

Sustainability is the Name of the Game!

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Keywords

Sustainability, climate change, pollution, solution, gamification, game-based theory, engagement, motivation, elementary, digital native

Abstract

In a world of escalating weather and climate related catastrophes, sustainable solutions are our best hope of staving off the effects of decades of mistreatment, misuse, and abuse of natural resources and harmful practices that have created a problem for the continued existence of the human race. Doom and gloom do not solve the problems; therefore, the need for solutions and for those with power to do something about our climate crisis has never been more urgent. Children of today will be the adults of tomorrow facing the worst of these increasingly unhealthy and unsafe realities. Through gamification, as a means to increase engagement and motivation with the subject matter, students will be challenged with the task of learning about, creating, and disseminating information about sustainable solutions to climate change. Using creativity, fun, and meaningful challenges, students will become a part of the change that needs to occur to make the world a livable place beyond the models and projections.

Unit Content

Content Objectives

In 1998, James Roger Fleming wrote, “Apprehensions have been multiplying rapidly that we are approaching a crisis in our relationship with nature, one that could have potentially catastrophic results for the sustainability of civilization and even the habitability of the planet” (p. 3). How could such a claim be made so long ago and yet we still find ourselves on the cusp of climate catastrophe? Travel back in time farther and note that Senator Gaylord Nelson’s creation of Earth Day in 1970, in response to a lack of regulation of toxins spewing into our air and waterways and our destruction of forests, had to force the formation of the U.S. Environmental Protection Agency (EPA). All this is to say, the climate problems facing us today were recognized and seen as urgent, but in some places, for some people, substantial change did not occur. Still, without the formation of the EPA, we can only imagine how bad it would be today.

The EPA’s *Milestones in EPA and Environmental History* webpage (2023) spotlights major events in history that either led to or came from its creation. In 1969, the Cuyahoga River in Ohio was so polluted, it caught on fire. Think about it, a river, made of water, was on fire! This event gave national exposure to a problem that many people didn’t realize was a problem. A known carcinogenic pesticide, a chemical put on the food we would eventually eat, called DDT was in wide use and had to be legally banned to get its use stopped in 1972. Until the Clean Air Act of 1970 and the invention of the catalytic converter in 1973, car exhaust filled the air with lead, sulfur dioxide and other harmful pollutants. Lead-based paint was used on toys and cribs until 1971’s Lead-Based Paint Poisoning Prevention Act-- two years later, it was banned in

gasoline. In October of 1972, the Marine Protection, Research, and Sanctuaries Act, or Ocean Dumping Act, was passed in Congress to stop ocean pollution. And in 1974, the EPA was allowed to regulate public water via the Safe Drinking Water Act. These milestones only represent the first 4 years of the EPA's administration, yet one can only imagine, in a panic and fury, what the world would be like without them. From the food we ate, to the air we breathed and the water we drank to the toys we gave our babies to play with, we were under attack from deadly and harmful chemicals and pollutants. Longitudinal impact research and regulation was, and in some sectors is still, needed to keep corporations from continuing practices without accountability for their outcomes.

Today, the average US citizen takes regulation for granted. In other words, most people think they are safe. It is not until a major incident that we think we are still under attack, and even then, blame is placed, a "clean up" is done, and we go back to our daily hustle and bustle. Unfortunately, Flint, Michigan's fight for potable water still continues in 2023 as a reminder that all is not well under the sun, especially in communities of color and low-income who are disproportionately affected by environmental injustice.

The human race isn't in a position to reverse all the environmental damage caused by industries over the decades. What we are in a position to do is think about ways to not make things worse, whether through mitigation, adaptation or sustainable practices. By definition, sustainability is "avoidance of the depletion of natural resources in order to maintain an ecological balance" (Oxford Language, retrieved 2023). Therefore, helping reduce climate change is what sustainability addresses: processes that stop or regress damage to the planet.

Does this global crisis hit close to home? Students living in an urban environment, like Philadelphia, may be able to relate to many of the issues that climate change has caused without even realizing it. Their teachers too. Several topics can be seen firsthand depending on the neighborhood and time of year. Urban Heat Islands (UHI) are areas where, due in part to a lack of greenspace, the use of heat producing machines to cool spaces and 30% of the ground covered in asphalt and concrete (Maguire, 2021), exists particularly in North Philadelphia and can result in heat stroke and death. "Your future risk of dying from heat will be determined more than anything else by where you live and the local consequences of today's economic inequality" (Roston, et al., 2020). Air pollution spewing from highways and factories or refineries has caused cancer for nearby residents in South Philadelphia. In an article entitled, *Pollution Is Killing Black Americans. This Community Fought Back*, Villarosa (2020) writes that "African-Americans are 75 percent more likely than others to live near facilities that produce hazardous waste".

