K-STATE Research and Extension

SCIENCE & ENGINEERING PRACTICES

The Next Generation Science Standards (NGSS) lay out a framework or guide to developing youth competencies in science and engineering by having youth engage in practices of inquiry and discussion while participating in science or engineering related activities. Many existing 4-H projects have a multitude of science and engineering components, providing an opportunity for 4-H members to improve their skills in the science and engineering practices. As 4-H volunteers and parents, you can help 4-H members improve their skills by highlighting and focusing on one, or several, or all of the science and engineering practices in the project(s) they are working on.

WHAT IS SCIENCE?

Science is the study of how the world (or the universe) works. It is a systematic way of acquiring knowledge to understand how things work; it can be through observation or experimentation.

WHAT IS ENGINEERING?

Engineering is engaging in a systematic way to design a solution to a human problem.

EIGHT PRACTICES OF SCIENCE AND ENGINEERING

You will notice that many of these practices overlap and connect to each other. A young person does not have to engage in all eight practices in a 4-H project to improve their skills in science and engineering practices. However, the energy and enthusiasm youth have for their own project work (as oppose to doing assigned work) presents an opportunity for 4-H adults to encourage youth into areas that they would not typically aim for, providing them with skills and confidence in those areas.

1. ASKING QUESTIONS AND DEFINING PROBLEMS

- ✓ Science – asking questions that lead to inquiry with the goal of explaining how the world/ universe/phenomena work; we search for results that have quantifiable answers
- ✓ Engineering – defining a human problem that leads to designing a solution; there is not one correct solution so in defining the problem we must also know the constraints or limitations

2. DEVELOPING AND USING MODELS

- ✓ Science- models are used to represent a system, or part of a system, to assist in developing questions and explanations
- ✓ Engineering – models can be used to analyze, study, or test a system to see where flaws may develop
- ✓ Models can be drawings, analogies or physical replicas and can be used to develop predictions or describe phenomena.

3. PLANNING AND CARRYING OUT INVESTIGATIONS

Whether the project is science or engineering related, youth should follow these steps (not unlike the steps in completing a 4-H project):

- ✓ State the goal of the investigation
- ✓ Predict the outcomes
- ✓ Plan a course of action to provide the best evidence to support conclusions

In controlled experiments, youth should be able to identify the independent variable (the variable they are changing) and the dependent variable (the variable that is being measured). Youth should also consider the sample size (when you increase the data, you get better data).

4. ANALYZING AND INTERPRETING DATA

Data can be analyzed by organizing it a manner that shows patterns or relationships (notes, tables, graphs)

- ✓ Science: Data is interpreted / analyzed by comparing and evaluating it as evidence to support or refute predictions or theories
- ✓ Engineering: Data is interpreted / analyzed to determine if the solution is optimal, or to suggest different designs or solutions to optimize (and then retest those new suggestions)

The limitations of the data analysis should be discussed (consider things such as causation versus correlation).

5. USING MATHEMATICS AND COMPUTATIONAL THINKING

Mathematics is used to represent variables and establish relationships (for example – area, volume, weight, time, ratio, percentage). These mathematical relationships can be used to describe, support or refute predictions, theories, phenomena or solutions.

Computational thinking involves strategies for organizing and searching data and using or creating simulations.

6. CONSTRUCTING EXPLANATIONS AND DESIGNING SOLUTIONS

- ✓ Science: goal is to create explanations for the way the world (or universe) works using their own discoveries as well as other's discoveries
- ✓ Engineering: goal is to solve problems by designing, testing, evaluating, and improving solutions based on identified criteria and constraints

7. ENGAGING IN ARGUMENT FROM EVIDENCE

Goal is to construct arguments, critique arguments, and understand importance of peer review in science. This practice relates to critical thinking by being able to explain and argue for the explanations constructed or the solution designed and defend that explanation with the interpretation of data (their own and others).

- ✓ Science: identifies the best explanation for how the world (or universe) works

- ✓ Engineering: identifies the best solution given the constraints and criteria

"Scientific argumentation" is a process for reaching agreements about explanations and design solutions. It is based on evidence and reasoning that lead to acceptance by the community.

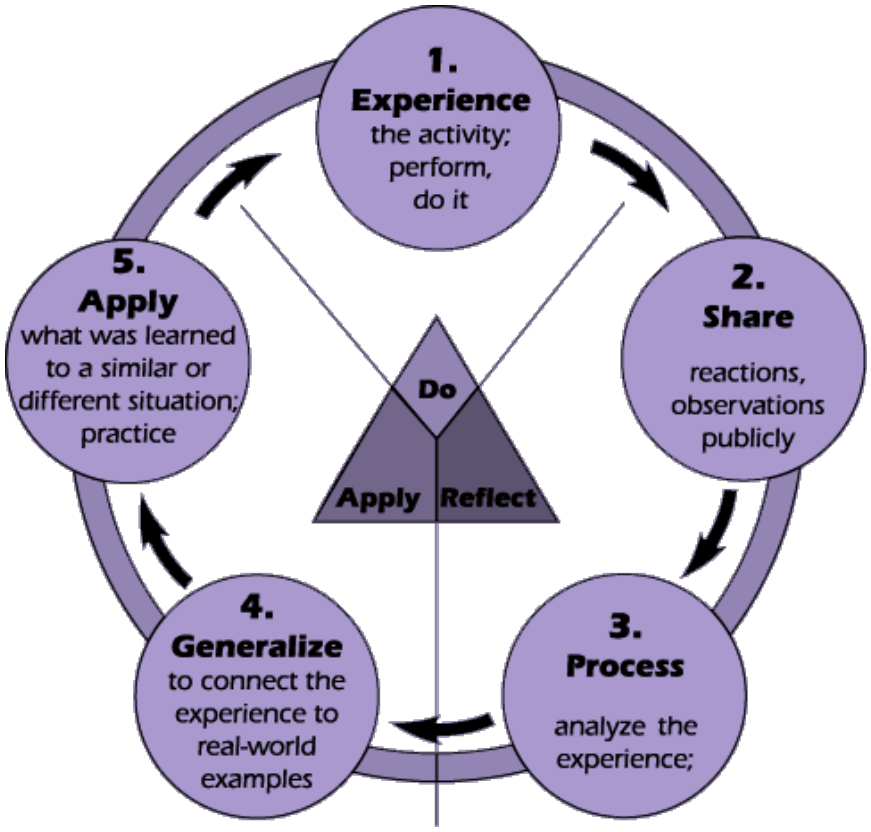
8. OBTAINING, EVALUATING, AND COMMUNICATING INFORMATION

This practice also relates to critical thinking by developing abilities to read reports and identify important ideas, identify sources of error or flaws in designs, distinguish observations from inferences, and differentiate claims and evidence.

Also included in this practice is the ability to effectively communicate information and an understanding of the data, evidence, and explanation or solution.

Peer review of science explanations and engineering solutions is a fundamental component of science and engineering. Efforts to encourage in this practice develop competencies in reading and understanding scientific and technical text as well as critical thinking.

One way to remind youth of the science and engineering practices they engaged in is by asking questions that lead them to discuss that practice during reflection and application.



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