pictorial, graphical and algebraic representations.
Express mathematical ideas and arguments with clarity and coherence. Use mathematical language and notation to represent ideas, describe relationships and model situations

Computing and Estimating

Compute accurately and make estimates with whole numbers, fractions, decimals, percents, integers and rational numbers. Select and use an appropriate method for computing from among mental arithmetic, paper and-pencil or calculator. Use estimation to assess the reasonableness of results

Number and Quantity

Understand, represent and use numbers in a variety of forms (integer, fraction, decimal, percent, exponential, scientific notation) in real-world and mathematical problem situations. Demonstrate an understanding of order, magnitude and equivalent forms with whole numbers, fractions, decimals, percents, integers and rational numbers. Use arithmetic operations and understand how the operations are related to one another. Understand and apply rations and proportions.

Geometry, Measurement and shape
Represent and solve problems using geometric models. Interpret and draw two-and three-dimensional objects. Understand and use the concepts of rotation, reflection and translation to demonstrate geometric figures and apply relationships of congruence and similarity. Deduce and use properties of, and relationships between, figures from given assumptions. Use coordinate representations of geometric figures. Estimate, make and use measurements to describe and compare phenomena. Select and use appropriate units and tools to measure, including conversions, capacity, weight and mass. Understand and use rates and other derived and indirect measures. Develop and use formulas and procedures for determining measures. Understand and apply the relationship between precision of measurements and accuracy of calculations.

Statistics, Probability and Data
Systematically collect, organize and describe data. Construct, read and interpret tables, charts and graphs of data from real-world situations. Draw and defend inferences from charts, tables and data. Understand sampling and recognize its role in statistical claims. Understand and use basic probability to make predictions and to evaluate the likelihood of events.

Relations, Functions and Algebra
Understand and use the concepts of a variable, expression and equation. Represent and analyze situations involving variable quantities with tables, graphs, verbal rules and equations; understand the interrelationship among these representations. Describe, analyze, extend and create a wide variety of patterns. Understand and use direct and inverse variation. Use tables and graphs to solve problems. Create and use equations and inequalities, including formulas, to model situations and solve problems. Analyze and use functional relationships to explain how a change in one quantity results in a change in other.

Let’s face it—the most—asked question in the classroom probably is “Will this be on the test?” Students are strongly motivated to learn what they need to know to pass a test. Traditionally, mathematics tests have questions with “right or wrong” answers. These tests reinforce the misleading image of mathematics as a subject with unique correct answers. These tests are also administered on special days after a chapter is competed, providing a snapshot of performance under the most stressful conditions. Poor test scores often lead to students with poor self-images who believe they “aren’t good in math.”

“Assessment should be an integral part of teaching. It is the mechanism whereby teachers can learn how students think about mathematics as well as what students are able to accomplish.” (Everybody Counts, p.69) As the mathematics curriculum begins to emphasize problem solving, communication, and higher-order thinking skills, so must the ways of assessing students emphasize those same skills. Students are expected to demonstrate mathematical power in their work. But, how can you tell if your students are demonstrating mathematical power? Many teachers are using a testing method called performance assessment to help them assess mathematical power.

Performance assessment is used to focus on student work rather than on the students themselves. The purpose of a performance assessment task is to determine what students know and what they can do. The task should be meaningful, authentic, and worth mastering. Authentic, as used in this booklet, means realistic or in accord with real-life applications.

Performance assessment differs from traditional assessment in a number of ways. It should happen as a part of the regular instructional program. Be realistic, interesting, and thought provoking. Allow students to display their thinking and understanding of a mathematical situation. Stress depth more than breadth and mastery instead of speed. Allow for revision and resubmission of work to bring performance up to high standards. Provide an opportunity for an evaluation of the processes involved in the tasks.

In any assessment of what students know or can do, there is always the question of what standard their performance is being compared against. With traditional tests, a numerical score compares students in relation to one another or to an established norm. Assessing a student’s performance on a performance task, however, involves an evaluation of the student’s work against the task itself. One way to assess performance is to use a scoring rubric.

A rubric is a set of guidelines for judging work on a performance task. It establishes the criteria for high level work and gives additional characteristics of other levels of work. A rubric may be general or specific. It uses a four-point scale: well done, acceptable, revision needed, and restart, However, the scale can be easily modified to add additional points for finer judgments. Students should know what constitutes each level of performance. Thus, specific performance criteria, as provided on the rubric, should accompany each performance task when given to a student.

