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| **Coffee: From seed to cup**Author: Olivier Ntaganzwa. |
| **Unit Overview**  |
| **Target Audience: Middle school (Grades 6&7)** | **Est. Time:** 50-minute periods | **Content Area(s):** Life sciences, agriculture, economics |
| **Abstract:**Coffee is one of the most popular drinks in the world. It is smelled and tasted in thousands of restaurants and coffee shops and millions of households daily. In this mini-unit, students will learn about the countries and regions of the world where coffee is grown and the conditions of its growth. They will also learn the steps of its transformation and how its price changes as the product is transformed along the value chain. Then students will roast coffee and make a cup of coffee by themselves. They will make measurements and discuss the results. As it gets harvested and transformed, coffee goes through many stages. It gets dried, hulled, roasted, and ground. In this mini-unit, students will do inquiry-based learning to answer some questions. They will do project-based learning by using the knowledge they gained in the first two lessons to grind coffee and make cups of coffee. STEM will be integrated into the lessons, whereby the first lesson will be about the biology of the coffee plant. In the second lesson, students will learn that the value of coffee increases as it gets transformed and shipped, and they will make some calculations. Students will also learn about the chemistry and physical changes that coffee goes through as it gets transformed and the technological and engineering processes involved. The third lesson will focus on physics and engineering, where students will calculate temperatures and weights, observe physical transformation due to heat, and use machines to accomplish their tasks. |
| **Unit Goals/Objectives:*** Identify the regions and countries where coffee is grown
* Identify the effect of climate, soil, and altitude on the coffee plant
* Describe the coffee value chain
* Apply basic mathematical skills to analyze the price of coffee
* Compare the different states of coffee: berry, roasted, unroasted, ground
* Use tools to transform coffee from one state to another
* Identify the environmentally-friendly transformation of coffee waste
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| **Lesson Summaries:***Lesson 1- Where and how coffee is grown*Students apply an inquiry-based approach to identify countries and regions where coffee is grown. Students explain the factors that contribute to optimal growth, flowering, and berry production of the coffee plant, such as the adequate climate, soil, temperature, and altitude ranges.*Lesson 2- Coffee transformation and change in price*Students watch a video about the transformation of coffee from seed to cup. They are asked to write down the steps of transformation they can still recall. They then apply a problem-based approach by playing a coffee trading game to explain how the price of coffee changes from foreign farmer to trader to exporter, to grocery store or coffee shop owner in their area.*Lesson 3- Let’s make coffee!*Students will apply a project-based approach to roast their coffee, and to make a cup of coffee using coffee grounds. Students will use a coffee roaster to roast coffee. During the activity, they will measure temperatures, quantities, and time required to obtain a light roast. Students will then prepare coffee drinks using a coffee maker or an electric kettle. During the activity, they will measure temperatures, quantities, and time required to obtain a regular cup of coffee. |
| **Lesson Timeline:****Lesson 1 (50 minutes):** Introduction and assessment of prior knowledge about coffee *10 minutes*Identify the regions and countries where coffee is grown on a map: *15 minutes* Discuss the conditions of coffee growth: *15 minutes*Discuss results and review (formative assessment): *10 minutes* **Lesson 2 (50 minutes):** Introduction and video: *10 minutes* Discuss the steps of transformation of coffee, and use touch and smell to explore the states of coffee: *20 minutes* Play the coffee trading game: *20 minutes*Discuss results and review (formative assessment): *10 minutes* **Lesson 3 (50 minutes):** Introduce the activities of roasting coffee and preparing coffee drinks: *5 minutes* Discuss the roasting of coffee, the machines, and the chemical processes involved: *5 minutes* Roast coffee beans and make coffee drink using different machines: *30 minutes*Discuss the results and review (assessment): *10 minutes* |
| **Standards:**Indiana Academic Standards |
| **STEM Integration within the Unit:**Within this unit, the students will explore coffee growth and transformation, and by doing so they will come face to face with different STEM concepts woven together to help students find answers to questions, and explore the fascinating world of coffee. They will need knowledge of chemistry, biology, and geography to learn about the growth conditions of coffee. Physics, chemistry, and engineering will come into play to explain the transformation of coffee from plant to cup. By roasting and making coffee using machines, students integrate concepts from mathematics, physics, electronics, and engineering. |

