Sustainable Design for a Bountiful Future

Activities for engaging teenagers in humanity's 21st century group project

Photographs: Ben Wheeler, Exploris West Middle School

By **Ben Wheeler**

You already know the bad news. The future of life as we know it on planet Earth is in peril due to a perfect storm that we have cooked up for ourselves. The convergence of growing world population and climate change is already upon us. The good news is that, unlike collapsed civilizations of the past, for the first time in the history of our species we are well aware of the scope of the challenges that civilization faces. We currently possess the knowledge and technology to set ourselves on a better trajectory. According to Lester Brown, author of *Plan B 4.0: Mobilizing to Save Civilization*, a positive outcome for humanity will require immediate progress toward these four goals: stabilizing world population at eight billion or lower, achieving an 80% reduction of carbon dioxide emissions by 2020, eradicating extreme poverty, and restoring the natural systems that we depend for our survival—especially topsoil, aquifers, grasslands, fisheries, and forests.[1]

What do these global perils—and the solutions that they cry out for—mean for classroom teachers? Our students will be neither motivated nor inspired with the prospects of doing nothing or just getting by. Providing basic literacy in the language and concepts of sustainability may be the single most important thing teachers can do to gain both perspective and focus amidst a storm of global problems. Education for sustainability (EfS) upholds the moral standard of caring for the needs of others and the future by attending to the triple bottom line of environmental health, social justice and economic opportunity.

If teachers can think of sustainability as humanity's group project for the 21st century what is important is to pick a starting place that fits your own teaching interests and course goals. Then, teach like the future depends on it.

Sustainable Design: Harnessing Nature's Genius for Humanity's Well-Being

In our industrial, agricultural and domestic systems, what if "waste" was really "food" for further production and consumption? What if the discard of a product in a landfill was considered a design flaw rather than a sad necessity? What if we design products and domestic, industrial and agricultural systems that are 100% effective *and* sustainable? This is the vision afforded by sustainable design, which is informed by the bounty and beauty of natural systems all around us. Sustainable design is one favorable direction for teachers interested in orienting their students towards the 21st century group project of global sustainability.

Sustainable design was one of the more fascinating and compelling units I've developed in 20 years as a secondary social studies educator. It can be taught in a variety of

classrooms (science, social studies, math, industrial design and art, for starters), or in an integrated fashion across subjects. I found the subject resting comfortably within social studies standards—with delightful forays into science and design. Sustainable design is an important component of the national movement for STEM Learning (science, technology, engineering and math), a network of educational programs designed for future generations that will enhance their competitiveness on the international stage. In *The Designer's Atlas of Sustainability* Ann Thorpe defines sustainable design as "Theories and practices for design that cultivate ecological, economic, and cultural conditions that will support human well-being indefinitely."[2] Thorpe's vision of design embraces sustainability's triple bottom line of environmental, economic, and social well-being, and also the moral imperative to allow future generations to be able to meet their needs.

Sustainable design is key to both short and long-term global sustainability. While we are transitioning to renewable energy sources, short-term reductions in carbon emissions will come from products and systems that are sustainably designed, from biodegradable cups, plates and utensils, LED lights and a vast array of products that are less resource intensive, to mass transit systems and green building technologies. All reduce carbon emissions. Sustainable design will still be vital over the long haul for decades and centuries to come as humanity crafts an existence that avoids catastrophic food and water shortages, and that wisely stewards natural resources.

Teaching Sustainable Design

What follows is a collection of lessons for the teacher interested in sustainability and sustainable design. My 8th grade students undertook these lessons (and many more) during a six week unit on sustainable design. The lessons may be pursued as a series or individually, and modified as suits the subject matter and teacher. Although designed with secondary students in mind, they can be adapted for younger students. I list them in a suggested sequence for the teacher who aims to do as much of this as possible. These lessons can also be successful for a faculty in-service training or teacher's workshop on sustainability or sustainable design.

