Videoing Individual Relationships with Earth's Elements and Materials

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Abstract

In communicating the importance of our society's sustainable materials requirements, it is necessary to understand the impact and consequences of four threads:

- First, our **earth's structure and resources.** Both the engineering (i.e., resource location, ease of extraction, processing, and handling), and
- The **politics** (i.e., ownership, access, control, distribution) are important.
- Third is the **manufacturing of these elements into usable products** (i.e., rare earth elements used to make smartphone speakers, chips, transducers and sensors).
- And finally, it is necessary to **specify the product with a particular aspect of our life** (i.e., 'standard of living' or 'why we need it').

In addition, leaders closely involved in the process of understanding our dependance on sustainable materials have expressed a need for a better way to communicate this understanding[1,2]. It has been known and confirmed widely that 'video media' is a powerful means of communicating ideas[3]. Making videos that connect us our standard of living and the Earth's elements we all regularly consume, is the focus of this educational module.

Module Content: This module has a number of web-based references, with much of the introductory exploration done via the use of the Internet. There are no specific technology aspects of video creation discussed because of the evolution and breadth of technology present. Examples of all aspects of the module are described.

Videoing Individual Relationships with Earth's Elements and Materials

Module Objectives

Students will be able to:

- Determine the use of, and dependence on, selected elements and materials.
- Define and contextualize mineral resources for Earth Abundant Elements, Rare Earth Elements, Critical materials (their planetary distribution and accessibility).
- Define the 'life cycle' of specific elements and materials as used with products.
- Analyze aspects of material location, prevalence, extraction, and processing into products with respect to our 'quality of life'.
- Assess the impact of specific materials in a sustainable context.

Core Competencies Addressed

0A Demonstrate Good Communication Skills

3A Practice Appropriate Computer Skills and Uses

7F Identify the General Nature and Properties of Other Materials Used in Engineering

17A Explain General Means for Processing Materials

19B Apply Statistical, Cost, Lifecycle and Related Management Principles to Manufacturing Processes and Management

Module Data

Type of Module / Mode of Presentation: This module guides students to create personal videos about a relationship with how critical earth materials support our current manufacturing and product needs. The scope of effort includes basic research of concepts related to both materials and video development. The module is designed to occur in a classroom or virtual setting. It outlines one to two hours of research, and then flexible time for video creation and interaction.

Key Words / Key Phrases: Earth Abundant Element, Rare Earth Element, Critical Material, Video Enhanced Learning, Video in the Classroom, Standard of Living, Material Life Cycle, Sustainability, Resource Dependence.

Time required (three to four hours): This module has three parts: one to research the threads, one to create personal videos, and one to interact with and assess video effectiveness.

- The first research session includes an introduction (15 to 30 minutes), and at least one to two hours of research. This duration may vary depending on your interests.
- The video session can be done in person or off-line, depending on your resources and intentions. This involves learning to make the videos (both technical and planning issues), with a duration of one to two hours.
- The third part involves presentations, interactions and assessments. This duration also depends on logistics and depth, but can easily take an hour.

Pre-requisite knowledge: Students should be able to:

- Define earth's elements and mineral resources.
- Describe material processing required to make products (e.g., mining, smelting, forming).
- Use a computer and video capture equipment (smartphone or other).

Audience: Introductory level technical programs (grades 9 – 14).

Equipment and supplies needed

Environment: This module is designed as an individual or group activity. Minimum requirements:

- Internet access
- Tables for groups to interact (face-to-face setting)

Curriculum Overview and Instructor Notes

Major aspects of the module are: Enable a research activity, create a personal video, and then interact and debrief. In general, Part 1 is all about material discovery and exploration of key aspects as stated before in the four threads. Part 2 is flexible (planned sessions or virtual/self-directed) focused on video creation and story line creation. Part 3 is all about interaction and evaluation.

Terminology

It is important to ensure that we use appropriate terms in the discussion of abundant vs. critical materials and how they are used in applications:

- Abundant materials refer to elements that are readily available. Availability depends both and availability withing Earth's resources, and availability relative to obtaining the materials (mining, processing, cost). Examples include Aluminum, Iron, Silicon.
- Critical materials are those materials that are critical for our way of life. Some may be abundant, others not. Examples could include Silicon for electronics, Neodymium for magnets, Lithium for batteries,
- Rare Earth materials refer to a specific group of elements in the periodic table, some of which may be relatively abundant, some critical. Examples include Erbium and Ytterbium for lasers, Rhodium for catalytic converters.

