Journal of Sustainability Education
Vol. 32, March 2026
ISSN: 2151-7452

A Sustainability Simulation: Mining for Strategic Minerals

Matthew L. Simon

Northeast Iowa Community College, Calmar, IA. simonma@nicc.edu.

Abstract: The recent rapid shift towards the adoption of electric vehicles and other low-carbon technology has increased the global demand for strategic minerals. Increased demand for these strategic minerals means nations around the world are working to extract them, creating a significant challenge for sustainable development. Eight key educational competencies have been developed to address the types of thinking and challenges found in working to reach sustainable development goals. This paper presents a reality-based simulation to encourage students to practice these competencies within the context of mineral mining. The simulation includes three scenarios of resource development within the simulation that operate at different levels of sustainability; students develop a sustainable solution in the final scenario. This simulation is intended to be a tool to encourage transformative, emancipatory, and collaborative learning. The overall goal of this activity is to help students better understand the complexities involved in the interactions between economic, social, and ecological motivators when dealing with large, landscape-scale resource development projects.

Keywords: Active learning, metal mining, sustainability simulation, sustainability competencies, sustainable development

---

Matt Simon is a college science instructor in Iowa's Driftless region. His experiences studying and participating in the mass destruction of our natural resources in Appalachia's coal-fields has motivated his interest in sustainability. His previous work in industry and as a consultant informs his teaching and research interests. Matt has published research on a variety of topics ranging from mining reclamation assessment, restoration ecology, and teaching case studies.

Introduction:

Sustainable development has been identified as a priority by the United Nations, and it is frequently described as development that meets current needs without compromising the needs of future generations (Bruntland, 1987). The recent, rapid shift towards the adoption of electric vehicles and other low-carbon technology has increased the global demand for strategic minerals, including copper (Cu) and cobalt (Co). With increased demand for these strategic minerals, nations are examining their geologic resources and working to develop them, creating a significant challenge for sustainable development. Mining for strategic metals can drive environmental and social problems in areas where they are mined, but the metals are necessary to facilitate the shift away from carbon-intensive energy technology (Lèbre et al., 2020). This dichotomy is driving conflict in areas around the globe that are rich in strategic metals.

Locations around the world that are rich in strategic metals resources have frequently experienced myriad environmental and social problems associated with mining activity. Degraded ecosystems, and soil quality, reduced water availability and quality, and poor air quality are among the environmental impacts associated with metals mining. Social problems include exacerbation of income inequities furthering social tension, forced migration, child labor and modern slavery (Gross, 2023; Luckeneder et al., 2021; POST, 2022; Samosir et al., 2025). To address these social and environmental problems associated with the wicked problem (Rittel & Webber, 1973) of metals mining, education for sustainable development is necessary (Wiek et al., 2011).

Eight key educational competencies have been developed to holistically address the types of thinking and challenges found in working to reach sustainable development goals (SDGs). These include; systems thinking, futures thinking, values thinking, strategic thinking, an interpersonal competency, integrated problem solving, an intrapersonal competency, and an implementation competency (Brundiers et al., 2021). Developing holistic pedagogical approaches has been recognized as a priority to provide depth and meaning to sustainability education for the SDGs. Games for sustainability learning are one such route to achieve these ends.

Gamification provides guided, controlled progression where players follow their own progress and choice of authentic options, motivating them to progress through the game, learning as they go. Learning the SDGs in a system with scoring points where learners have a say in the outcome does not appear often in education (Réti et al., 2022) and the paucity of research to indicate the long-term efficacy of sustainability games in achieving SDGs has been identified as an important gap in sustainability education (Fernández Galeote et al., 2025). The current paper presents a game-like simulation of metals mining which activates the educational competencies

outlined by Brundiers, et al. (2021), except the implementation competency which is beyond the scope of this simulation.

Active learning pedagogies, like games, have been shown to be beneficial to student learning outcomes in sustainability education (Kagawa, et al., 2006; Réti et al., 2022). A four-part framework integrating transmissive, instrumental, transformative, and emancipatory pedagogies provides a map to guide students and educators along this path. The framework builds from prescribed informational learning to work towards self-directed, collaborative inquiry which challenges normative assumptions towards meaningful changes in the status quo (Papenfuss, et al., 2019).

This simulation is intended to be a tool to encourage transformative, emancipatory, and collaborative learning, building on information learned via transmissive and instrumental methods. Building on relevant topical knowledge and basic academic competency from the classroom setting and linking this transmissive and instrumentally-based knowledge (Papenfuss, et al., 2019) to the sustainability competencies outlined in Brundiers et al. (2021) forms the basis for this simulation. The simulation allows students to engage with their base of knowledge by collaborative active interaction, building confidence in their understanding of the sustainability competencies. For example, students will have to think strategically about the system they are engaging in while making values-based decisions, all while interacting with others during the simulation (Figure 1). Transformative and emancipatory learning happens by focusing learners towards "peace, collaboration, responsibility, respect for limits, and interconnectedness" (p. 9), as well as a "constructive deviance" (p. 10) when developing novel sustainable solutions for the simulation (Papenfuss, et al., 2019).

