

2018

Market PBL: A Cross-Curricular Exploration of Technological Innovation in Pre-Modern Civilizations

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UNDERSTANDING BY DESIGN

Unit Cover Page

Unit Title: Market PBL: A Cross-Curricular Exploration of Technological Innovation in Pre-Modern Civilizations

Grade Level: 10th Grade

Subject/Topic Area(s): AP World History, English II Pre-AP, Chemistry Pre-AP & Algebra II Pre-AP

Designed By: M. Melendy Jacobie, Blake Keeling, Elizabeth Muire, Kay Newsome & Lisa Stuckey

Time Frame: 17 days

School District: North East ISD

School: STEM Academy @ Lee High School

School Address and Phone: 1400 Jackson Keller Rd, San Antonio, TX 78213

Brief Summary of Unit (Including curricular context and unit goals): This project-based learning unit incorporates knowledge from history, English, math and science courses. Students explore how geography and available resources, coupled with technological advancements, shape a civilization's industry and therefore the quality of life of the inhabitants. Students design a product that could be made from the natural resources of their civilization and attempt to sell their product in a simulated market.

Unit: Market PBL - A Cross-Curricular Exploration of Technological Innovation in Pre-Modern Civilizations

Grade: 10

Understandings

Students will understand that...

Geography and available resources, coupled with technological advancements, shape a civilization's industry and therefore the quality of life of the inhabitants.

Essential Questions

How does geography influence technological advancement?

How does a society's ability to create affect its population?

How does technological development affect a society?

How does the organization or presentation of an idea persuade a listener or reader?

How can a team most effectively unify disparate skills to reach a common goal?

How does economics affect innovation?

Knowledge & Skills

(NEISD scope & sequence; TEKS; Core; etc.)

World History TEKS:

(27) Science, technology, and society. The student understands how major scientific and mathematical discoveries and technological innovations affected societies prior to 1750. The student is expected to:

(A) identify the origin and diffusion of major ideas in mathematics, science, and technology that occurred in river valley civilizations, classical Greece and Rome, classical India, and the Islamic caliphates between 700 and 1200 and in China from the Tang to Ming dynasties;

(B) summarize the major ideas in astronomy, mathematics, and architectural engineering that developed in the Maya, Inca, and Aztec civilizations;

ELA TEKS:

Writing/Persuasive Texts. Students write persuasive texts to influence the attitudes or actions of a specific audience on specific issues.

Research/Research Plan. Students ask open-ended research questions and develop a plan for answering them.

Research/Gathering Sources. Students determine, locate, and explore the full range of relevant sources addressing a research question and systematically record the information they gather.

Research/Organizing and Presenting Ideas. Students organize and present their ideas and information according to the purpose of the research and their audience.

Listening and Speaking/Speaking. Students speak clearly and to the point, using the conventions of language.

Listening and Speaking/Teamwork. Students work productively with others in teams.

Chemistry TEKS:

C.4D classify matter as pure substances or mixtures through investigation of their properties.

C.5B identify and explain the properties of chemical families, including alkali metals, alkaline earth metals, halogens, noble gases, and transition metals using the Periodic Table

C6B describe the mathematical relationships between energy, frequency, and wavelength of

light using the electromagnetic spectrum

C.6D express the arrangement of electrons in atoms of representative elements using electron configuration and Lewis electron dot structures

Algebra II TEKS:

2A.1(A) apply mathematics to problems arising in everyday life, society, and the workplace

2A.1(C) select tools, including real objects, manipulatives, paper and pencil, and technology as appropriate, and techniques, including mental math, estimation, and number sense as appropriate, to solve problems

2.A1(D) communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate

2.A1(E) create and use representations to organize, record, and communicate mathematical ideas

2A.1(F) analyze mathematical relationships to connect and communicate mathematical ideas

Performance Task:

Develop a product to improve life in the civilization and then sell the product at an international market.

Other evidence:

(quizzes, tests, academic prompts, self-assessments, etc.

note – these are usually included where appropriate in Stage 3 as well)

- Development of Metallurgy timeline in Chemistry
- Field trip assignment
- Poetry Assignment
- Role sheet
- Checkpoint grade:
 - Lead Designer: Turn in a design of product (digital or hard copy/sketch)
 - Marketing Director: Turn in a draft of the 90 sec. commercial video script
 - Financial Analyst: Turn in spreadsheets detailing materials costs and expected profit margins as well as shell sheets for market day
 - Spokesperson: Turn in a list of 5 anticipated questions and answers for Q&A
 - Project Manager: Ensure all team members meet deadline and turn in a rationale of the product design

(Steps taken to get students to answer Stage 1 questions and complete performance task)

Chemistry class: Making metallurgy timeline - Pre rollout of PBL

Day 1: students will discuss what metallurgy is and define a list of important terms, elements, alloys, and technology.

Day 2: Students will be divided into groups of 2 - 3. Each group will be given an element, alloy or technology to research.

Day 3: Each class will construct a timeline showing the development of metallurgy

Teachers group students - for project (3-5 students, based in English class) and field trip (10 students, several project groups from different English classes).

Field Trip to San Antonio Museum of Art

- Students are given a list of minerals and natural resources available to their civilization, and they must “discover” their assigned civilization by comparing that list to artifacts in the museum

Work Days

- 1: *Students decide group roles (project manager, lead designer, financial analyst, marketing director, and spokesperson), and then complete the poetry assignment.*
- 2: *Students decide on a product; the goal is to create something which will improve life in their civilization, using only materials and technology available to them.*
- 3: *Checkpoint: Team leaders give verbal explanation of product rationale*
- 4: *Work Day*
- 5: *Checkpoint: Product Design, Anticipated Questions & Financials Due*
- 6 & 7: *Work Days*
- 8: *Checkpoint: Script and Rationale Due*
- 9 & 10: *Work Days*
- 11: *In-Class Presentations: Product Model, Commercial, diagram of exhibit, and Rationale Due. Play the commercial in class, display model, and Spokesperson presents and answers questions.*
- 12 & 13: *Work Days: Students use feedback from in class presentations to make adjustments.*
- 14: **Market Day.** *In a large space, groups set up market stalls. Spokesperson and financial analyst stay to sell products to visitors . Project manager and/or other team members walk the market to buy items that will improve their civilization. Items cannot cost more than \$500, and teams have \$5,000 to spend. After sales end, financial analysts tally up profit (unspent money does not count here) and fill out spreadsheets. Teachers finalize grades for any changes students made.*
- 15: *Students complete reflection and group feedback form.*
- 16: *Final financials due*

Information for students:

<http://sites.google.com/neisd.net/stemsophomorepbl/fall-market-pbl>

San Antonio Museum of Art Field Trip Handouts

Group 1

Time Period: Post-Classical Era

Elements, Minerals and Metals:

Basalt (iron oxides and iron-titanium oxides)

Gold

Silver

Obsidian (silicon dioxide)

Mother of Pearl

Jade(ite) (NaAlSi₂O₆)

Other geographic features:

Access to oceans

Group Members: _____

Region: _____ (You will discover this at the museum)

Art as Evidence

Our trip to the SAMA is designed to help you understand how your civilization used tools and technology to improve their way of life. Examine the artifacts found in your region's section of the museum. Record the following information about at least five pieces of art from your region from 10,000 BCE to 1500 (15th century). All pieces must include some kind of metal and you must show at least two types of metals on this page. You should also have at least one group member take a photograph of each of these pieces of art for use in your presentation.

Item 1:

Region:

Time Period:

Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Item 2:

Region:

Time Period:

Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Item 3:

Region:

Time Period:

Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Item 4:

Region:

Time Period:

Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Item 5:

Region:

Time Period:

Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Item 6:

Region:

Time Period:

Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Item 7:

Region:

Time Period:

Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Group 2

Time Period: Post-Classical Era

Elements, Minerals and Metals:

Gold

Silver

Copper

Other geographic features:

Access to oceans

Mountain range

Group Members: _____

Region: _____ (You will discover this at the museum)

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Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Item 6:

Region:

Time Period:

Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Item 7:

Region:

Time Period:

Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Group 3

Time Period: Post-Classical Era

Elements, Minerals and Metals:

Nephrite (calcium, magnesium, and aluminium silicate)

Basalt (iron oxides and iron-titanium oxides)

Other geographic features:

Access to oceans

Group Members: _____

Region: _____ (You will discover this at the museum)

Art as Evidence

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Region:

Time Period:

Type of Metal:

Other Materials:

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Item 4:

Region:

Time Period:

Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Item 5:

Region:

Time Period:

Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Item 6:

Region:

Time Period:

Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Item 7:

Region:

Time Period:

Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Group 4

Time Period: Early Modern Era

Elements, Minerals and Metals:

Lead

Copper

Zinc

Cobalt

Tin

Marble (calcium and magnesium carbonates)

Limestone (calcium carbonate)

Other geographic features:

Access to oceans and river valleys

Group Members: _____

Region: _____ (You will discover this at the museum)

Art as Evidence

Our trip to the SAMA is designed to help you understand how your civilization used tools and technology to improve their way of life. Examine the artifacts found in your region's section of the museum. Record the following information about at least five pieces of art from your region from 10,000 BCE to 1500 (15th century). All pieces must include some kind of metal and you must show at least two types of metals on this page. You should also have at least one group member take a photograph of each of these pieces of art for use in your presentation.

