The Children's Engineering Journal

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Greetings from the Virginia Children’s Engineering Council (VCEC) Board of Directors. As we head back into our classrooms and schools, many of us are experiencing a new “normal.” Some school systems are preparing for offering both face-to-face and virtual instruction, while others are planning for face-to-face with many stipulations. Teachers are having to devise new ways for students to connect with each other socially while maintaining social distancing. In the past, children’s engineering lessons have focused on cooperative learning and creative thinking with materials and tools freely shared. Now, teachers are searching for ways to maintain safety while encouraging collaboration. Fortunately, educators not only teach children to think critically, they also practice that skill themselves!

We hope the following journal articles help you find your new “normal” while increasing growth in your STEM mindset. In addition, we want you to share with us your solutions to the challenges we are facing by writing an article for a future issue of The Children’s Engineering Journal. Please submit your articles to our editor, Yvonne Richard, at yrrichard@kgcs.k12.va.us.

In order to provide the best possible conference experience for you, our 26th annual VCEC Convention will be a virtual event on February 8-10, 2022! After hearing your comments from our conference held this past February, we will again host the sessions in the three evenings. By broadcasting our sessions virtually during after-school hours, you will not need to pay for a hotel room or write substitute plans! We will be announcing our keynote speakers in the next few weeks, and I know you will be as excited with these award-winning speakers as we are. Also, each session will be recorded and available for viewing after the convention. The early bird registration is open now and available on our website, so don’t delay – register today! If you are interested in moderating one of the sessions, please contact our convention chair, Barbara Adcock, at VCECpresenters@gmail.com.

We wish you the best this school year and hope to see you at our 26th convention in February.

Lisa A.H. Brown
Growth Mindset: Rethinking Engineering Design Challenges

by Barbara Adcock

Maya Angelou is quoted as saying, “Do the best you can until you know better. Then when you know better, do better.” I love this quote because it gives me grace. I think about my early years in teaching and am somewhat embarrassed! Like all teachers, I have gained knowledge and experience, and know that I am now doing better. In that vein of having a growth mindset, I realize that how I used to do design briefs and engineering challenges with my students needed improvement.

I have just completed my 34th year in education. I have taught kindergarten through fifth grade as a classroom teacher, and for the last six years, I have been an instructional STEM coach. My goal is to be a lifelong learner and to share that knowledge and experience to support teachers and students. In this article, I will share what I have learned and how I am now doing better with the creation of engineering design challenges.

The Difference between Engineering and Making a Model

One thing of which I was guilty was calling the building of a model an engineering challenge. It is not! We are all familiar with the engineering design loop. Engineering begins with a problem. That’s what engineers do: They solve problems. Given that, shouldn’t what we are calling engineering to students be about solving a problem? To make it even better (remember, we are always trying to do better), the problem should be real world and meaningful to our students, not contrived.

I am not saying that students should not make models. They absolutely should. We show our learning and understanding by creating models to explain our thinking, but we should call these models, as opposed to engineering. Our students should know the difference between creating a model and actually doing engineering, and so should we!

Make the Problem as Real World as Possible

Let’s think about why we do engineering with our students. It develops a culture of how to solve problems. It encourages the development of the five C’s (critical thinking, creative thinking, collaboration, communication and citizenship). It also teaches students how to be flexible and dynamic in their thinking. In short, it is a terrific strategy for developing effective skills for life!

To get the most out of this, we want our engineering design challenges to be as meaningful and real world as possible. Let’s look at an example. In third grade, students are often asked to create a model of a simple machine. Again, making models is good practice, but in this case, let’s flip it to an engineering design challenge where they need to solve a problem. Not a contrived problem, but one that might really happen. In one of my schools, there is a curb around the field. A track surrounds that. When the physical education teachers bring their equipment out, it has to be lifted onto the curb. The students were asked to create a solution. Another building had stairs to access the

VDOE Engineering Design Process image based on the National Aeronautics and Space Administration (NASA) engineering design model.

