

# STEM PATHWAYS

Engagement + Problem Solving = Learning



SCIENCE • TECHNOLOGY • ENGINEERING • MATHEMATICS



<http://www.ohio4h.org/STEM-Pathways>

# Challenge Curriculum

*Inspiring young people to create and  
invent solutions to Real-World problems and  
explore STEM Careers*



Learn more and access videos at:

<http://www.ohio4h.org/statewide-programs/4-h-science/stem-pathways/challenges>



THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



# STEM PATHWAYS

Engagement + Problem Solving = Learning

- Twelve challenges focused on real-world problems centered around issues like food security, water quantity and quality, health and wellness, energy and the environment.
  - A Boost Against Arthritis • Ag Bot Harvest
  - Ag Bot Animal Handling • Corny Polymer Balls
  - Cookie Prospecting • Eggstraordinary Power
  - Glucose Detective • Hayswift Kick
  - Natural Glue • Please Just Contain It
  - Submarine Exploration • Watersheds at Work
- Youth work in teams to find a plausible solution using the engineering design process or scientific method.
- Teen or adult facilitators guide the learning process engaging young people with probing questions throughout the challenge experience.



Videos  
sponsored  
by an  
Ohio 4-H  
Foundation  
Grant.

- A web-based video for each challenge frames the problem, shares career and expert information and showcases the challenge in action with youth.



*"...provide hands-on, problem-based and inquiry learning to support the "inspire to prepare" approach for propelling young people on a STEM career path!"*

**There is always more than one solution to the challenge!**



*"How do you think our design worked?"  
"I think we need to make some modifications, these eggs cracked during our testing."*

For More Information visit  
<http://www.ohio4h.org/STEM-Pathways> or  
contact your local OSU Extension office.



**THE OHIO STATE UNIVERSITY**

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES





# STEM PATHWAYS

## Getting Started with STEM Pathways Challenges:

1. Review the step-by-step explanation of how each challenge lesson is formatted using the sample challenge to follow.
2. Choose one of the STEM Pathways Challenges and visit [go.osu.edu/4HSTEMpathways](http://go.osu.edu/4HSTEMpathways) to view one of the YouTube Instructional videos. These videos are meant to give the facilitator more background information on the topic, help provide connections to careers and allow them to see how the challenge is facilitated with a group of youth.
3. Review the similarities and differences between the scientific method and the engineering design process. You will see quickly that both involve a team to define the issue, brainstorming solutions, create a prototype to test, make observations, retest and communicate results.
4. These design challenges can be used as stand alone lessons or can be used as a series of experiential and inquiry-based learning experiences. Challenges have been designed for use in both informal and formal teaching settings.
5. As a STEM Pathways Challenge facilitator, the goal is to be the “guide on the side”, not the “sage on the stage”. Your roles include:
  - Set up the challenge area with materials and supplies based on the number of youth and groups you will be facilitating;
  - Provide the teams with a copy of the first page of the challenge or stating the problem and challenge to the teams;
  - Have teams discuss the “Things to Consider” questions to get started in brainstorming solutions or creating their hypothesis to test.
  - Use the “Use the Engage the Learner” questions while teams are coming up with solutions to build to spur additional thought and consideration.
  - Once teams have built and tested their engineering design solution or tested their hypothesis, help them process their observations and conclusions. Be careful to not point out what worked? and what didn't?! Rather ask them to share what worked? and what didn't?



## STEM Pathways You Tube Videos...

1. Will help you be successful in facilitating youth in STEM Challenges;
2. If shown to participants, will help them understand the real-world problem and careers working to help solve such issues;
3. Help spark interest in STEM careers;
4. Reinforce that there is more than one solution to any problem and that every solution can be improved upon.

## STEM Careers...

1. Have youth brainstorm careers connected to the challenge.
2. Use the STEM Career Path information and Career Focus factsheet to help engage youth in exploring STEM careers.

## Evaluating STEM Pathways Challenge Learning...

1. Depending upon the delivery method you are using to facilitate STEM Pathways Challenges, choose one of the evaluation instruments to collect participant feedback.
2. Both instruments provide an avenue to gauge knowledge, attitudes, skills and behaviors of participants related to STEM concepts.
3. Complete the facilitator evaluation instrument to share your experiences as well.

## Questions and to Submit Evaluations:

Contact: STEM Pathways Program Leader,  
Patty House, [house.18@osu.edu](mailto:house.18@osu.edu); OSU Ext. Clark  
County 3130 East Main St., Springfield, OH 45505



# STEM PATHWAYS

Engagement + Problem Solving = Learning

**STEM Pathways Challenges** are designed to engage the learner in using the scientific method or the engineering design process to solve a real-world problem. This chart shows the similarities of engaging learners in problem solving that leads to learning.