Large-scale solutions with the biggest impacts to the above problems are not something the average community member can accomplish, but citizens of the planet can and should still seek to live more sustainably. Above all, collectively pushing for actions to be taken against corporate polluters and municipalities conducting urban planning without the care for the most vulnerable is priority number one. This curriculum unit looks to encourage students to become aware of the issues facing their communities, as well as coming up with solutions to make their future livable.

In Philadelphia, kids can see in their own neighborhoods the damaging effects of pollutants, poor planning, and companies that turn a blind eye to the damage they cause in the name of profits. It can seem futile to think that using metal straws, taking 2-minute showers, and never buying TastyKake again because they contain palm oil could ever possibly be enough to reverse climate change on their own. Becoming stewards of the planet is a tall order for kids, but the urgency for sustainable choices outweighs the complicated relationship the individual has with causing and fixing climate change. Sustainable living therefore is a collective, collaborative, conscientious way of living. Further complicating the call for sustainable actions in this city is the urgency of issues apart from climate change that surpass the immediate worry and need for change or better ways of living due to their more personal need for resolution- violence, racism, hunger, and other disparities. Rosan, et al. (2021) refer to these vulnerable Black and Brown communities as living in the “struggle space”, where day to day survival is more urgent than the climate crisis. Teachers must simultaneously arm kids to face the tragedies of today while equipping them to attack the problems of the world that they will face tomorrow. These are problems they didn't create and lack of power to correct for at their age and station. Without instruction and explanation, why not put trash in the sewers like everyone else, leave the water on while brushing your teeth to wash down the minty foam, or buy affordable, albeit unhealthy and unsustainable, snacks? We need to be aware of how our individual decisions impact the environment. But we also need to understand our own power and agency. As much as we wish kids didn't have to learn how to be community scientists while simultaneously being social justice warriors, this is where we are. Racism and classism have led to danger zones in the city.

While much of Philadelphia, a bustling urban hub for hundreds of years, has higher levels of harmful air, waste, and lead, among other toxins than the surrounding suburbs, these environmental hazards are concentrated in environmental justice zones. It doesn't even take a careful examination of the EPA's Environmental Justice (2023) maps to see that neighborhoods with people of color and poverty are also neighborhoods with the highest levels of pollution, hazardous waste, and poorest air quality which, coupled with violence and access to quality healthcare and food, leaves these same communities with the lowest life expectancy rates (Figure 1-2). These neighborhoods are indeed the “struggle spaces” (Rosan et al., 2021) in darkest red.