It is appropriate for the instructor to research abundant vs. critical materials, and the separate definition of 'rare earth elements.' Also, how critical materials are related to our 'quality of life' through inclusion in the various products we use. Key attributes include sustainability and cultural impact. Sustainability can be viewed from a simple commercial aspect, though there are other logistical/political issues like access that may be related. Cultural impact includes human issues (i.e., human suffering) as well as life cycle effects (e.g., toxicity, legacy).

Alternatives

There is a requirement in this module to make videos. This may be a 'barrier', and other media formats have been used (e.g., posters), but we will concentrate on videos. Creating a video that connects the four threads may be a challenge (Part 2)! It is possible to start at any of the threads and work across to connect them, though most individuals recognize a product need first and then trace the connections backward to the source. This module is flexible and the video creation portion can be executed during the resource exploration or sequentially. Means of interacting with the videos, and assessment, are discussed later in the module.

Safety

No aspect of safety has been identified with this activity. Normal classroom logistics and operations are envisioned. Any computer related aspects of safe operation are assumed to be in place.

Part 1: Research society's use of Earth's Elements and Resources:

Activity Description

Overview: students must learn of our earth's structure and resources. Both the engineering (i.e., resource location, ease of extraction, processing, and handling) and politics (i.e., ownership, access, control, distribution) are important to keep our 'quality of life'. There is also the importance of manufacturing of these elements into usable products (i.e., rare earth elements used to make smartphone speakers, chips, transducers and sensors). Finally, it is necessary to specify the product with a particular aspect of our life (i.e., 'standard of living' or 'why do we need it').

Preparation: the instructor should research and contextualize Critical Materials, Material Abundance, Rare Earth Elements, and mineral resources in general (their planetary distribution and accessibility). Please note that there are a number of interesting resources on-line, including a USGS site titled, "National Minerals Information Center" [4] and another on "Rare Earth Elements" [5]. These sites offer maps and other relevant information. Some concept checks for students include:

- Why does the earth have a solid core?
- What are the most common surface elements?
- Why are oxides so common?
- How do you process mined earth (minerals) to acquire usable elements/compounds?
- Where are rare earth elements located (e.g., geographically – location and depth, solid vs. water suspension, politically (e.g., nationally, internationally, in space)?
- For a selected rare earth example: how much do 'we' (i.e., U.S. vs. other nations) use, and is this sustainable?
- Who mines/processes our materials?
- Are all mining and processing activities in the world performed in a humane manner?

Background

There is a real disconnect between what we as citizens think of common products and materials vs. what actually exists. We generally don't think twice about roads or buildings or phones and how they are made. And we certainly are not trained to think of long-term goals or expectations. Quarterly reports determine much of our financial health metrics, whereas the possibility of not having 'critical materials' is independent of this[4]. One country with resources can deny anyone access to critical materials at any time. And what are the consequences? Do we have contingency plans? In general, can we plan for future contingencies like a lack of local raw materials (e.g., concrete) or a lack of energy resources (e.g., fossil fuels)?

Students should investigate a product supporting their quality of life, and some critical material that is required for the creation and function of that product.

Part 1 Procedure

Post the following directions on slide/screen.

Create and document the following:

1. Determine a product of interest that supports your own quality of life.
2. Determine a critical material that is required by (during the manufacture of) some component in your selected product.
3. Determine one source and distribution of your selected element/material.
4. List aspects of the 'sustainable' nature of this sequence of the material's: source, extraction, distribution; and final manufacture and sale of your selected product.
5. Detail the cultural and human risks associated with the material and product.
6. List options to this material and product that mitigate the risks listed in the previous step.

