VOICES FROM THE FIELD

getting intentional about STEM learning

by Michael MacEwan

In an afterschool space, desks are grouped in fours. In the center of each group is a seemingly random assortment of materials, including uncooked spaghetti, spiced gumdrops, and a small cardboard square. After a brief introduction to the activity, a staff member posts the challenge on the wall: Using only these materials and working together as a team, each group must build the tallest possible tower that can support a 20-ounce water bottle independently for 10 seconds.

Teams look at the materials, discuss the challenge, and brainstorm possible solutions. Then they begin to manipulate the materials. Through trial and error, they refine a solution until they feel confident it is ready to be tested.

I am describing a typical scene in the 21st Century Community Learning Center (21st CCLC) I used to direct. The team members are the fourth-graders my program served—but they could equally well be the staff leader and his counterparts, whose professional development included participating in this same activity before they led it.

As a program director, I worked to create a "culture of STEM" for both program participants and staff. Science, technology, engineering, and math (STEM) served as the central topic across all of our enrichment clubs. Almost every activity involved some aspect of STEM; everything we did was hands-on and inquiry based. We equipped staff to lead STEM activities using the same hands-on, inquiry-based approach. Most of the time, we integrated STEM with other content areas such as language arts. We thus had taken the first steps toward making STEM learning an intentional component of our program. The next step we might have taken was to use theme-based learning across the entire program.

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What Children Experienced

The community our program served was an urban New Jersey school district whose population was more than 90 percent Latino. We served only fourth-graders in all five of the district's elementary schools. As a direct result of the staff's hard work and commitment, program participants outscored their non-program peers on standardized tests in math, language arts, and science. Clear, definitive results showed that our methods were working.

Our young participants knew they were in a STEM-focused afterschool program. In retrospect, I don't know that they understood what that meant. At the time, I subscribed to the idea of "disguised learning"—hiding the educational value of program activities. I thought that participants would have fun while learning skills that would translate to other areas. Our goal was for participants to use critical-thinking and problem-solving skills to understand broad STEM concepts, rather than focusing on vocabulary and terminology. We therefore masked the content of activities. Though activities were STEM focused, we tended not to tell participants that they were learning engineering or physics or math.

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I now think we were doing a disservice to those youth. Even though my staff and I highlighted *that* the kids were learning, we didn't tell them *what* they were learning or how it fit into a larger picture. We could have drawn the connection for them, telling them that this fun activity in which they were engaged was actually helping them learn math, science, and language arts. This connection would demonstrate not only that they could "do science" or "do math," but also that they could have fun doing it.

Every enrichment club had its own STEM theme, though that theme did not carry over to other clubs. For example, in the Sports and Math club, youth participated in physical activities and solved related math problems. They might shoot a basketball from various spots on the court and calculate the average number of shots made and missed and the probability that a shooter would make or miss a shot from each location. They might also learn to calculate baseball or softball statistics or explore the physics behind how soccer players can "bend it" like David Beckham. To integrate their STEM sports learning with other curriculum areas, we had participants keep detailed journals including written descriptions of each activity, the math to support the activity, drawing and sketches to recreate each activity, and graphs of their data.

How Staff Were Equipped

Professional development is the key to developing high-quality STEM programming. The biggest obstacle to implementing STEM learning is not cost, but staff members' fear of leading STEM activities. Staffers do not need a STEM background to lead STEM activities; exposure to STEM through professional development will lead to comfort, making concepts less foreign and teaching the staff to reason through problems the same way we hope the kids will. Professional development for OST should strike a balance between teaching content and pedagogy skills while modeling best practices to engage youth.

Professional development thus looks almost exactly the same as the activities staff members will ultimately lead with kids. When I led STEM professional development, staff members would come into the training space and wonder what we were up to that day. I'd give the materials and the challenge and ask them to come up with their solutions. I modeled my interactions with them as I expected them to interact with the youth. The only difference was that, with the staff, I would stop to interject teaching tips, for example, highlighting where children might struggle and offering suggestions to ease their frustration. When staff do activities in professional development before they attempt them with kids, they learn to anticipate possible problems. We talk about strategies to engage all children and ways to alter the challenge to ensure that everyone, regardless of abilities, can complete the task.