ISSN: 2151-7452

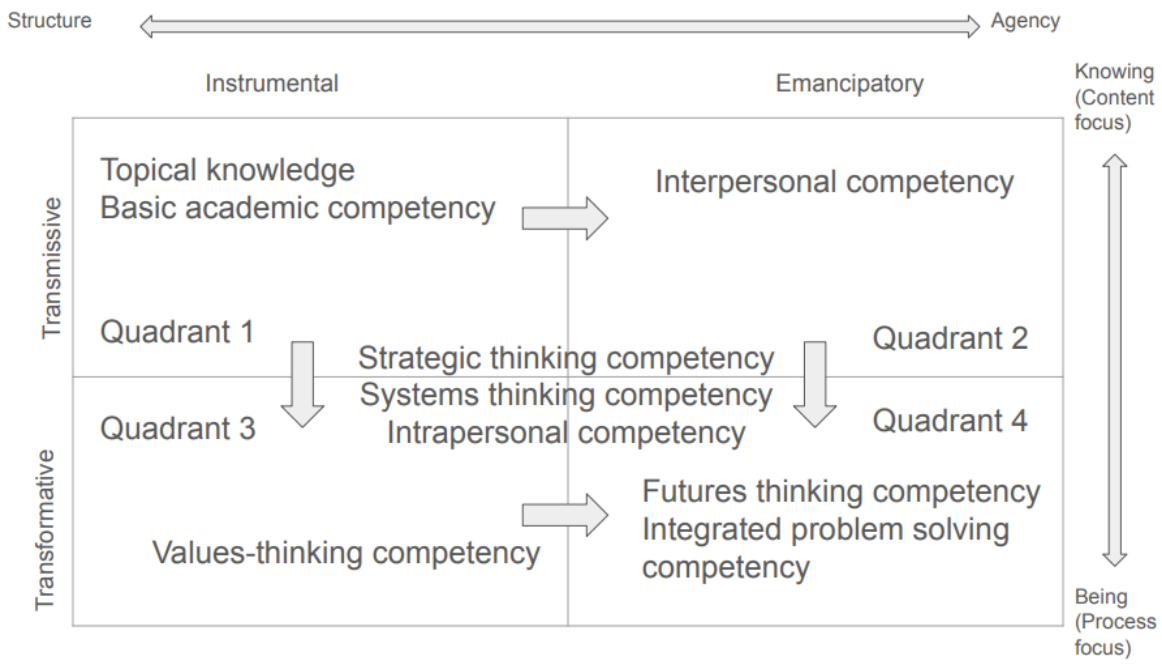

Figure 1. The interacting pedagogy framework for sustainability education (Papenfuss, et al., 2019) with the key sustainability competencies (Brundiers et al., 2021), highlighting their interactions.

This figure illustrates, for example, how topical knowledge and basic academic competency can build into emancipatory and transformative pedagogies leading to challenging the status quo, in Quadrant 4. The interconnectedness of these competencies within an educational ecosystem is especially important for the strategic thinking, systems thinking, and intrapersonal competencies, hence their centering in the diagram, but all competencies will overlap the quadrants to some extent.

Simulation Overview

This lesson is structured as an interactive simulation to help students understand some of the competing interests and viewpoints involved in the development of a large-scale natural resource extraction activity, in this case, metal mining. For this simulation there are four primary stakeholder groups interacting with each other and three "banks". The stakeholder groups include, the mining company, the government, miners (who come from the local area), and non-mining citizens in the area. The three banks represent the three pillars of sustainability: social, ecological, and economic sustainability (Purvis, et al., 2019). Within the simulation, participants

will interact with three different scenarios; a “Thoughtful”, “Capitalist”, and “Sustainable” scenario.

The Simulation Framework

In this simulation, participants roleplay various stakeholders and work through scenarios, addressing three models of development in which a multinational mining company shows interest in developing a large open-pit mine targeting strategic metals. These metals will ultimately be marketed globally for the development of batteries for electric vehicles. The company securing and distributing these metals promises higher wages and steadier employment than is usually available locally for community members, all while promising respect for the local environment and cultural history.

The first scenario is described as the “Thoughtful Scenario”, where there is governmental oversight, which implies sustainability, but by the end of the scenario, the system is ultimately unsustainable, reflecting modern mining systems in the developed world. There is usually governmental oversight, coupled with a concern for people and the environment, but in the end, corporate profit is the primary driver of development. As participants work through this scenario, they will demonstrate their ability to use systems, futures, and values thinking competencies during the final step, which carries into the class discussion following each scenario. The first scenario will take at least 35 minutes to complete.

The second scenario activates the same competencies and starts like the first, but eventually descends into the unfettered “Capitalist Scenario” of production as is frequently seen in places in the developing world. Mass ecological destruction and human suffering ensues, promoting robust conversation about the differences from the first scenario and understanding of how different oversight systems promote specific hierarchies and outcomes in society. The second scenario will take at least 20 minutes to complete.

During the third, “Sustainability Scenario”, participants are called upon to develop their own sustainable models, applying concepts learned during the first two scenarios, adopting past successes, and developing novel approaches to the final scenario. Along with the previously mentioned competencies, this activity intends to activate the strategic thinking, integrated problem solving, and interpersonal competencies necessary for developing sustainable solutions. The intrapersonal competency is achieved through participants’ critical analyses of their own personal understandings of their place, emotions, interactions, and feelings within each of the scenarios. The third scenario will take at least 20 minutes to complete.

ISSN: 2151-7452

Objective

The overall goal of this activity is to help students better understand the complicated interactions between economic, social, and ecological motivators when dealing with large, landscape-scale resource development projects. Building practice with sustainability competencies during the simulation will also help students develop a greater appreciation and understanding of the diverse viewpoints of various stakeholders.