When students have completed the performance task, their work is compared to the rubric and scored holistically according to the level that best describes the work. Holistic evaluation means to judge a work as a whole. Many educators have indicated that such an evaluation should be one’s first impression of the complete piece of work.

Assessment in the middle school has the added challenge of balancing high standards with encouragement and confidence building. Middle school students, who are constantly dealing with their self-image, need to know where they stand. By using performance tasks and rubrics, students compete with themselves rather than others. They are given productive feedback and with it, the opportunity to revise their work until it meets high standards. Such feedback reassures students and helps them develop their self-esteem, so critical to middle school students.

Scientists have developed theories about the formation of our solar system by observing its present-day structure and motions, which are artifacts of its origin. The formation of our solar system is thought to have been set into motion about 4.6 billion years ago, possibly when a nearby supernova (an explosion that signals the death of a very massive star) caused a massive cloud, or nebula, of gas and dust to contract. As the cloud contracted, it began to rotate, heating up in the process and flattening into a disk. This cloud, now thick with dust, formed a giant whirlpool. Much of the material gravitated to the center and gradually came to form the protostar. Smaller whirlpools and eddies collected materials that began to stick together, forming secondary concentrations of gases and dust that eventually built up to globules so massive that gravity within them began to squeeze the material inward, warming it. These planets moved in roughly circular paths around the protostar. When the protostar, still contracting, became hot enough for nuclear fusion to occur, turbulence, angular momentum factors and solar flare-ups conspired to sweep the solar system clean of most of the remaining gas. Left behind were the planets and much solid debris. The solar heat baked the inner planets into small, hard, dense spheres. Those in outer, cooler regions retained their gases and became the gas giants we know today.

Eight of our nine planets in our solar system are classified as either terrestrial or jovian. The terrestrial (Earth-like) are the ones closest to the Sun: Mercury, Venus, Earth, and Mars. They are basically metallic balls encased in rock, with either no atmosphere or a rather thin one. The jovian planets, or gas giants—Jupiter, Saturn, Uranus, and Neptune—lie beyond the asteroid belt . Characterized by greater mass, lower density, and larger size, they have thick atmospheres composed mostly of hydrogen and helium. Pluto, only two-thirds the size of our Moon (itself one quarter the size of Earth) and weighing far less, is singular among the planets. It is solid, like the terrestrial planets, but wasn't heat-tempered as they were. It is located in the realm of the gas giants, but it is neither gaseous nor giant. With recent findings about the compositions of comets, the icy satellites, and Pluto, astronomers are begining to suspect that it may be an icy satellite or a very large comet rather than a puny planet.

Planets in their orbits around the Sun and satellites in their orbits around the planets obey the laws of physics, in particular the law of gravitation. This law states that the force attracting two objects is proportional to the product of their masses and inversely proportional to the square of their distance from one another. Isaac Newton formulated this and other laws of physics in the mid-1600s, confirming three rules stated in the early 1600s by the German mathematician Johannes Kepler to describe the movements of the planets. Kepler's first law states that the shape of a planetary orbit is an ellipse, with the Sun at the focus. Kepler's second law states that a line connecting the Sun and a planet sweeps over equal intervals of time, as illustrated at left (the areas delineated are equal). This means that a planet moves faster along its orbit when it is close to the Sun and more slowly when it is farther away. Kepler's third law states that the square of a planet's sidereal period (the time it takes to orbit the Sun once) is proportional to the cube of the planet's average distance from the Sun. This equation has enabled astronomers to calculate the planets' distances from the Sun. In satellite orbits the parent planet replaces the Sun as the focus of the orbit. The planets all orbit the Sun in the same direction. The planets closer to the Sun move faster in their orbits than do the outer planets. It is this continual ballet of the planets, some speeding along, others meandering, that gives rise to the changing positions of the planets in our skies. (The word planet, meaning "wanderer," was given to these bodies because they seem to roam the heavens.) As we view a planet in the sky, it usually seems to move in an easterly direction against the background of stars. This rather slow movement can best be gauged by observing the planet's position on consecutive nights. Since we view the solar system from a moving platform, Earth, we perceive not just the movements of the other planets but, indirectly, our own movement as well.

