Photographs: Susy Ellison

Green Building: Tools for the Future

What you need to plan for if tackling a building project with teens

By **Susy Ellison**

TOOL BELT, SKILSAW, cordless drill with batteries and charger, measuring tapes, surveyor's transit, carpenter pencils…. Are these on your list of school supplies? If they are, then you might already be conducting building projects with your students. If not, you should consider incorporating this into your curriculum. In my 17 years as a science teacher at Yampah Mountain High School, a public alternative high school in western Colorado, my students and I have built a small strawbale classroom and a greenhouse. We have also assisted with the installation of a grid-tied solar energy system on the school's roof.

Carefully planned construction projects can create powerful, hands-on learning spaces that do double duty as they teach about energy efficiency, renewable energy, and other core STEM principles long after construction is completed. In this article I will guide you through the steps required to conceive, design, plan, fund, and complete your project. Building projects can address complex environmental issues and demonstrate solutions. If you have never built anything, don't be scared to learn as you go. Be a student with your students!

Brainstorming with the Standards

What better way is there to learn to "measure twice" (or three times) and "cut once" than finding out that your carefully planned foundation is 6" short on one side AFTER the footer has been poured? To get beyond this simple performance metric, use the specificity of the science standards to guide you. Federal, state or provincial standards can provide a more exacting planning tool of what your students will be learning. There are relevant outcomes nestled among the Physical, Life, Earth Sciences standards, as well as—in the case of the NGSS standards—within the Engineering Design standards. Perusing your local science standards or the Next Generation Science Standards can provide a meaningful theme for your project. (See box on next page.)

The NGSS Engineering Design standards, that set forth new STEM challenges for teachers, can guide your process from "*Analyzing a major global challenge*," to "*Design a solution*," to "*Evaluate a solution*," as students plan and construct your greenhouse or building. Even the physical science standards can be addressed, as you consider energy transformations that occur in photovoltaic electric systems, or as you put a shade cloth on the south side of your greenhouse in the summer to keep it from overheating. Planning, design, and construction performance metrics are embedded within these standards, awaiting your project!

Standards can guide specific focus to the work students do. If you are building a greenhouse, the obvious standards might fall into the Life Science realm as students use the greenhouse as a laboratory for experiments with photosynthesis, or feedback loops that affect plant growth. For example, growing food in a greenhouse might lead students to find ways to reduce the impacts on the environment. The design might then provide a concrete example of reducing

impacts of human activities on the environment. By growing food locally instead of requiring fossil fuels to transport food to market, students can understand core principles of sustainability on a deeper level.

STEM literacy focuses on a student's ability to understand and apply concepts from science, technology, engineering, and mathematics in order to solve complex problems[1]. Building projects combine all these skills—and in the end, you have created a useable space with your students, for your students! Before you order your supplies, buckle up your Carhartts, and convince your building administrators that building something is an essential learning experience for your students that will have an impact long after they have graduated.

Make sure you have a firm goal in mind. When I started on this path, my goal was to create learning opportunities for students that melded the STEM literacy skills with a focus on energy efficiency and environmental literacy. I wanted my students not only to learn some solid construction skills and focus on working with their hands and their minds, but also to be able to apply these skills to analyzing the built environment around them and to help them make informed decisions in the future. STEM Ed literacy and environmental literacy in action!

Setting a Goal

Plan your project with the final outcomes firmly in mind, just the way you would plan a classroom unit. Once the sawdust is vacuumed up, and your project is complete, what do you hope that students take away? Ask yourself these "big picture" questions:

- Why do I want to do this project?
- Is it tied to a larger school initiative or focus?
- Does it fit with my curriculum and curricular goals?
- Can I identify specific STEM or science learning objectives to guide my project?