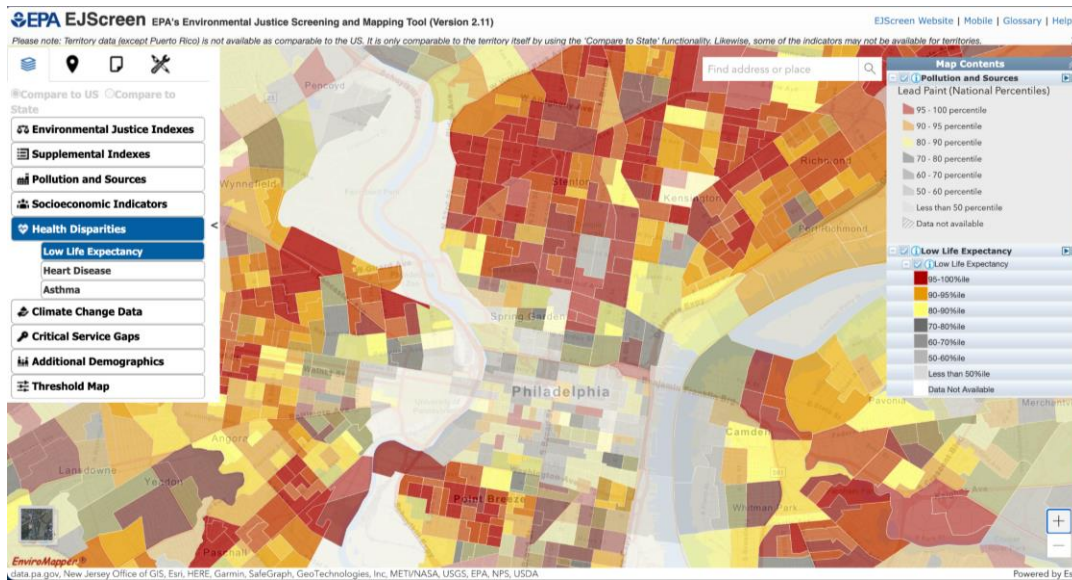


Figure 1: Concentration of People with Low Life Expectancy in Philadelphia

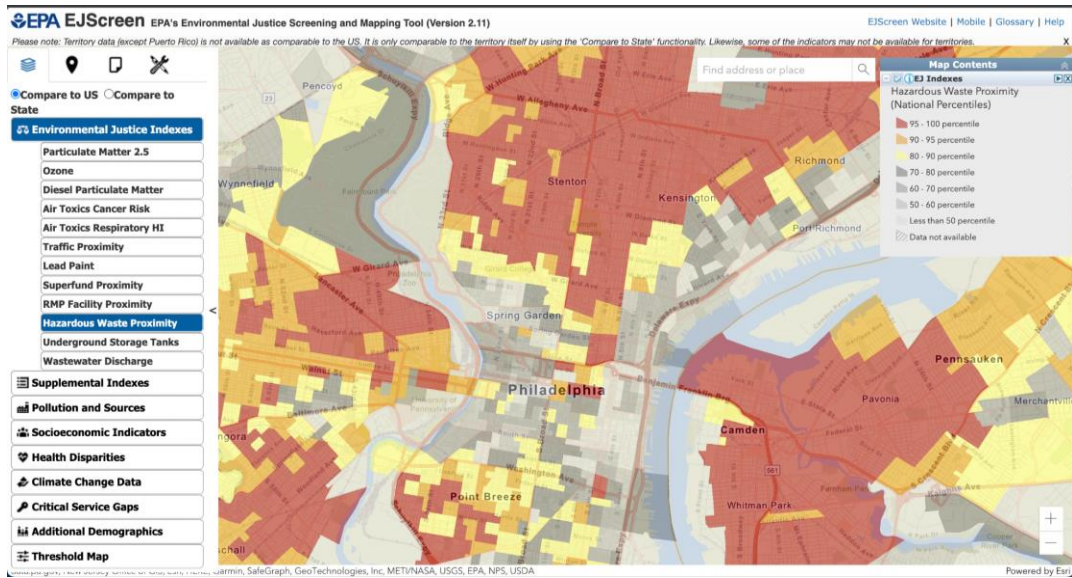


Figure 2: Concentration of Hazardous Waste Proximity in Philadelphia

In order to think sustainably on the community level, solutions need to move beyond planting trees and turning empty lots into gardens. Greening projects are often seen as solutions to sustainability issues, but in reality, have social, economic, and racial implications. As cities worldwide improve landscapes in neglected neighborhoods, these areas become more desirable and property values go up, thus residents of these newly renovated green spaces, who are poor, working class, and/or minorities are often pushed out as green gentrification begins and the disparity gap widens. (Anguelovski, 2022) It is clear that public planning that only improves the landscape is not enough. Policy changes that address sustainability need to also address environmental justice concerns, while including those affected in the conversation as priority

stakeholders. Wheeler and Rosan, (2021) address urban sustainability and propose solutions spanning from personal accountability to municipal and federal action (Table 1).

Combating Climate Change and Environmental Justice with Sustainable Solutions			
Make walkable communities	Create green streets & spaces	Build more affordable housing	Make clean electric vehicles available to all
Eat plant-based diets	Give rather than take	Protect vulnerable residents in gentrifying neighborhoods	Develop regulation and incentives to reduce consumption
Restore ecosystems	Limit air travel		

Table 1: Sample of Sustainable Solutions to Environmental Justice issues proposed by Wheeler and Rosan (2021)

So how do we turn students into environmental agents of change? Climate change is no laughing matter, but I'm pretty sure it would make a great game! I teach kids in 3rd-5th grade and no matter how enthusiastic the student, they will almost always rather play a game than write a report or take a quiz. Popular websites for turning studying and quizzing into a game are Kahoot, Quizziz, Gimkit, and Blooket. (Table 2) Gamification is applying the principles of game design to non-games in order to teach, and educators are taking a hint from the business world. Gamification has become popular as a way for businesses to do onboard training, professional development, and many fields use it for new equipment/rules/ procedures training. The thinking was that there needed to be new ways to do teaching and training to keep participants engaged and motivated.

