



# Passing Time

**An Exploration of Precision and Scale  
from Eons and Epochs to Picoseconds**

A Data Gathering/Problem Solving Unit  
for Highly Capable 5<sup>th</sup>/6<sup>th</sup> Grade Students

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## 2 Thematic Framework and Rationale

### 2a Central Questions

The central questions for the unit are:

- How is time measured?
- What is a time scale?
- Does *why* time is measured change *how* it is measured?
- Has the way people think about time changed over time?
- What does accuracy or precision mean when talking about time?

Through a series of lessons that ask them to consider time (and its close relative, distance) in different ways, students will work towards an understanding that there are various ways to measure time and distance, and that the degree of precision required is defined both by the problem and the technology at hand.

### 2b Rationale

The concept of time is a rich (timeless) source of explorations that will allow my students to gain experience and understanding of units of measurement, precision, and problem-solving. I want them to encounter mind-boggling measures of time and distance that stretch from the incredibly minute to unfathomably far, and excruciatingly slow to the unbelievably fast. The unit stretches the gamut from eons to picoseconds, where precision ranges from plus/minus millions of years (geologic time) to less than one second every 1.4 million years (cesium atomic clock).

People in all cultures and all eras have thought about and measured time. In addition to gaining facility in the mathematical skills of measurement, calculation, and conversion of time and distance from one standard to another, students will gain perspective on and develop appreciation for historical and cultural

conceptions of timekeeping and technologies associated with measurement of time. As citizens of a world where the pace of change seems set to an ever-increasing metronome, I believe it is important for students to become aware of the amazing range in scales of time and distance.

The ranges of magnitudes in our universe— sizes, durations, speeds, and so on— are immense. Many of the discoveries of physical science are virtually incomprehensible to us because they involve phenomena on scales far removed from human experience. We can measure, say, the speed of light, the distance to the nearest stars, the number of stars in the galaxy, and the age of the sun, but these magnitudes are far greater than we can comprehend intuitively. In the other direction, we can determine the size of atoms, their vast numbers, and how quickly interactions among them occur, but these extremes also exceed our powers of intuitive comprehension (Project 2061, p. 179).

These students are young, so the activities in the unit are concrete. I do not expect them to develop deep philosophical reflections about the nature of time and the expanse of the cosmos, but I do hope to spark some fascination with more abstract conceptions of scale, rates, time, and distance that they might carry with them into the future. If they are to become our innovators of the future, I hope they will develop a sense of historical time and an appreciation for different cultural perceptions of time.

Passing Time is a topic that can illuminate the idea that math and science are interwoven and interconnected with almost everything. In the future, I might use this as an integrating theme for an entire year, so that I could integrate it with language arts, economics, history, and geography.

I use 7<sup>th</sup> grade standards benchmarks for these students. The unit aligns with many EALRs in math and science, but most particularly to the understanding and application of concepts and procedures from measurement (Math 1.2). These include understanding of appropriate degrees of precision and scale, such as meters vs. kilometers or light years. Students in this class are just beginning to work with a variety of graphs, metric conversions, decimals, ratios, proportions, and scientific notation. The activities in this unit allow for practice with those skills and will develop their number sense,

particularly with powers of ten (Math 1.1). Throughout, the focus will be on problem-solving, the ability to formulate questions and to construct solutions, and on applying viable strategies and organizing relevant information (Math 2.3). Graphing skills using Excel are also developed. The Shoreline District's 7<sup>th</sup> grade SHELs are aligned with the above EALRs.

Though math and arithmetic are fundamental to this unit, the skills and processes of scientific inquiry are necessary for students to be successful. Because they will be engaged in active investigations, they will develop their abilities to apply science knowledge and skills to solve problems or meet challenges (Science 2).

## **2c Learner's Levels and Description of Learners**

### **Intellectual**

The 25 students (16 boys, 9 girls) in this classroom are all highly capable fifth or sixth graders. Many are reading well above grade level, and all are working from a math textbook one year above grade level. They are capable of abstract thought, and enjoy debating highly abstract hypothetical situations, but they also need to learn to back up their conclusions with evidence. They will need a combination of lessons that focus on both concrete-operational and abstract thought. Diverse learning styles are accommodated through a variety of activities and assessments (a mixture of kinesthetic, musical, written, oral, individual and group activities). As a group, these students are very creative. I will emphasize higher-level thinking skills (analysis, synthesis, evaluation) and creativity (awareness of world from different perspectives, problem-solving). It is my hope that this theme will engage them and challenge their critical thinking skills. Many of the students in the class read science fiction and fantasy. I think the theme of Time, especially in regards to the shifting nature of time, will capture their imaginations.