Do you want students to understand the impacts our built environment has on the planet, or are you trying to educate them about options for energy production and consumption, or both? Would you like students to critically examine how food is produced and consumed by building and maintaining a greenhouse? Perhaps your goals are in the realm of engineering, exploring building design with an eye towards resource use throughout its lifetime. Having a goal in mind may seem like an obvious piece of advice—but it is crucial. Building projects are not for the faint-of-heart; I spent countless hours outside of school hunting down funding and materials for these projects and, occasionally, wondering exactly why I had started each project. Having a solid goal will keep you going through those nights when you are lying awake in bed wondering why you ever started this project!

Making a Plan

Buildings are constructed from the ground up, but are designed from the roof down with each element supporting the one above. So, too, is the plan you'll create to build your project. This is just like creating detailed lesson plans with the desired result(s) driving your actions. Your goals will be your foundation. They will be there to support your project from start to finish. Focus on just a few goals and targets but keep in mind that there will be all sorts of learning opportunities along the way that you never even dreamed of!

There are so many details to consider while building. When you are in the classroom, so many decisions are already made for you; your classroom space is pre-determined and, quite often, your curriculum has been set. Building with students requires a new set of tools and decisions. For example, you need to carefully choose where you will build. If your project requires electricity or water, be sure to choose a location that will allow you access to those resources, or identify how you will get them to the building site. If your project focus includes solar energy for either heating or electricity, make sure your site is appropriate.

Start by asking yourself these logistical questions:

- What and where are you going to build? Are you building a shed with recycled materials? A greenhouse? A small strawbale classroom?
- Does your site provide convenient access for delivery of materials and for student use after the project is completed?
- Do you need any special approvals from your school district or building administrator?
- Do you need any building or electrical permits or engineering review?
- Is this project small enough to complete in a quarter or semester, or will it take the whole year, or perhaps even longer?
- Do I *really* want to do this? Ask yourself this a few times!

The plan you create through answering these questions, and numerous others that may arise, will become your guiding document and keep you focused on the whys and hows of this undertaking.

Identify Resources

With your plan tucked into your tool belt, the next step is to identify the resources you'll need. Consider these broad

NGSS in the US

The Next Generation Science Standards (NGSS) standards are in the process of being adapted throughout the United States. Built on previous articulations of a comprehensive review of the scientific content all learners should know and do, they offer the teacher tools and a framework for deepening the practice of scientific inquiry, acquisition of content and scientific thinking. Founded on what they call the Three Dimensions, the new standards weave together core content, practices of real scientists and big ideas (Cross-cutting Concepts) to provide trans- and inter-disciplinary studies. With a new emphasis on STEM ideas they present the teacher new opportunities to orchestrate authentic design and problem-solving projects in local communities. For more information about the Next Generation Science Standards: www.nextgenscience.org.

A student-built, strawbale classroom arises on the hillside campus of Yampah Mountain High School.

categories; skills, people, materials, and funding. Identify the skills you and your students have or need to learn. Spend some time to determine which students have skills they can share. Are there existing classes or volunteer opportunities for some "on the job" training to focus on needed skills?

Which *people* in your community can help you meet your goals? Reach out to engage local experts, parents, friends, contractors, businesses, or programs that can help you along the way. Consider including field trips to building sites or scheduling classroom visits with some of the people you identify. Students involved in our strawbale building project met with local architects, engineers, lumberyard owners, and solar thermal and solar electric experts. We met with local contractors to learn about the process of taking a building from design to reality. The class travelled to nearby building sites and got first-hand experience working with strawbale construction. We even took classes through a local non-profit, Solar Energy International, to learn how to design our space to take advantage of our region's solar resource. The final design and construction incorporated all that we learned through these contacts, from site selection and building orientation to choosing appropriate materials and construction techniques to create an energy efficient, well-engineered, and aesthetically pleasing building.

What *materials* will you need to complete the project? Are they readily available or will you need to include materials research into the list of student tasks? You don't need to identify everything you'll need, but it's important to know what some of the major items will be.

