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The Human Sundial

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Grade level: Grade 6.

Provincial curriculum links: Ontario.

Subject: Science and Technology.

Keywords: Earth and Space Systems, Human Sundial Project.

Introduction

The Human Sundial Project will provide an opportunity for students to learn how the relationship between the Earth and the Sun can be used as a tool for measuring time. First, the phenomenon of the Earth's simultaneous rotation on its axis and revolution around the Sun will be introduced and explained. The students will come to understand how these rotations and revolutions explain the passage of time - night and day, the cycle of the seasons, the changing of years. Next, the students will observe how markers placed outdoors in a certain configuration cast shadows in different places throughout the day. From their observations, the students will learn to build an outdoor sundial structure and to take measurements of time at two distinct times during the day. After compiling data from this continuous practice of measurement and examination, students will learn how to present their findings to other students, parents and teachers. In addition, the students will have the opportunity to learn about greening their school grounds by planting flowers or other plants in and around the sundial bed.

Curriculum Framework

Ontario Curriculum: Science and Technology: Earth and Space Systems: Grade 6: Space. Designed for the science curriculum, the sundial project fulfils most of the expectations for Grade 6: Science and Tech: Space. However, the project has immense potential to fulfil expectations in other subject

areas such as math (geometry) and visual arts (colour schemes). This lesson has an Academic level focus.
Specific Lesson Goals:
By the end of the Lesson, students will be able to:
Basic Concepts:

- describe the physical characteristics of components of the solar system - the sun, planets, natural satellites, comets, asteroids, and meteoroids (e.g., relative size, surface temperature);
- identify the bodies in space that emit light (stars) and those that reflect light (e.g., moons, planets);
- describe, using models or simulations, the features of the moon's surface (e.g., craters, maria, rills);
- identify cycles in nature (e.g., cycle of day and night, cycle of seasons) and describe the changes within the cycles describe, using models or simulations, how the Earth's rotation causes the cycle of day and night, and how the Earth's revolution causes the cycle of the seasons;
- describe, using models or simulations, the effects of the relative motion and positions of the Earth, moon, and sun (e.g., solar and lunar eclipses, tides, phases of the moon);
- follow safety procedures when observing the Sun (e.g., never look at the Sun directly or through a lens or coloured glass; look only at a projection of the sun's image; do not use a lens or magnifier to focus the sun's rays to a small area; exercise caution when using mirrors so that they do not reflect the sun's image directly into someone's eyes) Skills of Inquiry, Design and Communication;
- construct a device that could have been used to tell time before mechanical clocks were invented (e.g., sundial);
- formulate questions about and identify needs and problems related to objects and events in the environment, and explore possible answers and solutions (e.g., use print, media, and electronic resources to identify and investigate space technologies and to investigate images of space and identify what they represent; use a computer simulation program to show the relative size of the planets and their distance from the sun);
- plan investigations for some of these answers and solutions, identifying variables that need to be held constant to ensure a fair test and identifying criteria for assessing solutions;

- use appropriate vocabulary, including correct science and technology terminology, in describing their investigations and observations (e.g., use terms such as constellations, planets, moons, comets, asteroids, and meteors to describe objects in space);
- compile data gathered through investigation in order to record and present results, using tally charts, tables, labelled graphs, and scatter plots produced by hand or with a computer (e.g., use print and electronic resources to organise information about the solar system);
- communicate the procedures and results of investigations for specific purposes and to specific audiences, using media works, written notes and descriptions, charts, graphs, drawings, and oral presentations (e.g., prepare a multimedia presentation showing Canada's contribution to space exploration
- Science, Technology and the World: identify and describe past and present-day contributions of astronomy to the quality of human life (e.g., development of the calendar; prediction of events such as eclipses and seasons; provision of information about space and time

Preparation Time

This project will require some long-term research and planning as the teacher will have to approach the school regarding an outdoor space for the sundial to be located. Once a decision is made as to the location, design layout and preparation of the space will be required. It will also take some time for the actual creation of the sundial. Please see Procedure under Section A: The Planning Process. The teacher will also have to spend a few hours of class time preparing her students with scientific information about the planets and their rotations.