Kahoot.com	Quizziz.com	Gimkit.com	Blooket.com
Kahoot presents a game show style with multiple choice questions, often on image format, and students race to answer correctly.	Quizziz presents multiple choice questions while offering players different power ups along the way.	Gimkit is a learning game designed to allow players to answer as many questions in a row that they want in order to gain energy points for arcade style gameplay.	Blooket allows players to choose a character and play different mini games in between each multiple-choice question.

Table 2: Free Educational Gamification Sites for Teachers

The whole idea is to appeal to a person's competitiveness, motivation through challenge, and goals achieving nature. Using gamification or game-based learning in the classroom has been explored, conducted, researched, and reported on. When done right, it works wonders.

Kids still like getting gold stars; however, when turning learning into games, they can be called badges. Students like game-based learning in literacy that includes badge earning (Kingsley & Grabner-Hagen, 2015). Gamification and game design principles applied to classroom lessons increase student motivation and achievement due to extrinsic motivators like XP and intrinsic motivators like leveling up to harder challenges and students being able to choose the direction of play (Oxarart et al., 2014). In a literature review of dozens of studies about types of motivation and gamification (and although further research is suggested due to a range of research that does not all conclude the same things) Alsawaier states, "Gamification provides the component of fun that helps in transforming the students' attitudes toward learning" (2017, p. 64). The review notes that two critical aspects are how teachers' game and whether students want to game. Still, the choice to continue to gamify is encouraged.

In 2001, Marc Prensky coined the terms "digital native" and "digital immigrant". Digital natives grew up in the digital age and have been using technology their whole lives. Digital immigrants, as the term suggests, have learned to use tech, but it does not come as easy to use for them as they started using it way later in their lives than natives. Our students are digital natives. And it shows. Social media, YouTube, the billion-dollar video game industry, and TikTok are clear examples of digital natives living their best lives. Educators should take heed to this knowledge and step up their game!

Considering that students learn best when they are highly engaged and connected to what they are learning, this curriculum unit allows students to consider multiple avenues for change as they weigh the pros and cons of choices that affect them locally, along with the people around them, by using game design as a vehicle for learning about and disseminating prevention of and solutions for climate change. This curriculum unit also serves to be a blueprint for one-way teachers can motivate and engage their students in a time when the things that catch their attention are usually under 30 seconds, in colorful 4K HD, and loud with a catchy tune. Allowing students, the opportunity to design their own game will help create a sense of ownership over their learning, which also increases engagement and motivation, as well as makes the learning experience long lasting.

Good game design for both teachers and students takes a lot of time and effort. This curriculum unit offers a shortcut. The many strategies for game design and templates for games can be tailored across curricular subjects, although for this unit sustainability and environmental justice will be the focal points. The progressive steps needed to build an understanding of sustainability and for students to create a game can be modified for different ages-- a few modifications are included.

Prior to gameplay and design, students will need a crash course in sustainability. Or better yet, a full unit on climate change and roads to sustainability. Best yet, a lifestyle change. Since it is not

a unit in most elementary science curriculum right now, these lessons seek to be additions to what is already being taught.

Teaching Sustainability

There are many facets of sustainability. My new favorite website, the EPA (2023), defines it as:

Sustainability is based on a simple principle: Everything that we need for our survival and well-being depends, either directly or indirectly, on our natural environment. To pursue sustainability is to create and maintain the conditions under which humans and nature can exist in productive harmony to support present and future generations.

However, morphing this definition into a teachable concept that can be lived on a daily basis gets more complicated than just reading the definition to students. The real questions then are: What does sustainability look like? What is a sustainable city? What is a sustainable neighborhood?

Posing these questions are the first step in getting students to really think about sustainability and how to live a sustainable life. Many young people already know a lot about sustainability. In *Kids are the Next Big Opportunity in Resale*, author Roshitsh (2021) explains how the resale market of used merchandise among people 18-24 on Mercari's retail website shows that young folks know the value of buying secondhand for economic and environmental reasons. Opportunities to save landfills from textiles market themselves on social media apps like Instagram. This is all to say that Greta Thunberg is not the only young person aware of the environmental problems created for this upcoming generation and poised to do some things about them.