The Scientific Method	The Engineering Design Process
State Your Question	Define the Problem
Do Background Research	Do Background Research
Formulate Hypothesis & Identify Variables	Specify Requirements
Design Experiment & Establish Procedures	Brainstorm Solutions & Develop Plan for the Best One
Do Experiment To Test Hypothesis	Build a Prototype
Analyze Results & Draw Conclusions	Test, Observe & Redesign
Communicate Results	Communicate Results



**THE OHIO STATE UNIVERSITY**  
COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



# STEM PATHWAYS

## Sample Challenge

**PROBLEM:** States the challenge that the participants need to find a plausible solution.

### FIND A SOLUTION:

Focuses the more in-depth scientific method and engineering design process into four components.

- **ASK:** brainstorm possible ideas or come up with hypothesize
- **PLAN:** Decide on the best idea or decide on your variables
- **CREATE/TEST:** Build your prototype to test or conduct your experiment.
- **IMPROVE:** Make observations, review and share your results and make changes to retest.

OHIO STATE UNIVERSITY EXTENSION

STEM PATHWAYS

Ag Bot Animal STEM Challenge!

**The Problem**

Greg's sons have gone off to college and at age 60 he faces working his livestock alone. He needs your help to design a cost effective, safe and efficient livestock handling system. Put your engineering skills to the test to help Greg move his ag-bots from the corral into the barn?

**Find a Solution**

ASK: What are some possible ideas?  
 PLAN: Test out your Ideas  
 CREATE: Put your ideas to the test  
 IMPROVE: Review results and make

**Things to Consider**

1. How does your animal (Ag Bot) move?
2. What handling obstacles will your design need to take into account?
3. How will design materials chosen impact costs, animal behavior and labor?

**Choose Your Design Materials**

Tape Strip - \$50/each  
 Straw - \$250/each  
 Stiff Plastic - \$500/each  
 PVC Pipe - \$1500/each  
 Cardstock Strip - \$150/each  
 Popsicle Sticks - \$300/each  
 Tubing - \$1000/each  
 PVC Connector - \$750/each

**SAFETY ALERT:**  
 Scissors are sharp! Please be careful when cutting!

**THE OHIO STATE UNIVERSITY**  
 COLLEGE OF FOOD, AGRICULTURAL,  
 AND ENVIRONMENTAL SCIENCES

CFAES provides research and related educational programs to clientele on a nondiscriminatory basis. For more information: [go.osu.edu/cfaesdiversity](http://go.osu.edu/cfaesdiversity).

**PHOTO:**  
A visual connection for the participant and the facilitator!

**CHOOSE YOUR DESIGN MATERIALS:**  
This is a list of materials that participants will use to build their prototype or use as variables for their experiment.

**SAFETY ALERT:**  
A reminder for participants and facilitators to keep everyone safe. Please cover safety before beginning any challenge.

**THINGS TO CONSIDER:** These are the questions participants will see to spur discussion by the team to begin thinking about their approach to the problem and start the brainstorming.



**THE OHIO STATE UNIVERSITY**  
COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES





# STEM PATHWAYS

## Challenge Sample Facilitator Processing

### It's All About...

- Guiding the Process
- Engaging Learner Discovery

### ENGAGE THE LEARNER:

These are the questions to be used by the facilitator with the participants while they are building their models or prototypes or conducting their experiments for the first time. Questions are designed to inspire discussion and critical thinking rather than single responses or a single solution or approach.

OHIO STATE UNIVERSITY EXTENSION

**FACILITATOR PROCESSING**

## STEM PATHWAYS

### AgBot Animal STEM Challenge!

**TIME: 30-45 MINUTES**

**Materials and Supplies**

- Masking Tape
- Popsicle Sticks
- Straws
- Cardstock strips
- Stiff Plastic Sheet
- Tubing
- PVC Pipes
- PVC Connectors
- Timer
- Hexbugs (4-6)
- Calculator

**Design Space 4 x 4 ft. area**

- PVC pipe for perimeter to keep ag-bots on engineering surface
- Toy Barn Structure(s)
- Hex Bugs or Similar Micro-Robot (4 to 6)
- Stop Watch (time through design)

**SAFETY ALERT:** Scissors are sharp! Please be careful when cutting!

**Engage the Learner**

- How do engineers go about solving problems? (Refer to Engineering Process)
- How will time through the handling system impact handler safety and success of moving the herd?
- How does shape and texture of materials impact animal movement?
- How would approaching the design from the animal's viewpoint change your approach?

Refer to Career Focus Card for more details.