During the final scenario of this simulation, students are encouraged to utilize the "membrane" concept for integrated transfer of knowledge and values between stakeholders in sustainability conversations (Widhalm, 2011). During a "membranous" exchange of information, the traditional communication walls or stakeholder silos are made more porous, so collaboration and understanding of various perspectives is enhanced. This is especially important when working within a system in which there are many stakeholders and various power structures and hierarchies, like large-scale mining.

Stakeholder Groups

There are four primary stakeholder groups interacting with each other: local miners, the mining company, the government, and non-mining citizens in the area. The banks also interact with the stakeholders by providing or taking resources during each round. Prior to beginning the simulation, participants should discuss the motivations and limitations of each stakeholder group. This may be uncomfortable for students, as acknowledging that humans' worst motivations can lead to undesirable outcomes.

Mining Company

For the mining company, the primary motivation is maximizing financial profits regardless of social or ecological concerns. The company is responsible for paying local miners and governmental agencies for their mining work and permitting regulatory work, respectively. They are encouraged to use their capital to work around agreed-upon regulatory structures to increase their profit.

Miners

Local miners' primary motivation is gainful employment in the mine. Local miners do live in the community though, and are concerned about their social standing and the local environment. Miners' social standing is usually raised by employment, and mining is frequently seen as a "better" job than traditional agriculture or other locally-available employment. Their financial needs are much less than the mining companies, but the need for social standing and

good local ecology is much higher. Even though they work for the mining company local miners still need access to clean water, productive local food sources, and important cultural ties.

Government

For members of the government, the primary motivation is the development of natural resources. This needs to be balanced with the needs of the people and the people's prosperity cannot simply be measured in terms of money. People also place high value on their social situation and the health of their local environments. Government's primary focus is *supposed* to be on the people; however, as a human institution governments are not incorruptible. Students in this role during the simulation will need to consider their own values, experiences and knowledge of how governments can work (for better or worse) to inform how they act during this simulation.

Local Non-Mining Citizens

Non-mining citizens live in the community around the mine, and their motivations are varied. They are concerned with making money, and the mine provides some induced employment in the area to support the miners and the mining operation. This is a diverse group of people, though, and their needs and expectations are highly variable and not always positively-minded towards the mining operation. Ecological and social concerns are also relevant for this group, similarly as the miners.

Banks and Resources

The banks represent the three pillars of sustainability: social, ecological, and economic.

- The Economic Bank represents the global and local economies and provides funding to the other stakeholder groups.
- The Social Bank represents the social component of sustainability. Important components include, but are not limited to, good jobs, connection to their place, a thriving culture, good healthcare, and education. and the Social Bank provides a quantifiable value to these societal needs.
- The Ecology Bank represents the natural capital in the local area such as: clean water and air, adequate soil resources, plant and animal biodiversity. The Ecology Bank can import and export resources (depending on the situation), but unless ecological restoration is specifically called for during an action, ecology units that are used up should be considered as permanently lost during each scenario (see Appendix 1 for details).

ISSN: 2151-7452

Each stakeholder group starts with varying amounts of economic, ecological and social resources that are represented by three differently colored poker chips, each representing one of the three pillars of sustainability.

- **Local miners** and **non-miners** start only with ecology chips because most individuals in those populations have little money and live closely with their environments. Their social status is usually not sufficient to enact change at an individual level so these groups start with no social chips. These two stakeholder groups represent the citizens in the area of the mine that are doing the actual work of mining or as non-miners are in such roles as family members, neighbors, and friends. The miners work directly for the mining company and the non-miners are employed variously in the surrounding community in jobs that indirectly support the mining industry, such as manufacturing mining equipment, and the local population.
- **The government** starts with no resources, but acquires them, and can serve as a liaison, helping to negotiate between competing stakeholder groups while regulating them.
- **The mining company** starts with the most money and social capital as a group. In this simulation, the mining company represents a large multinational corporate entity that brings capital investment to start the mining operation, runs the mine, and profits from the work.

Implications for Practice

Audience

The intended audience for this simulation is college students; however, high school students may find this activity valuable as well. The activity can be implemented in a variety of class sizes. There are four primary roles during the simulation (mining company, government, miners, and other citizens), so a suggested minimum is four students and an instructor. Larger classes can separate each role into small groups and utilize as many copies of the simulation simultaneously as needed. For example, three students could represent the "Government" and collectively represent that role, which would likely increase conversation and diverse viewpoints during the simulation.

Student and Teacher Preparation

Prior to engaging with this simulation, the instructor should expose students to foundational concepts related to sustainability, such as the three pillars of sustainability (Purvis et al., 2019) and the understanding of the diversity of perspectives that explorations of

sustainability can entail (i.e. sustainability is not just a problem of the environment) (Miller et al., 2025).

Instructors may not be familiar with the situational context within this simulation. It is important to familiarize instructors and students with the mining and power systems involved in the utilization of rare earth elements,the rise of electrification around the world, and implications of that shift. Linked resources in the Materials and Technology section of this paper can provide a starting point for exploration of these situational topics.

Simulation Mechanics

There are three scenarios: the "Thoughtful Scenario", the "Capitalist Scenario", and the "Sustainability Scenario". There is limited flexibility for outcomes in the "Thoughtful" and "Capitalist" scenarios as they are in place to help familiarize students with the situation and practice how stakeholder groups interact with each other. Additionally, students can see how resources move in and out of a simulation with a particular framework. The third "Sustainability Scenario" is a chance for students to apply new skills and lessons from the previous models to achieve a sustainable path forward. The detailed procedures are described in the scenario instructions (Appendix 1) for the first two scenarios. Each of the first two scenarios has nine steps in which the banks and stakeholder groups interact and exchange resources as described in each step of the scenario. The final "Sustainability Scenario" utilizes the basic payment and costs from the previous scenarios, but participants must engage in discussion and collaboration between stakeholder groups to hopefully reach a sustainable outcome, balancing the needs and desires of the stakeholder groups while maintaining economic, social, and ecological parameters.

