Helping 4-H Members Find STEM in Plain Sight: Intentional STEM Infusion (ISI) for 4-H Project Leaders

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4-H volunteers with increased awareness of their role in fostering STEM education and STEM literacy can be a valuable resource in preparing 4-H youth with STEM-ready professional skills. Keeping in mind eight questions can help 4-H project leaders center 4-H member learning and improve 4-H member STEM literacy.

4-H volunteers can add the ISI approach to the 'Do. Reflect. Apply' strategy to design 4-H project activities within nontraditionally STEM-related 4-H projects for members to develop STEM literacy. The ISI approach puts both the 4-H volunteer and member in the role of learner. Volunteers and members can be assisting each other in building STEM skills into their current projects.

Volunteer Guiding Questions to Implement Intentional STEM Infusion (ISI)

Guiding Questions	Application
1. Is the project activity problem- or activity-based?	Ensure that STEM problems and activities are identifiable in the Project Work Explanation
2. Are there connections between project work and STEM topics?	Science, Technology, Engineering or Math are necessary to help reach the activity and project Goals
3. Is the STEM that youth are going to be asked to do connected to the project goal?	Materials, Tools, and Activities are Selected from Real-Life Application
4. Are 4-H members asked to use the resources authentically?	Identify aspects of the activity that Would Expose 4-H Members' Gaps in Knowledge, resources help bridge those gaps
5. Are 4-H members encouraged to seek out more information related to STEM topics in the project?	You Can Recognize Opportunities During Project Work to Foster Critical Thinking and further exploration
6. Are activities offered with multiple methods or variations for ability levels?	Activities are flexible enough to cover different abilities levels and situations
7. Are 4-H members encouraged to ask critical questions about the project and STEM?	Prepare opportunities for questioning and reflection throughout activity
8. Are 4-H members asked to relate learning to their own non-4-H project experiences?	Prepare Opportunities to Reflect on the Connections Between STEM Concepts Applied During Project Work and Real Life

STEM Problems and Activities are Identifiable in the Project Work Explanation

4-H members often participate in projects because they have a genuine interest in the project or topic, this is called their spark (Arnold, 2018). The real-world, direct application of skills and knowledge that are characteristic of 4-H provide a natural outlet to identify problems that need solutions. This provides a source of activities that require members to actively engage, mentally and/or physically, with the context of the project. As problems are addressed and activities have members "doing," members are required to problem solve or think critically as they work to create, design, or apply their skills and knowledge.

Volunteer actions. The 4-H volunteer should highlight when youth are doing science, technology, engineering, and math while working to solve problems and applying their knowledge during project activities. By highlighting this use of STEM content, the volunteer makes it obvious to members that STEM is present in the identified problem or well-designed activity. Making the connection between how STEM content is applied in the context of a real-world problem puts the volunteer in the position of facilitating to develop members' STEM literacy.

Member experience. In application, if you were leading a Sewing Project you might work with a 4-H member that picked a pattern that was not the right size. The member has an authentic problem to address and one that will need STEM skills to solve. Engaging with STEM concepts, the member will apply his or her knowledge to design and resize the pattern utilizing math and engineering skills. With the assistance of volunteers, the member will be able to recognize, engage with, and then acknowledge their developing STEM literacy.

Science, Technology, Engineering or Math Help Reach the Activity and Project Goals

Identifying STEM concepts that work alongside activities that will meet the goals of the project brings authenticity to the work members are doing. The authenticity makes the connection between the STEM concepts and the work related to the project obvious and relevant to youth. It is important to stay focused on the project's goals when identifying STEM concepts. If the science, technology, engineering, or math is not naturally present, then it should not be forced. However, STEM can organically be included in various project types.

Volunteer actions. Initially, STEM components may not be obvious to 4-H volunteers. These follow-up questions will help volunteers identify the application of STEM in their projects:

- Can youth make changes to make the work easier?
- Can youth use science concepts in the project?
- Can youth use tools or technology?
- Can youth use math in the project?
- Can youth design something?