In today,s quickly changing world, students need to have the ability to think critically, solve problems, make decisions and communicate their ideas to others. The purpose of this curriculum is to develop students' ability to apply these skills in a realistic and interdisciplinary context. This curriculum unit was developed with the

Connecticut Mastery Test and CAPT Test in mind.

In *The Solar System and Space Technology,* students use knowledge and skills they have gained through their study of Science, Mathematics and other subject areas. Students are presented with several source materials (e.g. maps, charts or graphs, newspaper or magazine articles on various space technology) related to a significant issue. Students begin with a discussion about the solar system. The purpose of this collaborative activity is to give students the opportunity to begin thinking about the solar system and to share their ideas with others before starting the task. They read the source materials to gain information about the solar system and to consider various perspectives on the issue. Students then use the information they have gained from their readings as well as their prior knowledge to take a position on the issue. They will participate in a persuasive writing project in which they will state their position and support it with information from the source materials.

Teachers are urged to read Ms. Holly S. Anthony's curriculum unit, which was developed in collaboration with this curriculum unit. Upon reading Ms. Anthony's science unit, it will become apparent how science and mathematics play a critical role in developing answers for the questions that can be addressed in Astronomy/Cosmology.

With the goals that I, as a secondary mathematics teacher , expect to develop with in *Solar System and Space Technology* curriculum is a modularized, individualized problem-solving scientific/ mathematics packet for students in 7th and 8th grade. Contents of the packet focus on space exploration and its relationship to science and mathematics. The curriculum is designed to integrate reading, writing and, collaborative between science and mathematics activities. The intended outcome is to enable students to demonstrate and interpret steps used to attain solutions for scientific problems.

Why is this curriculum essential? In this high-tech age, modern technology flourishes. It is imperative that students understand how data is processed and translated into meaningful knowledge. The following quote from the Mathematical Sciences Education Board's publication *Reshaping School Mathematics* provides the theme for this curriculum. "As the economy adapts to information-age needs, workers in every sector—from hotel clerks to secretaries, from automobile mechanics to travel agents—must learn to interpret intelligently computer-controlled processes. Most jobs now require analytical rather than merely mechanical skills, so most students need more mathematical power in school as preparation for routine jobs. Similarly, the extensive use of graphical, financial, and statistical data in daily newspapers and in public policy discussions compels a higher standard of quantitative literacy for effective participation in a democratic society."

This curriculum will present students with a variety of math and science problems that each student can attempt to solve. Students will use writing skills to solve problems that are developmentally appropriate. Students will acquire enough knowledge to be used to examine data and to process ways of analyzing the data in order to later write about it. Consequently, writing and problem-solving abilities of the students will improve as they practice multiple approaches.

Students will get practice in writing using the scientific method, solving problems to the best of their ability, and analyzing old and new information. They will receive a variety of guided explanations and demonstrations on problem-solving, along with reviewing basic language skills and learning to monitor their own progress.

Students will also work in cooperative groups as cooperative groups play an important role in school and outside of school. Students will interact and work in small groups throughout each of the activities. Teams building and working together are important skills' students will need in the real world. For some students, working with others will be a new experience. The expected outcome is to develop the skills necessary for collaborative group participation, as well as to develop respect for, and openness to, the ideas of others.

As students are working in groups, sharing and listening to others they become the key to successful mathematical/ scientific decision making. The teachers' role will be that of facilitators. This includes listening and effective questioning to help students stay on or get themselves back on track. Each student has a role in the group such as recorder or materials manager so that they become responsible for their own learning. Students assume new roles as they change activities so that each group member has an opportunity to fill each role.

Finally, it is important that the teacher discusses with the class, either verbally or in writing, how the group has functioned. Questions such as "In what ways did your group work well together?", "How was everyone in the group given the opportunity to speak and to be heard?", and "Describe how the responsibilities were shared" help determine the effectiveness of the group and where improvements need to be made.

As students interpret data, discuss and support approaches to problems, read blueprints, write reports, defend solutions, and draw conclusions, each student may not have the same level of proficiency required to carry these out. To foster participation and effective communication by all students,therefore, the teacher must try to assess the students' communication skills. This can be accomplished by listening to the students as they talk about and interpret the task. Who is having difficulties understanding the requirements? Which students cannot identify and explain the components and objectives of the activity? Next, the teacher needs to examine the written work. Which students cannot fully explain the solution? Is this due to a lack of mathematical or scientific knowledge or the inability to express thoughts in written or oral form? Some reasons for this diversity among students include lack of proficiency in English, poor knowledge of mathematical or scientific terminology, limited exposure to the rules and use of language in mathematical or scientific contexts, and the lack of background and experience with technical forms of communication.