Still, what else does sustainability look like? Most kids have grown up at this point reusing water bottles and legislation regarding plastic bags- eight states have completely banned single use plastic bags, while 20 more (not including cities that have legislation on the books apart from their states) have some sort of legislation to address the issue (NCLS, 20223). Additionally, there have been headlines that kids may be familiar with that create a feeling of action: turtles and not using straws, orangutans and giving up palm oil, and polar bears and doing just about anything to reduce your carbon footprint. However, most of these solutions, done individually, aren't enough to change the detrimental effects of decades of environmental abuse. If you are reducing your carbon footprint, get others to join you and work to change the system. Aside from taking actions to protest, either through letter writing campaigns or promoting awareness of climate crisis offenders and their negative habits and practices, students need to start to think of solutions that change our present way of life in ways that can make a significant impact. Spreading awareness, taking collective action, and calling for change across neighborhoods, municipalities, and countries are the basic first steps everyone should take.

A focus that may benefit our students most is to expose them to large-scale efforts made by governments and corporations and encourage them to imagine a future that creates sweeping changes as well. The agents of change we need are ones that are willing to think grand and demand as much. Students need to learn about how biophilia, the love of nature, can be applied to lifestyles and city planning, like the city-state of Singapore, aka the City in a Garden. Their

[airport](#), [bay](#), and [Khoo Teck Puat hospital](#) are wonderful examples of biophilic planning and development. Students also need to learn about alternatives to conventional ways of doing things, like the green ski slope rooftop of a [waste management plant](#) in Denmark. These innovative and expansive solutions are the type needed to really impact our human/ nature relationship in order to bring about true sustainability.

Smaller, crash course, close to home, community based solutions can be found on local municipalities’ websites (Table 3). Students can look for ways to raise awareness and increase participation in programs that seek climate friendly solutions. Through looking at cities leading the charge for change, our students can begin to see a future that they can live in that is healthy, equitable, and of their making.

Philadelphia, Pennsylvania	San Francisco, California	Vancouver, Canada
Office of Sustainability Homepage City of Philadelphia	Sustainable Neighborhood Program SF Planning	Climate Emergency Action Plan City of Vancouver
<p>The Environmental Justice team advances environmental justice</p> <p>The Climate Solutions team advances Philadelphia’s citywide equitable clean energy transition</p> <p>The Municipal Energy Office reduces the City’s carbon footprint</p> <p>The Office of Climate Resilience communicates climate risk and develops programs, policies, and place-based strategies that reduce risk, protect residents, address historic injustice, and improve quality of life.</p>	<p>Healthy Air (zero emissions, non-toxic, comfortable)</p> <p>Renewable Energy (carbon-free, efficient, smart)</p> <p>Robust Ecosystems (green, biodiverse, healthy)</p> <p>Clean Water (high-quality, regenerative, flood-safe)</p> <p>Zero Waste (responsible, reduced, recovered)</p>	<p>Changing the way we plan</p> <p>Changing the way we move</p> <p>Changing the way we build</p> <p>Investing in natural climate solutions</p> <p>Prioritizing climate justice</p> <p>Supporting climate leaders</p>

Table 3: City based initiatives/ commitments to combat climate change

Game Design Elements

There are many game design principles or components that can be incorporated into games. Laine and Lindberg's (2014) literature review of over "56 previously identified game motivators" suggest 14 areas of design principles to keep in mind when designing games for education. Within each area there are over 54 design principles combined that could or should be included in an educational game. They conclude that if these design principles are combined in any manner of ways, games can be effective.

In order to create a framework that can span grade levels and curriculum subjects, four main principles will be employed in the game created for this unit, BiophilaFutura: badges, XP, and avatars (Table 4). Cooperative play is also essential, but students will experience this design element during gameplay. In BiophilaFutura, players must traverse the land solving climate issues, thus becoming eco-heroes. As each player presents their solution to a problem, the other players evaluate the solution and award xp based on how they rate the proposed plan of action. Players earn badges once they solve all 3 problems in each region. Players will create backstories for their avatars and can level up their solutions if they incorporate their characters' elemental power into the climate solution.

Design Element	Significance	Example:
		Pollution Solutions Game
Badges	Badges are earned as players work their way through the game. Each badge stands for a lesson or idea learned. Badges should be the goal of each mission.	Litter Mission: Once a player picks up 100 pieces of litter, they earn the Litter Bug Terminator Badge.
XP (experience points)	XP are points gained through learning how to play and play well. Survival and avoiding obstacles gains XP points, while failing a mission loses XP. XP should be able to be earned throughout gameplay.	Player earns 200 XP if litter is collected in one bag, 100 XP if it takes more than one bag. ("trash" are Tetris-like pieces). Finding hidden trash is 50 XP each.
Avatars	Creating backstories for avatars has been linked to therapeutic results for players and can create ownership. Players get to use their imagination in creating characters' strengths and weaknesses and link it to real	Carin is a kid who grew up wishing the neighborhood was cleaner and then found out that pollution x-ray vision was a super power!

	world scenarios where those strengths and weaknesses would be applicable.	
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Table 4: Game elements of BiophiliaFutura

If having kids create their own game is your preference, the resources here can help as well. Students can create different games where the goal is to learn how to live the most sustainably. They will have to create rules, a board for play, player pieces, rules, and actions that give points or advantages to progress players.

