Kidding Around with Design Thinking

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A residential school in Pennsylvania puts an emphasis on applied learning for elementary students—and that includes keeping the baby goats safe.

There is an enduring paradigm in education: Study content long enough, and eventually there will be a magic tipping point when you know enough to start doing something with your knowledge. This tipping point frequently comes in college or graduate school. It occasionally happens in high school. Elementary school is rarer still. Yet the elementary grades are exactly what we're focusing on with a campus-wide problem-based STEAM initiative at the Milton Hershey School in Hershey, Pennsylvania.

Milton Hershey School—where Jaunine is the director of STEAM and the agricultural and environmental education program and Joel is the elementary Innovation Lab instructor—was started in 1909 as a philanthropic endeavor by Milton and Catherine Hershey when they discovered they could not have children of their own. Today, Milton Hershey School provides cost-free housing, support services, and education on our residential campus for more than 2,000 preK–12 students from deeply impoverished backgrounds from all over the country.

Approximately 400 of those students are in our elementary school, where about three years ago we built an Innovation Lab. As an educator with an interest in technology and design, Joel took on direction of the project. We also collaborated with stakeholders in the school, our alumni community, and experts in the fields of technology, education, and business. What resulted is our K–4 Innovation Lab curriculum: a vertical alignment of STEAM integrations, 21st-century skills, career and technical education, social-emotional learning, and interdisciplinary connections across every content area—all of which lay the foundation for problem-based learning in grades 5–12.

Beginning in kindergarten, the Innovation Lab programming exposes students to progressively more sophisticated levels of keyboarding, digital citizenship, coding and logic, robotics, and—the *pièce de résistance*—design thinking. Students are engaged in design thinking through a hybrid model of stand-alone curriculum, classroom collaborations, enrichment and extension clubs, and other opportunities (such as exploring a problem of their own interest).

The Case for Problem Solvers

Humans are natural problem solvers. This is especially true of young children, who, presented with a whole world that is new and infinitely worth exploring, quickly gain knowledge and skills. Rather than allowing young students' restless curiosity to atrophy as they get older, we're trying to harness and nurture it. We honor student choice and voice at the earliest of ages. We encourage and actively facilitate young students in seeking out and engaging in topics of their own interest, both as part of and in addition to their regular academic work. We want to give elementary students opportunities to explore what they can *do* with what they know as early as possible.

To support this kind of exploration, we use the design-thinking process. As conveyed by Stanford d.school's K–12 Lab model, design thinking is a platform for creative problem solving and an authentic way to engage students in applying content knowledge and skills to rigorous and relevant issues. Students empathize to understand the user's perspective, define their focus and clarify the problem to solve, ideate by brainstorming and creating solutions, design prototypes of one or more ideas, and test ideas to gather user feedback. Drawing on user feedback, they repeat this process to continually improve the prototype in the next iteration.

In *Bringing Innovation to School*, Suzie Boss (2012) describes the switch to design thinking as a move that requires teachers to develop strategies that shift the focus from teacher-driven instruction with a correct answer to "open-ended questions for which there's not one right answer" (p. 69). This move can be more difficult for the teacher than it is for the student because we often need to step away from how we're used to planning a lesson, such as by planning backward from the end goal of what we're assessing. With design thinking, we can't see around the corner to know what the end product will look like. Design-thinking projects are open-ended by nature and have multiple possible solutions (fig. 1). Instead of assessing only the end product, we also assess the process and the application of the content.

Figure 1. Essential Elements of a Design Thinking Project

1. Builds empathy for an authentic audience

   Direct or analogous
   Interactive whenever possible

2. Is "open-ended"

   Has multiple possible solutions (room for student choice and student voice)
   Is collaborative and requires sustained inquiry (can't just find the answer on the internet)
   Add constraints to decrease complexity and time

3. Is prototype-driven

   Solutions require the creation of at least one prototype to test
   Prototypes can be physical manifestations of products or processes

4. Requires application of content knowledge and skills

   Authentic application of content and/or skills in at least one content area (this is what keeps it from feeling "fluffy")
   Applies content in a novel context
   Includes feedback/debrief around both the prototype and the Design Thinking process itself

Source: Author

Design Thinking in the Classroom

To get a sense of what design thinking looks like in action, let's examine our 2nd grade project, which focused on the design challenge question, "How might we keep our baby goats safe?"