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| **Lesson 1: Where and how coffee is grown** |
| **Est. Time: 50 minutes** |
| **Lesson Learning Goals/Objectives:*** Be able to identify the regions and countries where coffee is grown
* Be able to describe the role weather and soil play in the growth of different plants
* Be able to articulate how coffee is grown, from the state of seed and the production of berries

Approach: Inquiry-based | **Standards:*****Indiana education standards (middle school)*****EA-3.1** Understand the basic needs of plant growth from germination to soil fertility**EA-3.**2 Explore and recognize the importance of plant and soil science as it relates to the agricultural industry |
| **Assessments****Pre-Assessment:** Ask students to write three things that come to mind when they hear the word “coffee”**Formative:** Ask students to write down 3 things they learned, 2 things they liked most, and 1 question they still have about the lesson**Summative:** Ask: Can coffee grow in this state? How altitude, climate, temperature, and soil of this state make it a good or bad region for coffee growth?Other summative questions are in the end-of-unit summative test. |
| **Concept Prerequisites or Background Knowledge Needed:** Knowledge about map reading, regions and countries of the world, knowledge of temperature, altitude, and plant development stages |
| **Vocabulary:**Temperature, altitude, germination, flowering, equator, tropics, sandy loam, volcanic soil, |
| **Materials & Technology Needed:**Presentation board, computer, and projector, map of the world showing coffee growing countries and regions without the countries (printed), 3x5 index cards for students, pencils or pens |
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| **Lesson Component** | **Instructions** | **Materials** |
| **Introduction***10 minutes* | Tell students that they are going to learn about coffee. Ask students to write down the first three things that come to mind when the word ‘coffee’ is mentioned. After three minutes, ask students to take turns to share what they have written. | 3x5 index cardsPens/pencils |
| **Instructional Activities***30 minutes* | Activity 1. * Project a slide showing a map of coffee-growing regions and give printed copies of the map to students
* Ask students to work in groups of 3 or 4 and to refer to the map to identify countries that correspond to the regions. A group that finishes the activity is allowed to stand up but stay silent.
* After all the groups are up, invite the students to regain their seats, then switch to a slide showing a map with all the countries that produce coffee.
* Invite groups to share the number of countries they guessed right

Activity 2. * Ask students to guess the adequate climate, weather conditions, soil, and altitude necessary for optimal growth of the coffee plant
* In their groups, students discuss and each group chooses one person to present their results.
* Ask students “What happens when the conditions of growth are not fulfilled?”
 | Presentation screen Computer and projectorPencils/pens and A4 papers |
| **Wrap Up,****Synthesis/Closure***10 minutes* | Show a slide describing the climates, temperatures, and soils that are good for the coffee plant to grow and produce berries. Then tell students what happens when conditions are not fulfilled (diseases, absence of flowering, etc.)Ask students to write: What 3 things you learned about coffee? What 2 things did you like most? What question do you still have? | Presentation Board Computer and projector3x5 index cardsPencils/pens and A4 papers |
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| **Resources:** The map can be found at:[**https://seasia.co/2018/01/27/the-coffee-belt-a-world-map-of-the-major-coffee-producers**](https://seasia.co/2018/01/27/the-coffee-belt-a-world-map-of-the-major-coffee-producers)A list of coffee-growing countries can be found at:[**https://en.wikipedia.org/wiki/List\_of\_countries\_by\_coffee\_production**](https://en.wikipedia.org/wiki/List_of_countries_by_coffee_production) |