There are nine fifth grade students who may not have encountered all of the math (decimals, ratios, metric conversions) required in this unit, but these skills are new to the sixth graders as well, so I believe that brief, targeted lessons to the whole class will enable all students to be successful with the requisite arithmetic. All students know how to read music; one lesson uses this knowledge. These students question teaching and grading methods, so clear rubrics and expectations are absolutely necessary.

## **Social**

There is great diversity in emotional and social development among these students. Because it is a 5/6 classroom, the age range is 10-12. Their physical development varies considerably, especially among the boys. As a class they are very talkative and according to a survey<sup>1</sup> most enjoy working in small groups on tasks that are clearly outlined. A large minority would prefer that the class be quieter with more opportunity for individual work than currently exists. Both extraverts and introverts need a safe environment from which to take risks— many of the activities in this unit are creative problem-solving activities that do not have a single “right answer.” Because of their tendency toward perfectionism and hypersensitivity, these students need opportunities to make mistakes, work together, and practice respectful listening to other peoples’ ideas. Much of the work in this unit will involve cooperative group activities, with accountability for individual participation. Expectations for appropriate behavior have been communicated since the beginning of the school year through literature circles and other group activities. These expectations will be reinforced throughout this unit in order to foster an environment of pleasurable and focused inquiry.

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<sup>1</sup> One page survey of student interests and preferences created by this author and given October, 2003.

## **Special Needs**

Students in this particular class are all reading and studying mathematics above grade level and none requires unusual special accommodations. However, my observations during small math groups and evaluation of homework and tests show that not all students understand key concepts about precision and ratios, and that some are struggling to keep up with the math in an environment where very little direct instruction or explanation is provided. Students vary in their previous school experiences and some are surprised to discover that they are suddenly behind in some fundamental skills and that they are expected to catch up on their own. This unit will provide an opportunity for them to practice and reinforce recently acquired math skills in a more natural context (outside the textbook). Racially, the class is not particularly diverse; the students are 25% Asian, 2% Black, otherwise Caucasian. None of the students are on free or reduced lunch or on IEP, though two (possibly more) students are taking medication for ADHD.

I have chosen activities and historical examples of time measurement from across several cultures. The lessons address a variety of learning styles. I provide scaffolding for the assignments by modeling where appropriate, and providing rubrics and clear instructions for assignments. Though not specified in the Learning Targets, communication skills and group cooperation are highly valued.

# Assessment

## Math 1.1, 1.2, 2.3 Science 2

3a Learning Targets	EALRs	3b Evidence of Achievement
<p>1. Students will understand that time is measured with varying degrees of precision for different purposes. (concept)</p>	<p><i>Math 1.2.2: approximation and precision:</i> understand that precision is related to the unit of measurement used and the calibration of the measurement tool</p> <p><i>systems and tools:</i> understand the appropriate uses of standard units of measurement for both direct and indirect measurement.</p>	<p><b>Summative Assessment (in conjunction with clock-building project):</b> Short essay response to two prompts:</p> <p>a) What do we mean by “accurate” time? Give 3 examples of different ways and reasons people measure time. Explain why each method is useful and when it is appropriate (<i>accurate enough</i>).</p> <p>b) describe the clock you built and the problems you encountered and solved in making it ‘accurate enough.’ Is it accurate enough? What would you do differently next time?</p>
<p>2. Students will be able to design a simple time-counting device. (process)</p>	<p><i>Science 2.2.2</i> identify and examine common, everyday challenges or problems in which science/technology can be or has been used to design solutions; identify, design, and test alternative solutions to a challenge or problem</p> <p><i>Math 5:</i> understand how mathematical ideas connect within mathematics, to other subject areas, and to real-life situations.</p>	<p><b>Summative Assessment:</b> Student teams will plan and build a ‘marble clock’ that accurately marks 3 seconds (i.e. it takes 3 seconds for the marble to run its course) or a water clock that times one hour and is accurately marked with 5 minute intervals.</p>