The game presented here for students to play allows teachers to have students play a game where the objective is to “save” the fictional realm of BiophiliaFutura by utilizing their knowledge of sustainable solutions to 5 climate issues: air pollution in Soot City, water pollution in Water Way, land/ soil pollution in Pollution Park, the urban heat island effect on Heat Island and drought in Drought Dungeon. For each location, there are troubling climate problems on a spinnable wheel and students will have to spin and come up with a solution to the problem they spun while other players give points for the solution based on its efficacy in addressing the problem. Each player will create a backstory for their avatar in the hopes that their creativity will give their character an advantage in becoming a climate hero, even choosing an elemental power to boost their solution points gain.

Teaching Strategies

The overall teaching strategy utilized in this unit is gamification. While the BiophiliaFutura game is presented as a teaching strategy, tweaking it to meet educator needs is also part of the fun of using games to teach. The following are lessons leading up to playing the game included or for making their own game.

Strategies for Teaching About Climate Change	
Essential Question: What is climate change?	
Recognize/ Define	Recognize and define the meaning of climate change.
Identify	Identify the causes and effects of climate change.
Sort	Sort the causes and effects of climate change into categories.
Study/ Utilize	Study and utilize maps and timelines as they pertain to climate change.

Create	Create a list of causes that can be mitigated.
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Strategies for Teaching About Sustainability	
Essential Questions: What is sustainability? Why do we need to live sustainably?	
Recognize/ Define	Recognize and define the meaning of sustainability.
Identify/ Sort	Identify sustainable solutions to 3 climate change causes on each of the community, local, and global levels.
Evaluate	Evaluate climate change solutions from around the world.
Discuss/ Brainstorm	Discuss the solutions with the whole class in order to...
Create	Create a "bank" of causes and solutions.

Strategies for Teaching About Gamification	
Essential Questions: What is gamification? How can I create a game?	
Define	Define the meaning of gamification.
Identify	Identify important elements of gaming in order to motivate and engage players.
Examine/ Evaluate	Examine different known games and evaluate their usability to become a game about sustainability
Identify	Identify the game elements needed to create your own game.
Identify	Identify the causes and solutions of climate change for the game.

Develop/Plan	Develop and plan the look, rules, and gameplay.
Create	Create your game.
Present	Present your game as a commercial, YouTube style.

Classroom Activities

The classroom activities in this unit are designed to be short mini-lessons, as they are supplements to district mandated lessons. They can, however, be taught back-to-back to take up a full 45-minute teaching/ learning block. Although these lessons are seemingly science based, due to their use of logic and reasoning in game development, they can be added to math lessons or extended with writing activities and used in ELA. The Next Generation Science Standards listed are for 3rd-5th grade, however these lessons and the creation of a game in order to teach sustainability concepts can be used from 3rd grade upwards, with a wonderful outcome of more games utilizing more advanced and/or sophisticated gaming elements and technologies depending on the experience and imagination of the students creating them.

Lessons About Climate Change	
Essential Question: What is climate change?	
Standard(s)	<p>3-LS4-4. Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.</p> <p>4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment</p> <p>5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.</p>
Objective(s)	SWBAT recognize environmental changes IOT define climate change

Lesson 1	<p>Think, Pair, Share on a KWL: What is climate change?</p> <p>Students share their “Want to Know” questions.</p> <p>Class watches a video and adds info to KWL.</p> <p>All answers are recorded on chart paper/ Slide for later use.</p>
Lesson 2	<p>Chart paper/ Slide is used to activate prior knowledge.</p> <p>Question: What do you think are some causes of climate change?</p> <p>Class watches a video and takes notes of causes.</p> <p>Class creates an infographic or mind map of causes and effects, thus sorting and matching causes to effects.</p>
Lesson 3	<p>Teacher displays EPA milestones webpage. Students create a timeline of 5 events they think are crucial to the topic of climate change. Students must find one more recent/ current event to add to their timeline via web research.</p> <p>Teacher displays before and after pictures of locations drastically affected by climate change. Students map these locations.</p>
Lesson 4	<p>Notice and Wonder: EPA EJ Screens of Philadelphia.</p> <p>(Teacher guides students if they do not make the connection between race, class, and environmental problems.)</p>
Lesson 5	<p>Students create a way to record/ present causes of climate change: list, infographic, table, or other method of choice.</p>

Lessons About Sustainability	
Essential Questions: What is sustainability? Why do we need to live sustainably?	
Standard(s)	3-LS4-4. Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.