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| **Lesson 2: Stages of coffee transformation and effects on price** |
| **Est. Time:** 50 minutes |
| **Lesson Learning Goals/Objectives:**1. Be able to identify the steps of transformation of coffee.
2. Be able to apply mathematical notions to determine the value of an agricultural commodity.
3. Be able to identify the economics behind agricultural products.
4. Demonstrate how the manufacturing process raises the value of a product.
5. Be able to articulate the contribution of agriculture to the income of households and companies.
 | **Standards:*****Indiana education standards (middle school)*****EA-7.1** Explore how various foods are grown and processed through the concept of farm-to-plate**6.C.3** Solve real-world problems with positive fractions and decimals by using one or two operations.**EA-4.2** Explore the interaction between local natural resources and the economy**6.AF.3** Define and use multiple variables when writing expressions to represent real-world and other mathematical problems and evaluate them for given values.**EA-9.1** Evaluate the nature and scope of agriculture in society and the economy. |
| **Assessments****Pre-Assessment:** Ask students: how much does a cup of black coffee cost in your city/town?**Formative:** Ask students to write down the steps of coffee transformation they can recall**Summative:** Why does a coffee farmer in Rwanda sell 1lb of coffee for $0.5 per 1lb of coffee, and a Starbucks shop sells 1lb of coffee for $15?Other summative questions are in the end-of-unit summative test |
| **Concept Prerequisites or Background Knowledge Needed:** Knowledge of addition, percentages, and multiplication. Basic knowledge of pricing and markup in trade |
| **Vocabulary:**Interest, supply chain, value chain, markup, trade, sale, export, manufacturing, shipping, roasting, grinding |
| **Materials & Technology Needed:**Presentation board, computer, and projector, Color-printed A4 papers displaying the 10 steps of transformation of coffee, 3x5 index cards for students, pencils or pens |
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| **Lesson Component** | **Instructions** | **Materials** |
| **Introduction***10 minutes* | Before the lesson starts, prepare samples of unroasted, roasted, and ground coffee on three disposable plates. Cover the plates so that students don’t see what’s on them.Ask the students about their experiences when they were buying coffee with adults at the grocery store. Invite students to watch a video about the coffee supply chain titled “The life cycle of a cup of coffee- A.J Jacobs” | Presentation screen ProjectorComputer with Internet access |
| **Activity 1***20 minutes* | * Tell students that in the video, three kinds of coffee were mentioned. Ask them to identify which ones they were.
* Tell students: We are now going to discover roasted, unroasted, and ground coffee. Are you ready?
* Ask students to stand up, line up one behind another, and close their eyes. They take turns touching and holding the samples.
* Ask students to use their sense of touch and smell (not taste!) to guess which coffee is roasted, unroasted, or ground coffee. Tell them to not be fearful, and to answer freely, just for fun.
* As the student finishes guessing, ask them to open his/her eyes and discover whether they guessed right
 | Unroasted coffee sampleRoasted coffee sampleGround coffee samplePaper platesPaper towels |
| **Activity 2***20 minutes* | * Tell students: We are now going to play the coffee trading game. Are you ready to buy and sell some coffee?
* Ask students to form 4 groups. One group will be called Farmer. Group 2 will be called Trader. Group 3 will be called Exporter. Group 4 will be called Coffee Company. Group 4 will be called Coffee Shop.
* The farmer sells a 50 lb bag of coffee and gets 1 dollar per lb of coffee beans. Trader sells the same quantity to Exporter and asks $1.5 per lb. Exporter transforms the beans into unroasted coffee. After the transformation, only 45 lb remain. He transports the coffee to the US and sells 45 lb of unroasted coffee to the Coffee Company for $4 per lb. The coffee Company roasts the coffee and sells 45 lb of the roasted coffee to the Coffee Shop for $7 per lb. Students calculate the total prices using multiplication and calculate the difference in price between Farmer and Coffee Shop using division and percentage.
 | 3x5 index cardsPencils/pensFake US dollarsWhiteboard |
| **Wrap Up,****Synthesis/Closure***5 minutes* | Project a slide showing the most famous coffee brandsAsk students to discuss what they learned in the lesson about the price of coffee | Presentation Board Computer and projector3x5 index cardsPencils/pens and A4 papers |
| **Resources:** YouTube video showing coffee supply chain<https://www.youtube.com/watch?v=M0VWroX0gZA>Coffee supply chain:<https://www.allthingssupplychain.com/the-amazing-supply-chain-of-your-morning-coffee/> Steps of transformation of coffee:<https://www.weforum.org/agenda/2020/08/from-bean-to-brew-the-coffee-supply-chain> |