<p>3. Students will gain an appreciation of the history of timekeeping and for the vast differences in time scales. (disposition)</p>	<p><i>Science 3.2</i> know that science and technology are human endeavors, interrelated to each other, to society, and to the workplace; know that science and technology have been developed, used, and affected by diverse individuals, cultures, societies, throughout human history</p>	<p><b>Formative assessment:</b> observation, anecdotal notes, classroom and small group discussions. Some evidence may be seen in summative essay (above).</p>
<p>4. Students will be able to calculate times and convert between standard units of measurement (hours, minutes, seconds, milliseconds, etc.). (skill)</p>	<p><i>Math 1.2.2:</i> select and use tools that will provide an appropriate degree of precision, for example, using meters vs. kilometers. <i>Math 1.1.2:</i> demonstrate understanding of integers, fractions, decimals, percents, place value; understand and apply the concepts of ratio and direct proportion;</p>	<p><b>Formative assessment:</b> Short written exercises and worksheets, including some overlapping assignments from the math textbook.</p>
<p>5. Students will be able to calculate longitude given a time at a point of origin and time at a current position. (skill)</p>	<p><i>Math 1.3:</i> understand and apply concepts and procedures from geometric sense; locate and describe the location of objects on a number line, map, or coordinate grid  <i>Geography 1.2.2</i> Locate physical and human features and events on maps and globes.</p>	<p><b>Formative assessment:</b> Class Treasure Hunt requiring each student to correctly determine what city/location they are in, traveling through a series of clues in search of a final prize. Errors will cause them to become “lost” and move further away from the treasure.</p>

6. Students will be able to demonstrate that bits per second transmission rates affects availability of data. (concept and skill)	<p><i>Math 3.3.2</i> Test conjectures, support arguments and justify results using evidence; reflect on and evaluate results in new problem situations.</p> <p><i>Math 5:</i> understand how mathematical ideas connect within mathematics, to other subject areas, and to real-life situations.</p>	<p><b>Formative Assessment:</b> Given a variety of web pages, students will calculate the time each takes to download using several common data transmission rates, then graph their results and write a short explanation of why some people advocate for ‘text only’ web pages.</p>
7. Students will develop timelines and graphs to describe data and events. (skill)	<p><i>Math 4.3</i> represent and describe patterns with share information using notation such as physical or pictorial models, tables, charts, graphs, or symbols.</p>	<p><b>Formative Assessments:</b> Students will create timelines on various scales. Students will create several bar and line graphs using Excel. See attached rubric (page 24) and individual lessons.</p>
8. Students will work cooperatively with others in a variety of group settings. (skill/process)	<p><i>Communication 3.2</i> Work cooperatively as a member of a group</p> <p><i>Communication 4.1</i> assess strengths and need for improvement</p>	<p>Complete self-assessment on group process (this is also part of Collaborative Action Research)</p>

### 3c. Assessment Instruments

#### **Pre-Assessment**

Students will complete a short survey about their existing knowledge about time, units of time, precision and scale. (See page 20).

#### **Formative Assessment**

See page 21 for one example. This type of worksheet will be used approximately once each week to make sure the math concepts are understood. These students enjoy doing these kinds of problems as morning warm-ups.

### **Summative Assessments**

In addition to building water or marble clocks with their teams, students will individually write short essay response to two prompts:

- a) What do we mean by “accurate” time? Give 3 examples of different ways and reasons people measure time. Explain why each method is useful and when it is appropriate or *accurate enough*.
- b) describe the clock you built and the problems you encountered and solved in making it ‘accurate enough.’ Is it accurate enough? What would you do differently next time?

### **Self-Assessments**

After the Geologic Time Walk and Clock-making Project, students will assess their own group participation. (See page 23). There is also an element of self-evaluation in the second summative writing prompt.

### **3d. Positive Impact on Student Learning**

The preassessment instrument will be used to determine instructional levels and students’ existing knowledge about time and ways of keeping time. I will vary the depth or breadth of this unit or certain lessons within the unit as appropriate. If the class has a knowledge base of certain topics, I will encourage these students to contribute and enrich the lessons with what they know, and I will adjust the background resources accordingly. I will need to be flexible with this material in order to respond to instructional levels of the students.

*Every* lesson has either informal or formal formative assessments. I will use these to learn whether or not I need to revisit certain topics or modify future lessons. I will be relying on observation, class discussions, and short written exercises (quizzes/problems) to ‘check in’ on how well they are connecting the lessons to the targets. I will be explicit about learning targets and objectives for each

lesson. The graphing exercises will be accompanied by assessment rubrics. If I find that the class or individual students are 'not getting it' I will drop some of the more peripheral lessons in order to focus on the most important targets. This may have to happen if students are not as capable of the arithmetic involved as I think they are.