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Region:

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Region:

Time Period:

Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Item 6:

Region:

Time Period:

Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Item 7:

Region:

Time Period:

Type of Metal:

Other Materials:

How it was acquired by the SAMA

Group 5

Time Period: Early Civilizations

Elements, Minerals and Metals:

Tin

Steatite (magnesium oxide and silicon dioxide)

Gold

Hematite (iron oxide)

Copper

Limestone

Other geographic features:

Access to oceans

River valleys

Group Members: _____

Region: _____ (You will discover this at the museum)

Art as Evidence

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Time Period:

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Other Materials:

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Item 7:

Region:

Time Period:

Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Group 6

Time Period: Early Civilizations & Classical Era

Elements, Minerals and Metals:

Limestone (calcium carbonate)

Copper

Tin

Serpentine (magnesium hydroxide, silicon oxide)

Gold

Steatite (magnesium oxide and silicon dioxide)

Granodiorite (sodium, potassium)

Carnelian (silicon dioxide)

Feldspar (Potassium, aluminum, silicon oxides)

Other geographic features:

Access to oceans and river valley

Group Members: _____

Region: _____ (You will discover this at the museum)

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Type of Metal:

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Region:

Time Period:

Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Item 6:

Region:

Time Period:

Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Item 7:

Region:

Time Period:

Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Group 7

Time Period: Classical Era

Elements, Minerals and Metals:

Marble (calcium and magnesium carbonates)

Tin

Electrum (gold, silver, and copper)

Garnet

Copper

Gold

Silver

Other geographic features:

Access to oceans and river valleys

Mountain range

Group Members: _____

Region: _____ (You will discover this at the museum)

Art as Evidence

Our trip to the SAMA is designed to help you understand how your civilization used tools and technology to improve their way of life. Examine the artifacts found in your region's section of the museum. Record the following information about at least five pieces of art from your region from 10,000 BCE to 1500 (15th century). All pieces must include some kind of metal and you must show at least two types of metals on this page. You should also have at least one group member take a photograph of each of these pieces of art for use in your presentation.

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How it was acquired by the SAMA:

Item 7:

Region:

Time Period:

Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Group 8

Time Period: Classical Era

Elements, Minerals and Metals:

Marble (calcium and magnesium carbonates)

Silver

Tin

Basalt (iron oxides and iron-titanium oxides)

Lead

Gold

Copper

Chalcedony (silicon dioxide)

Travertine (calcium carbonate)

Nenfro

Other geographic features:

Access to oceans and river valleys

Mountain range

Group Members: _____

Region: _____ (You will discover this at the museum)

Art as Evidence

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Item 7:

Region:

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Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Group 9

Time Period: Post-Classical Era

Elements, Minerals and Metals:

Chlorite (various metals hydroxide and oxides)

Sandstone (silicon oxides)

Schist (silicon dioxides)

Copper

Granite (silicon and aluminium oxides)

Zinc

Other geographic features:

Access to oceans

Mountain range

River valleys

Group Members: _____

Region: _____ (You will discover this at the museum)

Art as Evidence

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Region:

Time Period:

Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Item 7:

Region:

Time Period:

Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Group 10

Time Period: Post-Classical Era

Elements, Minerals and Metals:

Gold

Copper

Tin

Other geographic features:

Access to oceans

Mountain range

River valleys

Group Members: _____

Region: _____ (You will discover this at the museum)

Art as Evidence

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Type of Metal:

Other Materials:

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Item 6:

Region:

Time Period:

Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Item 7:

Region:

Time Period:

Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Group 11

Time Period: Post-Classical Era

Elements, Minerals and Metals:

Granite (silicon and aluminium oxides)

Sandstone

Copper

Tin

Iron

Other geographic features:

Access to oceans

Group Members: _____

Region: _____ (You will discover this at the museum)

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Type of Metal:

Other Materials:

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Item 6:

Region:

Time Period:

Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Item 7:

Region:

Time Period:

Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Group 12

Time Period: Post-Classical Era

Elements, Minerals and Metals:

Copper

Frit

Gold

Iron

Silver

Tin

Other geographic features:

Access to oceans

Group Members: _____

Region: _____ (You will discover this at the museum)

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Time Period:

Type of Metal:

Other Materials:

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Item 7:

Region:

Time Period:

Type of Metal:

Other Materials:

How it was acquired by the SAMA:

Key

1. Aztecs
2. Incas
3. Oceania
4. Ming China
5. Mesopotamia
6. Egypt
7. Greece
8. Rome
9. India
10. Korea
11. South East Asia
12. Middle East (Iran)

Introductory Documents for Students

Market PBL

Market Day - Wednesday, December 12

Market day is the culminating event of this PBL. It will be a chance to share your work publicly - with your peers and our guests. At market day, each team will prepare a booth with a model of your product and a short video commercial. Each team will be given money to purchase goods at the market. Teams will be given full authority to spend their money on whatever goods they want to purchase.

At the end of the day, prizes will be given to teams who:

1. Profit the most from their sales
2. Get the best deals on the goods they purchase
3. Find the best balance of both profits from their sales and deals on their purchases

The essential questions for this PBL are:

How does geography influence creation and adaptation?

How does a society's ability to create affect its population?

In order to answer these questions, your team will research your civilization and develop a product that would improve the economy and life of your population (as well as neighboring civilizations or barbarians). You will need to ensure that you have the resources required and that you will be able to successfully profit from the sale of your product. In order to effectively sell the product, you will also need to develop a commercial advertisement to assist in sales.

In order to help your team prepare for market day, we have set up two formal checkpoints to monitor your progress towards meeting your goal.

Tuesday, Nov. 27 & Friday, Nov. 30: Checkpoints

In this project, each team member will have an individual role which will be graded individually. However, you also must work effectively as a team and therefore will also receive a team grade based on a combined assessment of your team's work. To assist your team, all members will have a checkpoint deadline for their role on:

Tues. Nov. 27:

- Lead Designer:** Turn in a design of product (digital or hard copy/sketch)
- Financial Analyst:** Turn in spreadsheets detailing materials costs and expected profit margins as well as shell sheets for market day
- Spokesperson:** Turn in a list of 5 anticipated questions and answers for Q&A

Fri. Nov. 30:

- Marketing Director:** Turn in a draft of the 90 sec. commercial video script
- Project Manager:** Ensure all team members meet their deadlines and turn in a rationale of the product design

Friday, December 7: In-class presentations

At these presentations in English classes, teams will display their product and play their 90 sec. video advertisement for their product. The spokesperson will then have 2 min. to answer questions about the product.

ROLE SHEET

Please complete this form as a team and turn in to your English teacher by Wed. Nov. 14.

Team Members (3-5): _____

Region: _____ English Teacher: _____

Notes for choosing roles as a team:

For teams with 3 members, the team leader is also financial analyst & spokesperson is also marketing director.

For teams with 4 members, the team leader is also the spokesperson.

For teams with 5 members, each team member will have an assigned role.

Project Manager: _____

This person is responsible for supporting team members in their designated roles and making sure there is cohesion within the team and the project and that deadlines are met. This position will receive an individual grade on the rationale.

- By Fri. 11/16: Give verbal explanation of rationale (in English)
- By Fri. 11/30: Turn in a written rationale of the product
- By Fri. 12/7: Ensure model and video are complete and spokesperson is prepared for Q&A. Final draft of rationales due.

Lead Designer: _____

This person is responsible for overseeing the design of the product. The individual grade will be the product model.

- By Wed. 11/28: Turn in design of product (digital or hard copy/sketch)
- By Fri. 12/7: Final model of product due

Marketing Director: _____

This person is responsible for writing the script of the commercial advertisement of your product or commodity. The individual grade will be the commercial advertisement.

- By Fri. 11/30: Turn in draft of commercial script
- By Fri. 12/7: Complete video of 90 second commercial advertisement submitted

Financial Analyst: _____

This person is responsible for setting the market price of the product based on resource costs and manufacturing processes. The individual grade will be the financial documents - we recommend that the person serving in this role is currently in Algebra II with Ms. Stuckey.

- By Wed. 11/28: Turn in spreadsheets detailing design, materials costs, manufacturing costs, unit price and expected profit margins as well as shell sheets for market day
- By Fri. 12/14: Complete financial documents submitted

Spokesperson: _____

This person is responsible for presenting the product and answering questions at the in-class presentation as well as representing the team at the market day. The individual grade will be based on the ability to answer questions during in class Q&A and display during Market Day.