This image comes from the 2018 VDOE Science Standards, which now include engineering. If you Google images of the engineering design process, you will find many variations; however, they all begin with a problem (or with defining the problem).
stage. When heavy items needed to be brought up, which simple machine could help? Students needed to design a solution to this real problem. Look around your building or, better yet, have your students look around for problems that could be solved using a simple machine. Then, have them design and build a prototype. Students will be thinking about how they can use simple machines long after your unit is complete. That is our real aim---to help our students become thinkers about their world!

Cooperative Learning Built into the Tasks

Think of our world. As technology advances, our world gets smaller and smaller. It is of the utmost importance for our students to be able to work with others. This is a skill they will need no matter what field they choose to pursue. It is our job to create our engineering design tasks in such a way that not only encourages working together but pushes students to work cooperatively. We learn best when we “do” but also when we talk about what we are doing. Planning together and learning from one another; these are things that not only make us grow as learners but also make us grow as humans! According to dictionary.com, cooperative means “working or acting together willingly for a common purpose or benefit.” Students need to work together toward a common goal. This is harder for some students, but that does not mean they cannot do it. The growth of your students in the area of cooperative learning will be the most wonderful gift you can give them as a teacher and which you can receive as you see it happen.

Let’s Keep Doing Better

As teachers, we must continue to grow in our pedagogy. The world is constantly growing and changing. We are preparing students for jobs that may not already exist. They need to be flexible, cooperative workers, problem solvers and critical thinkers, but you know what, so do we! Let’s keep working to do better to give our students better opportunities for growth. Let’s make sure we are talking to our students and encouraging discourse when they work. They just might teach us something, too!

email content to yrrichard@kgcs.k12.va.us or yvonnerichard1@gmail.com
Deadline ~ December 1, 2021
It’s fun to think about the future of STEM: amazing new jobs, robots as co-workers, virtual reality (VR) becoming part of our everyday lives; cars that drive us where we want to go while we sit back and enjoy the scenery or read a book.

The future of STEM education is exciting, although it’s hard to know exactly what it will look like. In the few decades since the invention of the STEM acronym, we’ve seen great strides in helping every child have access to great resources, materials, and opportunities. But we’ve also seen what happens when schools, districts, and governments adopt a STEM focus just to receive positive press or to look better than the school in the neighboring county. Things that start with a bang often end with a thud, or in this case, that exciting new STEM lab will end up being remodeled in just a few years, just like the computer labs of the ’90s and the home economics class-rooms of the ’60s.

STEM is not just a class we teach. It’s a culture we build. STEM is not just something we add to our school’s name to make it sound smarter or more hi-tech. It’s about helping our students be ready for an advanced world.

When we take the focus off the kits and put it on the students, that’s when STEM will truly make an impact in our educational system.

With that in mind, here are three goals I believe can help STEM become a bigger and better part of education in the next five to ten years.

**Increased Relevancy**

STEM education happens best when it’s connected to other subjects. Teaching STEM ideas in a vacuum gives students the impression that STEM is just another project to complete or another class to get a grade in. We don’t need more education silos, we need to get rid of the ones we already have! A focus on STEM is the perfect vehicle for creating more cross-curricular learning opportunities. Imagine what classrooms could look like if they were built on foundations of wonder, creativity, and exploration, no matter what subject was required to reach the learning outcomes. Helping students see the interconnectedness between disciplines increases their motivation to be more than just “good at math” or “good at reading” and instead be “good at learning.”
How do we go about building a focus on relevancy? Start by showing students news stories where STEM is prominently featured. This can include stories or videos about robots and drones being used in agriculture, aerospace, or Amazon; new technologies that affect how we live; or engineering innovations that help people live healthier lives. These connections are all over the news, and can be a great way to show students that STEM is foundational for our world.

You can also build relevancy with STEM by pointing out how it fits in other subject areas. If you’re an elementary teacher, this can be as simple as discussing the engineering that went into building or living in the time period you’re learning about in history, or having students think about how the engineering design process is similar to the writing process. And combining literacy and STEM is such an underutilized connection. Have students write stories using STEM themes, challenge them to carefully write the steps involved when building something, or provide books in your classroom that have a STEM focus, whether they’re fictional stories or they’re biographies of great STEM thinkers and innovators.