I have incorporated cooperative work and student choice into several activities. There are a couple students in this class who are capable of self-directed study and research with little support. Others need the structure of projects broken down into smaller chunks, so I will be assisting them with organization, time management and research skills as necessary.

The build-a-clock project and final essays are the summative assessments of the unit. These will allow me and the students to evaluate how well the learning targets have been met. The final essay includes a self-assessment component.

I will create a recordkeeping system, keep anecdotal notes, and save examples of student work for analysis during TEED 540.

### **3e Letter to Families/Students**

My cooperating teacher does not want me to send any letter of introduction when I begin student teaching, nor does she recommend sending letters at the beginning of each unit. However, here is a letter I might send if it were my classroom:

Dear Family:

Our class will soon start a unit on Time. We will be exploring the history of timekeeping, technologies of timekeeping, and comparing time scales, such as geologic time vs. atomic time.

This is a vast subject with many connections between math, science, technology, and history, so be prepared for some stimulating conversations with your child. Our guiding questions include:

- How is time measured?
- What is a time scale?
- Does *why* time is measured change *how* it is measured?
- Has the way people think about time changed over time?
- What does accuracy or precision mean when talking about time?

As always, please contact me if you have any questions.

## **4 Timeline/Lesson Outline**

### **4a Unit Overview**

This unit proceeds at a rapid pace over four to five weeks. It has been designed for a very active highly capable classroom with access to the internet (computer labs and wireless I-Books) and good computer skills. I will present focus lessons on Excel as necessary and will develop a web page of resources for students to use for directed research.

The unit begins by developing the concept of internal clock and an awareness of pulse rates. From there, various activities challenge students to think about time and the measurement of time. The sequence of the unit is from Body Time to Geologic Time to Earth Time and then revving into Unbelievably Fast Time - a look at time in communication technologies (micro-times) and light-years (very near and very far but all very fast).

## 4b Lesson Outlines

### Week One – Body Time

**Intro:** begin by playing *Time* by Pink Floyd (from *Dark Side of the Moon*). Give pre-assessment on time. Have students pair off to do the “close your eyes until you think 60 seconds has passed” exercise. Brief class discussion about time and activity ‘Hand Sweep’ where students predict and time how long it takes for a hand squeeze to make it around a circle of students. Graph the results for growing numbers of students and predict larger numbers.

#### Lesson 1: What’s the Beat?

Students will learn to take their pulse and how to take the pulse of their cats or dogs. We will collect data and create stem and leaf plots of student pulse rates. We will also research (web-based) pulse rates and life expectancies of various animals. Research can be done in pairs or triads, but each student must create line graphs of these results with Excel (see graphing rubric). Guiding question: is there a relationship between pulse rate and size of animal and/or longevity? We’ll also calculate various lengths of time using heart beats as the unit of measurement.

#### Lesson 2: Dance to the Music

How does music tempo relate to pulse? Is there some relationship between the normal pace of a march and a heart beat, or a lullaby and heart beat? Does pulse rate increase or decrease when music is fast or slow? Student teams will design and conduct experiments and record/graph results in a spreadsheet.

Additionally, students will be asked to make a graphic representation of their own use of time over this week, and to come up with lists of ‘things that take a minute’ and ‘things that take a second.’

**Rationale:** To introduce the theme of time in a familiar context. To develop an awareness of our own sense of time. To develop skills of estimating and predicting time, data collection and graphing, and to make certain all students know how to use Excel for simple graphs.

**Assessments:** *What’s the Beat?* And *Heartifacts* Worksheets, Excel spreadsheet (see rubric), and class participation.

### Week Two – Geologic Time

#### Lesson 3: Walking a Geologic Timeline

Moving onto the football field, students are broken into 6 teams of 4 and given a task using data charts to place markers within different time scales. Each group must mark off their strip of field to create a properly proportioned timeline. Together, the class marks off 4.6 billion years according to the chart in *Science Is* (page 231). Then one group takes the most recent 100-million years and divides it, marking significant events. The next group takes the most recent million years and breaks it into 100,000 year increments, and so on, down through the powers of ten. The remaining team does the current decade. The field will contain place markers with significant events within each time line, and each time line will expand the most recent section of the previous line. Students will walk the timelines.

Upon returning to class, pass out a pictorial handout and discuss.

Vocabulary: Era, period, epoch, millennium, century, decade

Background reading:

<http://www.ucmp.berkeley.edu/help/timeform.html>.

<http://pubs.usgs.gov/gip/geotime/contents.html>

<http://www.powersof10.com>

Unscramble pictures to arrange them from farthest away to the closest up.