- By Wed. 11/28: Turn in a list of 5 anticipated questions (and answers) for presentations
- By Fri. 12/7: Answer questions after team's commercial
- By Wed. 12/13: Design and set up display for product at Market Day

Project Manager Deadlines

Checkpoint #1: Friday, November 16

In English class, you will give a verbal explanation of your product rationale that includes:

- Explain which resources you will use in your product
- Explain a problem that your product will solve OR explain how your product will improve the quality of life in your civilization
- Explain the design of your product
- Explain how your product will impact your civilization

Checkpoint #2: Friday, November 30

You turn in a draft of your written rationale. [This rubric](#) will be used to assess your rationale.

Final Deadline: Friday, December 7

In English class:

- Project manager will turn in the final copy of the rationale
- Lead designer will display the product model
- Marketing director will play the commercial for the class
- Spokesperson will then answer questions from the class

Questions? Contact Mrs. Jacobie via email (mjacob3@neisd.net) or in her room (M-331)

Lead Designer Deadlines

Checkpoint #1: Tuesday, November 27

You will turn in a draft of your tool, either digitally or hand drawn that includes:

- A schematic of the tool to include the dimensions
- The parts labeled
- List of materials to be used
- The amounts of raw materials needed

Final Deadline: Friday, December 7

In English class:

- Project manager will turn in the final copy of the rationale
- Lead designer will display the product model
- Marketing director will play the commercial for the class
- Spokesperson will then answer questions from the class

Questions? Contact Ms. Newsome via email (knewso2@neisd.net) or in her room (M-323)

Marketing Director Deadlines

Checkpoint #1: Friday, November 30

You will turn in a draft of the 90 sec. commercial video script. Your script should:

- Be written in the form of a script
- Begin with a description of the setting of the video
- Include all spoken dialogue, including directions for delivery
- Include the text of all titles, headings, subtitles, and words appearing on screen
- Contain descriptions of any static images included in the video
- Contain directions for actors
- Contain directions for the movement of the camera (if any)
- Make clear that the video will meet the 90 second length requirement

Final Deadline: Friday, December 7

In English class:

- Project manager will turn in the final copy of the rationale
- Lead designer will display the product model
- Marketing director will play the commercial for the class
- Spokesperson will turn in diagram of display and then answer questions from the class

Questions? Contact either English II teacher: Ms. Muire via email (emuire@neisd.net) or in her room (M-306) or Ms. Keeling (bkeeli@neisd.net) on in her room (M-302)

Financial Analyst Deadlines

Checkpoint #1: Tuesday, November 27 by 5:00 pm. Use this form to submit your spreadsheet: <https://tinyurl.com/FallPBLFinancials>

You will turn in a draft of the financials spreadsheet. The spreadsheet should include:

- Your name, your group's name and all group members
- One Sheet that clearly describes your product and contains the following:
 - Working with the lead designer, make a list of the product's raw materials, cost of materials, manufacturing process of materials if applicable, the reasonable cost of manufacturing. Costs should be in today's dollars.
 - The (reasonable) amount of each material you will need to produce one unit.
 - The cost (in today's dollars) to produce one unit.
 - Links to cost sources (Where did you find the prices of materials?)
 - The suggested retail price of one unit (not to exceed \$500.00)
- One sheet set-up with headings, columns and formulas to fill-in after market day. See financial analyst rubric for what information your "Sales Data" Sheet should contain
- One sheet to create charts and/or graphs of financial data from market day.
- A plan to collect sales data on market day. This can be with a spreadsheet, a google form, or on paper, but you need to present a plan to collect this data.
- A plan to record and store the checks and cash you receive on market day.
- A plan to balance the checks and cash received to the numbers you enter into your "Sales Data" sheet.

Final Deadline: Friday, December 14, midnight.

Questions? Contact Ms. Stuckey via email (lhindl@neisd.net) or in her room (M-301)

Spokesperson Deadlines

Checkpoint #1: Tuesday, November 27

You will write a list of 5 anticipated questions and answers for Q&A. Your questions should include:

- Five separate, unrelated questions a person might ask about your product (follow-up questions do not count towards your five questions)
- An answer to each question
- Proper spelling, grammar, and punctuation, including capitalization
- Evidence of thought about the impact of the product on the society

Things to consider when writing questions:

- Potential danger to any group
- Negative effects of the product
- Concerns of your civilizations
- Larger ramifications of the product on society, economics, etc.

Final Deadline: Friday, December 7

In English class:

- Project manager will turn in the final copy of the rationale
- Lead designer will display the product model
- Marketing director will play the commercial for the class
- Spokesperson will turn in a diagram of their Market Day exhibit and then answer questions from the class

Questions? Contact either English II teacher: Ms. Muire via email (emuire@neisd.net) or in her room (M-306) or Ms. Keeling (bkeeli@neisd.net) on in her room (M-302)

Rubrics

Project Manager (Rationale) Rubric				
	Exceeds	Meets	Approaching	Does Not Meet
Use of resources	Natural resources are used effectively and creatively. These purposes are clearly explained in the rationale.	Natural resources are used appropriately and explained in the rationale.	Natural resources are used, but inappropriately or may not be clearly stated in the rationale.	Natural resources are not used or explained in the rationale.
	19 points	15 points	5-14 points	0 points
Problem Addressed	Rationale explains how the product clearly solves a problem or greatly improves the quality of life of inhabitants of the civilization.	Rationale explains how the product has potential to solve a problem or improve the quality of life of inhabitants of the civilization.	Rationale explains how the product attempts to solve a problem or improve the quality of life of inhabitants of the civilization, but the problem is not clearly addressed or explained.	Rationale does not explain how the product will solve a problem experienced by the civilization or improve the quality of life for inhabitants of the civilization.
	29 points	25 points	10-20 points	0 points
Explanation of Design Elements	Design elements are thoughtfully described and explained. Design clearly serves a purpose and improves the function of the product.	Design elements are described and explained. Design elements serve a purpose in the function of the product.	Design elements are vaguely described or the purpose of the design is unclear.	Design elements are not described or explained. The design does not serve a purpose.
	29 points	25 points	10-20 points	0 points
Explanation of Impact	Rationale clearly and accurately explains and anticipates the impact of the product on the society and neighboring communities.	Rationale anticipates and explains the impact of the product on the society.	Rationale attempts to explain the impact of the product on the society, but attempts may not be accurate or fully anticipated.	No explanation of impact.
	29 points	25 points	10-20 points	0 points
Written conventions	Rationale is exceptionally well crafted, using advanced vocabulary (fiske words).	Rationale is free from grammatical errors.	Rationale has a few, minor grammatical errors.	Rationale has many and/or major grammatical errors.
	14 points	10 points	5 points	0 points

Lead Designer (Product Model) Rubric				
	Exceeds	Meets	Approaching	Does Not Meet
Creativity of the Item	Design elements are original, or, if borrowed from other places, are modified to meet the specific needs of your civilization, and are incorporated into the design in thoughtful and creative ways	20% of the design elements are borrowed from other places or are modified to meet the specific needs of your civilization and incorporated into the design in new and creative ways.	50% of the aspects of the item are unique, with 50% of the elements being copied directly from source materials, history, or other students.	100% of the design is copied directly from source materials, history, or other students.
	30 points	25 points	10-20 points	0-5 points
Attractiveness/Craftsmanship	The design and construction look carefully planned. The item is neat.	The design and construction look planned. The item has a few flaws, but these do not detract from the overall look.	The design and construction were haphazardly planned. The item has several flaws, that detract from the overall look.	The item looks thrown together at the last minute; little to no design or planning was done. Craftsmanship is poor.
	30 points	25 points	10-20 points	0-5 points
Use of Materials	The model of the product appears to consist of 100% of materials available from the civilization	80% of the model of the product appears to make thoughtful use of the materials available to the civilization.	50% of the model of the product appears to consist of materials available from the civilization	The model of the product does not appear to make use of any of the materials available to the civilization.
	30 points	25 points	10-20 points	0 points
Purpose	The item has a clear and revolutionary purpose that meets a demonstrated need to improve your civilization	The item has a relevant purpose which can be demonstrated to improve the civilization	The item created has purpose, but the purpose is not relevant to the task of improving the civilization	The item created does not have a clear purpose
	30 points	25 points	10-20 points	0 points