In the spaghetti tower challenge, groups encounter many obstacles before they start to show success. Teams figure out fairly quickly that they need to use the gumdrops as connectors for the spaghetti. The first obstacle is that the spaghetti breaks pretty easily when they try to push it into the gumdrops. Once groups understand the limitations of the spaghetti, they can build taller towers. With height come additional obstacles: Usually the towers start to twist or lean. Groups overcome this problem by adding cross-supports or a "kickstand." Then they find that the tower twists because of the weight of the gumdrops. Eventually someone figures out that the gumdrops do not have to remain whole; pieces can be torn off to bind the spaghetti, thus reducing the weight as the height increases.

Groups will inevitably discover loopholes. For example, the last time I led this activity with adults, I had a particularly creative (and slightly theatrical) group call me over to their table, quickly pour the water from their bottle into a travel coffee mug, and then place the empty bottle on top of their tower with a flourish, pointing out that I had never specified that the bottle be full of water. They were absolutely correct, but in the spirit of the challenge, I had them try it with a full bottle— and they were successful anyway. A key teaching tip I always leave adults with is that kids are masterful at finding these loopholes.

At the conclusion of the spaghetti activity, we discuss the challenge, the obstacles, and ways leaders can help groups find solutions. We also discuss the content areas included in the activity, as well as other topics that can be linked to it. It is easy to see the connection to engineering and math, but links to architecture and language arts may not be as obvious. For architecture, staff could lead a discussion about how some structures have to look a certain way because of their function or the materials with which they are constructed. To incorporate language arts, I would have the young people write a tower-building instruction manual with step-by-step instructions, illustrations, and a troubleshooting guide.

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Leading professional development in this way has many advantages. Staff members gain many of the same benefits the children gain from these experiences. Working in small groups allows staffers to bond with their peers. They learn that problems sometimes have multiple solutions. Having done the activity themselves, they are able to better assist children who are struggling and have a better idea of what the results can be. These exercises also reinforce staffers' confidence in their ability to lead activities, fostering the belief that they can "do STEM" with children.

Ultimately we want both staff and participants to see that STEM is not some group of isolated subjects but a common factor in many activities they already enjoy. STEM needn't be intimidating. We all do math and science every day without giving it any thought. While driving your car, you are continually doing math and physics while going from point A to point B.

How It Could Be Better

As illustrated in the spaghetti tower challenge, staff in my program worked to show the connections between STEM and other content areas. However, we could have done more to bridge all content areas by implementing a fully integrated program-wide theme encompassing all enrichment activities.

For example, the theme of "technology through the ages" could highlight how every generation invents or improves solutions to meet the challenges of its time. An OST program could allow participants to choose a technology used in an ancient civilization and then find modern equivalents, or participants could track the evolution of a single technology, like the telephone. Tracking a technology through the cultures that used it infuses social studies into the theme. Engineering can be included by having students determine how the technologies were created, how they worked, and how they were improved over time. Math questions could be interspersed throughout the activities; for instance, participants could research and graph the number of home telephones in the U.S. for each decade from invention through the present. Additional math problems could support what the students have discovered. Literacy and language arts skills should be included in all activities relating to the theme. Participants could maintain data logs of their research or write newspaper articles announcing the technologies as they are introduced throughout history, outlining the context, the problem the technology solves, and how it was created.

This approach counteracts the current tendency to conduct education in silos, teaching content areas like science and language arts separately. Children are not trained to approach a problem as a whole, considering all of its parts. Instead, they have been taught to categorize activities by content area: "Oh, this is math." Depending on their perception of math, this categorization leads some children to embrace the activity, while others shut down. A child who struggles in math is likely to do better if numbers are presented in a context that has relevance to him or her. This kind of relevance is where theme-based curriculum excels. The theme-based approach can have a profound effect at any grade level.

Weaving STEM through all program activities is one step toward offering intentional, high-quality STEM learning after school. Taking the next step to create a program-wide theme-based curriculum would optimize the "culture of STEM" and, at the same time, foster a culture of holistic learning for the whole child. Such a program would help to produce well-rounded, thoughtful youth; the effects would carry over to participants' school and home lives.