Overall, *Solar System and Space Technology* is a curriculum designed to promote cooperative groups, scientific thinking, problem-solving, communication skills, and mathematical/ scientific applications in the field of astronomy/ cosmology. This curriculum is designed for 7th and 8th grade Earth/ Space Science and Mathematical Applications students, but it can be altered easily for other grades. Students will find this curriculum extremely interesting and useful as it fosters creativity, curiosity, and imagination of our universe.

The U. S. has plans to launch a space station. NASA has been studying various proposals from aerospace companies, with the intention of launching sometime in the 1990's. Budget problems have plagued the Space Station incessantly, and recently the press publicized an internal memo in which several astronauts severely criticized the safety and comfort of the present designs. The delay in the space program caused by the Challenger disaster will allow some of these problems to be resolved.

Surpnoingly, space scientists have been among the most vocal of those opposed to building the space station. Many of these individuals feel that the money that goes into the human space program kills robotic projects. Certainly, in the past, the unmanned space program has often been shortchanged because of budget problems caused by the much more expensive piloted program. Scientist James Van Allen, has been a leader in challenging the of piloted spacecraft. Such scientists hope to do away with the Space Station so that more funding will be available for Earth-based astronomy projects, robotic space probes, and other space programs that don't rely on astronauts.

On the other hand, scientists such as former astronaut Brian O'Leary are strong supporters. Ironically, O'Leary once attacked the human space program, even after being a part of it personally (his views at that time can be read in his autobiography, *The Making of an Ex Astronaut)* . But O'Leary eventually came to recognize the profound, long-range importance of humans living and working in space.

Let's take a look at what NASA plans to do with the Space Station if it is built. The station would orbit a couple of hundred miles above Earth, easily accessible to the Space Shuttle. It would serve as a place to check satellites before launching them into their final orbit, whether Earth orbit or interplanetary spacecraft orbit; and it could be used as a fuel base to refuel spacecraft, both piloted and robotic.

Certain materials and medicines that are difficult or impossible to manufacture on Earth could be made in the station's zero-gravity environment. Its laboratory would also make it possible to perform long-lasting experiments for commercial use of space. It is a great place to keep equipment with which to repair other satellites when they break down.

This activity is designed to create a cooperative team-building spirit and a foundation for the mathematical ideas in this curriculum. Students form construction crews and work to submit a bid for the construction of a Space Station Module. Each crew works from the same set of blueprints, determining the amount of materials, time, and money it will require. Each crew orders raw materials, builds a Space Station Module, records their completion time, and has their Space Station Module inspected. After crews compare their actual costs to their bid, they share information with the other crews. Each crew analyzes the information to predict the amount of time and money needed for a contract for five Space Stations Module and writes a report based on the analysis of the data.

Mathematical Overview

This activity involves estimation, measurement, geometry, spatial visualization, accuracy, and the use of the students' numbers to estimate the amount of construction materials that are needed to build a Space Station Module and then submit a bid for the job. They then build the Space Station Module out of wood craft sticks and compare their estimate to the actual materials used.

Lesson Summary

Construction crews are formed and receive blueprints of the Space Station Module. Each crew is asked to submit a bid for the construction job. Each crew estimates the amount of raw materials needed and the amount of time it will take to construct the Space Station Module. After submitting a bid and ordering materials, the crews start to build their Space Station Module at the same time. The amount of time needed to complete the Space Station Module is recorded for later use. Finally, students write individual narratives about their crew's construction process.

Procedure

1. *Setup* : Separate the class into four-member construction crews. The teacher divides the class into crews. If the entire class does not divide evenly into fours, some crews could be formed with three students per group. When groups of less than four students are used, one student can do two math work sheets. The teacher can record crew members on the form called TEACHER'S CREW PLAN. Students will sit together by company group. As you form the crews, we recommend that you try to balance each group for skill and ability. Allow each crew to choose a name. Each

crew should choose a crew leader who has two primary reponsibilitries. First, each member of the crew, including the crew leader will, estimate one page of the project bid. Second, the crew leader will fill out the construction Bid Sheet and deliver the crew's bid to the teacher prior to bid closing time. It is highly recommended that you rotate the job of crew leader. The teacher directs all crews to go to work on a particular part of the Space Station Bid and announces a bid closing time—a time when all bids must be turned into the teacher. All crews should start working at the same time. The entire classroom should be working on the same part of the Space Station Module.