Another way to build relevancy is to work with other teachers in your school, especially if you’re a middle or high school teacher. Put aside reservations about time or budget constraints and talk with a colleague seriously about ways your students could work on projects that incorporate subjects you both teach.

Some of the best and most memorable learning my students have experienced are these types of opportunities. This past year, my mathematics students picked up litter using the Litterati app. They were able to look at the data of how much and what types of litter was picked up, and think about their own impact. The social studies teacher, gym teacher, and art teacher all were able to connect learning in their classroom to our initial cleanup and analysis in mathematics.

When I asked the students at the end of the year about what they liked most, many mentioned picking up trash. The best part is, with a consistent focus on STEM in whatever subject you teach, your students will start to see the STEM in their world. That’s a sure sign that what you’re doing is making an impact.

A Problem-Solving Focus

Not only should STEM education in the future be relevant, it should have a focus on real-world problem solving. We need to help our students realize that just talking about problems is not enough. Problems are meant to be solved.

Any problem solving we do should include bigger global issues (such as food production and circular economies) as well as local issues that affect the neighborhoods and schools our students live and learn in (such as traffic safety and water runoff). We can even help students think about galactic-level problems by considering what to do as space exploration graduates to space colonization. There are
countless ethical and practical questions that must be debated and answered as more people travel beyond our planet, and each of those questions can be a great opportunity to bring STEM learning beyond marshmallow towers and egg drops.

How do we build problem-solving skills in our students? No matter what age of student you work with, begin by asking them what problems they’re aware of. Don’t let them repeat what they’ve heard in the media; help them be specific.

When a student says, “We can recycle” as a solution for trash, ask them what that would look like. Should recycling only focus on plastic and glass bottles? Can seemingly insignificant items like paper clips or plastic bags inside cereal boxes be recycled? Where do reuse, reduce, repair, refuse, and repurpose come in? Coloring a picture with people placing items in a recycling bin may build awareness, but problem solving requires action. Collecting food for a local food bank is a great problem to help with, but our students can take it a step further by planting a school garden to contribute even more food or designing reusable bags that people can use when picking up food from the food bank.

This year I challenged my students to create nameplates for the staff mailboxes in our main office using Tinkercad and 3D printing. Now they want to create signs for other parts of our school, including some with braille. Once we build a mindset of problem solving, our students will start noticing problems to solve. Our students idolize superheroes because they save the world. Building a problem-solving focus in STEM education helps our students be super, too!

Career Readiness

One of the most important and overlooked parts of STEM education is a focus on careers. We all know that STEM is a big part of jobs now, and we’ve probably even repeated the line “the jobs of the future haven’t even been created yet.” Those are both true, but it doesn’t give us an excuse to gloss over discussions of STEM careers with ambiguous statements. In fact, if you ask students what types of STEM jobs they know about, most will only list off the typical scientist, engineer, teacher, doctor, and astronaut. But more than ever, they need to know about careers that incorporate STEM skills right now and where jobs are headed in the future.

How do we build a better focus on careers with a STEM focus? Begin by examining and analyzing the elective courses currently being taught in your school and district. If you talk with the staff teaching those classes, you can get a better idea of how to prepare your students for the opportunities those courses provide. For instance, if your district has welding classes (which includes careers with STEM connections), show your students some videos of people using welding to create art, fix bridges, or build props for movies. If your school offers courses in culinary arts (again, more STEM connections), challenge your students to create videos of themselves making a favorite family dinner. And if you’re one of the ed-
ucators teaching elective courses, be sure that you’re looking for the latest information and advancements connected to your content.

If you currently don’t have a lot of elective courses in your school, or the ones you currently have are being taught for the 287th time, brainstorm some ideas of new courses (with student input) that could take STEM learning to the next level. Sustainable design, drone technology, tiny house building, podcasting, and digital media are just some ideas of courses that would probably have students lining up at the door. It’s important that we help students get a broader view of STEM. Elective courses are the best way to expand the focus on careers and career readiness in the future of STEM education, and they’re great at crossing those curricular boundaries and tearing down education silos.

I’m excited about the future of STEM education. We must make sure that the focus of STEM remains on helping students, not just buying kits. A sustainable and holistic culture of STEM education can be built if we keep it relevant, solution focused, and integrated with career opportunities and ideas. These goals can ensure that STEM skills are available for every student in every classroom every day.