The first two lessons are from Facing the Future and can be downloaded for free at www.facingthefuture.org. For the remaining lessons I am indebted to Ann Thorpe, author of *The Designer's Atlas of Sustainability*, whose website (www.designers-atlas.net/index.html) offers an open-source array of teaching ideas for sustainable design. Student handouts by the same name are paired with the brief activity descriptions below.

Is It Sustainable? (one hour)

Students define and discuss sustainability and its three key components: economy, environment, and society. I do a quick 5 minute modeling of the student activity with an apple. Is it organic? Fair trade? Local? Using a Venn diagram to organize their thinking around the three aspects of sustainability, students work in small groups or pairs to determine the sustainability of a product, individual activity or government service, and then they share out to the group by placing a sticky note in the appropriate section of the Venn diagram. The BIG IDEA: In addition to grasping the breadth of sustainability, students also come to realize that sustainability is "gray." It depends on many factors, and is more of a moving target than a fixed or final result.

Deep Space 3000 (one hour)

In small groups of three to five, with markers and poster paper students envision and create a sustainable environment through the design of a "closed-system" spaceship. The goal is to bring a healthy and happy future generation back to Earth in 3,000 years. Nothing may leave the ship and the only thing that comes in from outside the ship is solar energy. In their design and drawing students try to meet these human needs: food, water, air/oxygen, energy, waste disposal, governance, community rules, entertainment and other quality of life factors. Students share out their spaceship's features. The BIG IDEA comes with the final question, "What else is—like the spaceship—a closed system?" (Earth!) This lesson is a perfect precursor to sustainable design lessons because it begs the question," What principles can guide us as we design sustainable products and systems?" *Deep Space 3000* is a good follow-up to *Is It Sustainable?*

Biomimicry: Nature as Teacher (one hour)

For this lesson I borrowed free photos of nature-based design (laminated hard copy or digital projection) from the Biomimicry Institute and National Geographic. The task for groups of students is to have them match up the human effort with the real thing in nature (e.g. the Velcro fasteners on the NASA space suit with the cocklebur, the bathing suit with the shark skin, the water resistant paint with the lotus leaf). Over the course of 3.8 billion years, 10-30 million species evolved and are available to us today as a storehouse of nature's genius. This makes a compelling case for conservation biology and habitat preservation. Our species' preservation may depend on it.

A good biomimicry extension is to focus on hexagons in nature. Hexagons are particularly interesting in that they are an efficient way to pack or "tessellate" objects with a minimum of external perimeter. For example, in a bee honeycomb the hexagon template provides the maximum space using the least amount of material. Thus, bees can maximize the volume of stored honey while being economical on beeswax production. Hexagonal shapes are throughout nature, from tortoise shells to snowflakes and rock formations. How can hexagons inform architectural and industrial design? The BIG IDEA: With nature as our guide, the human built environment can be effective, productive, and sustainable.

Biomimicry Institute: www.biomimicryinstitute.org

Biomimetics: Design by Nature. ngm.nationalgeographic.com/2008/04/biomimetics/tom-mueller-text

Ecosphere Elements and Impacts and Invisible Materials (see handouts; one hour each)

In these lessons (adapted from Ann Thorpe) students choose a product to analyze or the teacher can choose and display a product made of multiple materials, such as a shoe or a baby toy. Students quickly discover that most products entail the extraction of resources from all the spheres, but especially the lithosphere (soil and minerals), and that products often

result in negative inputs into the lithosphere, hydrosphere (water), biosphere (plants and animals), and atmosphere (air). Regarding invisible materials, it is eye opening to begin to understand, for example, exactly what plastic is, where it comes from, where it is stored or discarded in landfills, and the ways in which it may escape to degrade environmental health. The BIG IDEA: Materials analysis at even this basic level is fascinating and central to the field of sustainable design, especially in the analysis of the "life cycle" of a product, from cradle to grave, or more ideally, from cradle to cradle. For more advanced students (high school and up) this can be pursued in more rigorous detail, especially if one gets into chemistry. These websites offer a good start:

http://toxtown.nlm.nih.gov/ (very user/student friendly)

http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB (searchable by substance)

www.dmoz.org/Science/Environment/Environmental_Health/Toxic_Substances/

Objects, Activities, and Happiness
(see handout; one hour)