Marketing Director (Commercial) Rubric				
	Exceeds	Meets	Approaching	Does Not Meet
Structure	The commercial's format adds to the persuasiveness of the advertisement and cleverly twists recognizable commercial structures to its own use.	The commercial is put together in a logical order and uses recognizable frameworks from advertising without borrowing straight from extant commercials.	The commercial is ordered confusingly or randomly. The commercial mimics extant commercials.	The commercial is incoherent or illogical. The commercial does not fit in the genre.
	27 points	20 points	5-20 points	0 points
Need for Product	The commercial is persuasive in conveying the need for the product in any society.	The commercial clearly explains the need for the product in your society.	The commercial somewhat explains the need for the product in your society.	The commercial does not adequately explain the need for the product in your society.
	27 points	20 points	5-20 points	0 points
Intended audience		Intended audience is reasonable and clearly stated.	Intended audience is either necessarily reasonable or clearly stated, but not both.	Intended audience is unreasonable or not clearly stated.
		20 points	5-20 points	0 points
Visual Aids (Props)	The commercial's sense and meaning is enhanced by the effective use of visual aids or props.	The commercial makes use of visual aids to assist in conveying information.	The commercial includes visual aids or props, but they do not significantly contribute to the commercial and/or they are not well done.	The commercial does not include any visual aids or props.
	26 points	20 points	5-20 points	0 points
Length		The commercial is presented within the time frame.	The commercial is presented slightly outside the time frame.	The commercial is presented significantly outside the time frame.
		20 points	5-20 points	0 points

Financial Analyst Rubric

	Exceeds	Meets	Approaching	Does Not Meet
Sheet 1: Product Cost Data	<p>The product is thoroughly described by its materials, manufacturing process, and total weight or exact dimensions. Manufacturing processes are clearly described and costed out. The product contains almost the exact amount and proportion of raw materials that would realistically be needed. All raw material costs are based on current market prices and all sources are cited.</p>	<p>The product is described by its materials, manufacturing process, and weight or dimensions. Manufacturing processes are described or referenced. The product contains a reasonable amount and proportion of raw materials. Raw material costs are based on current market prices and sources are cited.</p>	<p>The product and/or manufacturing process is not completely described. The product contains an unreasonable amount of raw materials. Raw material costs are not realistic and few sources are cited.</p>	<p>Sheet is missing. Product is not described and or raw material costs are missing. No sources are cited.</p>
	29 points	25 points	10 - 15 points	0 - 10 points
Sheet 2: Cost and Sales data	<p>Sales to other civilizations include the buyer's civilization name, sale price and units sold. Clearly shown are units sold to each civilization, the sales price for that customer, total revenue from that customer, total cost of that customer's order, and total profit from that customer. Shown separately are totals sold to the public and to barbarians. Sales to barbarians and the public include units sold, costs, revenue and profits. Grand totals are included--total revenue/ profit from other civilizations, total revenue/ profit from the public, total revenue/profit from barbarians. A grand total of revenue/profit from all customers is also included. Formulas are used in spreadsheets and all numbers are accurate.</p>	<p>Sales to other civilizations include the buyer's civilization name, sale price and units sold. Total units sold, revenues, costs and profits from each buyer is clearly shown. Grand totals are included--total revenue and profit from other civilizations, total revenue and profit from the public, total revenue and profit from barbarians. A grand total revenue and profit from all customers is also included. Formulas are used in spreadsheets and all numbers are accurate.</p>	<p>Sales to other civilizations include the sale price and units sold. Total units sold, revenues, costs and profits is shown, but it is not clear who the customers are. Grand totals are included--total revenue, costs and profits, but is not shown by customer or customer type. Formulas are not used in spreadsheets and some numbers are not accurate or realistic.</p>	<p>Sales to other civilizations do not include their name, sale price and/or units sold. Revenues, costs, and/or profits are not calculated or are inaccurate. Sales by customer type is not clear. Revenue, Costs and Profit by customer are inaccurate or missing. Total Profit for each type of customers is inaccurate or missing. Grand totals are inaccurate or missing.</p>

	29 points	25 points	15-20 points	0-10 points
Sheet 3: Costs, Sales, and Profit Charts	Sheet contains one chart/graph for sales to civilizations, and other chart(s)/graph(s) for sales to public and barbarians. All charts/graphs include units sold, revenue, costs, and profit for each customer or type of customer. A grand total chart or graph is included showing total units, revenue and profits. Charts are formatted to be aesthetically pleasing and easy to read. Legends are included for each data column or line and all charts/graphs have appropriate titles.	Sheet contains one chart/graph for sales to civilizations, and other chart(s)/graph(s) for sales to public and barbarians. Charts include units sold, revenue, costs, and profit for each type of customer. A grand total chart/graph is included showing total units, revenue and profits. Charts are formatted and easily understandable. Legends are included for each data column or line and all charts/graphs have appropriate titles.	Sheet contains data charts and/or graphs, but are missing one or more of the following: units sold, revenue, costs, or profit. Chart(is)/graph(s) are not separated by customer or customer type. Charts/graphs are not formatted to be aesthetically pleasing and/or easy to read. Legends are incorrect or not included for each data column or line and charts/graphs are not titled.	Charts/graphs are incomplete or missing. Charts and/or graphs are not formatted at all. Legends are incorrect or confusing.
	24 points	20 points	10-15 points	0-10 points
Leadership Skills: Communicate with Clarity and Precision	Sheets are renamed for ease of user. Numbers are properly formatted. Data is organized and easy to interpret.	Numbers are properly formatted. Data is organized, but the reader might not be able to interpret the data easily.	Some numbers are not formatted and all data is not neatly organized. The reader may struggle to interpret data.	Data is missing or not formatted, Work is not neat and organized. The reader is unable to interpret data.
	24 points	20 points	10-15 points	0-10 points
Application of Knowledge	The work demonstrates a mastery of financial concepts (revenue, costs, and profit). The work demonstrates a mastery of google sheets or other spreadsheet program (formulas are used, formatting is thoughtfully done, charts are pleasing to the eye and easy to read.	The work demonstrates an advanced level of understanding of financial concepts. The work demonstrates an advanced level of google sheets or other spreadsheet program.	The work demonstrates a proficient level of understanding of financial concepts and spreadsheets.	The work demonstrates a lack of care or understanding of financial concepts and spreadsheets.
	14 points	10 points	5-7 points	0-5 points

Spokesperson Rubric				
	Exceeds	Meets	Approaching	Does Not Meet
Anticipated Questions	Anticipated questions show critical thinking and an understanding of multiple perceptions and concerns for the presentation.	The anticipated questions are realistic and relevant.	The anticipated questions are only somewhat realistic and/or irrelevant.	The anticipated questions are neither realistic nor relevant.
	24 points	20 points	5-20 points	0 points
Answers to Anticipate Questions	The answers to the questions are clear, concise and thoroughly answers the question without overanswering.	The answers to the questions are clear and answers the question.	The answers to the questions are unclear or off topic, but ultimately answers the question.	The answers to the questions are unclear, off topic or does not actually answer the question.
	24 points	20 points	5-20 points	0 points
Q&A Session	Students answer questions eloquently, with conciseness as well as coherence.	Students answer questions clearly.	Students answer questions completely, but with a lack of clarity, control, or coherence.	Students do not answer questions.
	24 points	20 points	5-20 points	0 points
Exhibit	The exhibit displays information in a manner that improves the clarity of the message, and is aesthetically pleasing.	The exhibit displays the needed information clearly and in a logical format. The aesthetics do not detract from the clarity.	The exhibit is an attempt at logical organization, but does not convey the required information in a clear manner.	The exhibit is confusing and poorly laid out.
	29 points	25 points	5-25 points	0 points
Enunciation and Diction	Presenters' speech is eloquent, coherent, and understandable.	Presenters' enunciation/ diction is excellent.	Presenters' enunciation/ diction is average.	Presenters' enunciation/ diction is below average.
	19 points	15 points	5-15 points	0 points

Poetry Assignment

Text from Your Civilization

The following poem was written in your civilization and translated into English in the modern day.

Read the poem in your group and answer the following questions:

1. What clues about life (work, shopping, education, recreation, etc) does the poem offer? Quote from the poem and then explain what the line tells you.

2. What, if any, information about problems or difficulties about life in the civilization does the poem offer? This could be obvious or implied. Consider this thoughtfully, and quote the poem before you explain your thinking.

The Aztecs

STAND UP, BEAT YOUR DRUM

By Nezahualcoyotl, Translation by John Curl

Stand up, beat your drum:
give of yourself, know friendship. -Aya!-
Let your hearts be taken
with many colours -Yehuaya!-
only here perhaps are lent to us
our tobacco pipes, our flowers,
Ohuaya Ohuaya.

Stand up, my friend,
elated take your flowers to the drum:
your bitterness flees.
Adorn yourself with them:
the flowers raise their heads,
cocoa flowers of precious gold -Aya!-
are being scattered,
Ohuaya Ohuaya.

Beautifully sing here
the turquoise bird, the quetzal, the trogon:
the macaw's song presides, and
all the jingling rattles and drums answer,
Ohuaya Ohuaya.