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| **Lesson 3:**  |
| **Est. Time:** 50 minutes |
| **Lesson Learning Goals/Objectives:**1. Be able to identify the machines and technology used in the transformation of coffee.
2. Analyze the science behind coffee transformation: the chemical and biological processes involved

Approach: Project-based learning | **Standards:*****Indiana education standards (middle school)*****ETE – 2.1** Analyze the interdisciplinary nature of engineering and technology**EA-8.2** Identify and understand the uses of various hand and power tools. |
| **Assessments****Pre-Assessment:** Ask students if they have ever made coffee or if they have ever seen someone make coffee**Formative:** Ask the students to list at least two changes they observed when they were roasting coffee beans and making a drink of coffee**Summative:** What is the temperature required to boil coffee?How long does it take to roast unroasted beans?What temperature is necessary to obtain a light roast of coffee beans?*Other summative questions are in the end-of-unit summative assessment* |
| **Concept Prerequisites or Background Knowledge Needed:** Knowledge of addition, multiplication, temperature, use of a thermometer, precision scale, and coffee maker. |
| **Vocabulary:**Transformation, coffee maker, kettle, coffee roaster |
| **Materials & Technology Needed:**Presentation board, computer, and projector, map of the world showing coffee growing countries and regions without the countries (printed), 3x5 index cards for students, pencils or pens |
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| **Lesson Component** | **Instructions** | **Materials** |
| **Introduction***5 minutes* | Tell students: We are now going to roast coffee and prepare the coffee drinkAsk students to get into two groups: Group A and B |  |
| **Activity 1***30 minutes* | * In group A, students measure a certain quantity of unroasted coffee beans and put them in a coffee roaster. They hold the roaster over an open fire source to roast coffee. They measure temperature and
* In group B, students measure a certain quantity of ground coffee and use a coffee maker or an electric kettle to produce a drink of black coffee
* Students register quantities, and times and estimate costs for the quantities of beans or ground coffee they used

Students draw a table with the observed process | Unroasted coffee beansRoasted coffee beansGround coffeeOpen heat sourceCoffee maker or electric kettleCoffee roasterThermometerPrecision kitchen scaleStopwatchDisposable cupsProtective gogglesA4 papersPens/pencilsWhiteboards and markers |
| **Wrap Up,****Synthesis/Closure***10 minutes* | * Ask students to talk about their experience of coffee roasting and coffee drink-making
* Present a slide that reveals the different uses of coffee grounds
 | Presentation screenComputer and projector3x5 index cardsPencils/pens and A4 papers |
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| **Resources:** Coffee bean roaster tool[https://www.amazon.com/gp/product/B0B12CH9H5/ref=ox\_sc\_saved\_image\_1?smid=A191RHH7JI1QNE&th=1](https://www.amazon.com/gp/product/B0B12CH9H5/ref%3Dox_sc_saved_image_1?smid=A191RHH7JI1QNE&th=1) **Sustainable use of coffee waste**<https://www.weforum.org/agenda/2019/07/your-next-pair-of-sneakers-could-be-made-from-coffee>  |