For example, if you were facilitating a bread project, you could ask members to disassemble the kitchen stove to learn about how the stove works. However, this activity, while STEM-related, does not contribute to the project goal and therefore is not a recommended strategy. Instead, volunteers could plan to lead youth in using varied temperatures of water to investigate the differences in how bread rises so 4-H members can better understand what affects the reaction of the yeast in the bread making process.

Member experience. In application, if you were leading a Bread Making project you might ask members to: research where chemistry exists in the bread-making process, or how technology influences the bread making process, or how engineering can improve the bread making process. As a result of their research online or at the library, youth will identify that reactions between the yeast and sugar cause the dough to rise. Asking members to double the recipe requires accurate math. Then asking the question, “Can youth make changes to make the work easier?” could facilitate the 4-H members’ consideration of alternative cooking methods.

Materials, Tools, and Activities are Selected from Real-Life Application

Using materials, tools, and other resources that are directly related to the project and that members would use in their own lives creates authenticity in the activity. When members gain experience with real-life resources in activities that are directly related to the project goals, the authenticity of the experience helps make connections to what is learned and to the member’s own life. These connections help build confidence in using the tools, materials, and knowledge in new situations. The use of tools and manipulation of materials is a hands-on application of engineering and technology.

Volunteer activities. Volunteers should gather the tools of the trade, provide members with real, unaltered materials that relate to the project, and plan activities that use those resources. Returning to the bread project, the volunteer should provide members with the ingredients in their original packaging that can be purchased from a local grocery store. Volunteers should plan activities that require members to use the ingredients, read the labels, and possibly try alternative mixing methods to determine best results.

Member experience. In application, members should be experiencing the authentic tools and materials in their project work. Instead of simplifying activities and removing youth interactions with the tools, make time to train the youth to use the equipment necessary. The tools used and the project activities will need to be matched to the age of the youth engaged in the activity. In the effort of ensuring STEM education, it is important to keep youth interacting with the tools. But to ensure youth safety, STEM-infused lessons will need to be adapted to the age of the youth, including potentially greater supervision, training, or selecting projects that utilize appropriate tools. For example, in a woodworking project, youth under a certain age and experience should not be using many power tools on their own. However, youth are not able to build their experience with science, technology, engineering, and math without being around, involved with, and helping complete the work that is being done. They can become familiar with technology by observing appropriately modeled use of the equipment by older and more experienced youth and adults.

Identify Aspects of the Activity that Would Expose 4-H Members' Gaps in Knowledge

Through open-ended and exploratory questioning, volunteers will be able to determine what members may be familiar with and what may challenge them. This opens the door to using members' prior knowledge to get project activities off the ground in interesting ways. Activating prior knowledge helps members make stronger connections with the new information they learn in the activities, thus making the transfer of new and old knowledge more likely in new situations (Evans, 2002; Linn et al., 2003; Ricketts & Rudd, 2002). Being aware of members' gaps in knowledge will prepare volunteers to plan activities that will provide members with opportunities to think critically and ask questions to learn more.

Volunteer actions. Identifying gaps in members' knowledge gives volunteers the opportunity to think critically and to seek out the deeper components of the projects they facilitate. Deeper components are the STEM aspects that are under the surface of the activity– they are the underpinning concepts that both the volunteer and the member may not fully understand. However, if the volunteer and member explore the projects STEM-based concepts together, then there is an opportunity for learning to occur.

A volunteer should ask members what they know about the project and with what they are not familiar. As a volunteer reveals this information, they should ask follow-up questions about members' knowledge; these gaps can provide a roadmap for designing activities that will address these deeper components that will challenge members, and in some cases, even the volunteers. The volunteer is not expected to be the STEM expert; thus, volunteers and members learning together can be an enriching experience for all. For example, turning the tables to have members research the chemistry of yeast and sugar in the bread-making process provides a stronger STEM-literacy building opportunity for members even if the volunteer is not familiar with the process.