I drink cocoa:
with it I am glad -Aya!-
my heart takes pleasure, my heart is happy,
Ohuaya Ohuaya.

The Inca

Selections from *The Sacred Hymns of Pachacutec*
Author unknown, translated by John Curl

Prayer

O, my Lord,
my Creator, origin of all,
diligent worker
who infuses life and order into all,
saying, "Let them eat,
let them drink in this world:"
Increase the potatoes and corn,
all the foods
of those to whom you have given life,
whom you have established.
You who orders,
who fulfills what you have decreed,
let them increase.
So the people do not suffer and,
not suffering, believe in you.
Let it not frost
let it not hail,
preserve all things in peace.

Prayer to the Sun

Lord Wiracocha,
Who says
"Let there be day, let there be night!"
Who says,
"Let there be dawn, let it grow light!"
Who makes the Sun, your son,
move happy and blessed each day,
so that man whom you have made has light:
My Wiracocha,
shine on your Inca people,
illuminate your servants,
whom you have shepherded,
let them live
happy and blessed
preserve them
in peace,
Free of sickness, free of pain.

Oceania

My Eyes are like the Flax-Flowers
Traditional Maori chant, translator unknown

Like a flood, ah me!
My tears stream down;
They burst like ocean-waves
Breaking yonder on the shore, Ah me!
Lonely I sit
Beneath my rata tree,
Gazing, ever gazing
On the long sea-strand, Ah me!
My weeping eyes
Are like the drooping flax-flowers;
When the wind rustles them
Down fall the honey showers Ah me!
I'm like the wind-blown rushes,
The wiwi bending in the gale,
Quivering, shaking, trembling
With the strength of my love Ah me!
Once love was my companion
When I turned me to slumber;
It was the spirit of my love
That joined me in the land of dreams.

Ming China

A Song of a Girl from Loyang

By Wang Wei, Translated by David Hinton

There's a girl from Loyang in the door across the street,
She looks fifteen, she may be a little older.
...While her master rides his rapid horse with jade bit and bridle,
Her handmaid brings her cod-fish in a golden plate.
On her painted pavilions, facing red towers,
Cornices are pink and green with peach-bloom and with willow,
Canopies of silk awn her seven-scented chair,
And rare fans shade her, home to her nine-flowered curtains.
Her lord, with rank and wealth and in the bud of life,
Exceeds in munificence the richest men of old.
He favours this girl of lowly birth, he has her taught to dance;
And he gives away his coral-trees to almost anyone.
The wind of dawn just stirs when his nine soft lights go out,
Those nine soft lights like petals in a flying chain of flowers.
Between dances she has barely time for singing over the songs;
No sooner is she dressed again than incense burns before her.
Those she knows in town are only the rich and the lavish,
And day and night she is visiting the hosts of the gayest mansions.
...Who notices the girl from Yue with a face of white jade,
Humble, poor, alone, by the river, washing silk?

Mesopotamia

The Valorous Sun

Author unknown, Translation probably by Benjamin R. Foster

Imposing doorbolt of the sky,
Most exalted of the gods, whom heaven relies on,
Shamash, the sun, who holds in his hand the life of the land,
He is the king's right arm ...,
The beloved of Ea the leader.

God of joyful occasions,
Shining light, fiery radiance,
Awe-inspiring splendor of the depths,
Vanguard of the Anunna-gods,
He it is who gives overpowering strength and fierce weaponry to young men.

Daylight, chief herald on the mountain ranges,
Herald of the brightening sky...,
God of gods, imposing light, he makes his rounds,
Keeping watch over the land by day and by night,
The lands of Ea.

He sustains the campaigners and traveling merchants in foreign lands,
The foreign lands render up lapis and silver to the traveling merchant,
The cedar forest yields unworked timber, boxwood, cyprus, standing tall like splendid standards,
Fit for a nobleman to adorn his house.
He loads his barge with aromatics, oils, honey, the goods that merchants bring,
And incense of the gods, juniper, almond, and ... -oil.

Awe-inspiring splendor lights up the bison of the sun,
His radiance he sheds afar.
The joy of Enlil, the great courtyard,
He fills with copper, gold, silver, lapis,
The wide courtyard of his temple. (remainder of text mostly untranslatable)

Egypt

The Harper's Song for Inherkhawy
Author unknown, translated by John L. Foster

All who come into being as flesh
pass on, and have since God walked the earth;
and young blood mounts to their places.

The busy fluttering souls and bright transfigured spirits
who people the world below
and those who shine in the stars with Orion,
They built their mansions, they built their tombs-
and all men rest in the grave.

So set your home well in the sacred land
that your good name last because of it;
Care for your work in the realm under God
that your seat in the West be splendid.

The waters flow north, the wind blows south,
and each man goes to his hour.

So seize the day! hold holiday!
Be unwearied, unceasing, alive,
you and your own true love;
Let not your heart be troubled during your sojourn on earth,
but seize the day as it passes!

Put incense and sweet oil upon you,
garlanded flowers at your breast,
While the lady alive in your heart forever
delights, as she sits beside you.

Grieve not your heart, whatever comes;
let sweet music play before you;
Recall not the evil, loathsome to God
but have joy, joy joy and pleasure!

O upright man, man just and true,
patient and kind, content with your lot,
rejoicing, not speaking evil –
Let your heart be drunk on the gift of Day
until that day comes when your anchor.

Greece

Loves

By Theocritus, translated by C. S. Calverly

'Sincerity comes with the wine-cup,' my dear:
Then now o'er our wine-cups let us be sincere.
My soul's treasured secret to you I'll impart;
It is this; that I never won fairly your heart.
One half of my life, I am conscious, has flown;
The residue lives on your image alone.
You are kind, and I dream I'm in paradise then;
You are angry, and lo! all is darkness again.
It is right to torment one who loves you? Obey
Your elder; 'twere best; and you'll thank me one day.
Settle down in one nest on one tree (taking care
That no cruel reptile can clamber up there):
As it is with your lovers you're fairly perplexed;
One day you choose one bough, another the next.
Whoe'er at all struck by your graces appears,
Is more to you straight than the comrade of years;
While he's like the friend of a day put aside;
For the breath of your nostrils, I think, is your pride.
Form a friendship, for life, with some likely young lad;
So doing, in honour your name shall be had.
Nor would Love use you hardly; though lightly can he
Bind strong men in chains, and has wrought upon me
Till the steel is as wax- but I'm longing to press
That exquisite mouth with a clinging caress.

No? Reflect that you're older each year than the last;
That we all must grow gray, and the wrinkles come fast.
Reflect, ere you spurn me, that youth at his sides
Wears wings; and once gone, all pursuit he derides:
Nor are men over keen to catch charms as they fly.
Think of this and be gentle, be loving as I:
When your years are maturer, we two shall be then
The pair in the Iliad over again.
But if you consign all my words to the wind
And say, 'Why annoy me? you're not to my mind,'
I- who lately in quest of the Gold Fruit had sped
For your sake, or of Cerberus guard of the dead-
Though you called me, would ne'er stir a foot from my door,
For my love and my sorrow thenceforth will be o'er.

Rome

Excerpt from First Georgic,
By Virgil, translated by David Ferry

When spring begins and the ice-locked streams begin
To flow down from the snowy hills above
And the clods begin to crumble in the breeze,
The time has come for my groaning ox to drag
My heavy plow across the fields, so that
The plow blade shines as the furrow rubs against it.
Not till the earth has been twice plowed, so twice
Exposed to sun and twice to coolness will
It yield what the farmer prays for; then will the barn
Be full to bursting with the gathered grain,
And yet if the field's unknown and new to us,
Before our plow breaks open the soil at all,
It's necessary to study the ways of the winds
And the changing ways of the skies, and also to know
The history of the planting in that ground,
What crops will prosper there and what will not.
In one place grain grows best, in another, vines;
Another's good for the cultivation of trees;
In still another the grain turns green unbidden.

India

Precepts from Dhammapada

Author unknown, translated by Romesh Chunder Dutt

Return Love for Hatred

Hate for hatred if ye render
Hatred lives and mortal strife;
Love return for bitter hatred
Hatred dies, and sweet is life! (5)

Precepts without Acts

Pius precepts, gentle friend
Never acted, wisely meant
Are like gay and colored flower,--
Without fragrance, without scent! (51)

The Golden Rule

As you dread all pain and suffering
Love your life and death abhor,
So doth every living creature,
Harm not things that live and breathe. (129, 130)

Live Without Hatred among Men you Hate

With the men who live in hatred
Ye shall live devoid of hate,
Unto men who smite in anger
Show your love and meekness great. (197)

Good Works survive

Good works done endure for ever,
And in higher life will meet,
E'en as gentle loving kinsmen
Home-returning kinsmen greet! (200)

Overcome Anger by Love

Anger by your love o'er-master,
Good for evil acts return;
By charity the miser conquer,
By your truth let false men learn! (223)

The Elder and the Sage

Not an Elder, not a Sage,
Is the man advanced in age;
Truth and virtue, love and pureness,
Make the Elder and the Sage. (260, 261)

Korea

1082

By Koengp'il Kim, translated by Jaihiun Kim

In a rain hat and rush-cape,
I pick up a hoe in the misty rain
To weed a hillside patch.
I lie down in the leafy shade
And a herdboy wakes me
As he drives home his cattle and sheep.

