Leveraging Agricultural Technologies to Facilitate Integrated STEM Collaboration

by Hui-Hui Wang, Bryanna Nelson, Neil Knobloch, Petrus Langenhoven, Yaohua "Betty" Feng, and Roger Tormoehlen

Have you been hearing about STEM education but have been puzzled by the acronyms STEM (or STEAM)? STEM is an abbreviation that stands for science, technology, engineering, and mathematics. Some teachers add Art into the acronym to become STEAM. As for others, like agriculture teachers, the "A," stands for Agriculture (NRC, 2009). STEM education in K-12 should be taught in an integrated way because STEM subjects don't exist in isolation in the real world. For example, 45 states have formally included engineering design as part of their state science academic standards. This educational movement indicates when teachers teach science, they should also teach engineering design concepts. Integrated STEM (iSTEM) is "a holistic approach that links disciplines so learning becomes connected, focused, meaningful, and relevant to learners (Smith and Karr-Kidwell, 2000, p. 22)." Using an iSTEM approach to teach STEM subjects has been identified to bring real-world, authentic design problems to K-12 classrooms. Integrated STEM instructions should incorporate essential concepts and align with important skills, such as systems thinking, creativity, collaboration, and communication (Wang & Knobloch, 2018; Wang et al., 2020) when having students apply their STEM knowledge and skills to solve a real-world design problem.

Agriculture isn't always at the top of the list in K-12 education when it comes to talking about STEM education. However, agriculture is an excellent option for teachers to engage student learning by adapting iSTEM instructions and facilitate interdisciplinary collaboration. Utilizing agriculture, as a context, provides authentic and relevant iSTEM real-world problems. Moreover, agriculture is a form of technology to adapt the natural world to meet human needs (ITEA, 2007). Technology means the act of making or crafting (ITEA, 2007), which is evident in how agriculturalists capture energy from the sun to generate products people can use for food, clothing, shelter, and biofuels. Students apply STEM knowledge and skills to solve 21st-century agriculture grand challenges that have impacts on their everyday lives. Also, agricultural technologies can serve as a "driver" for STEM interdisciplinary collaborations (Vallera & Bodzin, 2020; Wang et al., 2020). In this article, we describe cases in which STEM and agriculture teachers leverage agricultural technologies, e.g., hydroponics, agricultural robotics, and food technology, for iSTEM instruction, and facilitate interdisciplinary collaboration to help students make interdisciplinary connections. Additionally, we provide collaboration strategies to shine a light on how agricultural educators can serve as experts on new and innovative technologies in agriculture, food, and natural resources, and lead the integrated STEM collaboration at the end of this article.

Hydroponics Example

Hydroponics is a complex system, which provides accessible entry points for integrated STEM learning. To create and maintain a healthy and productive hydroponic system, it involves concepts from STEM subjects, such as photosynthesis, energy conservation, plant nutrients and solutions, and so on. A mathematics and an agriculture teacher worked together as an interdisciplinary team to co-develop integrated STEM lessons and instruction by using hydroponics at Westville High School in LaPorte, Indiana. The mathematics topics included measurement and proportional reasoning and exponential functions and summarizing statistical data. The agricultural topics included plant physiology, fertilizers, and hydroponics. The two teachers mainly used an 11th to 12th grade Math Ready class as their integrated STEM collaboration instruction site. The design challenge for these students was to modify an existing 500-gallon fish tank in the Agriculture classroom to become a hydroponics system. Before the lesson, the students had an opportunity to visit the agriculture teacher to see the fish tank and ask questions. After that, the mathematics teacher taught scale drawing, miniature model construction, budget proposal, germinating seeds, and plant experiments. In total, she taught five lessons to her Math Ready students. In her class, five students were in both Math Ready and Agriculture classes. These students worked on modifying the actual fish tank in the Agriculture classroom based on the miniature model and budget proposal they had developed in the Math Ready classroom. These students also acted as student teachers, who helped the mathematics teacher teach the concept of growing food with hydroponics, and collected and shared data with their peers, so students who only took the Math Ready class could utilize these data in the Math Ready classroom.