In January 2017, our 2nd grade teachers approached Joel because they were looking to develop a design-thinking project around the Common Core mathematical standards on 2–D and 3–D shapes (CCSS.Math.Content.2.G.A.1-3). Knowing that elementary students' interest in anything skyrockets when animals are involved, Joel and the teachers called our agricultural and environmental education department and connected with Jennifer Wise, our animal center coordinator. It happened to be kidding season for the goats in the center, and Jennifer noted an ongoing problem she had been encountering with baby goats.

Baby goats are dastardly little escape artists that can squeeze out of very small gaps in their pens. Like human children, goat kids are natural problem solvers, so no matter what she tried, Jennifer often found herself having to round up wayward, bleating baby goats separated from their herd. This was an obvious safety concern, and, as it turns out, a beautiful opportunity to engage students in an authentic design-thinking challenge.

As the project got underway, Joel explained to fellow elementary teachers and administrators that the 2nd graders would be using engineering and 4th grade mathematics to design 3–D structures to contain the baby goats at the barn. The most common response: "You have little 2nd graders doing what?" But the students quickly rose to the challenge, showing the adults that they are capable of applying sophisticated strategies when the project is interesting enough to them.

During the prototyping process, students used the results of group brainstorming sessions to create 2–D drawings that incorporated their best ideas. Student groups then turned their 2–D drawings into 3–D prototypes using inexpensive materials (such as toothpicks and marshmallows). This allowed them to troubleshoot design flaws before iterating and constructing their models using building materials.

To build those models, we decided to use PVC piping with dry-fit connections because it was age-appropriate and inexpensive. It also allowed students to pull apart the piping if necessary. The students chose orange construction netting as another material. The squares on the netting made for easy nonstandard units for measuring. Instead of counting by inches, students could count the number of squares across the construction netting, helping to build their number and measurement sense. The end products were fences measuring several feet high and a lower step-over barrier for the main gate, with zip-ties and strings to secure the PVC piping and construction netting together.

"I was amazed how one little structure on two pieces of paper could be created into a huge wall for the goats," commented Jay, a 2nd grade student. Through this experience, Jay quickly realized that design thinking doesn't take place in your head. It gains purchase out in the real world where it's visible. It's *design doing*.

GOat Pro

The biggest challenge wasn't in the creation of the prototypes (though most of them were bigger than the students themselves) or the application of content (some of which was 4th grade mathematics and even physics). Rather, the challenge was developing empathy for the end user: the baby goats. The students didn't necessarily have trouble identifying emotionally with the hairy escapees, but to really design a better way to contain the baby goats, the teachers needed to help the 2nd graders understand what it was like to *be* a baby goat.

One of the ways we sought to have the students develop greater empathy and gather user feedback was to mount a GoPro camera (fondly nicknamed GOat Pro) on the back of a baby goat to capture its perspective from inside the pen. The data from the camera was incorporated into students' reflection and feedback loop as they worked on their models. Interviews with our animal care coordinator also helped students identify where to place their prototypes in the goat pen.

Once the prototypes were installed, the students also wanted to gather data on how all the baby goats interacted with the prototypes over a longer period of time. To do this, students set up several time-lapse cameras to record the baby goats' activities. This way, if the baby goats were to escape, the students could better understand how their prototypes had failed, enabling them to iterate and design a better solution. The time-lapse footage captured more than 24 hours of activity and revealed a structural weakness in one of the prototypes. (A goat stood on top of the PVC piping, causing the fence to fail.) That marked the beginning of the students learning about the difference between static and dynamic load-bearing force on materials.

We sketched out how we would improve our designs with a greater focus on structural integrity (adding more crossbeams to create a stronger structure) and how to stop the goats from chewing on the strings (trimming them). We also discussed how we might measure the weight and force of a goat to ensure our designs could withstand that amount of force. Unfortunately, we could not make a new prototype of these iterations because our school year was ending, but we are discussing the possibility of working on this project this year. After all, complex problems are often not solved on the first attempt. However, students celebrated that we were able to contain the baby goats for more than 72 hours before they escaped. (View a video of the full project.)