Member experience. In application, if you were facilitating an archery shooting sports project meeting you might ask members: what will happen to the path of the arrow when the member changes the angle of the arrow's trajectory by dropping or raising the arrow tip or how the resistance of the bowstring changes the velocity of the arrow. As members provide answers to this question, the volunteer will have fodder for follow-up activities that will help the volunteer design activities to investigate the path of an arrow. Your questions will pique members' interest and draw attention to what they already know about shooting sports and how the member is applying their prior knowledge to the situation.

You Can Recognize Opportunities During Project Work to Foster Critical Thinking

Critical thinking and problem solving become habits of mind through practice and application. The 4-H project provides an interesting context for members to consider many STEM aspects related to the project. Volunteers can design opportunities that challenge members to think more about what they already know about the project topic. In these opportunities, members need to think about how to apply their prior knowledge and experience, consider alternatives, or investigate new ideas or methods. Working in the context of the project provides a real situation for members to apply their thinking and see the consequences of their decisions. The immediate feedback may inspire members to ask their own questions and seek out more information they find interesting, prompting youth to take ownership of their growing knowledge.

Volunteer actions. Volunteers should use critical questions as a way to help youth find the gaps in their knowledge. Volunteers should also create space for youth to ask their own critical questions: Why did this work this way? How can this be better? When I do this, what else could happen? Using these questions to design activities that are related to the project, volunteers begin to create a dynamic experience to build members' critical thinking skills as they work within the context of a project that members find intrinsically interesting.

Member experience. During this critical thinking process, youth monitor their own learning and self-evaluate their project work as well as their understanding of STEM concepts. As a result, this leads to an increase in STEM literacy. Revisiting the previous archery project, the volunteer has designed an activity that asks members to investigate how an arrow travels from different distances and how the set-up trajectory changes that path. Members approach this activity as an investigation by collecting data, making conjectures, and drawing conclusions, thus exercising the scientific method as they continue to learn and hone archery skills. Through the process, members are required to consider what happens as they shoot, why changes in their aim cause different results, and how they can justify their thinking about those questions. The members are asking good questions and thinking critically as they work through the volunteer-designed activity.

Prepare Opportunities to Reflect on the Connections Between STEM Concepts Applied During Project Work and Real Life

4-H project work is an integrated learning environment where youth can explore STEM topics that apply to the real world. Project work is chosen by youth and completed by youth, providing an authentically motivated context for applying STEM. This youth motivation allows an opportunity for youth to apply formally learned academic STEM knowledge to these activities. However, this application may not occur without first being facilitated by the volunteer. At the same time, new concepts learned from 4-H project work should be connected to academic knowledge and non-4-H project experiences. When youth can take STEM concepts and apply them in unique situations, the goal of STEM education—STEM literacy—has been achieved.

Volunteer actions. A volunteer can promote reflection in many ways. Simply concluding an activity with the simple question, *"What did you learn today?"* may be enough to promote members to reflect on what they learned. Preparing activities that build in opportunities for members to talk to one another about their experience or bringing in new or young members as a recruiting session with the current project participants also can be effective ways for collaboration and reflection.

Member experience. At the end of the activity, meeting, or project you are the one who should intentionally create the opportunity for members to talk about their experience, what they learned, how they will use that knowledge and skill in the future, how what they learned could help others, or when they will be able to apply what they learned in new ways. Invitations to present new ideas or showcase what was learned provide members with an outlet to reflect on their learning and begin to realize the application and relevance of their new knowledge – thus realizing their STEM literacy.

The ISI Approach is A Tool

The ISI approach is not a magic bullet that will make you, or your 4-H members a complete Science, Technology, Engineering, Math whiz. However, the more you think about how you can identify STEM for your 4-H members and start looking for the connections, the more STEM literacy 4-H members will develop.

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