Students choose two objects in their lives (personal and functional) and one activity, and then analyze each in terms of the nine aspects of quality of life and happiness that Ann Thorpe offers in *The Designer's Atlas of Sustainability*: Subsistence, Protection, Affection, Understanding, Participation, Leisure, Creation, Identity, and Freedom. Students also consider what redesigns of material goods or activities might make them more valuable in terms of quality of life and happiness. The BIG IDEA: Students are typically surprised at 1) the limited overall efficacy of most material goods in achieving lasting happiness, and conversely, 2) how their human relations are deeply sustaining.

Eco Baby (one hour)

This is a simplified version of one of Ann Thorpe's design challenges. The teacher and/or students bring in an array of baby products to display for group discussion of materials and life-cycle analysis. What energy, materials and labor bring the product into being? Because babies are particularly susceptible to pathways of exposure for environmental hazards (dermal, inhalation and ingestion) particular care should be granted to the design of infant products. What happens to the product when a family is finished with it? Students brainstorm together what types of baby products deserve attention (e.g. car seat, cup, clothes, bed, food), then break off in pairs or groups to redesign one product on a poster, and label it with a name and tag line (e.g. "Maybe baby deserves better…"). Considering materials used and pathways for their harmful escape, students present a poster on reducing infant exposure to toxins. The BIG IDEA: A good way to focus student learning about materials and life-cycle analysis, and then develop more sustainable designs, is to use as an entry point a particular type of consumer good—such as baby products—that is familiar and potent in terms of its potential health impacts.

Local and Slow
(see handout; one hour)

This lesson combines a couple of different ideas explored by Ann Thorpe. With the goals of 1) reducing ecological footprint by way of design that favors local materials and labor, and 2) increasing quality of life by way of design that slows down the often frantic pace of life, students work in pairs to design something that optimizes use of local materials and labor. It could be a simple product like a skateboard or a more complex system like a house. They draw and label their design on a poster for presentation to the class. The BIG IDEA: This activity places a premium on creativity and "thinking outside the box," rather than working out technical obstacles. It's perfect for grabbing kid's interests and engaging their imaginations.

Research and Write a 'Zine Article
(see handouts on Green Teacher website at www.greenteacher.com))

Exploring Sustainable Design is the title of a magazine produced by my students. Having completed all the above lessons on sustainable design, each student researches a topic of their own choice, completes a prospectus (proposal), conducts extensive Internet research, formulates an outline, and writes at least two drafts of their article, including MLA referencing and bibliography. A portion of the article critiques traditional design by addressing the cradle-to-grave life cycle, down-cycling (i.e. the processed material from recycling is of degraded quality and value), ecosphere extractions/inputs, and invisible materials. Their plan for a more sustainable design attends to bio-mimicry, nutrient separation, up-cycling, substance lists, human needs, and local/slow design.

Sustainable Design Poster and School Wide Festival (see 2 handouts at www.greenteacher.com)

In preparation for a school-wide Sustainable Design Festival where students present their work from across the entire curriculum (for example, see the Bowl Project handout), students prepare posters highlighting key elements of their Sustainable Design research articles, with an emphasis on effective graphic design to enhance or further the viewer's comprehension (e.g. graphs, sketches, flowcharts, materials lists, charts, blueprints). In presentations, students are expected to be "the expert." Local professionals from the green building professions attend and present to the student body on this important aspect of the green economy.

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Some of the handouts for the above activities were too large to include in this magazine. Some of those on the following pages have been shrunk for space reasons. The full versions of all the activities can be freely downloaded from www.greenteacher.com, by clicking "Check out the contents of our latest issue" (From 2011 on, click "Search back issues" and find GT#90.)

References

1. Lester R. Brown, *Plan B 4.0: Mobilizing to Save Civilization* (New York: W.W. Norton, 2009), 23-24.

2 Ann Thorpe, *The Designer's Atlas of Sustainability: Charting the Conceptual Landscape through Economy, Ecology, and Culture* (Washington, DC: Island Press, 2007), 13.