AgRobotics Example

Because Ag Robotics is applicable to many areas of agriculture, it's not surprising there are numerous ways to integrate it. As much as agriculture teachers would like to have an autonomous tractor or robotic weed puller for schools and home farms, large scale robotics are difficult to access for classroom use. To apply the same principles, and start where the experts do, small-scale table bots are used for modeling and development for large scale robotics. A biology, technology, and agriculture teacher worked as an interdisciplinary team to co-develop STEM lessons utilizing ag robotics at Frontier High School in Chalmers, Indiana. The team developed lessons related to conservation and resource management that were related to a freshman biology class. Students received specialized instruction each week from one of the three teachers relating to the conservation of resources, animal and land surveying using technology, and finally, planning and developing a robot. The robot was designed to be autonomous and follow a specific path to retrieve wildlife cameras from a designated area and return them.

Food Safety Example

Food Safety and Science encompasses a large number of topics, including food product development, farm and factory practices, consumer marketing and relations, and even home cooking practices. Food safety goes beyond making sure you wash your hands (despite being a relevant topic this year with the COVID-19 virus) and avoid cross-contamination. Three teachers, two agriculture and one science teacher from Tri-County High School in Wolcott, Indiana, collaborated to develop STEM lessons related to food safety and science. They implemented them in their classrooms, resulting in three different classrooms receiving similar lessons and integration. Topics varied slightly between the classrooms, but teachers focused on proper handwashing, how germs grow and spread, preventing foodborne illness, and how to create a food safety plan to prevent foodborne illness. The classes focused on creating a Hazard Analysis Critical Control Point plan (HACCP) for a product of their choosing. Students worked through creating a HACCP plan just like industry experts do.

Tips for Collaboration Strategies

The authors worked with cross-disciplinary teams of teachers at LaPorte, Frontier, and Tri-County High Schools. Based on the interactions with these teams, we highlighted several tips to help promote teacher collaboration and iSTEM learning across different and complementary content areas.

1. Provide teachers and their students a project to engage in hands-on learning and practice iSTEM skills.
2. Provide teachers professional development training so they can discuss ways their content areas complement each other by engaging collaboratively around a common project.
3. Encourage and create structures for teachers to communicate with each other. In doing so, teachers can leverage their complementary strengths to contribute to interdisciplinary student learning around a collaborative iSTEM project.
4. Focus on solving a problem driven by the iSTEM project that encourages cross-disciplinary communications and collaboration.
5. Connect problem-solving and iSTEM learning to support content learning. Encourage teachers and students to see the interplay among problem-solving, context, content areas, and cross-disciplinary connections.
6. Highlight the ways of knowing (aka, expert thinking) of scientists, technologists, engineers, mathematicians, and agriculturalists. For example, scientists use inquiry to solve problems; technologists and engineers use design to solve problems; mathematicians use modeling; and, agriculturalists use systems thinking.
7. Consider how each content area teacher and their students contribute to interdisciplinary and collaborative iSTEM learning. Wang and Knobloch's (2018) framework outlines a rubric teachers can use to focus on defining, designing, implementing,

and evaluating iSTEM learning experiences.

8. Encourage teachers to help students apply knowledge through solving problems based on real-world settings. Encourage teachers to share which outcomes students developed, especially the essential skills needed in the 21st century.

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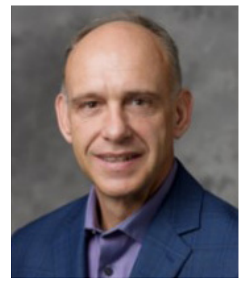

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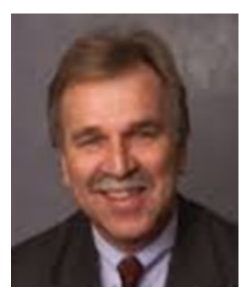

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