<http://www.powersof10.com/activities/nickelodeon/nickelodeon.html>

**Video:** *Powers of Ten*, by Charles Eames. 9 minutes. I have not viewed the film yet, but hope to be able to use it. It is about the size of things at powers of ten. It's tangential to this unit (on time) but very relevant as to scale. The film starts with an image of a sleeping man at one meter square ( $10^0$ ) and gradually pulls back, moving ten times away for every ten seconds of time that passes, eventually reaching the edge of the universe ( $10^{25}$ ). The camera then zooms forward, into the sleeping man's hand, finally reaching the inside of an atom ( $10^{-18}$ ). I think it will be cool to give the kids a taste of the interconnectedness of space and time (without going into it in detail).

**Rationale:** develop sense of scale and place human activity in proportion to whole of geologic time. Practice ratios, proportions, measuring with metric units. Develop an understanding of large numbers.

**Assessment:** observation of participation in Time Walk and class discussions. Self-assessment on group participation in Time Walk.

### **Week Three – Earth Time**

**Lesson 4: Swing Time (Pendulums)** Given string, scissors, metal nut and stopwatch, students complete the task of making the pendulum swing exactly 10 times in 10 seconds. Work in pairs. Formative Assessment: write a paragraph describing how you solved this problem.

**Background:** As they finish their pendulum experiments, allow students to play with mechanical metronomes for a little while. Students will then read a brief history of timekeeping and I will present some material (basically some good stories about time technologies and their development). Handouts will be distributed of "Taking the Measure of Time," an article from Smithsonian magazine (December, 1999), and students will also explore [www.britannica.com/timekeeping](http://www.britannica.com/timekeeping) to learn about different timekeeping techniques, from sundials, water clocks, pendulums, to atomic clocks.

#### **Lesson 5: Set Sail: The Story of Longitude**

As a refresher on latitude and longitude, students will work in teams to solve the National Geographic mystery, *Crack the Code* ([www.nationalgeographic.com/xpeditions/activities/01/crackcode.html](http://www.nationalgeographic.com/xpeditions/activities/01/crackcode.html)). Thieves have stolen items, but left a scrap of paper containing a list of coordinates. These coordinates turn out to be cities, and there is a rhyme left behind as a clue: *First letters from each place-name read. Spell out the town and come with speed.* Correctly identifying the cities listed by the coordinates gives

the location where the thieves have taken the loot.

Read excerpts from *Longitude* by Dava Sobel about the race and prize for inventing ship's chronometers. Tell the story about hourglasses, ropes, and knots to determine ship's speed (knots).

Introduce concepts of Prime Meridian, International Date Line. Using the globe and a flashlight as the sun, lead students in a discussion to help them figure out how and why sailors wanted to use accurate time pieces to help them know their location. Let them work in pairs to figure out correspondence between time differences and miles between longitude lines or degrees.

Model some calculations of location given time at some known location (Greenwich Mean Time) and current latitude and time, then have students participate in a Treasure Hunt, using clues that require them to solve problems using their knowledge of time and longitude. (**Formative assessment**).

**Rationale:** Learning Targets 1, 3, 4, 5. Understanding earth's rotation as fundamental to time and history of navigation.

## **Week Four – Communication Time: From Smoke Signals to WiFi**

**Lesson 6:** In a dramatic voice, read a proclamation stating that as of this date (1967), time has been redefined. The official international unit of time, Universal Coordinated Time, has replaced the previous method of keeping time. Ask the students what this could possibly mean. Ask them 'What is a second? What determines how long a second is?' Hopefully they will say things about the earth's rotation, 24 hours in a day, etc. Then introduce the idea of the atomic clock and vibrations of an atom. Don't need to get too detailed, just let them consider the idea that atomic time has replaced earth time as the world's official timekeeper. Cesium atoms oscillate precisely 9,192,631,770 times per second, and the cesium clock allows time calculation with an error of one second every 1.4 million years. Wow! The earth itself is slowing down about one second per year. If they ask why a clock would ever have to be this accurate, make them wait for the answer, because that's what these lessons are going to be about – time for data transmission and communications like GPS satellites, space travel, etc.

Then, hold up a dry spaghetti noodle. 10 inches is approximately the distance light travels in a nanosecond. What is a nanosecond? Continue discussion in this vein, introducing picoseconds, nanoseconds, etc. Have the students identify various objects and distances that 'measure' light traveling. Given the speed of light, have them calculate distance in a second, a minute, an hour, a day, a week, a month. Really go for the Wow factor here.