The responsibility of the instructor during the first two scenarios is to ensure that participants correctly complete each step and, depending on the classroom, provide the necessary related historical information, concepts, and content. Assigning students to familiarize themselves with the content information is also possible. The instructor could also operate the banks and essentially act as a "narrator" if the class context allows. The teacher can also mediate disputes that may arise; however, students should be empowered to find their own solutions.

Ethical and Emotional Considerations

This simulation is based in reality and there are ethical and emotional considerations while participating in this activity. The topics addressed during this simulation are centered around serious exploitation of workers and communities, system-scale corruption, greed, and catastrophic environmental harm. Discussion of challenging topics is important to build student

awareness of different perspectives, critical thinking and argumentation skills, ultimately improving civic engagement and knowledge (Gert-Jan Wansink et al., 2023).

Throughout the simulation, students should work to set aside their personal feelings to genuinely represent their stakeholder interests. Participants are encouraged to commit to the worldview of whichever stakeholder group they are representing. For example, if a student fervently believes that mining companies should not be allowed to extract resources and they are playing as the mining company, they should set aside their personal beliefs and act in the mining company's interest, even if it contradicts their personal opinions. This may be challenging for some students and there are opportunities to discuss these topics before, during and after each scenario, as well as in the self reflection (Appendix 3). Viewing complex situations through a variety of perspectives is an integral part of this simulation. Instructors should encourage students to be open and thoughtful in their personal reflections and share any emotional or philosophical discomfort they may encounter during this activity. Instructors should feel empowered to provide support to students as they encounter challenging situations during the simulation.

Materials and Technology

Materials

The materials necessary for this lesson are:

- The included simulation place cards labeled: Social Bank; Economic Bank; Ecology Bank; Mining Company; Government; Miners; and Other Citizens (Appendix 2).
- Each of the three scenarios also has individual instructions and action choices for each stakeholder group (Appendix 1).
- A grading rubric for the simulation and a set of self-assessment questions is also included (Appendix 3).
- Standard poker chips (red, white and blue colors) are also needed to represent value for each of the three pillars of sustainability, but are not included. Other colored chips or counting systems, such as locally available currency, can certainly be used in place of poker chips.
    - 100 white, 50 red and 50 blue chips will be needed for each group completing the simulation. Due to the large amounts of white "economic" chips needed, demarcating approximately 10 white chips as having a value of 10 units is necessary to keep the numbers of chips to stay within reason. Additionally, demarcating approximately eight red "ecology" chips and six blue "social" chips as having a value of five units will also be necessary.

Technology

Below are digital resources for additional information on some topics encountered during this simulation and examples for the scenarios.

- Most resource extraction-related repression today occurs in developing countries. Here is an overview article with links to additional resources: (Global Witness, 2024).
- National Public Radio story describing the general conditions of workers, communities and the environment in the Democratic Republic of the Congo. 36-minute listen and/or five-minute read: (Gross, 2023).
- Al Jazeera story describing the conditions in the Democratic Republic of the Congo and many of the challenges faced there in cobalt mining. 18:48 minute video: (Al Jazeera English, 2024).
- Are students skeptical that governmental agencies could be mobilized against miners? Here is an example of U.S. soldiers being deployed against Americans, on American soil during a labor dispute to enforce the will of mining corporations in the early 20th century: (National Park Service, 2021).

Conclusion

This simulation builds from the four-part framework outlined by Papenfuss, et al. (2019) to guide students and educators towards more comprehensive sustainability education. By integrating transmissive, instrumental, transformative, and emancipatory pedagogies with the key sustainability academic competencies described by Brundiers et al., (2021), this simulation is intended to be a tool to encourage meaningful sustainability learning. Following Bloom's Taxonomy (Anderson, 2001) the learning outcomes from this activity are focused on higher-order outcomes. Students will be able to *use* their knowledge of sustainability concepts in simulated stakeholder interactions. Students will *compare* various sustainability strategies within their simulation. Students will *critique* their simulation for its adherence to sustainability goals. Since this simulation is a fictionalized trio of scenarios, the implementation competency is beyond the scope of this simulation; however, students can take these lessons and apply them to real future contexts.

Vocabulary

Direct job: Employment that exists to fulfill the primary task– in this case, mining.

ISSN: 2151-7452

Indirect job: Employment that exists to supply goods and services for those in the "direct job" category. In this simulation, some of the non-mining citizen roles account for these indirect jobs, like people who work to provide equipment for the miners.

Induced job: Induced jobs are created when the miners spend their extra income on goods and services within their communities. In this simulation, some of the other citizen roles account for these induced jobs. As long as the job did not exist prior to mining and has been induced by the influx of money from the mining operation, it would be considered an induced job. For example, a person who operates a movie theater, or additional dining opportunities for miners and other citizens in the area, they have an induced job.

Permitting: Permitting is the regulatory processes involved in the development of a mining operation. Components may include environmental review, safety planning, and engineering specifications. Typically, the mining company pays permitting fees to governmental agencies for regulatory oversight of the mining operation associated with the mining process.

Dark Money: Money paid for political gains through irregular (often illegal) channels to prevent citizens from knowing where the money is coming from and aids in unaccountable behavior.