Length of Lesson

The Human Sundial Project is an ongoing process and will provide several hours of lessons for the students. The lessons will include understanding the concept of the sundial, several weeks of once-weekly observation of the sundial, data gathering, and compilation of data into a presentation.

Resources Required

Garden Sundial

- markers e.g. rocks, small spruce trees to represent hours e.g. 12, 1, 2, 3, 4, 5, 6.
- waterproof markers for marking the area of the months.
- shovel
- mulch*
- annuals and other plants*
- camera*

*optional materials that will enhance the sundial project

Sidewalk Sundial

- paint
- brushes
- paint thinner
- painting clothes
- rags
- protractors
- rulers

A. The Planning Process (for the Teacher)

Research

Research history, theory, and models of construction of all sundials focusing particularly on the analemmatic sundial. Following are key terms to learn and share with students about analemmatic sundials.

analemma: A scale in the shape of a figure 8 representing the changes in the sun's position in relationship to the Earth. See Appendix III.

analemmatic sundial: A horizontal sundial in which the gnomon is vertical (in contrast to traditional sundials which use a fixed triangular wedge as the gnomon) and must be moved (or moves in the case of a human) with the date. The time is read from the dial by noting where the shadow of the human is.

date scale: the central part of the marked with the twelve months of the year, on which the gnomon positions her/his-self.

ellipse: a curve or conic section, essentially, the shape of the dial of the sundial. The Earth revolves around the Sun on an elliptical path.

gnomon: the shadow-casting object used to tell time. For the current project, the human student is the gnomon.

number markers: the objects used to mark the numbers representing time of the sundial.

Proposal

Present a proposal to the school for plans for the human sundial including visual aids, relevant research including benefits to the educational program and benefits to the school and local communities, proposed site, required preparation of site, budget. In collaboration with staff decide whether you will construct a paint-on-pavement sundial or a garden (living) sundial.

One benefit of constructing a living sundial is that the whole project is less fixed than a paint on cement sundial, and therefore the design and the process of building the sundial could take place with a new class each year. Once the sundial part is constructed, annuals could be added to the bed as a visual arts component. These annuals could be removed in September when their season is over leaving the bed empty and ready for the next class of sundial designers. There are many additional benefits and they align with the benefits of greening a school ground.

Location

Prepare the location. The site must be flat, sunny, and free of heavy traffic. A minimum area of 22 x 15 feet is required for the sundial. It is essential that the sundial site is distinguishable from common greenspace or pavement so that students can take accurate measurements and traffic is minimal. The analemmatic sundial will take the shape of an ellipse thus a rectangular or oval-shaped garden bed would be a wonderful site and can be easily constructed using a chalkline, lifting and relocating sod.

Prep with students

Prepare for creating sundials with students: The simultaneous rotation of the Earth on its own axis and around the Sun at a fixed angle of 23.5 degrees from the plane of rotation is what makes our days/nights/years interesting and what makes the sundial work. However, to make learning accessible to students at the Grade 6 level, it is essential that they are provided with the resources and tools to recognize how and why a sundial works. For example the hour markers (1, 2, 3, 4, 5, . . 12) could be set in place prior to introducing students to the site and the challenge for the them could be to find out where to stand in the sundial to allow their shadows to fall on the correct time. A significant challenge is finding a way for the students to record their position when they have found the right spot to correspond with the hour. The problem can be addressed by bringing out a rectangular piece of plywood with each visit to the sundial site, placing it in a fixed position and using markers to mark positions. Back in the classroom, positions could be re-marked on to a piece of graph paper the same size as the plywood rectangle. Alternatively students could mark their positions with labelled wooden stakes however these would be removable to the curious bypasser and neighbourhood animals.

Teacher fills classroom with literature and visual aids on space and sundials.

Safety

a. Safety procedures for observing the Sun must be discussed and reinforced throughout the duration of the sundial project.

b. During in-school hours (i.e. aside from recess), students should accompanied by the Teacher or in a group of several students depending on school policy.

Security and Vandalism

Vandalism of the site is a potential problem and action steps to address vandalism must be addressed by the school grounds committee prior to the construction of the site. Community involvement and building awareness about the project through posting signs and contacting local newspaper to share the idea will greatly decrease threats of vandalism.