I’m helping build a culture of STEM learning in my school. Are you?

Did You Know?

You can use Children's Engineering to teach Virginia's 5C's
WORK ZONE AHEAD!!! Building Blocks and Building Social Emotional Skills. That is what I introduced my first-, second- and third-grade students to this school year at King George Elementary School. I am a school counselor who loves trying new, hands-on lessons, and I was grateful to have found two great digital brick-based counseling resources through Counselor Keri and in print with Brick Based Counseling by Derek Tulluck.

Brick Based Counseling was a great resource for individual and small-group settings. Students were able to practice social-emotional learning (SEL) development by using art and play therapy to identify their emotions through the colors of their Lego blocks, practicing growth mindset exercises, friendship building, and more. Tulluck’s lessons made it easy to implement project-based exercises.

When I discovered Counselor Keri’s “STEM-pathy” lesson, I knew it was a perfect fit for my elementary classroom setting! My elementary school is in a rural area and is a high-needs school with a number of students with mental health needs and special needs. The lesson included bright task cards that helped students identify barriers that other students might face in their daily life with a picture and short story. The story could be anything from a student with a hearing disability worried about hearing a movie with her friends to a student in a wheelchair needing to transfer successfully on a plane. The students used the information on their task cards to create their own original inventions with their colorful building blocks that would help break down the barriers for everyone!

I created my STEM-pathy kits with small pre-filled storage containers with a random set of building blocks (easy clean-up, sanitizing and storage!) and a set of task cards on a metal ring. My students worked independently as they started through the engineering design process to develop their creations. Students started with a design sketch, chatted among themselves for ideas or ways to improve their inventions and built their creation with their block kits. They were eager to share their inventions with the class (and with me)! This lesson would also work great in small groups or teams.

My students presented their creations of collapsible and compact wheelchairs for airplane rides, robotic arms for art contests, voice-activated devices to help play basketball games, air-driven medical equipment, and solar charging playground equipment. There were many amazing ideas from my smart and creative seven- and eight-year-olds! Throughout the classroom lesson time, my students were intently focused on their ideas and could not wait for their next task card! I loved seeing the imagination fill the classrooms! My favorite part was hearing how happy their hearts were to help others.

As a school counselor, this met several SEL American School Counselor Association standards, such as empathy, critical-thinking skills, creative approaches
to learning, tasks and problem solving, and creating positive, respectful, and supportive relationships with students who are similar to and different from them. This lesson is a great resource for classroom teachers, school counselors, STEM teachers, and parents. The “STEM-pathy” lesson taught students the importance of social awareness and the ability to understand, empathize, innovate and feel compassion for others with a STEM twist!
Ms. Jimenez is a fourth-grade teacher at Milton Springs Elementary School. Like many of us, Ms. Jimenez strives to build her learners’ capacity to self-regulate their own learning. She is clear in her goal that, “I want them to have the capacity to not only learn the content, skills, and understandings associated with the core subjects but to also take ownership of their own learning journey and drive their own learning. I want them to know what to do when they don’t know what to do and they are no longer in my class.” While facts and figures have a valuable place in teaching and learning, the capacity building Ms. Jimenez’s seeks to reach through the goal of self-regulated learning moves beyond fractions, ecosystems, inferences, and westward expansion.

Recent research in the cognitive sciences and within our own field of education have increasingly emphasized the long-term benefit of learners fostering, nurturing, and sustaining metacognitive skills (thinking about one’s thinking). Our collective aim is not for students to only recall and recognize information; these are entry points for metacognition and the capacity for learners to take ownership of their own learning journey and drive their own learning. Recalling and recognizing information is not the destination. Ms. Jimenez, as well as the rest of us, strives for a learning destination that encompasses cognitive learning outcomes, conceptual understanding, creative problem solving, the development of communication skills, and social-emotional outcomes. This requires the use of cooperative learning. In the end, outcomes today are measured in terms of transfer of learning—that is, the ability to apply knowledge in new situations to meet new challenges (Bransford et al., 2000).