**Conclusions**

- What worked? What didn't? Knowing what you know, what changes will you make?
- If you could choose another material, what would it be?
- What might you do differently to improve your handling time by 25% or reduce costs by 25%?

Post who had the best time and most cost effective design to encourage friendly competition.

**STEM Career Path ... Ag Engineers**

- Who else might be involved? *Animal scientists, veterinarians, animal behaviorists, agriculture systems technologists, economists.*
- Who benefits? *Economic benefits to producer, higher quality products for the consumer, improved animal well-being*
- What other issues are agriculture engineers helping to solve? *Technology application to improve machinery & equipment, storage, processing, natural resources protection, alternative energy*

Refer to Career Focus Card for more details.

**THE OHIO STATE UNIVERSITY**  
COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES  
CFAES provides research and related educational programs to clientele on a nondiscriminatory basis.

### SET-UP:

Photo, materials supplies and design/experiment space are explained for easy set-up and clean up.

**SAFETY ALERT:**  
Another reminder

### STEM Career

**Path:** This section aids the facilitator to be able to incorporate discussion of careers connected to the challenge. More detailed information can be found on the Career Focus Card.

**OBSERVATIONS & CONCLUSIONS:** These are processing questions to be used to engage the learners in sharing what worked, what didn't, what changes would they make to their experiment or model. Even some friendly competition can be incorporated.



**THE OHIO STATE UNIVERSITY**  
COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



# STEM PATHWAYS

## Did You Know?

- A thought provoking question to be used as a way to lead into the challenge.
- A means for youth to engage parents about their challenge experience.

Connecting Participants  
To Real-World STEM Jobs!

The  
Career  
Focus

## CAREERS IN EACH STEM DISCIPLINE:

A career and a sampling of the type of information this career may contribute to coming up with a plausible solution to this problem is provided. This information can be used as additional background for the facilitator. It also serves as a career connection point for the participants to investigate further and share with parents.

OHIO STATE UNIVERSITY EXTENSION

**STEM PATHWAYS** career focus

## Ag Bot Animal STEM Challenge

Did You Know? Livestock have panoramic vision! How do animal's senses impact the approach to designing a handling facility?

<b>SCIENCE</b> Animal Scientist	<b>What conclusions can you draw knowing livestock?</b> <ul style="list-style-type: none"> <li>Hear high frequency noise that humans can't. 7,000 to 8,000 Hz versus humans hearing 1,000-3,000 Hz.</li> <li>Have wide angle vision (300 degrees). We see at 180 degrees.</li> <li>Have poor depth perception especially when their heads are up.</li> <li>Are dichromats (two-color) being most sensitive to yellowish-green and blue-purple light. We are trichromats and see the full color spectrum.</li> <li>Move best from dim to a more lit area, but not into bright light.</li> </ul>
<b>TECHNOLOGY</b> Agriculture Systems Technologist	<b>How can automation benefit handler safety and animal stress?</b> <ul style="list-style-type: none"> <li>Pigs often balk when approaching an incline. Hydraulic lifts enable load-out chutes to lay flat allowing pigs to walk at one level onto and off of transport trucks.</li> <li>Automatic sorting technology is used to feed groups of pigs to market weight, computer...</li> </ul>
<b>ENGINEERING AGRICULTURE</b> Engineer	<b>What...</b> <ul style="list-style-type: none"> <li>...</li> <li>...</li> <li>...</li> </ul>
<b>MATH</b> Agriculture Economist	<b>What...</b> <ul style="list-style-type: none"> <li>...</li> <li>...</li> <li>...</li> </ul>

THE OHIO STATE UNIVERSITY  
COLLEGE OF FOOD, AGRICULTURAL AND ENVIRONMENTAL SCIENCES  
CFAES provides research and related educational programs to clientele on a nondiscriminatory basis.

OHIO STATE UNIVERSITY EXTENSION

**STEM PATHWAYS** career focus

## Ag Bot Animal STEM Challenge

### ANIMAL SCIENTIST

Finding Solutions For...

- Systems that improve performance and enhance animal care to reduce injury to humans and animals including facilities and handling systems.
- Improving desirable traits through breeding programs that improve animal growth, reproduction and behavior characteristics.

Job Forecast Looks Like...

- Median Income: \$61,060
- Job Outlook: 9% growth 2012-2022
- Job Environment: Work in office and lab settings as well as on-site research with livestock producers, food processors and others.
- Expected Growth Areas:
  - Animal health
  - Food security and traceability.

Skill Set Needed...

- High School Courses:
  - Math: algebra, trigonometry, and calculus
  - Science: biology, chemistry, and physics
- Communication: Need good written and verbal skills to share information with a producers, scientists and consumers.
- Decision-Making: ability to know if their findings will have an impact on farm production, agriculture policy and food production.
- Critical-Thinking: determine the best approach to a research question.
- Observation: precise skills in observing and analyzing data for conclusive and accurate interpretation of results.