2. *Implementation* : Display letter to employees on the overhead, or hand out letter to employees and ask students to read it. Ask students to examine the construction Bid Sheet and the blueprint. Explain that each crew member should carefully estimate the amount of materials and time needed to complete the Space Station Module as accurately as possible. Each crew should record their estimates on the appraisal lines of the Bid Sheet. Calculators should be available.

When monitoring the groups, you may need to point out the elements of the Construction Plan Sheet in the letter to employees, including details of the plan, materials, construction, and inspection procedures. Then you should distribute the raw materials according to the submitted bids.

Each construction crew should begin construction at the same time. You may want to display the Cooperative Group Chart while the Space Station Module are being built. Upon completion of the space station, each crew should record their actual time on their bid sheet and then complete the bid sheet by determining their actual costs. You may want to have a group record their times on the Cooperative Group Data Sheet.

After all of the crews have completed construction of the space station, a number of student inspectors should be selected from the class. These inspectors are to confirm the accuracy and quality of the space station construction. An inspector may not verify the accuracy of the space station that he or she actually worked on.

If a Space Station Module is found to be inaccurate, a delay penalty should be assessed to the construction crew's time and the crew is then required to make corrections and the time and is to the crew's original time along with the penalty on the Bid Sheet. If additional materials are required, they must be purchased and an additional delivery fee of $1500.00 is charged and included on the Bid Sheet.

3. *Processing:* The students should complete the narrative on how their crew functioned during the space station construction Cooperative Group . You may then want to initiate a whole-class discussion of the space station construction with a focus on group interaction and the various approaches used. Other ideas and concerns may be raised at this time. For example, factors that influenced the construction time, how the budget is affected by the completion time, and the amount of materials needed may be issues. You may want to explain that the ordering of additional materials in the beginning is quite common in actual construction because the benefits outweigh the costs. You may want to ask students to come up with part of the materials that they think it would be wise to order as extra materials. Problem- solving experiences the crews had may be shared during this discussion.

THE SPACE STATION

Dear Employees:

Our company has been awarded a contract to construct a space station over the next several years. We have selected a specific design for the space station and the blueprint has been drawn. Before we begin to set a construction schedule and order materials, we need actual construction information. Our company, therefore, is interested in improving the original estimates by building some prototypes to determine the amount of raw materials and the time required to complete the terms of this contract.

Our company will commission several construction crews to build the prototype space station. Using the information recorded from this initial sample, the company will create long term projections and material orders. As designated construction crews, you are formally commissioned to plan and build a prototype space station as accurately and quickly as possible. Each construction crew member will receive a blueprint of the space station. Each crew will receive a construction plan sheet and construction budget sheet. Each construction crew must determine the amount of raw material needed, estimate the amount of time needed to construct a space station, create a budget, and write a construction plan before the building starts.

Space station modules

(figure available in print form)
Pressurized Modules Facts

1. 1 Privacy/sleeping niches—9’2’ high by 6’8” high
2. Dishwasher/handwasher—21” wide by 29” high
3. Oven—21” wide by 29” high
4. Refrigerator, Freezer, and Trash masher—41” wide gy 6’2” high
5. Toilet—44” wide and 6’ high
6. The laboratory module’s will be 6’2” by 41.5”
7. **The over all size of the Space Station Module is 44.5 feet long with a 14.6 exterior diameter.**

Space Station Modules Blueprint

(figure available in print form)
Side View

1. 4 Ring frames 3” wide
2. Waffle skin 14.5’ wide
3. External longeron 14.5’ by 1.5” wide

Blue Prints

Sleeping niches Area

(figure available in print form)

Dishwasher/Handwasher Area

(figure available in print form)

Oven

(figure available in print form)

Refrigerator and Freezer Trash masher

(figure available in print form)

Toilet

(figure available in print form)

Portholes

(figure available in print form)

Teachers Crew Plan

(figure available in print form)

(figure available in print form)