Islamic Empires

IV

By Rumi, probably translated by Coleman Barks

I've said before that every craftsman
searches for what's not there
to practice his craft.

A builder looks for the rotten hole
where the roof caved in. A water-carrier
picks the empty pot. A carpenter
stops at the house with no door.

Workers rush toward some hint
of emptiness, which they then
start to fill. Their hope, though,
is for emptiness, so don't think
you must avoid it. It contains
what you need!

Dear soul, if you were not friends
with the vast nothing inside,
why would you always be casting you net
into it, and waiting so patiently?

This invisible ocean has given you such abundance,
but still you call it "death",
that which provides you sustenance and work.

God has allowed some magical reversal to occur,
so that you see the scorpion pit
as an object of desire,
and all the beautiful expanse around it,
as dangerous and swarming with snakes.

This is how strange your fear of death
and emptiness is, and how perverse
the attachment to what you want.

Now that you've heard me
on your misapprehensions, dear friend,
listen to Attar's story on the same subject.

He strung the pearls of this
about King Mahmud, how among the spoils
of his Indian campaign there was a Hindu boy,

whom he adopted as a son. He educated
and provided royally for the boy
and later made him vice-regent, seated
on a gold throne beside himself.

One day he found the young man weeping..
"Why are you crying? You're the companion
of an emperor! The entire nation is ranged out
before you like stars that you can command!"

The young man replied, "I am remembering
my mother and father, and how they
scared me as a child with threats of you!
'Uh-oh, he's headed for King Mahmud's court!
Nothing could be more hellish!' Where are they now
when they should see me sitting here?"

This incident is about your fear of changing.
You are the Hindu boy. Mahmud, which means
Praise to the End, is the spirit's
poverty or emptiness.

The mother and father are your attachment
to beliefs and blood ties
and desires and comforting habits.
Don't listen to them!
They seem to protect
but they imprison.

They are your worst enemies.
They make you afraid
of living in emptiness.

Some day you'll weep tears of delight in that court,
remembering your mistaken parents!

Know that your body nurtures the spirit,
helps it grow, and gives it wrong advise.

The body becomes, eventually, like a vest
of chain mail in peaceful years,
too hot in summer and too cold in winter.

But the body's desires, in another way, are like
an unpredictable associate, whom you must be
patient with. And that companion is helpful,
because patience expands your capacity

to love and feel peace.

The patience of a rose close to a thorn
keeps it fragrant. It's patience that gives milk
to the male camel still nursing in its third year,
and patience is what the prophets show to us.

The beauty of careful sewing on a shirt
is the patience it contains.

Friendship and loyalty have patience
as the strength of their connection.

Feeling lonely and ignoble indicates
that you haven't been patient.

Be with those who mix with God
as honey blends with milk, and say,

"Anything that comes and goes,
rises and sets, is not
what I love." else you'll be like a caravan fire left
to flare itself out alone beside the road.

Southeast Asia

Excerpt from The Story of Tum Teav

Author unknown, translated by George Chigas

30 This telling begins with the name Tum.

In the rice farming district of Ba Phnom,
He was born naturally of parents
About whom however nothing is known.

31 When he was big enough,

And many years had passed, his mother dressed him up
And brought him to study and threw away his toys.
She sought out a well-known temple

32 Where the Abbot received Tum gladly,

And taught him to be skillful in the fields of healing and prayer.
Tum was able to please the Abbot because of his intelligence and diligence
And resolved to be a novice monk.

33 Living at the temple under the Abbot for a long time

Was another monk who was also skilled
And well liked, by the name of Pech.
The two monks made baskets to sell.

34 Tum was eloquent and had other talents as well.

He had a beautiful voice and handsome body.
His good nature radiated through his disposition,
And eventually he considered Pech as his younger brother.

35 Pech knew how to play the flute.

He was intelligent and his musical skills were well developed.
The two novice monks thought similarly,
And the knowledge they each possessed was about equal.

36 They made the baskets and brought some to sell

At the houses of relatives near the temple.
But when the cold season arrived,
They became worried.

Metallurgy Timeline

Developing a Metallurgical Timeline

Objective: SWBT understand how metals are extracted from their ores.

Vocabulary:

A. Materials

- ore
- copper
- bronze
- brass
- iron
- steel
- lead
- pewter
- gold
- silver

B. Technology

- Metallurgy
- Kiln
- Mining
- Ingots
- Smelting
- Cold Hammering
- Forging
- Annealing
- Quenching
- Casting
- Alloy

Procedure:

➤ Day 1:

- Handout vocabulary list (above)
- View video on Minerals and Ores https://youtu.be/fZM_NF93gWo
- Discuss the PowerPoint on Metallurgy and Chemistry

Day 2: LAB: Mining for chocolate chips

Day 3: Students will be placed into groups of 2- 3, then randomly assigned either a material or technology from the list above to research. For this activity, metallurgy is excluded. They are to find the dates and civilizations where the material or technology was discovered or developed. In addition, answer: how did this impact the local populations? On a blank, color sheet of paper, one per civilization, they are to summarize their findings. Each one page needs to include:

- Group Member Names
- Name of Material or Technology
- Date
- Civilization

- Description of Material/Technology
- Illustration (hand drawn)
- How/who made discovery
- Impact

Each page needs to include source citations on the back. Once complete, place the page(s) onto the class timeline.

Resources:

<http://pages.ucsd.edu/~dkjordan/arch/metallurgy.html>

<http://www.historyworld.net/wrldhis/PlainTextHistories.asp?historyid=ab16>

<http://www.flowofhistory.com/units/pre/1/FC8>

Rubric:

CATEGORY	(20 pts)	(15 - 19 pts)	(10 - 14 pts)	(0 - 9 pts)
Content/Facts	Facts were accurate for all events reported	Facts were accurate for almost all events reported	Facts were accurate for most (~75%)	Facts were inaccurate or omitted
Illustration	Illustration highlights the significant information in the text and clarifies viewer understanding.	Illustration clearly related to the text and neat	Illustration is somewhat related to text and messy	No illustration
Readability	Information is presented in a creative way while still being easy to read	Information is presented in clear and easy to read manner	Information is in somewhat of a coherent and	Information haphazardly placed on paper
Requirements	Extra, relevant data is included	6 - 7 of the required data is included	3 - 5 of the required data is included	2 or less of the required data is included

Mining Simulation Lab

That's the Way the Cookie Crumbles

Introduction: Many energy resources are unevenly distributed and have limits to their usefulness. In fact, in most processes, energy is not uniformly distributed. Thus, processes that require greater quantities of energy are often less economical and therefore abandoned for "cheaper" and "easier" techniques. Consider this idea as you complete the exercise.

In this lab, you will demonstrate mining of the earth's surface and underground, and will observe the limits of several energy sources.

Materials:

- 1 chocolate chip cookie (**NOT** for consumption)
- Ruler
- Forceps
- Dissecting probe
- Toothpicks
- 3 sheets of white paper (preferably recycled)
- Digital balance
- Weighing boat or paper

Procedure:

- 1) Mass your cookie and record this value on the whiteboard at the front of the classroom. Mass a sheet of paper and jot this value down.
- 2) Measure the diameter of your cookie and estimate the area using the standard formula. Record this value on the class data table.
- 3) Set your cookie in the center of one of your sheets of paper. Count the number of visible chunks of chocolate embedded in the surface of the cookie. Record this number and put it in the class data table on the whiteboard.
- 4) Predict, based on your cookie size and you and your lab partner's "cookie mining experience" how many chocolate deposits you will find total in your cookie. Record this value in the class data table.
- 5) Utilize the instruments as hand to begin mining your cookie. As you mine, separate your chocolate from your crumbled cookie, by carefully placing your chocolate on one sheet of paper and the crumbled cookie on the other.
- 6) Consider the process complete when you have excavated as much chocolate as possible for the quantity of time and energy invested.
- 7) Mass your cookie crumbles, your mined chocolate, and your remaining cookie. Record these values on the class data table. Count your "large" chocolate pieces and record this on the class data table.
- 8) Clean up your stations, wash your hands, and get a cookie for you and your lab partner to snack on it while you complete your analysis.