	<p>4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment</p> <p>5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth’s resources and environment.</p>
Objective(s)	SWABT define sustainability and identify mitigation efforts IOT think of ways to live a more sustainable life.
Lesson 1	<p>Flowchart causes, effects and mitigation practices for climate change, with students brainstorming the mitigation practices. (Worksheet 1)</p> <p>Students research additional practices/ solutions.</p> <p>Students then asked to use these solutions to define sustainability as an If/Then: “If solutions to climate change are ____, ____, and ____ and we call that living sustainability; then what do you think <i>sustainably</i> means?”</p>
Lesson 2	Identify, either by brainstorming or research, sustainable solutions to 3 climate change causes on each of the community, national, and global levels. (Worksheet 2)
Lesson 3	<p>Students learn about sustainable solutions for one problem as tackled by several sources and critique the solution, identifying the pros and cons of each, sharing their reasoning with the class. (Worksheet 3)</p> <p>Older student bump up: Atwoodian table or debate style critiques.</p>
Lesson 4	<p>Students create a “bank” of solutions to the climate crisis by pooling all their ideas and researched actions taken by individuals, communities, and so on.</p> <p>Older student bump up: Assign a 3, 2, 1 star based ranking system to indicate the efficacy of solutions to the same climate crisis issue, which in gameplay can help give different points to different solutions.</p>

Lessons On Gamification

Essential Questions: What is gamification? How can I create a game?

Standard(s)	<p>CCSS.ELA-LITERACY.RL.4.3: Describe in depth a character, setting, or event in a story or drama, drawing on specific details in the text (e.g., a character's thoughts, words, or actions).</p> <p>3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.</p>
Objective(s)	SWABT identify the essential elements of gaming and apply them to teaching sustainability IOT design and create a game about sustainability.
Lesson 1	<p>Think, Pair, Share: What is your favorite game and why? Students tasked to come up with one word to describe their whys (ie. challenging, fun, scary, action-packed) that are listed on the board. Think, Pair, Share: What is the favorite thing you learned so far this year in school and why? Whole class discussion: How could we combine your love of games and your love of [insert favorite learning topic]? Teacher explains that gamification is when you use the principles of gaming and apply them to non-games. Poll: Who thinks it would be interesting/ fun/ helpful to try and teach other kids about sustainability using a game?</p> <p>Technology link: Play Kahoot, Quizziz, Gimkit, and/or Blooket.</p>
Lesson 2	<p>Brainstorm more in depth the why's of a favorite game to tease out gaming techniques and principles. (Worksheet 4, based on Laine & Lindberg (2014))</p> <p>Technology link: Download and play Gamestar Mechanic.</p>
Lesson 3	<p>Homework: Students must play a game at home (video, board or card) and without telling the name of the game, explain the rules and how to win so that other students can guess it. (Worksheet 4) Discuss: Which of the games discussed could be turned into a game about sustainability and why?</p> <p>Older student bump up: Discuss the viability, pros and cons, of different game types: adventure vs trivia, RPG vs team, ranking/ rating responses vs point based.</p>
Lesson 4	Have students play Biophilia Futura (Slide Deck 1) and evaluate it as a game and as a tool for teaching sustainability. (Worksheet 4)

Lesson 5	<p>Students work in pairs or teams to create a game about sustainability. (Worksheet 5) Students must be provided with materials to create their game or have it be an at home project once they are designed it.</p> <p>Bonus: As a take-home project, family members will be exposed to sustainable choices and game design principles.</p>
Lesson 6	<p>Students make a commercial for their game that explains the rules, gameplay and purpose. This can be a written script, image based print style or video commercial.</p>

Appendix

Next Gen Science Standards

3-LS4-4. Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.

4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment

5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

Common Core Literacy Standard

CCSS.ELA-LITERACY.RL.4.3: Describe in depth a character, setting, or event in a story or drama, drawing on specific details in the text (e.g., a character's thoughts, words, or actions).