Education and Training Required...

- Entry Level Jobs: Require Bachelor's degree
- Additional Training and Certifications: Earning potential increases with a Master's or Doctorate. Internships are helpful in securing jobs and provide valuable experience.

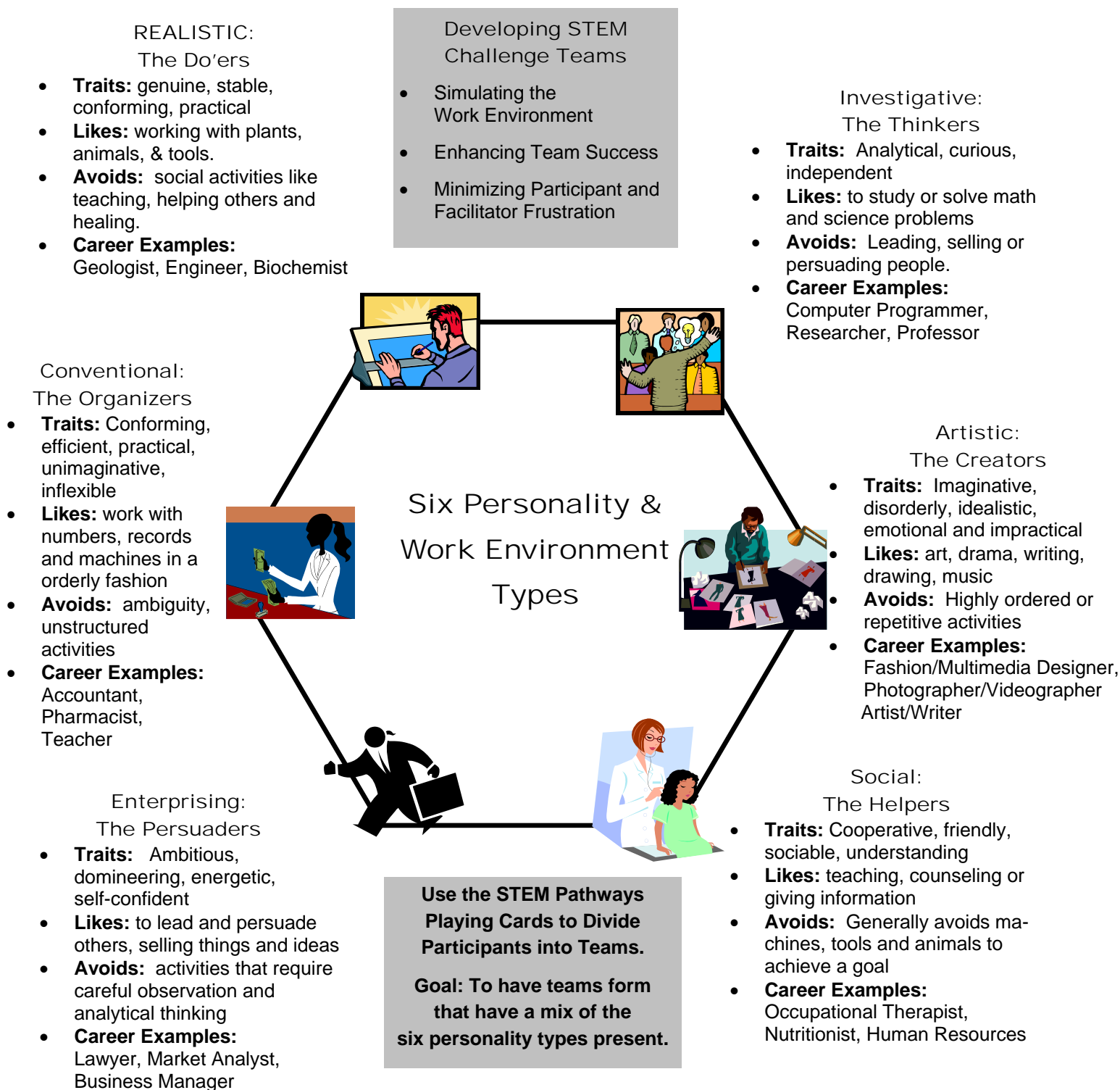
THE OHIO STATE UNIVERSITY  
COLLEGE OF FOOD, AGRICULTURAL AND ENVIRONMENTAL SCIENCES

Source: U.S. Department of Labor, Occupational Outlook Handbook, 2014-2015 Edition, [ls.gov/occup](http://ls.gov/occup)

**STEM FOCUSED CAREER:** One of the careers is focused in more detailed. Information is provided on the types of solutions this career focuses; the outlook for this job in the next 10 years, the skill set and high school course work recommended; and the education and training required beyond high school.