It is recommended that the instructor present the following information to the students in an appropriate format. This could depend on available resources or student interests among other things. It may be appropriate to begin your research activity in-person or 'flipped' (i.e., on-line preparation). And it may also be helpful to continue the research activity for some period so that asynchronous activity can occur. However, the activity is performed, students must document the outcomes (1- 6) listed below, before commencing with Part 2:

Expected Outcome 1: Your research should answer the question: why do we care about 'materials'? One reason is that we can't live without them. Consider the house you live in, the food and water you drink, and all the 'stuff' that we use: it is an amazing collection of 'materials' and products. This inventory of your items helps define your standard of living. You can text your friend with your smartphone. You can get a drink of water by turning the tap on and filling your cup. All of these items are 'fair game' to consider in our research of critical materials.

Expected Outcome 2: Let us next define what a 'critical' material is: it is one that we need[5]? It could be common or rare. For example, sand is a material (SiO2) currently in relatively short supply. We need sand for concrete and to build structures. Though sand comprises a large fraction of our planet's crust, it is found only in certain places like riverbeds and shorelines. Thus, it is not obvious that every country or region and individual has the sand they want.

On the other hand, there are a number of materials that do not exist plentifully in our environment. For example, helium can be used in balloons. But it is also used to cool superconducting magnets (e.g., a medical MRI). It is rare, comprising about 5 parts per million of our atmosphere.

One group of elements are termed 'rare earth elements'. These materials include platinum, palladium and rhodium, and really are 'rare'. There is not an 'abundance' of these elements. They are costly to mine and process; and are quite useful. For example, they are used in catalytic converters found in most automobiles.

Expected Outcome 3: Metals like iron and copper are traditionally mined in the earth's crust. These mines dot our planet and exist whilst the local economy and politics allow operations. In my home state of Minnesota there is the 'Iron Range' up north. This was the U.S. source of much of the iron used to make steel in the twentieth century. Coal came from Pennsylvania and it met with iron in Indiana for smelting (i.e., combining ores to make a useable steel commodity). This type of activity occurs over much of the world[6-10].

As these large activities (e.g., open pit mines, mountain removal) are constrained by public impact on lands and/or environmental issues, we think up alternative ways to get these elements. Recently, efforts to mine our oceans have become of more interest because of the abundance of elements in the water. Even extraterrestrial mining is envisioned, though economically unfeasible at present.

Some material needs are controlled by our environment, economy and politics. For example, rubber is a commodity that could be considered in short supply. It is typically processed from trees grown in tropical climates. But the price of rubber and agricultural issues (e.g., health and economy) affect what farmers will grow.

Expected Outcome 4: The concept of 'sustainable' living becomes more important as our planet becomes more developed[11]. Typically, laws are generated to mitigate issues that degrade our standard of living. We want drinkable water, so we regulate piping materials, protect sources and treat the water for potability. When landfills overfill, we recycle to minimize waste and find other creative ways to mitigate the amount of trash we generate. And when critical elements are involved, we try to keep them available for reuse.

Expected Outcome 5: Cultural impact and human rights can be an important aspect of mineral extraction and processing.

Expected Outcome 6: Alternatives to the particular element/material and product can be difficult to discover, if not impossible. It is recommended that students look to previous versions of the product to see if any other materials were used. Many materials have similar properties, so students may wish to research alternatives[12]. Also, it may be helpful to investigate similar products to find alternate methods of achieving the same performance.

Part 2: Creating videos!

Activity Description

Creating a video that connects the four threads may be a challenge! It is possible to start at any of the threads and work across to connect them, though most individuals recognize a product need first and then trace the connections backward to the source. This module is flexible and the video creation portion can be executed during the resource exploration or done sequentially. Means of interacting with the videos, and assessment, are presented.

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Background

Producing video these days can be as simple as pressing a button on your smartphone. Development of a video is another story and is the subject of Part 2. The important thing is that you (and your students) keep a K.I.S.S. mindset, it is not expected to create an Oscar worthy video, rather creating a video that communicates a purpose is important so emphasis on the planning part is appropriate.

Videos have been used in many educational settings, video production and development (as a teaching and learning strategy) are just becoming popular and there are many tools and examples out there. Educators have come to realize that video production and development can develop many of the skills desirable in many courses of study and even jobs. For example: organization; conveying one idea or concept; creativity; teamwork; as well as a multitude of writing, thinking and visualization skills.

This activity is designed to be simple, straight forward, and FUN!