Mining Simulation Lab

That's the Way the Cookie Crumbles

Data:

Mass of Cookie (undisturbed): g

Mass of Sheet of Paper: g

Diameter of Cookie: cm

Area of Cookie: cm²

Visible Chocolate Chunks:

Estimate Total Chocolate Chunks:

Mass of Cookie Crumbles: g

Mass of Removed Chocolate: g

Total "Large" Chocolate Chunks:

Analysis Questions:

- 1) This is a mining simulation activity. What does the chocolate represent? What does the cookie represent?

- 2) Compare and contrast the number of chocolate deposits visibly observed and actually in existence. How does the actual number of deposits compare to the predictions?

Mining Simulation Lab

That's the Way the Cookie Crumbles

- 3) Was there a correlation between chocolate harvested and surface area and or mass?

Retrieve the class data and create a graph of the relationship you believe is most likely and paste it into the space below:

- 4) Where was the most time and energy invested in the mining process? What are other sources of time and energy not measured by the activity?

- 5) Describe at least three environmental impacts of surface mining.



**Heavy Metal Thunder:
Early history of metal use in human culture**

Major revolutions in human culture closely follow developments in the use of geological materials (including metals). This is reflected in the terms commonly used for technological “ages” (e.g. Stone Age, Copper Age, Bronze Age, Iron age).

Although many metals have found wonderful uses in technology, many of them were originally used for ornamental purposes (as artistic media).

This is true for both precious metals and base metals.

The Stone Age

Prior to the use of metals, humans relied on materials such as obsidian, chert/flint and quartzite for the fashioning of tools.

Increased sophistication of tool making is apparent in tool types found at archeological sites of different ages.



Simple tools with a single (unifacial) cutting edge



Tools with more refined and stereotyped shape and two cutting (bifacial) edges



Bifacial tools with maximized cutting surface



Sophisticated spear and harpoon points

Late Stone Age: Early Uses of Native Metals

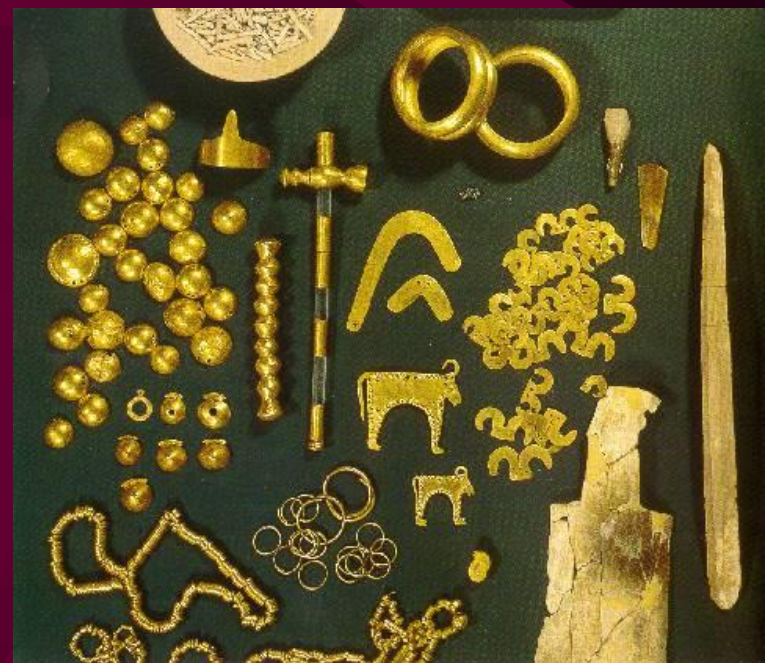
At some point, Stone Age (Neolithic) humans discovered that native gold was sufficiently soft and malleable to be fashioned into artistic objects of beauty.

It is likely that nuggets of placer gold were used for this purpose.

Obviously, the rarity of native gold and silver (also used) would have made such objects extremely valuable.

The resistance of gold to corrosion and oxidation would have made gold even more valuable.

Right: Placer gold nuggets (top) and (below) 6000 year old gold “trinkets” from Bulgaria.

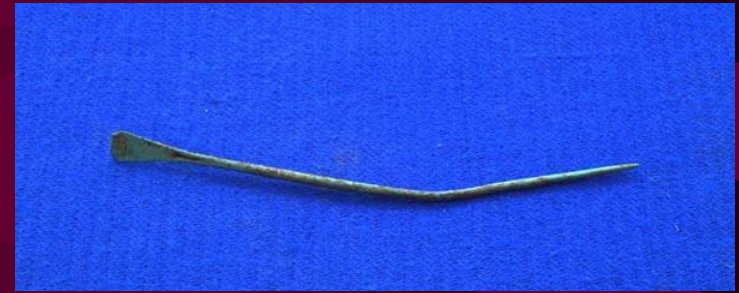


The Copper (Chalcolithic) Age (Began at about 4,500 BC)

At roughly the same time, native copper was also discovered and used by humans (earliest use dates back to about 6,000 BC, but widespread use dates to about 4,500 BC).

There was considerable overlap during the Neolithic in the use of lithics and relatively novel copper tools. Consequently a transitional interval between the Stone Age and later ages of predominant metal use has been identified, known as the Chalcolithic or Copper Age.

Native copper, which occasionally occurs in large masses was “cold-worked” to make delicate objects such as hooks and needles, which were otherwise difficult to make from stone and bone.



Cold-worked copper needle

Greek: “Chalkos” = Copper
“Lithos” = Stone

Rough-hewn early Copper tools

As cutting implements or weapons, early Copper tools left much to be desired and were definitely not an improvement over lithics (the latter were much sharper and easier to use).

Consequently, many of these were used merely for demonstration or status purposes.

Only members of the nobility of the time could afford these luxury items made from metal.

Actual use of cold-worked copper was limited by the brittleness and softness of the metal, which could not hold a sharp edge for very long.



Cold-worked copper daggers

Other Metals Used by Copper Age Humans

Other metals that could have been used more or less as-is included silver (which occasionally occurs in native form as veins)

AND

Iron/nickel alloy, occurring naturally in iron-nickel meteorites (core material).

Earliest documented use of the latter dates back to about 4,000 BC

Both sources, of course, were rare.



Native silver



Iron-nickel meteorite

Heat treating and Annealing Copper

A major improvement in copper technology came when it was discovered that copper could be annealed when heated. Annealing involves reordering of the microstructure of the material through heating to relatively high temperatures, followed by slow cooling. In this process, metal atoms actually move within the solid material. Redistribution of material reduces the areas of weakness within the metal and makes it more pliable under cold-working conditions (more malleable).

This permitted stronger tools to be made, although such tools were still “status items” of the rich (still not really useful for cutting as such).



Copper dagger, central Bulgaria, 4000-3500 BC

The Copper Age: Discovery of Smelting Methods

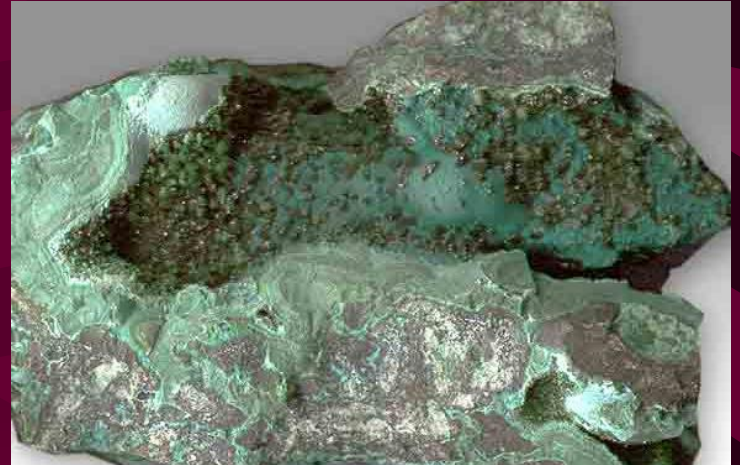
The availability of copper was a major limiting factor in the use of this metal (deposits of native copper are quite rare).

This was also true for other metals.

This situation changed with the discovery that copper could be smelted (separated) from mineral compounds by heating.

The first copper mineral to be smelted was probably malachite.

Why would this have been a good material from which to extract copper?



Malachite



Smelting

It has been suggested that the art of smelting began as result of accidental “cooking” of metal ores in campfires.

This is unlikely, for two main reasons:

1. The heat generated in a campfire is unlikely to have reached temperatures necessary to allow metals such as copper to separate from the ore (the melting point of copper is over 1000 degrees C – well above the temperature of your average campfire).
2. The presence of large amounts of oxygen in a campfire would have readily oxidized any metal that was produced by melting (metal oxides are brittle and cannot be worked).

The Beginnings of Smelting

For these reasons, it is more likely that the first smelted ore was produced in a pottery kiln.

The production of pottery preceded the smelting of metals by thousands of years (earliest pottery extends back to at least 10,000 years before present).