Resources

Biomimicry Institute, (www.biomimicryinstitute.org), a not-for-profit organization that "promotes the study and imitation of nature's remarkably efficient designs…. to create sustainable technologies." Includes free data base of examples of "innovation inspired by nature."

Buckminster Fuller Institute, (www.bfi.org), sponsors an annual student design contest.

Facing the Future, (www.facingthefuture.org), is a non-profit organization that helps teachers help students achieve academic success, preparing them to create and maintain positive, healthy, and sustainable communities. They provide free and low-cost curriculum resources, teacher workshops, and service learning opportunities used in schools in all states and over 100 countries. For example, in addition to the lessons referenced in this article, in *Sustainable Design (Real World Math: Engaging Students through Global Issues)*, students analyze product characteristics in terms of sustainability.

Leonard, Annie, *The Story of Stuff*, (www.storyofstuff.com). This free, 20 minute resource provides a "big picture" overview of the serious flaws of traditional industrial design. An important companion piece that focuses on solutions is Facing the Future's free curriculum: *Buy, Use, Toss? A Closer Look at the Things We Buy.*

McDonough, William & Braungart, Michael. *Cradle to Cradle: Remaking the Way We Make Things*. New York: North Point Press, 2002. A bible in the field of sustainable design, this is an absorbing primer for adults, and my 8th graders did well reading excerpts. Printed on 100% recycled plastic, you can read it in the bathtub!

Mueller, Tom. *Biomimetics: Design by Nature*. Washington, DC: National Geographic Magazine, April 2008. This very readable introduction with amazing photographs is available for free at: http://ngm.nationalgeographic.com/2008/04/biomimetics/tom-mueller-text

Thorpe, Ann. *The Designer's Atlas of Sustainability: Charting the Conceptual Landscape through Economy, Ecology, and Culture*. Washington, DC: Island Press, 2007. Written for design students in college, but accessible to secondary school students, this book offers a positive "how to" approach to the life cycle design goals espoused in Cradle to Cradle. Thorpe's open source website offers teaching resources, some of which have been adapted here for secondary school students: www.designers-atlas.net/index.html

Name: _____ Product or System: _____

SEE ME! ECOSPHERE ELEMENTS AND IMPACTS

(adapted from *The Designer's Atlas of Sustainability*, Ann Thorpe, 2007, www.designers-atlas.net/)

DIRECTIONS: Use the Internet and common sense to prepare a presentation on the ecosphere.

	Resources: what we take out…	Impacts: what we put in…
Atmosphere Air		
Biosphere Living Things: plants and animals		
Lithosphere Earth's Crust: rocks and minerals		
Hydrosphere Water: Groundwater Watersheds Oceans Polar Ice		

Name: _____ Product or System: _____

SEE ME! INVISIBLE MATERIALS

(adapted from *The Designer's Atlas of Sustainability*, Ann Thorpe, 2007, www.designers-atlas.net/)

DIRECTIONS: Use the Internet and common sense to prepare a presentation on invisible materials.

Volume of Material & Waste in Production 90% of materials used in production go to waste. So, for every kilogram of product, 9 kilograms of waste are generated. We don't "see" them. In the life cycle of your product (from cradle to grave), where is there waste?	
Stockpile Typically, we only see products on the retail shelf or in use. Where is this product stored prior to sale (in a warehouse) or after sale and out of use (in a garage or storeroom)?	
Contents & Origin The ingredients in materials may be of unknown content and origin. Are there undesirable chemicals and raw materials in your product, and where did they come from?	
Escape Routes To Environment Substances in a product may escape into the environment. Does your product: Off-gas? (air pollution) Abrade? (rub off) Incinerate? (burn) Result in litter?	