(figure available in print form)

(figure available in print form)

Cooperative Group Data Sheet

(figure available in print form)

The Space Station

Construction Plan Sheet

1. Construction Plan: Each crew must submit a construction plan with a construction budget. This plan should detail the way the Space Station Module is to be built, including an explanation of tasks, strategies, construction methods, resource management, and duality checks. Time, cost, and the degree of cooperation are all equally important.
2. Construcion Budget: Each construction crew should estimate the amount of construction time needed, determine the amount of raw materials required, and total their cost projection. Labor costs are determined at a rate of $12,000 per minute. Raw materials costs are $12,200.00 per beam and $97.50 per bolt and nut. These amounts make up the budget.
3. Acquire Raw Materials: Once a crew submits a budget, the requested raw materials will be delivered to each team. Each crew will want to verify that all of their requested materials are delivered since no raw materials will be delivered during construction. No excess materials may

be sold back after construction begins. Additional materials may not be purchased until after the inspection.

4. Build Space Station Module: Each crew begins construction at a given signal. When a construction crew completes the Space Station Module, the finished time is recorded. Specific roles may be assigned but all must participate in the actual construction of the bridge.

5. Space Station Inspection: Each Space Station Module is inspected by an independent inspector after all space stations are built. The inspector guarantees that the space station is constructed in accordance with the company blueprint. All joints must be securely fastened. If a Space Station Module does not meet the standard, a delay is charged, and the space station must be adjusted. The total time accumulates while any revisions are made. An additional delivery fee of $1500.00 is added to the raw material fee if any additional materials are needed.

Name______________________

Construction Bid Sheet

Construction Crew: 1)_______________________

2)_______________________

3)_______________________

4)_______________________

PRICE LIST

Labor Cost: $

Outer Shell $

Beams: $

Nuts and Bolts: $

Budget Estimate of Construction

Price List	**Number**	**Unit Cost**	**Total**
Outer Shell	__________	__________	_________
Beams	__________	__________	_________
Nuts and Bolts	_________	__________	_________
Minutes	__________	__________	_________

Grand Total _________

Actual Cost of Construction

Price List	**Number**	**Unit Cost**	**Total**
Outer Shell	__________	___________	__________
Beams	__________	___________	__________
Nuts	__________	___________	__________
Minutes	__________	___________	__________
Inspector Adjustments		__________	

Penalties ___________

Grand Total ___________

The Solar System

Kepler's three laws of planetary motion. The first law states that the planets orbit in ellipses with the sun at one focus. Describes the foci of ellipses as the two points, the sum of whose distances to any point on the ellipse is a constant. Compare the foci of an ellipse to a circle, whose center is defined as the point whose distance to any point on the circle is a constant. Kepler's second law states that a planet sweeps out equal areas in equal times. This has the consequence that a planet speeds up when it is closer to the sun, and slows down when it is farther away. Kepler's third law is the relationship between a planet's distance to the sun and its orbital period.

To calculate orbital speed, use the formula

V= (2 ^{1} a) / P Where

V = orbital speed

a = orbital radius, (the average distance of the planet from the sun),

P = orbital period in seconds = P in years x 3.16 x 10^7 (approximately)

^{1} = 3.14

Example: Orbital Velocity of Earth
V = 2^{1}a / P = 2(3.14)(14.86x10^7)/1(3.16x10^7) = 2(3.14)(14.86/1(3.16)

= 93.3208/3.16 = 29.53 km/sec

Make a table that contains data about the sizes and periods of planetary orbits around the sun. Use the data to calculate the orbital speed of each planet. You can assume that the shapes of the orbits are circles. The orbits are really ellipses as you have learned, but the flattening is very slight, and using circles simplifies the calculations.

TABLE

(figure available in print form)

Make a Solar System

What is the solar system? The solar system, then, is the system of the SUN. This system is made up of the sun and all the objects that travel around the sun. These of the sun travel in "paths" called orbits. They are held in their orbits by the sun's gravity The path's of orbit is on ellipse. And the sun is not exactly in the center of the ellipse. It is slightly off center. For these reasons, the planets are not the same distance from the sun at all times.

In the space below, draw and label the solar system. Make the solar system to scale. Remember the solar system is an ellipse not a circle.

(figure available in print form)

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VIDEO:

“Beginning of the Universe” (found at Yale University Gibbs Library)