Artisanal mining: Mining that is distinct from large-scale mining in that it is usually labor intensive, using hand tools instead of large machines. In artisanal mining, there is usually a lack of safety protocols, environmental protection, and fair wages, as a result of the confluence of corporate greed and lax, or corrupt, governmental oversight.

Acknowledgement
Thanks to Dr. S. Partola, A. Sadler, and two anonymous reviewers whose comments and suggestions greatly improved this manuscript.

References

Al Jazeera English. (2024, September 12). *The horror of cobalt mining in DR Congo | The Listening Post*. YouTube. https://www.youtube.com/watch?v=eJdktQ97rZ8

Anderson, L. W., & Krathwohl, D. R. (2001) *A taxonomy for learning, teaching, and assessing : A revision of Bloom's taxonomy of educational objectives.* Longman.

Brundiers, K., Barth, M., Cebrián, G., Cohen, M., Diaz, L., Doucette-Remington, S., ... & Zint, M. (2021). Key competencies in sustainability in higher education—toward an agreed-upon reference framework. *Sustainability Science*, *16*(1), 13-29.

Brundtland, G.H. (1987) Our Common Future Report of the World Commission on Environment and Development. Geneva, UN-Dokument A/42/427.

Fernández Galeote, D., Gabrielaitis, L., Guillén, G., & Hamari, J. (2025). Play, games, and gamification to support sustainability transitions: a scoping review and research agenda. *Environmental Innovation and Societal Transitions*, *57*, 101025. https://doi.org/10.1016/j.eist.2025.101025

Gert-Jan Wansink, B., Mol, H., Kortekaas, J., & Mainhard, T. (2023). Discussing controversial issues in the classroom: Exploring students' safety perceptions and their willingness to participate. *Teaching and Teacher Education*, *125*, 104044. https://doi.org/10.1016/j.tate.2023.104044

Global Witness. (2024). *Critical mineral mines tied to 111 violent incidents and protests on average a year*. Global Witness. https://globalwitness.org/en/campaigns/transition-minerals/critical-mineral-mines-tied-to-111-violent-incidents-and-protests-on-average-a-year/

Gross, T. (2023, February 1). *How "modern-day slavery" in the Congo powers the rechargeable battery economy*. NPR.org; National Public Radio. https://www.npr.org/sections/goatsandsoda/2023/02/01/1152893248/red-cobalt-congo-drc-mining-siddharth-kara

Kagawa, F., Selby, D., & Trier, C. (2006). Exploring students' perceptions of interactive pedagogies in education for sustainable development. *Planet*, *17*, 53–56.

Lèbre, É., Stringer, M., Svobodova, K. *et al.* (2020). The social and environmental complexities of extracting energy transition metals. *Nature Communications* 11, 4823. https://doi.org/10.1038/s41467-020-18661-9

Luckeneder, S., Giljum, S., Schaffartzik, A., Maus, V., & Tost, M. (2021). Surge in global metal mining threatens vulnerable ecosystems. *Global Environmental Change*, *69*, 102303. https://doi.org/10.1016/j.gloenvcha.2021.102303

Miller, G.T., Spoolman, S.E., Andrews-Brown, D.M. (2025). *Environmental Science*. Cengage.

National Park Service. (2021, May 26). *The Battle of Blair Mountain (U.S. National Park Service)*. Www.nps.gov. https://www.nps.gov/articles/000/the-battle-of-blair-mountain.htm

Papenfuss, J., Merritt, E., Manuel-Navarrete, D., Cloutier, S., & Eckard, B. (2019). Interacting Pedagogies: A Review and Framework for Sustainability Education. *Journal of Sustainability Education*, *20*.

POST (Parliamentary Office of Science and Technology). 2022. POSTbrief 45, Mining and the sustainability of metals. UK Parliament.

Purvis, B., Mao, Y. & Robinson, D. (2019) Three pillars of sustainability: in search of conceptual origins. *Sustain Sci* 14, 681–695. https://doi.org/10.1007/s11625-018-0627-5

ISSN: 2151-7452

Muirhead, N. (2024). The horror of cobalt mining in DR Congo. Al Jazeera English. https://www.youtube.com/watch?v=eJdktQ97rZ8

Turner, R. A., & Wills, J. (2022). Downscaling doughnut economics for sustainability governance. *Current Opinion in Environmental Sustainability*, *56*, 101180. https://doi.org/10.1016/j.cosust.2022.101180

Réti, M., Lippai, E., & Nemes, M. (2022). Gamification for sustainability: A possible renaissance of role-playing game mechanics in pedagogy. In P. Vare et al. (Eds.), *Competencies in education for sustainable development*, Sustainable Development Goals Series, Springer.

Rittel, H.W.J. & Webber, M.M. (1973). Dilemmas in a general theory of planning. *Policy Sci* 4, 155–169. https://doi.org/10.1007/BF01405730

Samosir, A. G. M., Sutisna, S., & Prakoso, L. Y. (2025). Literature study: Review of the negative impacts of mining activities in various countries on the environment, society, and local economies, and mitigation strategies. *Golden Ratio of Data in Summary*, *5*(3), 87–101. https://doi.org/10.52970/grdis.v5i3.1299

Widhalm, B. (2011). Educators as architects of living systems: Designing vibrant learning experiences beyond sustainability and systems thinking. *Journal of Sustainability Education*, 2.

Wiek, A., Withycombe, L., & Redman, C. L. (2011). Key competencies in sustainability: a reference framework for academic program development. *Sustainability Science*, *6*(2), 203–218. https://doi.org/10.1007/s11625-011-0132-6

Appendix 1: Scenario Instructions

Distribute the simulation place cards and value chips to the appropriate people/groups. In the scenario instructions, notations such as "**+3W**" should be read as "three white chips were paid". The letter **B** indicates blue social chips, and **R** represents red ecology chips.