# STEM PATHWAYS



*Based on Holland Occupational Themes developed by psychologist John Holland.*



**THE OHIO STATE UNIVERSITY**  
COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES





# STEM PATHWAYS

## A Boost Against Arthritis **STEM** Challenge!

### The Problem

Brian and his dad Bob suffer from arthritis. They spend hours daily behind the wheel of a tractor and truck. Their doctor suggested they purchase a new tractor seat to improve posture and comfort.

### The Challenge

Design a freestanding seat that Brian and Bob can test for improved support, comfort and maneuverability.

### Find a Solution

**ASK:** What are some possible ideas?

**PLAN:** Test out your ideas

**CREATE:** Put your ideas to the test

**TEST:** How well did your ideas work?

**IMPROVE:** Review results & make changes

### Things to Consider

1. What seating dimensions are important?
2. What driver and/or environmental conditions do you need to consider?
3. How will design materials chosen impact vibration-absorbing suspension, pivoting and comfort?

Authored by: Patty House, OSU Extension, Clark County,  
4-H Youth Development Extension Educator, [house.18@osu.edu](mailto:house.18@osu.edu)  
937-521-3865. [go.osu.edu/4HSTEMpathways](http://go.osu.edu/4HSTEMpathways)



View This  
Video About  
The Design of  
A Chair  
<http://www.engineerguy.com/videos/video-chair.htm>



### Choose Your Design Materials

- Balloons (mixed sizes)
- Brown parcel tape
- Newspaper



**SAFETY ALERT:**  
Scissors are sharp! Please be careful when cutting. Alert the leader to any latex allergy!



**THE OHIO STATE UNIVERSITY**

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



# STEM PATHWAYS

## A Boost Against Arthritis **STEM** Challenge!



**Note:** Challenge can look a tractors, lawn mowers, cars, trucks, airplanes, amusement ride, stadium, office or home furniture chairs and seats.

**TIME: 30 - 45 MINUTES**

### Materials & Supplies

- Balloons (mixed sizes)
- Brown parcel tape
- Newspaper

### Design & Test Space

- Indoor or outdoor area sufficient for each team.
- When testing prototypes, make sure that the test area is free of sharp objects, corner, etc.
- Have someone from each group test their model.



**SAFETY ALERT:** Scissors are sharp! Handle with care! Check for latex allergies before doing the activity. Test chair/seat designs away from sharp objects.

### Engage the Learner

- How will age, size and mobility of the driver impact design features? *Lumbar support lower back and maintains the slight curve in your spine. Head and arm supports and rests. Distribution of weight is there a one size fits all seat.*
- What environmental conditions need to be factored into your design? *Driving machinery on rough terrain requires more shock absorbing.*
- How would you approach the design for someone with a disability?

### Observations & Conclusions

- What worked? What didn't? Knowing what you know, what changes will you make?
- If you could choose another material, what would it be?
- What might you do differently to improve the comfort or the support of your seat design?

**Post photos of the seat that ...**

- Held the most weight
- Was the most comfortable
- Provided the most support

### STEM Career Path... Occupational Therapist

- Who else might be involved? *Safety specialists, industrial designer, engineer, rheumatologists, physical therapist, agriculture systems technologist, economist*
- Who benefits? *Health benefits, reduced work-related injuries, improved efficiency, manufactures competitive edge*
- What other industries might benefit from this work? *Auto, truck, airplane, bus, stadium, amusement ride, office, school and home furnishing seating.*

Refer to Career Focus Card for more details.



**THE OHIO STATE UNIVERSITY**

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



# STEM PATHWAYS

career

## A Boost Against Arthritis STEM Challenge

**Did You Know?** Arthritis is the most common cause of disability in the United States. This disease effects 1 in 5 adults, 50 million, and 300,000 youth. In the agricultural community, arthritis effects 1 in 3 adults and is a leading cause of disability.

### SCIENCE

Occupational  
Therapist

**What seat features would you need to change to factor in a driver's disability?**

- Assess driver's limitations, equipment, handles, automation to aid the person getting into or out of the seat, adjustments and supports to improve posture, mobility, comfort, etc.

### TECHNOLOGY

Safety Specialist &  
Technician

**What impact will autonomous cars have on future seat designs?**

- You know those self-driving cars that seem so futuristic really aren't. Technology is progressing faster than rules and policies related to road use. GPS (global positioning systems) technology is already enabling farm machinery to drive unaided by a person. Safety technicians are actively involved in testing and recording results to assess reliability before a product goes into production and afterwards to ensure consumer safety.