Preparation

You may desire to do this second part in a computer lab so that students have access to appropriate video resources.

Part 2 Procedure

Most video production involves a progression of events. Post the following directions on slide/screen.

Some common steps:

1. Define the video's purpose AND audience. Our intention is to COMMUNICATE (to the general public) what connects us, our standard of living and the Earth's elements we all regularly consume.
2. Develop a storyline and break it up into short segments (3-5 short, 15 – 30 second, shoots).
3. For each segment of the storyline, document:
    a. Description of the environment/setting(s)/location(s) where the segment takes place: busy street, quiet corner, etc.

b. Description of the style: humorous, serious, fast paced, etc.

c. Description of what the audience will see and hear: single person, crowd, etc.; objects: a car, smartphone, etc.

d. Any narration/sound you intend to provide. Very important to speak to your audience, not above them, i.e., speak at their intellectual level.

e. You may also want to include description of motion: person A moves across the room, for example.

4. Sequence the segments in logical order and post-process before it is released. (NOTE: there may be other elements to create such as title screens, optional, depends on skill level.)

5. Video interaction and evaluation occurs after upload.

This is intentionally a very condensed scenario of the video production process and is not meant to include many other aspects of video communication. It may be appropriate to provide a more in-depth look at developing the storyline, examples can be located on the Internet without going into too much technical detail. A simple way to convey the process is to look at examples. A good example is any of, "The (things) that Changed America" series episodes, available on the History Channel. Another good example is comic strip cells, one cell of a comic strip could equate to one segment as defined here.

It is recommended that the instructor present the following information to the students in an appropriate format. This could depend on available resources or student interests among other things.

Expected Outcome 1: The purpose of these videos is to share a personal relationship of a student with a material regarding a product of interest and its societal impact. Even that sentence is complex, but you can break it up into parts and relate it to Part 1 of this module. The active verb is to 'share'. A video can be a powerful means to convey a message. It is common to interact with video media, and we should both create and observe in this realm.

Expected Outcome 2: The storyline is like an outline of a paper. You have to create it, so this is where brainstorming may occur. A rudimentary example may include a 'beginning, a middle, and an end' in which the student literally develops the storyline in accordance with Part 1 Expected Outcomes in order. More creative scenarios may include an initial display of product use, followed by supporting outcome information.

Expected Outcome 3: A video could be created in a style such as an 'interview' style (i.e., a talking selfie). It could also include specific shots of other items (e.g., the product, its use (why I need it), a material or element).

It is important to bring up legal issues at this point. Copyright is enforced worldwide, though some educational use exemptions exist. The caution here is to consider having students create raw footage rather than to import content from other sources.

Expected Outcome 4: The actual shooting of video can be easily done on a variety of devices. The specific methods will certainly depend on available resources and cannot be defined up front. Some advice follows:

- Keep it short (less than a few minutes). This is one reason many platforms exist for short videos. Also, humans tend to be distracted after mere seconds, much less minutes.
- Take some sample footage to improve sound, lighting, content, etc.
- Play back the samples and laugh at yourself (i.e., please make this an enjoyable activity). Many improvements can be made throughout this activity (and your life in general). Please ask a trusted person for advice and keep improving.
- You can shoot it all at once or do it in pieces with post editing.
- Post editing may be time consuming and certainly depends on more resources. Depends on student's skill level.

Part 3: Interacting with your videos and assessment

Activity Description

Characterizing and assessing a video can be done with regard to whether the intentions were clearly communicated and is quality evident, not just in what you see/hear (sound and lighting), but the information provided, is it evident that sufficient knowledge/content is part of the final product.

Background

Learning from videos dates back to WWII and grew in usage with rudimentary on-the-job training videos of the 50s, the medium was really popularized in the 70's with OSHA safety training. Today, video enhanced learning has evolved into many new genres of instructional and motivational videos used in workplace and individualized learning environments. In Part 3 students are involved in a process of not only learning subject matter content from each other's videos and the process, but also learning from each other how to communicate that content effectively in a video format.

Part 3 Procedure

The single most important goal is to evaluate if the final product, the video, satisfactorily communicated the connection between us, our quality of life and the sustainability of the earth elements/materials we consume.