To begin each scenario:

- the mining company (MC) starts with 30 W chips and 35 B chips
- the miners and other citizens start with 15 R chips each
- the government starts with no chips
- the remaining chips start with their respective banks

Scenario #1: Thoughtful Scenario

Step 1: Mining company (MC) sets up shop.

The MC invests in this operation and starts the process.

- Pays +3W and +3B to miners
- Pays +10W and +15B to the government (for permitting, promotional work, etc.)
- Pays +15W to bank (for initial capital investment)

The Social Bank

- Pays +2B to miners
- Pays +2B to other citizens for development of indirect and induced jobs in the area to support the mining operation

The Ecology Bank

- Pays +5R to MC for initial mine set up

The Economic Bank

- Pays other citizens +1W for indirect and induced jobs

Confirm that everyone has the chips they are supposed to, and understands what the next steps are.

Step 2: Mining begins

Mining starts with a fully modern mining operation and legal protections in place.

The MC:

- Pays +3W and +2B to miners
- Pays +1W and +1B to government
- Takes -5R from Ecology Bank

The Social Bank

- Pays +2B to miners

ISSN: 2151-7452

- Pays +2B to other citizens

The Ecology Bank

- Takes -1R from miners
- Takes -1R from other citizens

The Economic Bank

- Pays +15W to MC for mining products
- Pays other citizens +1W for indirect and induced jobs

Steps 3-7: Mining continues

Mining continues with a fully modern mining operation and locally legal protections in place. All payments should be the same as above for Step 2

Step 8: Assess your group's condition.

The MC:

- Do you have more money than you started with? Success!

The government:

- Do you have more money, social status and support from your constituency than before? Success!

The miners:

- Do you have more money, a higher social standing and a healthier environment than before? If the ecological capital in your area has dropped below 11 chips you cannot continue to live in your area and action MUST be taken.

The other citizens:

- Do you have more money, a higher social standing and a healthier environment than before? If the ecological capital in your area has dropped below 11 chips you cannot continue to live in your area and action MUST be taken.

Step 9: Action!

Discuss these possible actions and what the consequences may be.

The miners:

- If you are unhappy with your position, what can you do to make your situation better?
    - Attempt #1 - Money can be spent on ecological restoration. Five W chips can be spent to build back two R ecology chips. The W chips can come from citizens, the government or the MC.
    - Attempt #2 - Petition the MC - if they agree with you they will make the changes you request

    - Attempt #3 - Petition your government - if they agree with you they will control the MC.
    - Attempt #4 - Revolution

The other citizens:

- If you are unhappy with your position, what can you do to make your situation better?
    - Attempt #1 - Money can be spent on ecological restoration. Five W chips can be spent to build back two R ecology chips. The W chips can come from citizens, the government or the MC.
    - Attempt #2 - Petition the MC - if they agree with you they will make the changes you request
    - Attempt #3 - Petition your government - if they agree with you they will control the MC.
    - Attempt #4 - Revolution

The MC:

- If you have more money than you started with, you will not change your practices, content that you have "followed the law". If necessary, you will ensure the government stays in place to enforce the status quo using your financial resources.

The government:

- Did the MC enrich you with both money and status, directly and indirectly?
    - Yes? Ignore the miners and other citizens
- Do the people persist in their demands?
    - Quietly ask the MC if they will ensure you stay in power if you "enforce" the status quo
        - If the MC says "no" - bend to the will of the people
        - If the MC says "yes" - quell the rebellion with military and paramilitary forces

Throughout the simulation, the class should discuss each of these possible outcomes, why they arise, are they beneficial, what they mean for the people and groups involved, etc.

ISSN: 2151-7452

Scenario #2: Capitalist Scenario

Step 1: The Mining company (MC) sets up shop.

The MC invests in this operation and starts the process.

- Pays +3W and +3B to miners
- Pays +5W and +10B to the government (for permitting, promotional work, etc.)
- Pays +15W to bank (for initial capital investment)

The Social Bank

- Pays +2B to miners
- Pays +2B to other citizens for development of indirect and induced jobs in the area to support the mining operation

The Ecology Bank

- Pays +5R to MC for initial mine set up

The Economic Bank

- Pays other citizens +1W for indirect and induced jobs

Confirm that everyone has the chips they are supposed to, and understands what the next steps are.

Step 2: Mining begins

Mining starts with a fully modern mining operation and locally legal protections in place.

The MC:

- Pays +3W and +2B to miners
- Pays +1W and +1B to government
- Takes -5R from Ecology Bank

The Social Bank

- Pays +2B to miners
- Pays +2B to other citizens

The Ecology Bank

- Takes -1R from miners
- Takes -1R from other citizens

The Economic Bank

- Pays +15W to MC for mining products
- Pays other citizens +1W for indirect and induced jobs

Step 3, 4: Mining continues

Mining continues with a fully modern mining operation and locally legal protections in place.

Same as above for Step 2

Step 5: Mining continues, but …

Due to cost cutting motivation on the part of the MC, the modern mining operation is shifted towards "artisanal" mining practices and legal protections that were in place are ignored or grifted away.