### ENGINEERING

Industrial Designer

View:

<http://www.youtube.com/watch?v=CCmkKMBRZKI>

**How will changes in the workplace affect the future of the seat design for all types of uses?**

- Ergonomic principals are used to improve the productivity, health, safety and comfort of people trying to complete a particular function. Industrial designers work with health and safety specialists to factor in improvements to reduce stress and strain. As consumers transition to a more mobile office, seat designs for home, office and commute will change to meet those preferences and needs.

### MATH

Market Research  
Analyst

**What determines if a new seat design goes into production or not?**

- Increase use of data and market research to determine customer's behavior is used to make decisions on product development. A Market Research Analyst will account for the fastest growing occupation of all occupations at 32% from 2012-2022.



THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES





# STEM PATHWAYS

## A Boost Against Arthritis STEM Challenge

### Occupational Therapist

#### Finding Solutions For...

- Evaluate a person's home or workplace and offer advice for equipment, changes to improve health related limitations.
- Demonstrate exercises for stretching joints to provide arthritis relief.

#### Job Forecast Looks Like...

- **Median Income:** \$75,400 per year
- **Job Outlook:** 29% growth from 2012-2022
- **Job Environment:** Work with patients in medical facilities, hospitals, physician's offices, home health services, nursing homes, often on their feet for long periods of time
- **Expected Growth Areas:** aging population, persons involved in accidents, lose of limbs, chronic or disabling illnesses to improve daily living skills

#### Skill Set Needed...

- **High School Courses:**
  - Math: algebra, geometry and calculus
  - Science: biology, chemistry, and physics
  - Specialized: anatomy, health
- **Communication:** listen attentively and be able to give good directions.
- **Compassion:** strong desire to help people.
- **Flexibility:** must be creative in their treatment approaches and motivating their patients.
- **Interpersonal:** ability to earn respect and trust of others.
- **Patience:** people's limitations, injuries, illnesses and disabilities can become frustrating for them and you.

#### Education and Training Required...

- **Entry Level Jobs:** Master's Degree in Occupational Therapy after obtaining a bachelor's degree including coursework in biology and physiology.
- **Additional Training and Certifications:** Must pass the National Board for Certification of Occupational Therapists and must take classes to maintain that certification.



**THE OHIO STATE UNIVERSITY**  
COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



Source:  
U.S. Department of Labor, Occupational Outlook  
Handbook, 2014-2015 Edition,  
bls.gov/ooh

# STEM PATHWAYS

## Ag Bot Animal **STEM** Challenge!

### The Problem

Greg's sons have gone off to college and at age 60 he faces working his livestock alone. He needs to build a new livestock handling system that is cost effective, efficient and safe for him and his livestock.

### Your Challenge

To create the most cost effective livestock handling facility to move the ag bots from the corral to the barn safely in the least amount of time.

### Find a Solution

ASK: What are some possible ideas?

PLAN: Test out your ideas

CREATE: Put your ideas into action.

TEST: How well did your ideas work?

IMPROVE: Review results & make changes

### Things to Consider

1. How does your animal (Ag Bot) move?
2. What handling obstacles will your design need to take into account?
3. How will design materials chosen impact costs, animal behavior and labor?

Authored by: Patty House, OSU Extension, Clark County,  
4-H Youth Development Extension Educator, [house.18@osu.edu](mailto:house.18@osu.edu)  
937-521-3865, [go.osu.edu/4HSTEMpathways](http://go.osu.edu/4HSTEMpathways)



### Choose Your Design Materials

Tape Strip - \$50/each

Straw - \$250/each

Stiff Plastic - \$500/each

PVC Pipe - \$1500/each

Cardstock Strip - \$150/each

Popsicle Sticks - \$300/each

Tubing - \$1000/each

PVC Connector - \$750/each



#### SAFETY ALERT:

Scissors are sharp! Please be careful when cutting!



THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



# STEM PATHWAYS

## Ag Bot Animal STEM Challenge!



### TIME: 30 MINUTES

#### Materials and Supplies

- Masking Tape
- Craft Sticks
- Straws
- Cardstock Strips
- Stiff Plastic Sheet
- Tubing
- PVC Pipes
- PVC Connectors
- Timer
- Calculator
- Hexbugs (3-6) or Similar Micro-Robot

#### Design Space 4 x 4 ft. area

- PVC pipe for perimeter to keep ag-bots on engineering surface
- Toy Barn Structure(s)
- Hex Bugs or Similar Micro-Robot (3 to 6)
- Stop Watch (time through design)



**SAFETY ALERT:** Scissors are sharp! Please be careful when cutting!

### Engage the Learner

- How will time through the handling system impact handler safety and success of moving the herd?
- How would shape and texture of materials impact animal movement?
- How would approaching the design from the animal's viewpoint change your approach?