**Coffee: from farm to cup**

**Unit Summative Assessment**

**Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date\_\_\_\_\_\_\_ Score\_\_\_\_\_/20**

**Directions:** Please answer the following questions

1. List at least four countries where coffee is grown. (5 points)
2. Based on the optimal conditions of coffee growth, which US state is coffee grown in? Explain why. (Hint: it is not on most maps) (2 points)
3. List at least four stages of transformation of coffee in the value chain (Hint: remember the 10 stages shown on the colored paper) (4 points)
4. A coffee company in the US pays the same price per lb as a coffee exporter in Africa. True or False? Explain the reason for your answer. (2 points)
5. Please describe two visible changes that happen when coffee is roasted (2 points)
6. List:

(a) One machine that is used in roasting coffee (1 point)

(b) One machine that is used in making coffee drinks (1 point)

1. List three uses of coffee waste (3 points)

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**Coffee: from farm to cup**

**Unit Summative Assessment RUBRIC**

**Measuring objectives**

1. Students being able to explain the different stages of coffee growth
2. Students being able to identify the adequate climatic conditions for coffee growth
3. Students can identify the regions of the world where coffee is grown.
4. Students being able to identify the stages of the coffee value chain
5. Students being able to demonstrate the increase in the price of coffee along the value chain
6. Students being able to articulate the reasons for an increase in price
7. Students being able to explain the different stages of coffee transformation
8. Students being able to articulate the chemical processes involved in coffee transformation
9. Students being able to identify the different machines and engines involved in coffee transformation

**Question 1**

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| **0 point** | **1-3 points** | **4 points** |
| A student does not mention any country or countries that do not produce coffee | Student correctly mentions only one, two, or three coffee-producing countries | Student correctly identifies four coffee-producing countries |

**Question 2**

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| **0 points** | **1 point** | **2 points** |
| The student does not correctly identify Hawaii as the US state where coffee is grown | The student correctly identifies Hawaii as the state but does not explain why or mention at least one of these elements: warm climate, warm temperatures, volcanic soil | The student correctly identifies Hawaii as the state and mentions at least one of these elements: warm climate, warm temperatures, and volcanic soil. |

**Question 3**

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| **0 points** | **1-3 points** | **2 points** |
| The student does not list any stage of transformation of coffee in the value chain, or all the stages they list are incorrect | The student correctly lists one, two, or three stages of the transformation of coffee in the value chain | The student correctly lists four stages of the transformation of coffee. The colored paper shows all ten steps |

**Question 4**

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| **0 points** | **1 point** | **2 points** |
| The student replies with ‘True’ to the question, which invalidates the explanation | The student replies by ‘False’ but does not explain why | Student both replies with “False” and explains that as coffee goes through the value chain, its price increases |

**Question 5**

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| **0 points** | **1 point** | **2 points** |
| The student describes no visible changes that happen when coffee is roasted | Student correctly describes one visible change that happens when coffee is roasted  | The student correctly describes 2 chemical changes that happen when coffee is roasted, which are: a change in volume (expansion) and a change in color (darkening) |

**Question 6**

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| **0 points** | **1 point** | **2 points** |
| Student does not correctly list a machine that is used in roasting coffee or making a drink of coffee | Student correctly lists a machine that is used in roasting coffee but does not correctly list a machine that is used in making a drink of coffeeStudent correctly lists a machine that is used in making coffee but does not correctly list a machine that is used in roasting coffee | Student both correctly lists a machine that is used in roasting coffee (coffee roaster), and a machine that is used in making coffee (coffee maker, electric kettle) |

 **Question 7**

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| **0 points** | **1 point** | **2 points** | **3 points** |
| Student lists no correct uses of coffee waste | Student lists 1 correct use of coffee waste | Student lists 2 correct uses of coffee waste | The student lists 3 correct uses of coffee waste. The uses are animal feed, fertilizer, bio-diesel, food additives, packaging, shoes/sneakers from coffee grounds |

**Score\_\_\_\_\_/20**