The MC:

- Pays +1W and +1B to miners
- Pays +3W and +2B to government (The additional payments here represent dark money, bribes, etc., not put into official coffers with the original amounts)
- Takes -10R from Ecology Bank (additional value is taken from the ecology bank since governmental oversight has been restricted or removed, allowing for more ecological destruction)

The Social Bank

- Pays +1B to miners
- Pays +1B to other citizens

The Ecology Bank

- Takes -3R from miners
- Takes -3R from other citizens

The Economic Bank

- Pays +25W to MC (this is +10W than before because the MC is able to circumvent the legal and social norms from the previous step and increase production)
- Pays other citizens +1R for indirect and induced jobs

Step 6, 7: Mining continues

Mining continues with the same conditions as above for Step 5.

Step 8: Assess your group's condition.

The MC:

- Do you have more money than you started with? Success!

The government:

- Do you have more money, social status and support from your constituency than before? Success!

The miners:

- Do you have more money, a higher social standing and a healthier environment than before? Success!
- If the ecological capital in your area has dropped below 11 chips you cannot continue to live in your area and action MUST be taken.

ISSN: 2151-7452

The other citizens:

- Do you have more money, a higher social standing and a healthier environment than before? Success!
- If the ecological capital in your area has dropped below 11 chips you cannot continue to live in your area and action MUST be taken.

Step 9: Action!

Discuss these possible actions and what the consequences may be.

The miners:

- If you are unhappy with your position, what can you do to make your situation better?
    - Attempt #1 - Petition the MC - if they agree with you they will make the changes you request
    - Attempt #2 - Petition your government - if they agree with you they will control the MC.
    - Attempt #3 - Revolution

The other citizens:

- If you are unhappy with your position, what can you do to make your situation better?
    - Attempt #1 - Petition the MC - if they agree with you they will make the changes you request
    - Attempt #2 - Petition your government - if they agree with you they will control the MC.
    - Attempt #3 - Revolution

The MC:

- If you have more money than you started with you will not change your practices
- You will work to ensure the current government stays in power through your continued illicit financial support if asked.

The government:

- Did the MC enrich you with both money and status, directly and indirectly?
    - Yes? Ignore the miners and other citizens from Attempt #2 above.
- Do the people persist in their demands?
    - Are the people above in active revolt against the MC? Yes? See below.
    - Quietly ask the MC if they will ensure you stay in power if you "enforce" the status quo
        - If the MC says "no" - bend to the will of the people and enforce the laws initially agreed upon.

- If the MC says “yes” - quell the rebellion with military and paramilitary forces

The class should discuss each of these possible outcomes, why they arise, are they beneficial, what they mean for the people and groups involved, etc.

ISSN: 2151-7452

Scenario #3: Sustainability Scenario

The various stakeholders will collaborate and come to a solution to ensure the development of the mineral resource while maintaining ecological and social sustainability within the system. Reflect on the previous scenarios and build a robust, sustainable model based on previous experiences. It may be helpful for each stakeholder group to reflect on their positionality within the simulation. Working to understand the motivation of each group is important, especially if participants do not hold the same worldview as a particular stakeholder group. This mental work will help build learner confidence by interacting with each of the sustainability competencies.

Bringing outside ideas or ideologies to the conversation can build rapport and buy-in from other groups. For example, if representing the other citizens' stakeholder group, one could bring the idea of "doughnut economics" to the conversation and discuss how viewing the whole economic system through the typical lens of linear consumption is unsustainable and harmful to their group, while other groups benefit. Additional discussion about how to scale doughnut economics to local levels could be useful in generating buy-in from other stakeholder groups (Turner & Wills, 2022). Offering different perspectives and answers will likely aid the overall group in finding sustainable solutions.

Checking within and between each group as conversations progress to highlight the relevant sustainability competencies and SDGs may help to synthesize solutions with sustainable outcomes. For example, if a possible solution is presented, ensure that each group is checking that the solution is not counter to relevant SDGs, and understand how the solution fits within the competency framework. Is it a systems-level fix? Make sure the tenets of the SDGs are maintained and it is understood and explained to the whole group how systems thinking is relevant and promoted by the solution.

Assume all of the "costs" will remain the same as in previous scenarios; however, negotiate where appropriate. Example: The Economic Bank will only provide the "market" price for the minerals so that is not a negotiable point (15W per step for a managed system, 25W for unmanaged). Likewise, the cost of ecological restoration is the same ratio of 5W:2R. Negotiable points, for example, could be where the stakeholders collaborate and develop an agreement in which the mining company pays a share of their profits for ecological restoration to prevent ecological collapse. Mid-course corrections or modifications are also possible during this scenario; as in real-life, if things are not working and need to be re-evaluated or changed after a round or two, be empowered to do so!

Appendix 2: Simulation Place Cards

Each Bank (Social, Economic and Ecology) and Stakeholder (Mining Company, Government, Miners, Other Citizens) place card should be printed off on individual sheets of paper and distributed to the students representing each group.

ISSN: 2151-7452

Social Bank

START

5 value chips 1 value chips

Step:

1		**2**

3		**4**

5		**6**

7		**8**

Economic Bank

START

10 value chips 1 value chips

Step:

1	**2**
3	**4**
5	**6**
7	**8**

ISSN: 2151-7452

Ecology Bank

START

5 value chips 1 value chips

Step:

1	**2**
3	**4**
5	**6**
7	**8**

Mining Company

START

The Mining Company starts with:

30 Money chips 35 Social chips

Step:

1	**2**
3	**4**
5	**6**
7	**8**

Government

START

The government starts with no chips.