The students should do the following activities:

1. Flip book (use Science Is, page 233, of continental drift) and/or Phenakistoscope (rotating paper plate with succession of eyes drawn around perimeter, in stages of winking. When rotated on a pencil, the eyes wink).
2. Then introduce film and TV and the concept of frame rate (24 and 30 frames/sec, respectively). Pass around some lengths of film and have them calculate how many seconds they represent. If possible, show cardiac imaging video (recordings from where I used to work developing medical imaging devices).

Finally, talk about data transfer rates of DVD and HDTV. Do a *brief* presentation on the history of communication devices and data rates, using the Powers of Ten concept we addressed earlier.

From Powers of Ten website: "In the days of Xerxes, it took several hours to get one bit of Information (We Won!) from Marathon to Athens.

By the time of Napoleon, signal towers using semaphore flags were capable of sending about ten bits (about two letters) per second. This improved a little with the invention of the telegraph by Morse, but was shortly greatly improved by Edison's invention of the multiplexor (allowing at least one hundred bits per second over the same channel, although an individual pair of operators could still only transmit about ten bits per second), and the telephone (about 2000 bits per second).

Ticker-tape and teletype machines could also send about 100 bits per second. After World War II, commercial data transmission speeds increased to 1000 bits per second, and then 10,000 by 1970.

Meanwhile, Bell Labs began developing digital trunk lines to multiplex numerous telephone calls. Speeds of one million, ten million and one hundred million bits per second were achieved by 1980. When Metcalf et. al. developed the Ethernet at Xerox in the mid '70's, their baseline speed was ten million bits per second. By the mid '80's, networks operating at one hundred million bits per second existed, and that is now the industry standard. Some networks exist today that operate at speeds of one billion bits per second.

Off on a tangent, don't underestimate the bandwidth of a 747 full of DVD's. In the space program, when Mariner IV encountered Mars in 1964, the data rate was  $8 \frac{1}{3}$  bits per second (call it ten). When Voyager encountered Jupiter in 1979, the data rate was 160,000 bits per second (call it 100,000 at Saturn)."

Currently, there are networks in the terabit range.

As a class, create another timeline – it should look somewhat like the geologic timeline, only this time showing speed of data communication increasing rapidly.

**Formative Assessment:** After introducing bit rates (8 bits = one byte. One byte = one letter/character), give the students a short list of websites – some text only, others with large graphics. In groups or individually, they should each calculate the size of one page (browser will do this for them, just show them how), and then graph the download time for each page at different modem rates (9600, 38400, 57600, 115200, 1.1Mb/sec). They should get into groups to compare results and reach conclusions. Individually, they should write a paragraph explaining what they discovered and why some people might want text-only pages. This will lead into our next unit, which involves creating web pages.

Note: This is not meant to go overboard on the technical details. The point is simply to give them an idea of how fast data is transmitted and how quickly technology has developed. Calculating the speed of web page access at different transmission speeds is tedious, so I won't overdo it.

**Rationale:** Learning Targets 1, 3, 4, 6, 7. Introduction to atomic time and importance to data transmission. Beginning connection between time and distance (light-years, satellite transmission). Identification of cool careers that use math, tech, and time. Measurement and uses for Time is still changing!

**Summative Assessment:** Student teams will plan and build their choice of either a ‘marble clock’ that accurately marks 3 seconds (i.e. it takes 3 seconds for the marble to run its course) or a water clock that times one hour and is accurately marked with 5 minute intervals. They will have at least 3 hours in class to work on their clocks over two weeks. The class will have a Celebrating Time to evaluate accuracy of their clocks and explain their designs to the class. They will also take a short end-of-unit test that includes essay responses and self-assessment on the unit (described on page 10).

#### **4c. Special Needs**

See 2c (Special Needs).

#### **4d Classroom Management**

These students thrive on challenge and will work for long periods if they are interested in their task. If they are not interested in something, they tend to ignore it (and the teacher) and do something else. If they run out of things to do, they go wild. The most significant preventive classroom management tool is that work not completed during work periods must be done as homework. That seems to be enough to motivate most students to stay on task. Developmentally, these students need social and emotional engagement and support as much as cognitive challenge. They are essentially middle school students, so I am willing to give them as much autonomy as they can handle. They are free to work on whatever projects they choose during their work periods, so long as deadlines are met. Some of them need time management and organization skills. Lack of these does become a management issue, so I will do informal progress checks for longer assignments. Corrective and supportive measure include study hall, students writing essays about their responsibility for misbehavior, students placing calls home to parents, and taking away technology (internet) privileges. Fortunately, they like reading and hands-on projects. Introducing them to engaging content and activities is perhaps the best management tool of all. Books, magazines, and internet sources will be available throughout the unit, and I will have a check-out method in place so students can borrow resources to take home.