Because of its exploratory and interdisciplinary nature, the project gave students a wealth of rich learning opportunities. By the end, they had learned about and successfully applied content related to area, perimeter, angles, 2–D and 3–D shapes, and nonstandard units; organism needs, predator-prey relationships, and static and dynamic load-bearing; and augmenting digital images, video editing, time-lapse video, and GoPro video. Additionally, adults intentionally addressed 21st-century and social-emotional learning skills during each design-thinking session, including how to be a good group member, work through frustration, communicate respectfully and effectively in both written and verbal form, and give and receive feedback.

What About the Tests?

To develop the skills necessary to apply rigorous and relevant content, we believe it's important that all students in grades K–12 engage in a design-thinking opportunity at least once during the school year. Not just gifted students or those who identify as STEM. All students. By the time a 1st grader becomes a high school senior, a student in our school will have engaged in at least 60 problem-based learning projects.

We're frequently asked how the school has made room for this STEAM-supported design thinking when we're still responsible for performance on state standardized assessments. We've found that this question derives from a false premise: *Either*you prepare your kids for the state test *or* you prepare kids to be 21st-century problem solvers. In fact, you can do both at the same time. Pennsylvania's standardized math and science assessment standards for grade 4 include verbs like *observe*, *identify*, *explain*, *use*, *make*, *apply*, *solve*, *develop*, *extend*, and *create*. Sound familiar? They should. They're all used routinely as learning targets in well-crafted, problem-based learning scenarios like design thinking.

We measure the success of infusing problem-based learning opportunities across the curriculum in multiple ways. We've observed students' increased abilities to "un-silo" their knowledge and use it across content areas without prompting. Students regularly employ greater perseverance in complex problem solving, application of scientific concepts, and critical thinking and can generate more creative solutions in the face of problem-based scenarios. These skills show on state testing, too. Our students score double to triple that of the state averages for equivalent demographics.

We're committed to maintaining a balance between rigorous content knowledge and the application of that knowledge. In today's fast-paced world, you aren't valued solely for what you know, but for what you can do with what you know, regardless of your age. High-value intellectual assets include the ability to effectively and efficiently collaborate and communicate, and to combine knowledge and skills in new and innovative ways to tackle challenging and novel problems. We aren't proposing a new curriculum. We're proposing a new approach to curriculum.

Consider the Next Generation Science Standards. These standards aren't curriculum, and they don't pretend to be. Instead, they provide a framework for uniting cross-cutting concepts, core disciplinary ideas, and performance expectations that describe what students should be able to *do* with what they have learned (NGSS Lead States, 2013). These performance expectations are built on the eight science and engineering practices (fig. 2).

Figure 2. Eight Science and Engineering Practices

1. Ask questions (for science) and define (for engineering).
2. Develop and use models.
3. Plan and carry out investigations.
4. Analyze and interpret data.
5. Use mathematics and computational thinking.
6. Construct explanations (for science) and design solutions (for engineering).

7. Engage in argument from evidence.
8. Obtain, evaluate, and communicate information.

Source: NGSS Lead States. (2013). *Next generation science standards: For states, by states.* Washington, D.C.: The National Academies Press.

According to Schwarz, Passmore, & Reiser (2017), students make sense of the natural and designed world by engaging in practices that are central to science and engineering. In other words, it is impossible to truly understand science and engineering content without engaging that content using the practices of science and engineering. It's like trying to understand and experience a peach without using your mouth or hands. One without the other will always be incomplete.

In essence, design thinking follows this same logic. It is a distillation of science and engineering practices; it transcends science and engineering. Students are isolated from access to higher levels of rigor and relevance when we don't allow them to experience content through collaborative, problem-based learning opportunities that design-thinking models can support.

How do we design learning opportunities so that students remain actively engaged even when they may struggle? We should consider how content standards translate into opportunities that are big enough for and relatable enough to kids to matter, but small enough for kids to tackle. To help students meet rigorous standards while also developing 21st-century competencies, we need to present them with rigorous challenges that require them to work together to apply content knowledge and skills and that empower them to influence the outcome.

References

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