[Play BIOPHILIAFUTURA CLIMATE & SUSTAINABILITY GAME](#)

[Character Card BIOPHILIAFUTURA CLIMATE & SUSTAINABILITY GAME](#)

[Rules for BIOPHILIAFUTURA CLIMATE & SUSTAINABILITY GAME](#)

Lesson Worksheets

Annotated Bibliography

Alsawaier, R. S. (2018). *The effect of gamification on motivation and engagement*. The International Journal of Information and Learning Technology, 35(1), 56-79.

This article explores whether gaming increases motivation and engagement. While there is support that it does, the authors admit there is limited knowledge of what works best.

Anguelovski, I., Connolly, J. J., Cole, H., Garcia-Lamarca, M., Triguero-Mas, M., Baró, F., Martin, N., Conesa, D., Shokry, G., del Pulgar, C. P., Ramos, L. A., Matheney, A., Gallez, E., Oscilowicz, E., Mániz, J. L., Sarzo, B., Beltrán, M. A., & Minaya, J. M. (2022). Green gentrification in European and North American cities. *Nature Communications*, 13(1). <https://doi.org/10.1038/s41467-022-31572-1>

Brief state plastic bag legislation. National Conference of State Legislatures. (n.d.). <https://www.ncsl.org/environment-and-natural-resources/state-plastic-bag-legislation#:~:text=The%20law%20prevents%20retailers%20from,of%20Columbia%20have%20followed%20suit.>

This webpage describes plastic bag legislation nationwide.

Environmental Protection Agency. (n.d.). *Milestones in EPA and Environmental History*. EPA. <https://www.epa.gov/history/milestones-epa-and-environmental-history>

The EPA website has tons of information and historical articles about its inception and administration. This page chronicled events that made a major impact on environmental history.

Fleming, J. R. (1998). In *Historical perspectives on climate change*. introduction, Oxford University Press.

This introduction explains the need for a thoughtful and analytical examination of what has brought about climate change and contains a brief summary of each chapter. Note that it does not seem that the goal of the book is push an agenda, rather to see how climate change affects and has effected the planet and its inhabitants historically.

Kingsley, T. L., & Grabner-Hagen, M. M. (2015). *Gamification*. *Journal of Adolescent & Adult Literacy*, 59(1), 51–61.

This article showcases the use of gamification as a means to turn an existing curriculum into a game-based learning environment.

Laine, T. H., & Lindberg, R. S. (2020). Designing engaging games for Education: A systematic literature review on game motivators and design principles. *IEEE Transactions on Learning Technologies*, 13(4), 804–821. <https://doi.org/10.1109/tlt.2020.3018503>

This article is used as a response to the Alsawaier article and provides design principles for learning games. The authors did a lit review of 56 articles to come up with their findings.

McGuire, M. P. (2021, July 7). While we're considering removing highways, let's not overlook pavement. *Next City*. <https://nextcity.org/urbanist-news/while-were-considering-removing-highways-lets-not-overlook-pavement#:~:text=Even%20though%20cities%20only%20occupy,30%25%20of%20the%20ground%20surface.>

Oxarart, A., Weaver, J., Al-Bataineh, A., & Al Bataineh, M.,T. (2014). *GAME DESIGN PRINCIPLES AND MOTIVATION*. *International Journal of Arts & Sciences*, 7(2), 347-359.

Past research has shown that students are motivated by a sense of agency, achievement, and peer cooperation as seen in game design principles. In this study, students were exposed to game design principles in their regular classroom curriculum.

Roston, E., Murray, P., & Dottle, R. (2020, August 3). *As global temperatures rise, wealthy better able to prevent heat related illness, heat stroke*. *Bloomberg.com*. Retrieved April 30, 2023, from <https://www.bloomberg.com/graphics/2020-climate-heat-inequality/>

Wheeler, S. M., & Rosan, C. D. (2021). *Reimagining Sustainable Cities Strategies for designing Greener, healthier, more equitable communities*. University of California Press.

This book is a presentation of researched strategies that would change the world for the better in terms of equitable solutions to the climate crisis on the local level. It suggests involvement by community stakeholders, but puts the onus on the government to pass legislation.

Villarosa, L. (2020). *Pollution Is Killing Black Americans. This Community Fought Back* .: Feature. Retrieved April 30, 2023, from New York Times (Online), New York: New York Times Company. Jul 28, 2020.

This article does a profile on Black residents in South Philadelphia who live near an unhealthy oil refinery and how the practice of poor and minority residents being saddled with unhealthy living conditions is not new nor is it without environmental justice warriors.