### Observations & Conclusions

- What worked? What didn't? Knowing what you know, what changes will you make?
- If you could choose another material, what would it be?
- What might you do differently to improve your handling time by 25% or reduce costs by 25%?

Post who had the best time and most cost effective design to encourage friendly competition.

### STEM Career Path ... Animal Scientist

- Who else might be involved? *Veterinarians, agriculture systems technologists, agriculture engineers, livestock producers, economists.*
- Who benefits? *Economic benefits to producer, higher quality products for the consumer, improved animal well-being, fewer injuries to animals and humans.*
- What other issues are animal scientists helping to solve? *Improving food quality through management programs that improve animal performance, behavior and care.*

Refer to Career Focus Card for more details.



**THE OHIO STATE UNIVERSITY**

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES





# STEM PATHWAYS

## AgBot Animal STEM Challenge

Did You Know? Livestock have panoramic vision! How do animal's senses impact the approach to designing a handling facility?

### SCIENCE

#### Animal Scientist

#### What conclusions can you draw knowing livestock?

- Hear high frequency noise that humans can't. 7,000 to 8,000 Hz versus humans hearing 1,000-3000 Hz.
- Have wide angle vision (300 degrees). We see at 180 degrees.
- Have poor depth perception especially when their heads are up.
- Are dichromats (two-color) being most sensitive to yellowish-green and blue-purple light. We are trichromats and see the full color spectrum.
- Move best from dim to a more lit area, but not into bright light.

### TECHNOLOGY

#### Agriculture Systems Technologist

#### How can automation benefit handler safety and animal stress?

- Pigs often balk when approaching an incline. Hydraulic lifts enable load-out chutes to lay flat allowing pigs to walk at one level onto and off of transport trucks.
- Automatic sorting technology is used to feed groups of pigs to market weight, computer generated data sorts pigs into pens to meet dietary needs and time to load-out to market.
- Automation of squeeze chutes and head gate systems enhance producer safety and handling efficiency.

### ENGINEERING AGRICULTURE

#### Engineer

#### Which materials will help reduce livestock's flight response?

- Animals panic if they slip, even a little.
- Animals don't like to walk through water, even a puddle.
- Livestock are prey animals, and look for an easy way to escape.

### MATH

#### Agriculture Economist

#### What cost factors need to be considered?

- A well planned facility can help save money from reduced labor costs, improved efficiency of management practices and reduction in injuries to handlers.
- Interest rates for borrowing money to build a handling system as well as increases from income based on better animal performance from the handling system must be considered in budgeting for any handling system.



THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



# STEM PATHWAYS

## Ag Bot Animal STEM Challenge

### ANIMAL SCIENTIST

#### Finding Solutions For...

- Systems that improve performance and enhance animal care to reduce injury to humans and animals including facilities and handling systems.
- Improving desirable traits through breeding programs that improve animal growth, reproduction and behavior characteristics.

#### Job Forecast Looks Like...

- **Median Income:** \$61,060
- **Job Outlook:** 9% growth 2012-2022
- **Job Environment:** Work in office and lab settings as well as on-site research with livestock producers, food processors and others.
- **Expected Growth Areas:**
  - Animal health
  - Food security and traceability.

#### Skill Set Needed...

- **High School Courses:**
  - Math: algebra, trigonometry, and calculus
  - Science: biology, chemistry, and physics
- **Communication:** Need good written and verbal skills to share information with a producers, scientists and consumers.
- **Decision-Making:** ability to know if their findings will have an impact on farm production, agriculture policy and food production.
- **Critical-Thinking:** determine the best approach to a research question.
- **Observation:** precise skills in observing and analyzing data for conclusive and accurate interpretation of results.

#### Education and Training Required...

- **Entry Level Jobs:** Require Bachelor's degree
- **Additional Training and Certifications:** Earning potential increases with a Master's or Doctorate. Internships are helpful in securing jobs and provide valuable experience.



THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



Source: U.S. Department of  
Labor, Occupational Outlook Handbook, 2014-2015  
Edition,  
[bls.gov/ooh](http://bls.gov/ooh)

# STEM PATHWAYS

## AgBot Harvest **STEM** Challenge!

### The Problem

The world's population is expected to reach 9 billion by 2050 that's 2 billion more people to feed than we do now. Reducing harvest loss is one way to address the problem. Harvesters will need to operate efficiently at higher speeds with customizable and durable attachments for site specific operations.

### Your Challenge

Engineer a device that harvests the most grain in the least time for your site specific operation.