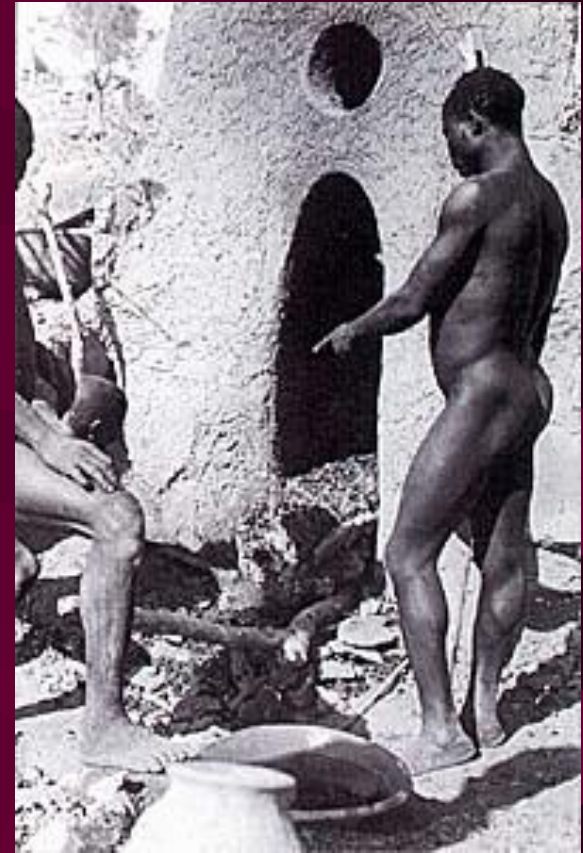
High temperatures could be achieved in a kiln (due to the prevention of heat loss to the open air and the increased temperature generated by forcing air into the kiln furnace to “fan the flames”). Primitive pottery kilns could generate temperatures exceeding 1,400 degrees C. Copper will melt at just over 1000 degrees C.

Special kilns were later developed for smelting (pieces of ore were put in direct contact with charcoal to ensure the highest temperatures possible and to prevent oxidation of ore).

The Beginnings of Smelting

The oxygen-starved conditions within a kiln would prevent the combination of pure metal with oxygen, so metal could be separated in pure form.

In addition, the presence of fluxes (e.g. limestone, quartz sand), used to lower the melting point of minerals within the pottery could have lowered the melting point of the metals that were inadvertently smelted.



How did ore minerals end up in a pottery kiln ?

This is obviously open to speculation.

However, one might picture a potter attempting to beautify his/her pottery by adding chunks of attractive coloured or highly lustrous minerals to the clay.

For example, the potter might have experimented with the green mineral malachite (copper ore), or galena (lead ore).

Beads of molten metal that were produced upon baking would have decreased the beauty of the article, but an astute potter would have noted that these beads could be collected and further purified to produce larger bodies of metal.



Metal sulphides and the earliest alloys

As supplies of easily smelted copper minerals such as malachite (copper carbonate) became scarce, it became necessary for copper to be obtained from sulphide minerals.

Copper sulphides (especially chalcopyrite) generally occur with sulphides of other metals such as arsenic (actually a metalloid; e.g. arsenopyrite).

Smelted copper with impurities of arsenic formed the first produced metal alloy used by humans. This is known as arsenic-copper, or “arsenic-bronze”.



Chalcopyrite
(CuFeS_2)



Arsenopyrite
(FeAsS)

The Bronze Age (Began at about 3,200 BC)

It was later noted that the deliberate addition of impurities (especially arsenic) could change the properties of smelted copper.

The arsenic was later replaced by tin (a true metal), possibly as a result of high incidence of death among early arsenic-bronze workers.

As an added bonus, tin lowers the melting point of copper (combined before melting), which made it easier for this metal to be smelted.

Bronze is quite attractive and is relatively easy to work, making it suitable for ornamental objects.



Bronze
statue

Perhaps more importantly, bronze is harder than pure copper, and is therefore much more useful for tools.

Bronze containing 90 % copper and 10 % tin is twice as hard as pure copper !

Cutting tools can, thus, will be more effective and will not require sharpening as often as pure copper tools would.



Bronze
axe

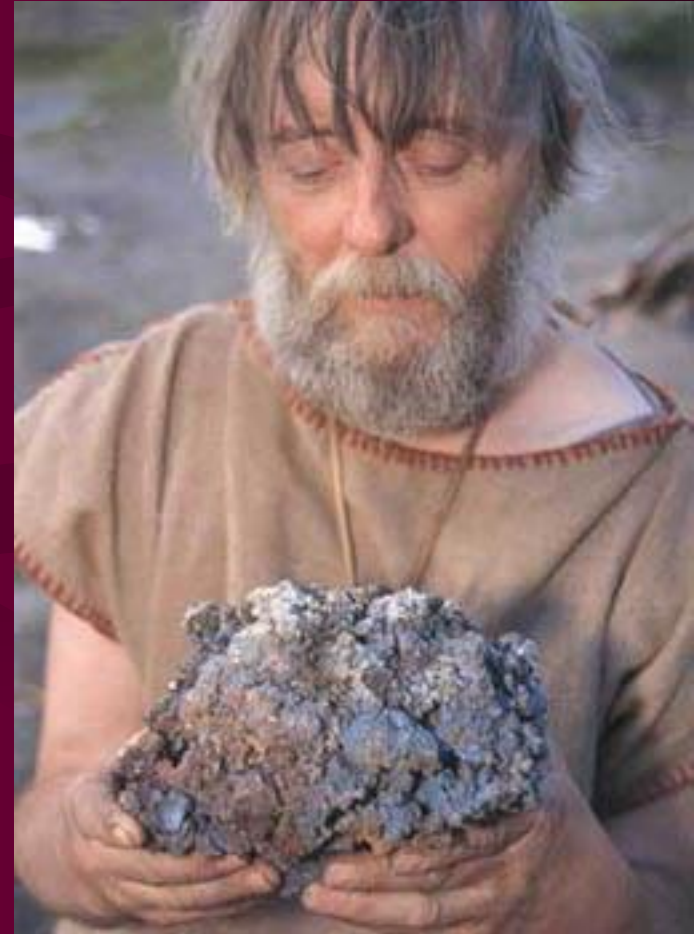
The Iron Age (began at about 1,200 BC)

The discovery of iron as a useful medium for tool-making probably also came about by accident.

However, it would have taken a keen eye to figure out how to process iron.

In a primitive kiln, smelted iron would not have formed liquid droplets as iron has a higher melting point (~1500 degrees C) than copper.

Instead, at the relatively low temperatures used, the material formed a spongy solid mass of elemental iron and slag (impurities, metal oxides and remnant sulphides) called a “bloom” (also known as “sponge iron”).



Iron bloom

Iron Age

Whereas copper metal naturally separated as a heavy liquid from lighter, silicate-rich slag, the solid iron bloom retained pockets of impurities (slag).

At some point, it was discovered that the slag bodies within iron bloom could be removed by reheating and pounding the bloom on an anvil.

When the hot bloom was pounded, the slag (lower melting temperature) simply squirted out from the mass. The elemental iron would remain in the solid state.

Purification of the metal was accomplished by repeated heating and pounding of the bloom.



The Iron Age

Humans are believed to have developed the earliest methods of smelting and forging iron by about 1,500 BC (in the region now known as Turkey), but these methods did not become widespread until about 1,200 BC.



Iron mask
from Africa



Iron spear tips

Working With Iron

Pure iron still has some undesirable qualities:

1. It is softer than bronze
2. It is too soft to hold a sharp edge
3. Iron tends to oxidize readily (rust)

The quality of iron implements increased via two main advances in technology:

1. Steeling
2. Tempering

Steeling

It was found that the addition of carbon to iron increased the hardness of iron metal – this iron-carbon alloy (containing less than 1.7 % carbon) is what we call steel.

The carbon could have been first introduced to the iron from carbon monoxide generated in the furnace or from carbon (charcoal or coal/coke) in the furnace fuel.



4th century AD
Steel hole punch
(Netherlands)

Tempering

An effective method of altering the properties of iron is tempering.

Tempering involves: the quenching (sudden cooling) of hot metal in water (to increase hardness) and reheating (to reduce brittleness)

The development of tempering must have involved lots of trial and error to produce a strong (but slightly elastic) metal!

The Japanese are famous for their tempered steel swords.



Casting

Meanwhile, in China, artisans developed extremely effective furnaces that were capable of melting iron.

The iron could then be poured into moulds.

The cast iron was then reheated to drive off the excess carbon, making the product more elastic and malleable for final use.



Of course, in the years to follow, steelmaking continued to develop, introducing many varieties of steel (each with different properties).

Steel, in combination with the increased use of coal as fuel, was the backbone of the Industrial Revolution, and remains one of the most important metals in today's society.