We should not be surprised that one of the practices that Ms. Jimenez implements in her classroom is design-based thinking tasks. Her fourth-grade team often implements these open-ended design tasks as a way to incorporate cognitive learning outcomes, conceptual understanding, creative problem solving, the development of communication skills, and social-emotional outcomes into multiple content areas. For example, she uses Pack Your Trunk (Virginia Children’s Engineering Design Briefs) to integrate English language arts, mathematics, and social studies.

Figure 1.
Fourth-grade design brief Pack Your Trunk.


However, like many of us, Ms. Jimenez encounters a common problem when implementing a design-based thinking task. She sums up the problem by noting, “The cooperative learning groups are often dysfunctional and learners never find their way out of the task. We have all been in the situation where we design, develop, and implement a cooperative learning task much like Pack Your Trunk, only to find that the cooperative learning teams experience one or more of the following barriers to the successful completion of the task:

1. The learners simply aren’t getting along while working on the design-based thinking task.
2. The learners are grouped together physically but are working independently with little or no cooperation.
3. The learners work well together but never converge toward a viable solution to the design-based thinking task.

4. Learners are hesitant to step up and lead or facilitate the work of the group. Instead, they all stand back, reluctant to display leadership skills.

5. The learners simply won’t communicate or talk with one another. There is no critical dialogue about the work of the group.

6. The group is more focused on getting the task completed than they are engaging in the processes that lead to cognitive learning outcomes, conceptual understanding, creative problem solving, the development of communication skills, and social-emotional outcomes.

7. When things do not go as planned, learners focus on finding someone or something to blame.”

As you read the above list, you likely recognized some, if not all, of these barriers in implementing designed-based thinking tasks and using cooperative learning in your classroom. The barriers reported by Ms. Jimenez are not primarily the result of the task. There is nothing inherently wrong with Pack Your Trunk. In fact, we believe this is the case for many of our attempts to implement open-ended cooperative learning experiences in our schools and classrooms. Instead, the problem lies in environmental conditions surrounding the task. Simply placing learners in groups does not result in cooperative learning any more than standing in a garage makes you a Cadillac.

Overcoming the seven barriers listed above requires Ms. Jimenez and all of us, for that matter, to ensure that the conditions necessary for high-quality, high-impact cooperative learning are in place as learners engage in design-based thinking tasks.

Rather than thinking in terms of cooperative learning, let’s reframe the conversation and strive to create student learning communities.

The Conditions of High-Quality, High-Impact Learning Communities

The idea of collective learning as a way of leveraging the collective wisdom to promote the growth of the group as a group and as individuals is not new. For adults, professional learning communities (PLCs) are networks of professionals that emerge as a response to the often-isolated nature of their profession. For example, in our schools we recognized there was an urgent problem with “business as usual,” closed classroom doors that left many of us teaching inside our own bubble. We can recall situations where we were left to our own devices to design, develop, and implement instruction and interpret assessment results. Many of the barriers identified by Ms. Jimenez reflect this same challenge among our learners. Why would teachers, learners, or any professional not want to pool their collective expertise and work collaboratively to advance their skills and improve outcomes?

PLCs acknowledge, and are guided by, another reality: None of us are sitting around with an abundance of spare time. We need assurance that the hours devoted to interacting with peers is worthwhile, that it is an investment that will yield tangible benefits for ourselves, our colleagues, and our learners.

Accordingly, successful PLCs, like all successful collaborative learning arrangements, are guided by a collective agreement to pursue useful goals in an organized way. This helps avoid the problem of “collaboration for the sake of collaboration” and keeps the work focused. In other words, just because there’s a round table doesn’t make the people sitting there a learning community. Certain conditions must be present. Over the years, we have learned that

1. Learning communities are a way to connect with purpose and success—a way to acquire and hone skills and achieve meaningful and rewarding outcomes.