## **4e Community Collaboration**

Throughout my student teaching I will use email, notes, and phone calls to contact family members as appropriate. The teacher sends a newsletter twice a month – I will be responsible for that during my student teaching. I'll also send a letter introducing myself. I have already met several parents at curriculum night, on field trip, and during classroom visitations. I'd like to make a positive contact with each one in early January. In this classroom, students are responsible for making phone calls to parents if they have forgotten homework or to explain behavior issues. I will continue that practice. Assignments that are graded 'unacceptable' (1) are sent home for parent signature.

The music teacher will be a resource for some of the activities that use music and rhythm, and the P.E. teacher may be able to provide chalk for marking the football field during the timeline activity.

## **5 End Stuff**

### **5a Unit Impact**

I'm a bit worried that this unit packs too much in too little time, but I prefer to err on the side of high expectations and adjust as necessary. I think the students will be engaged by the material and can handle the math, but this unit covers a lot of material and I had a hard time focusing on just a few most important concepts. I will have to be flexible in responding to feedback from the pre-assessments and formative assessments. I want also to be able to pursue questions that students generate. I know they will have questions of their own and I am willing to go with them if appropriate. Even if I don't know the answers, maybe I can point them in the right direction and we can explore together.

As mentioned in my rationale, it is my hope that students will come away from this unit with a beginning understanding of the vastness of time and space and the amazing precision with which mathematicians, physicians, technologists and scientists work when dealing with atoms, data transmission, and cells. Arithmetic figures prominently, as do the graphing technologies of spreadsheet programs, but to my mind these are fundamentals that serve the larger goal of instilling a passion for the pursuit of ideas. That's the best pursuit I know, the best way of Passing Time. In my classroom, I hope there's no such thing as a dull day. Time flies when you're having fun! I look forward to teaching this unit.

## 6 Annotated Bibliography

Bosak, Susan V. *Science Is...* (2000) Scholastic Canada, Ltd.  
Source for Geologic Time Walk idea and some of the body time (pulse) activities.

Campbell Hill, B., Ruptic, C., & Norwick, L. (1998). *Classroom Based Assessment*. Christopher-Gordon Publishers, Inc.: Norwood, Massachusetts.

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Valuable reflections on what it means to be well educated in science, math, and technology.

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Washington State Commission on Student Learning (1997). *Essential Academic Learning Requirements in Reading, Writing and Communication*.

### Websites

<http://math.rice.edu/~lanius/Algebra/hndsqa.html> : The Hand Squeeze activity.

<http://www.sciencenetlinks.com> – Adapted idea for water clock from this site. Rich resource.

<http://www.nationalgeographic.com> – Another great source of ideas, resources, lesson plans. I've adapted their Crack the Code longitude activity.

<http://www.britannica.com/clockworks/main.html> - an excellent resource for background info on history of clock making and measuring time. From sundials to the atomic second.

<http://www.childrensmuseum.org>. Children's Museum of Indianapolis has a large water clock. Pictures online.

[www.pbskids.org](http://www.pbskids.org): This site contains some great activities; many are linked to PBS videos. I got the Phenakistoscope idea from here.

Background information on geologic time from three sites:

[www.powersof10.com](http://www.powersof10.com) – A site devoted to the work of Charles Eames

<http://www.ucmp.berkeley.edu/help/timeform.html>.

<http://pubs.usgs.gov/gip/geotime/contents.html>

[www.askeric.org](http://www.askeric.org) – Good source for lesson plans and ideas.

<http://illuminations.nctm.org> – extraordinary lessons. *What's the Beat* lesson and assessment were adapted from here.

<http://rubistar.4teachers.org> – a source for assessments that can be easily adapted.

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## **Preassessment Instrument**

1. What is time? What do you think of when you think of time?
2. What are some ways people measure time?
3. What is the longest length of time you know?
4. What is the shortest increment of time you know?
5. Do you think longitude has anything to do with time? If so, explain.
6. Tell me anything you can think of that you know about time or the history of ways of telling time.

# Sample Formative Assessment / Worksheet

## What's The Beat?

When at rest, the normal adult heart beats about 70 times a minute.