A rubric is provided for evaluation of the final product. This rubric can be completed by instructor or peer group. See Appendix.

Activity Summary and Debriefing

Debriefing is an important aspect of this activity. A discussion could be managed in a way that addresses some of the basic goals. The bottom line is to assess if...

- concepts of critical materials were understood?
- concepts of sustainable materials were understood?
- concepts of societal impact were understood?
- if the video conveyed the intention/message appropriately?

Reflection Questions:

The following is a list of questions that might be used in a Socratic scenario after the activity:

- What was the most interesting element you discovered?

- How easy was it to find relations with products and required elements?
- What was the most interesting societal impact you discovered?
- Would you change the use of type of any product you currently use? Why or why not?

Comments

Many of the products and elements discussed in a setting such as this will change over time as products evolve. For example, as electric cars become more common, materials associated with gas powered autos will decrease in use and importance (e.g., catalytic converter materials). This is a salient aspect of the importance of continued cognizance (and vigilance!) regarding our interaction with our planet and a sustainable quality of life.

Evaluation of students: (questions, discussion or quiz items)

1) What are some of the issues surrounding sustainability of rare earth elements/critical materials?
    a. Answer example: our use of and dependence on it.
2) What are some of the issues found in using rare earth elements/critical materials in the manufacture of a product such as a cell phone?
    a. Answer example: distribution and accessibility.
3) What is meant by a life cycle/path to manufacture using the rare earth elements/critical materials found in a product such as a cell phone?
    a. Answer example: material location, prevalence, extraction, and processing.
4) Rank the following elements/materials as they fall on our dependance/need scale (1 = high, 5 = low) and provide an explanation of your ranking.
    a. Answer examples:
        i. 1 Lithium – highly used in batteries
        ii. 2 Neodymium – highly used in batteries especially cars
        iii. More TBD

5) Rank the same items above with respect to our 'standard of living'. (1 = critical to our standard of living, 5 = not so critical) and provide an explanation of your ranking.

   a. Answer examples:

      i. 1 Neodymium – the race to cleaner energy depends on it

      ii. 2 – Lithium – until another energy storage strategy is reached

      iii. More TBD

An example rubric is also presented here:

Rate each item: 1 = strongly disagree, 5 = strongly agree

1 The video is of sufficient length and depth to hold my attention.

2 There was a clear beginning, middle and end.

3 Style and technique were evident.

4 The video uses clear and understandable speech and terms (just the right technical level).

5 The video aesthetics (lighting, sound level, etc.), were appropriate.

6 The product and the element/material required were appropriately identified/described.

7 The connection between: a product and the element/material required for its production including location, extraction, processing, distribution was conveyed.

8 The connection between: us (our need for the product) and the impact on our lives was made clear.

9 Sustainability issues were identified including environmental, political and cultural.

10 Accessibility and supply issues were explained including alternatives such as replacement element/material, processing, disposal/recycling, etc.

11 The video was effective in conveying its message.

12 The video made me care about the subject element/material.

Total (60 possible): _________

Course evaluation questions: (to be filled out by the students)

1. Did the activity help you better understand the earth's resources and our dependence on their critical importance?
2. Did the activity help you better understand the concept of 'societal impact'?
3. Did the instructor explain and facilitate the activity well?
4. Were you able to get your questions answered easily?
5. Were you able to create a video that did what you desired?
6. Who would you show your video to, and why?
7. What was the most interesting thing that you learned?

Optional Modules:

MatEdU Module: (www.materialseducation.org) "Defining Sustainability ISO14000".

MatEdU Module: (www.materialseducation.org) "Implementing ISO 14001 Sustainable Design".

MatEdU Module: (www.materialseducaiton.org) "Materials for Sustainable Products".

MatEdU Module: (www.materialseducation.org) "PNNL Materials Science Applied to Household Appliances".

MatEdU Module: (www.materialseducation.org) "Recycling Materials".

MatEdU Module: (www.materialseducation.org) "Smart Materials".

MatEdU Module: (www.materialseducation.org) "Sustainable Design".

MatEdU Module: (www.materialseducation.org) "Global Impact of Design and Innovation"

MatEdU Module: (www.materialseducation.org) "The Third Element"

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