Finally, *funding*; how much will it cost and where is that money going to come from? If you're lucky, your school or district might help cover the costs. If not, then you will need to make a fundraising plan to secure much of the funding before you start building. Include your students in this process. They can be the most compelling spokespeople, explaining why the project is important and valuable, to them personally and to the community as a whole. Start locally, with parents, businesses, and service groups. Explore grant opportunities. Look for grants and granting organizations whose missions align with your goals. Although grant writing can be daunting, if you have spent time creating an educationally valid and clear project plan, you will be able to use that plan as the template for writing focused and compelling grant applications.

Timeline

Your tool belt is almost full. There's one more step before you plunge in: create a timeline. The timeline can be as general or specific as you feel necessary. Work with your students to list all the steps that need to be taken and when they need to happen. When will you start? How long will this project take from beginning to end? Do you need to go on some field trips? Plan them into the schedule. If you'll be working outside, think about the weather. How can you schedule your project to optimize your chances for the best possible weather conditions? Create a visible timeline that can be posted in your classroom or on the building site. Revisit it often and make revisions. Don't worry when you get off-schedule. There will be days where it seems that you are proceeding at a glacial pace and obstacles lurk behind every corner. It will rain on the day you need to be outside completing a crucial chore. Your students will show up unprepared. The building materials you ordered to arrive today will arrive tomorrow instead. Your timeline is merely a planning guideline. Don't get overwhelmed and learn to adjust as you go.

Putting the Pieces Together

Now you have a specific project, an educational plan, support from your building administrator and peers, approvals and funding in place, and a timeline. Wow! Take a moment to congratulate yourself for making it this far. You're ready to take a deep breath, get out your shovels, and begin. While you should try to be prepared for any and all interesting twists as you build, flexibility is key to success. If this is your first project, start small. Build a bench from recycled materials or try experimenting with cold frame design and construction before you try to build a greenhouse. Work to gain allies among your peers as your projects become a signature part of your school's programs and curricular offerings. Create in-service activities for your co-workers to help them understand your project and how to utilize the incredible resource you are creating. Find new ways to use your built environment. There is nothing better than finding the hidden

talents in your students. Use your first projects as showpieces for future funding. Become a shameless self-promoter! Above all, have FUN! Relying on these steps will help to smooth out any rough spots as you move from conception to inception to completion. They will also help you stay inspired and enthusiastic on those days when nothing seems to go right—materials don't show up, you discover an egregious miscalculation, tools break, or no one wants to help.

Don't expect perfection. A mantra I found helpful was "It's not my house". While you might always notice that one crooked wall or poorly constructed garden bed, your students will be excited and proud about what they have accomplished. Let your students own the project. This might be the most authentic assessment they have ever had. Above all, celebrate their success. Invite the local press to visit the job site and to interview students. Let the students explain why this project is important and what they have been learning. You might find out they've learned some things you never even considered in your planning!

Project-based learning on a grand scale such as this is both fun and rewarding. As you get excited and dream about what you can build, keep your ideas realistic. While it's great to say "Hey, let's get some chickens!" or "A greenhouse would be cool!" it is equally important to say "How does this fit my school's curricular goals and focus?" and "How can I ensure that this will be a program that will continue after I am gone?" A successful project will continue teaching long after you, and your students, have left the school.

When you are done, you will find the finished product—and associated outcomes—immensely satisfying. When we completed our school's greenhouse project we celebrated with an all-school event focusing on food. Greenhouse building had been incorporated into a trimester with a curricular focus of "Feeding a World of 9 Billion". Its completion was celebrated with a day of food-related speakers and a lunch featuring burgers from local cows and salads from a local greenhouse. Since completion, it has been used for life science classes studying botany and service learning classes growing food. Toddlers from our Teen Parent Program (which includes an in-school daycare facility) spend time exploring the green world and released ladybugs to combat the occasional aphid infestations. Classes studying food production and consumption have also traveled to nearby farms and orchards to pick fruit and other produce, and have volunteered in local sustainable food efforts. Students have earned credit and fresh produce during the summer by working as interns. It continues to be a "living" part of the school's curricular offerings, and an ongoing testimony to the power of authentic, relevant, hands-on place-based learning.

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Endnotes

1. https://y4y.ed.gov/learn/stem/introduction/stem-literacy