2. Learning communities activate collective skills and wisdom, and they are characterized by structures that allow us to help one another develop expertise and abilities.
Looking back on the experience of Ms. Jimenez and her learners, what steps can she take to transform a group of learners into a learning community focused on the design-based thinking task, Pack Your Trunk? The work of Shirley Hord (2004) paved the way for us as teachers and is the starting point for responding to the barriers identified by Ms. Jimenez. Hord (2004) identified six critical factors that contribute to successful learning communities:

1. Structural conditions that provide a framework for collaboration and the resources to engage in the collaborative work;

2. The fostering, nurturing, and sustaining of productive and professional relationships among members of the collaborative team;

3. The existence of shared values and purpose that motivate individual members to invest in the work of the collaborative team;

4. The intentional leveraging of the collective expertise;

5. All members working to enhance one another’s individual efficacy and credibility; and

6. All members leveraging their individual strengths to share leadership responsibilities.

The six elements that make collaborative learning transformative for teams of teachers—that turn them from “a group of people working together” into “a learning community”—have the potential to do the same for groups of learners. Consider your own classroom and your desire to engage learners in a design-based thinking task that incorporates cognitive learning outcomes, conceptual understanding, creative problem solving, the development of communication skills, and social-emotional outcomes. As you strive to have them engage one another in their learning, you must ensure that they have the skills and dispositions to be successful. This reduces the chances of cooperative learning groups not getting along, being reluctant to display leadership skills, and simply not communicating or talking with each other. This requires you to approach collective learning through the natural progression of gradually releasing responsibility for the work to them. If your learners are to foster shared agreements of success among members of their group, you must first model the process of unpacking the design-based thinking task, engage them in the process of goal setting, support them in linking individual goals to group goals, and teaching them how to monitor their progress through effective strategies. This will also reduce the chances of cooperative learning groups working independently with little or no cooperation and working well together but never converging on a viable solution to the design-based thinking task.

Likewise, if your learners are to leverage the support of their peers to amplify learning, you must first model and engage them in effective feedback. This reduces the chances of cooperative learning groups focusing more on getting the task completed than they are engaging in the process and focus on finding someone or something to blame if things do not go as planned. Through the intentional design and implementation of collaborative learning, we create the environmental conditions surrounding any design-based thinking task that fosters, nurtures, and sustains a community of learners and not simply a group of learners working together. This is how we can leverage student learning communities in design-based learning tasks.

Establishing Student Learning Communities through Design-Based Learning Tasks

While Ms. Jimenez has seen cooperative learning flop with the use of design-based learning tasks, she and her learners have also experienced success. We also have witnessed learners working together in ways that meet the “learning community” standard, leveraging their collective knowledge, skills, and understandings and consolidating what they know and can do to go further and deeper together than they could have alone. In the end, we and our learners see measurable growth in cognitive learning outcomes, conceptual understanding, creative problem solving, the development of communication skills, and social-emotional outcomes.

Leveraging student learning communities in design-based learning tasks is achieved by design and through effort, not by luck. In order for learners to suc-
cessfully engage in the process of cooperative learning we, their teachers, need to provide them with the necessary conditions, tools, and supports. That means (Frey, Fisher, & Almarode, 2019):

1. Designing and implementing design-based learning experiences and tasks that invigorate learning through academic discourse;

2. Attending to academic, social, and emotional learning for all of our learners;

3. Fostering shared agreements of individual and group success through unpacking the task and co-constructing those shared agreements;

4. Using thoughtful teaming practices to build cognitive, metacognitive, and emotional regulation skills;

5. Leveraging peer supports to amplify learning; and

6. Activating all students’ leadership skills in order to enhance their ability to succeed—alone and together.

Ms. Jimenez, as well as the rest of us, will meet a learning destination that encompasses cognitive learning outcomes, conceptual understanding, creative problem solving, the development of communication skills, and social-emotional outcomes as long as we are purposeful, intentional, and deliberate about the implementation of practices that move this learning forward. Implementing design-based thinking tasks is only part of this journey. Ensuring that we design the environmental conditions surrounding the task will ultimately determine if the task flops or flourishes in our schools and classrooms.

References


Need a Design Brief?
Teacher Resource Guide for Design, Engineering, and Technology in Grades Pre-K through 5

http://cteresource.org/ce-trg/index.html
Dear VCEC Friends,

We have tons of great sessions planned for February! Look at some of the sessions you can attend LIVE in February. There are lots more that we couldn't fit here.

See you soon,
VCEC Board

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