Name: _____

SUSTAINABLE DESIGN – OBJECTS, ACTIVITIES AND HAPPINESS

(adapted from *The Designer's Atlas of Sustainability*, Ann Thorpe, 2007, www.designers-atlas.net/)

Directions:

1. Choose two objects and one activity in your life. One should be a personal item like a photograph, a book you are reading, or an item of clothing. Another should be something with a specific function, like a tool, electronic device, or household appliance. The activity could relate to family, friends, recreation, volunteer service, learning, hobbies, etc.

2. Rank how much each contributes to quality of life in every category:
   1 = none 2 = some 3 = lots

3. Total each column.

4. Write two paragraphs on the reverse side.

The first paragraph **summarizes results and gives your response to the results**.
Any surprises? Confirmations? Based on these results, is there anything you would change in your life? Were the objects or activity more important in terms of quality of life? Why?

The second paragraph considers the **design of an object or activity**. Choose one object or the activity. How could it be redesigned to achieve better scores in some of the categories? Explain.

	Personal Item:	**Functional Item:**	**Activity:**
Subsistence and Survival			
Protection and Safety			
Affection and Kindness			
Knowledge and Understanding			
Participation and Involvement			
Leisure and Relaxation			
Creation and Imagination			
Culture and Identity			
Choice and Freedom			
TOTALS			

Name: _____ Product or System: _____

SUSTAINABLE DESIGN – LOCAL AND SLOW

(adapted from *The Designer's Atlas of Sustainability*, Ann Thorpe, 2007, www.designers-atlas.net/)

DIRECTIONS

With the goals of 1) reducing ecological footprint by way of design that favors local materials and labor, and 2) increasing quality of life by way of design that slows down the often frantic pace of life:

1. Choose a product that you think you can design so as to optimize the local and slow.
2. Brainstorm, problem solve, and enter notes under the prompts below for local and slow design considerations.
3. On a larger piece of poster paper, name the product and sketch the product, labeling key local materials/labor and features that will make it slow.
4. Present your design ideas and sketch to the class.

LOCAL DESIGN CONSIDERATIONS

1. List regional raw materials that will be required for its production, to be taken from...
   Local biosphere (plants and animals)

   Local Lithosphere (minerals, soils)

   Local Hydrosphere (water)

   Local Atmosphere (air)

2. What local recycled or found/reclaimed materials can be used?

3. What are some non-local manufactured materials or components that you need to use (e.g. mass produced electronic parts or lights)?

4. What local sources of energy will you use? Renewable or non-renewable?

5. What local sources of human labor will you use? Skilled? Unskilled? What types of specific skills will they need? How will the workspace and production process be organized?

SLOW DESIGN CONSIDERATIONS

1. Highlight the passage of time through gradual, desirable physical changes in the product over time (e.g. a glaze that slowly and beautifully cracks with age, shoes that become more comfortable).

2. Highlight the passage of time by a design feature that has product users creating stories about the object or interacting personally with it (e.g. labels, journals, art, decoration).

3. Include design features that actually make people physically slow down in movement (e.g. a glass with holes in the side that you must cover to keep water from leaking out).

4. Design the object so that the user must make choices between faster and slower processes for its use (e.g. a play structure slide that you can take quick stairs to or a longer winding ramp).

5. Design the object so that it can/must be used in a slower, more relaxed environment (e.g. rural setting or a quiet, sheltered space, indoors or outdoors).

6. Provide for an easy, almost automatic form of customer feedback, a sort of local "open source" mechanism for product improvement (e.g. website, phone, letter questionnaire).

Name and sketch your product, labeling its LOCAL & SLOW features!

SUSTAINABILITY AND THE DESIGN OF THE MORNING CEREAL BOWL

By Sarah Robertson-Palmer (art teacher at Explorer West Middle School)

Type of bowl by material and origin	How is this bowl made? Where do the materials come from?	What are the benefits?	What are the disadvantages?
Ceramic bowl Made by you at school			
Ceramic bowl Mass produced Made in China Sold at Target			
Glass bowl from Poland Sold at Macys			
Decorated plastic bowl Made in India Sold at the corner market			
Disposable plastic bowl Made in Mexico Sold at the dollar store			
Disposable paper bowl Made in USA Sold at QFC			