Step:

1		**2**
3		**4**
5		**6**
7		**8**

Miners

START

The miners start with: 15 Ecology chips

Step:

1		**2**

3		**4**

5		**6**

7		**8**

ISSN: 2151-7452

Other Citizens

START

The Other Citizens start with: 15 Ecology chips

Step:

1		**2**
3		**4**
5		**6**
7		**8**

Appendix 3: Assessment Resources

Assessment:

Assessing student learning of sustainability competencies during this simulation activity can be accomplished using the provided grading rubric for the simulation and self-reflection questions.

Overall Quality of Sustainability Interactions	**Exceeds Proficiency**	**Proficient**	**Somewhat Proficient**	**Not Proficient**
Sustainability Competency	4 points	3 points	2 points	1 point
Systems thinking	Demonstrates superior understanding of, and ability to analyze complex systems across different domains and scales.	Demonstrates the ability to analyze complex systems across different domains and scales.	Demonstrates some ability to analyze complex systems across different domains and scales, but needs work to build analytical skills and mental flexibility.	Demonstrates poor understanding of complex systems. Reliance on focus on single/few issues to formulate strategies.
Futures thinking competency	Demonstrates superior ability to craft rich "pictures" of the future to inform sustainability actions during the simulation. Utilization of imagination and critical thinking skills to develop logical predictive models of future outcomes in the simulation, based on possible actions and past experiences.	Demonstrates ability to craft rich "pictures" of the future to inform sustainability actions during the simulation.	Demonstrates some ability to craft "pictures" of the future to inform sustainability actions but needs to develop imaginative, critical thinking and predictive skills to better predict possible outcomes.	Demonstrates poor ability to craft rich "pictures" of the future to inform sustainability actions. Demonstrates a lack of ability to meaningfully plan ahead.
Values thinking competency	Demonstrates superior ability to understand and negotiate sustainability values, principles, and goals. Shows empathy and understanding throughout the simulation, especially to stakeholders with different viewpoints.	Demonstrates ability to understand and negotiate sustainability values, principles, and goals.	Demonstrates some ability to understand and negotiate sustainability values, principles, and goals. Must develop open mindedness to see and respect different perspectives that may be contrary to personal beliefs.	Demonstrates poor ability to understand and negotiate sustainability values, principles, and goals Demonstrates an unwillingness to understand new perspectives.
Strategic thinking competency	Demonstrates superior ability to design and implement transformative strategies towards sustainability outcomes. Ability to creatively plan strategies for sustainability.	Demonstrates ability to design and implement strategies towards sustainability outcomes.	Demonstrates some ability to design and implement strategies towards sustainability outcomes.	Demonstrates poor ability to design and implement strategies towards sustainability outcomes. Generally lacking strategic planning skills.

ISSN: 2151-7452

Interpersonal competency	Demonstrates superior ability to motivate and facilitate collaborative sustainability problem solving. Exceptional empathy, interpersonal understanding, collaboration, and communication skills.	Demonstrates ability to motivate and facilitate collaborative sustainability problem solving.	Demonstrates some ability to motivate and facilitate collaborative sustainability problem solving. Needs to work on interpersonal skills to enhance learning outcomes.	Demonstrates poor ability to motivate and facilitate collaborative sustainability problem solving. Unwilling to effectively collaborate in problem solving.
Integrated problem-solving competency	Demonstrates superior ability to combine and integrate sustainability problem-solving processes, utilizing varied and relevant ways of knowing.	Demonstrates ability to combine and integrate sustainability problem-solving processes.	Demonstrates some ability to combine and integrate sustainability problem-solving processes. Needs to develop additional integrative problem solving skills.	Demonstrates poor ability to combine and integrate sustainability problem-solving processes.
Intrapersonal competency	Demonstrates superior ability to reflect and express internal emotions and motivations. Ability to express how internal mindset influenced the simulation and interaction with others.	Demonstrates ability to reflect and express internal emotions and motivations.	Demonstrates some ability to reflect and express internal emotions and motivations. Needs to develop additional self-awareness and expression skills.	Demonstrates poor ability to reflect and express internal emotions and motivations.
Implementation competency	Not assessed	*Note This competency is beyond the scope of this activity.		

The intrapersonal sustainability competency can be assessed with the self-reflection activity.

Simulation Student Self Reflection

Understanding one's own positionality and values is an important component of learning for sustainability related issues. The intrapersonal competency links to the other competencies much the same as the interpersonal competency and provides the values, mindset and inspiration leading to application of sustainability competencies (Brundiers, et al. (2021).

For the following questions please provide full and thoughtful answers.

Reflect on your own experiences during this simulation. What emotions did this simulation excite in you? Why?

Prior to this simulation, what opinions/ values did you possess about sustainability? Were you able to express these values and opinions during the simulation? Why or why not?

- If you were in a position to act as a stakeholder that may be motivated differently than you, personally, reflect on how that made you feel. Did it expand your learning, or did you find it stifling to your creativity?

- If you were in a position to act as a stakeholder that shared your personal motivations, reflect on how that made you feel. Did it expand your learning, or did you find it stifling to your creativity?

How did you feel about other stakeholders during this simulation? Were you able to be self-aware and able to self-regulate your emotions and feelings towards others during the simulation? Describe

Project this situation into your own life. Who or what organizations in your life might be represented by the "Mining Company"? Where do you think you "fit" in your situation? Where would you want to be?

What other thoughts, emotions, and lessons did you experience during this simulation?

ISSN: 2151-7452

Author Thumbnail Photos and icon image for article:

Author thumbnail - actual photograph

The author on-site assessing acid-mine drainage in Central Appalachia, circa 2006

Vol. 32 March 2026
ISSN: 2151-7452