1. How many times will the heart beat in--

- a. one hour? \_\_\_\_\_
- b. one day? \_\_\_\_\_
- c. one week? \_\_\_\_\_
- d. one month? \_\_\_\_\_
- e. one year? \_\_\_\_\_
- f. ten years? \_\_\_\_\_
- g. twenty years? \_\_\_\_\_
- h. thirty years? \_\_\_\_\_
- i. sixty-five years? \_\_\_\_\_

2. Which is the greater—the number of heartbeats in an hour or the number of seconds in an hour? \_\_\_\_\_

How can you tell? \_\_\_\_\_

3. Does your heart beat faster than once a second? \_\_\_\_\_

How do you know? \_\_\_\_\_

4. What length of time is required for an average adult human's heart to beat 1,000,000 times?

\_\_\_\_\_

What helped you to make this decision?

\_\_\_\_\_

5. When at rest, the blue whale's heart rate is 5 beats each minute, the elephant's is 30

and the adult human's is 70. The shrew, a mouselike animal, has a heart rate of about 1,000 beats a minute.

a. About how many more times each day does the shrew's heart beat than the adult human's?

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b. About how many more times in one day does the adult human's heart beat than the elephant's?

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c. What conclusions can you draw from the information above? Write your response here.

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## Self-Assessment –Group Participation

CATEGORY	4	3	2	1
<b>Contributions</b>	Routinely provides useful ideas when participating in the group and in classroom discussion. A definite leader who contributes a lot of effort.	Usually provides useful ideas when participating in the group and in classroom discussion. A strong group member who tries hard!	Sometimes provides useful ideas when participating in the group and in classroom discussion. A satisfactory group member who does what is required.	Rarely provides useful ideas when participating in the group and in classroom discussion. May refuse to participate.
<b>Time-management</b>	Routinely uses time well throughout the project to ensure things get done on time. Group does not have to adjust deadlines or work responsibilities because of this person's procrastination.	Usually uses time well throughout the project, but may have procrastinated on one thing. Group does not have to adjust deadlines or work responsibilities because of this person's procrastination.	Tends to procrastinate, but always gets things done by the deadlines. Group does not have to adjust deadlines or work responsibilities because of this person's procrastination.	Rarely gets things done by the deadlines AND group has to adjust deadlines or work responsibilities because of this person's inadequate time management.
<b>Focus on the task</b>	Consistently stays focused on the task and what needs to be done. Very self-directed.	Focuses on the task and what needs to be done most of the time. Other group members can count on this person.	Focuses on the task and what needs to be done some of the time. Other group members must sometimes nag, prod, and remind to keep this person on-task.	Rarely focuses on the task and what needs to be done. Lets others do the work.
<b>Pride</b>	Work reflects this student's best efforts.	Work reflects a strong effort from this student.	Work reflects some effort from this student.	Work reflects very little effort on the part of this student.
<b>Monitors Group Effectiveness</b>	Routinely monitors the effectiveness of the group, and makes suggestions to make it more effective.	Routinely monitors the effectiveness of the group and works to make the group more effective.	Occasionally monitors the effectiveness of the group and works to make the group more effective.	Rarely monitors the effectiveness of the group and does not work to make it more effective.

## Rubric-based Assessment – Excel Graphing

CATEGORY	4	3	2	1	Points Earned
<b>Accuracy of Plot</b>	All points are plotted correctly and are easy to see.	All points are plotted correctly.	Points are not plotted correctly OR extra points were included.	No points are plotted.	
<b>Labeling of X axis</b>	The X axis has a clear relevant label that describes the units used for the independent variable	The X axis has a clear label that describes the units used for the independent variable.	The X axis has a label.	The X axis is not labeled.	
<b>Labeling of X axis</b>	The X axis has a clear relevant label that describes the units used for the independent variable	The X axis has a clear label that describes the units used for the independent variable.	The X axis has a label.	The X axis is not labeled.	
<b>Units</b>	All units are described (in a key or with labels) and are appropriately sized for the data set.	Most units are described (in a key or with labels) and are appropriately sized for the data set.	All units are described (in a key or with labels) but are not appropriately sized for the data set.	Units are neither described NOR appropriately sized for the data set.	
<b>Explanation</b>	The explanation accurately describes the graph with a valid interpretation of the data.	The explanation is mostly appropriate but contains small errors in interpretation.	The explanation is unclear or is not based on the data.	No explanation of the graph is provided.	