B. The Sundial Project (5 phases of student-directed activities)

Step 1: Weekly diagramming exercise

Materials required: rectangular piece of plywood or other durable material that students can stand on and write on, sundial notebooks (one per student), writing tools.

Beginning with school (in September), students and teacher will go to the sundial site twice a day, e.g., 9AM and 3PM one fixed school day per week. During this time, the plywood will be positioned in a fixed, predetermined spot, several students will find a spot on plywood representing the calendar that corresponds to the time (9AM or 3PM). They will then make chalk lines, measure, and diagram the perimeter of the area of the rectangle that corresponds to the current month.

While the first group maps the month space the other students work on other mini-projects such as:

- measuring their shadows
- drawing and/or photographing their own shadow and/or the shadows of other objects
- weeding the area
- taking an inventory of the living creatures found in the sundial bed

Step 2: Models of understanding.

Ideally the class will spend several months diagramming before officially beginning the Grade 6 Unit: Earth and Space Systems: Space. Throughout the unit, students will study the components of the solar system and use their experience at the sundial site to make predictions of the positions and movement specifically of the Sun and Earth. Based on their predictions, students will build solar system models and design experiments using paper, colouring tools, modelling clay, wire, light source, shadows, paper-mache planets, and globes to test their predictions.

Students may also create a horizontal top sundial to reinforce concepts learned. For excellent instructions for the top sundial, refer to: The Earth is a Sundial by Mitsumasa Anno (see references below). The class can also plan an evening visit to the sundial site to observe constellations and the moon and differentiate between modes of light transmission.

Step 3: Design

Students will organise and share all data collected and shared during weekly trips to the future sundial site. Students will mark on the plywood rectangle the location of the months. They will discuss sundial design including styles, materials for construction, and colour schemes. Students should also be encouraged to consult with local artists, landscape designers and astronomers for advice.

Step 4: Construction

Students will collect materials and resources, invite volunteers to help in construction including: painting, measurement, and placement of patio stones, planting flowers.

Step 5: Presentation

A day will be selected when the students will present to a larger audience including parents, other classes, The ceremony will include:

- the history of sundials: in the form of drama or legends
- an explanation of how it works: using models, visual aids etc.
- a photo of the event
- a time for questions
- an invitation to the audience to step on and try it out

Discussion and Questions

Discussions should take place both with the whole class as well as in small groups. The class could be divided up into groups for the creation of the sundial, for the measurement of the shadows cast, (ie. Group 1 in the morning of Week 1, Group 2 in the afternoon of Week 1, Group 3 in the morning of Week 2, Group 4 in the afternoon of Week 2, etc.) and for different aspects of the presentation. The teacher should try to circulate to each group, asking relevant questions to each activity. Some examples of questions are the following:

- Describe characteristics and components of the solar system
- Explain how the rotation of the Earth around its axis causes night and day

- Explain how the Earth's revolution causes the cycle of the seasons
- How does the positioning of the markers affect the way the shadows from the sundial are cast
- Describe past and present-day contributions of astronomy to the quality of human life

See Specific Lesson Goals for ideas for additional questions and discussion topics.

Student Evaluation

Although the final project will be impressive, the process is of greater value to the learning experience. Students can be assessed on:

- skills and concepts: through sundial notebook and anecdotal observation
- cooperative skills and responsibility: observation of how students work together (sharing tools) and helping each other understand concepts.
- communication: observation and rubric of how well Students present learning to the community audience during the sundial ceremony.

Enrichment and Extension Activities

Implementing a Garden Sundial (as opposed to a Sidewalk Sundial) will create direct links to school ground naturalization. By involving the students directly in the process of planning, designing and creating the sundial and the green space surrounding it, they will come to understand how to incorporate a green space into their schoolground. They should be involved in all planting of annuals and other plants in and around the sundial bed as well as caring for these plants. As the site will be used on a regular weekly basis for measurement, study and exploration, the students will become familiar with learning and experimentation in an outdoor classroom. In addition to housing the sundial project, the green bed around the sundial would be a perfect space to examine living creatures of all sorts.

Photos

The following photos are credited to Steve Irvine and can be found on his Web site (www.steveirvine.com). More information and a larger selection of

photos can be found at this Web site.

Figure 1: Keppel Henge - The Analemma Project

Figure 2: Keppel Henge - The Analemmatic Sundial

References

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