### Find a Solution

ASK: What are some possible ideas?

PLAN: Test out your ideas

CREATE: Put your ideas into action

TEST: How well did your ideas work?

IMPROVE: Review results & make changes

### Things to Consider

1. How does your (Ag Bot) machine base move?
2. What design will allow your machine to gather the most grain?
3. How will grain, size, shape and weight impact your design?

Authored by:

- Patty House, OSU Extension, Clark County, 4-H Youth Development Extension Educator, [house.18@osu.edu](mailto:house.18@osu.edu) 937-521-3865
- Mark Light, OSU Extension, Hardin County, 4-H Youth Development Extension Educator, [light.42@osu.edu](mailto:light.42@osu.edu), 419-674-2297  
[go.osu.edu/4HSTEMpathways](http://go.osu.edu/4HSTEMpathways)



### Choose Your Design Materials

½ wide Masking Tape

3 ounce Paper Cups

Craft Sticks

Cardstock Strips

Straws

Paper Clips

Toothpicks

Hex Bugs



**SAFETY ALERT:**

**Scissors are sharp! Please be careful when cutting!**



**THE OHIO STATE UNIVERSITY**

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES





# STEM PATHWAYS

## Ag Bot Harvest **STEM** Challenge!



**TIME: 30 - 45 MINUTES**

### Materials and Supplies

- Masking Tape
- Straws
- Hexbugs (3-6)
- Cardstock strips
- Timer
- 3 oz. Paper Cups
- Craft Sticks
- PVC Pipes
- PVC Connectors

**Design Space 4 x 4 ft. area**

- PVC pipe for perimeter to keep ag-bots on engineering surface
- Hex Bugs or Similar Micro-Robot (4 to 6)
- Stop Watch (time through design)



**SAFETY ALERT:** Scissors are sharp! Please be careful when cutting!

### Engage the Learner

- How will you control the machines movement through the field during harvest?
- What materials will assist you in your design to collect the most grain during harvest?
- How will increase “horsepower” effect your harvest goals?

### Observations & Conclusions

- What worked? What didn't? Knowing what you know, what changes will you make?
- If you could choose another material, what would it be?
- What might you do differently to improve your harvesting time by 25% or amount harvested by 25%.

**Post who had the best time and harvested the most grain.**

### STEM Career Path ... Agriculture Engineers

- Who else might be involved? *Agriculture systems technologists, economists, agriculture producers, agriculture safety specialists, etc.*
- Who benefits? *Economic benefits to producer, environmental benefits, higher quality commodity for processors and livestock producers.*
- What other issues are animal scientists helping to solve? *Technology application to improve machinery & equipment, storage, processing, natural resources protection, alternative energy sources.*

**Refer to Career Focus Card for more details.**



**THE OHIO STATE UNIVERSITY**

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



## STEM PATHWAYS

career

## Ag Bot Harvest STEM Challenge

Did You Know? Global positioning systems allow autopilot tractors and precision documentation of yields, application rates and more.

## SCIENCE

Agronomist

## How can plant genetics impact harvest yields and equipment?

- Agronomists develop innovative practices and technologies to boost crop yields, reduce pest and weed problems and protect the environment.
- The work with agricultural producers to identify the plant genetics (varieties) and crops that work best under various growing conditions including soil type, terrain, rainfall, available machinery, etc.
- Research focuses on genetics to improve plant structures that can withstand wind damage, pest problems and disease issues.

## TECHNOLOGY

Precision  
Agriculture  
Technician

## How can GPS technology help producers maximize yields and minimize resource consumption?

- Collect soil samples, use computer models to study drainage patterns, soil pH, rainfall, map weeds, crop yields and develop crop management plans.
- Precision agriculture technicians use these tools to help determine fertilizer and pesticide applications.
- Crop yield monitors mounted on GPS equipped combines, use satellite technology to map yield differences across the field.

## ENGINEERING

Agriculture Engineer

## Why is sustainability an important feature to include in new designs?

- The world's population will grow to 9 billion people in 2050 requiring agricultural producers to become more efficient using less land and potentially using new fuel sources.
- Agriculture engineers will continue to work to solve challenges that impact water quality, food security and production, land management and other natural resource issues.

## MATH

Finance Officer  
(Loans)

## What determines how much money a person can borrow towards a purchase like a new combine (car, house, farm, etc.)?

- Farm lenders look at a current debt load as well as income and potential earnings from agricultural commodities being grown.
- Sometimes, lenders will encourage borrowers to look at purchasing used equipment versus new equipment based on income projections and/or past performance.



THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES

# STEM PATHWAYS

## Ag Bot Harvest STEM Challenge

### Agriculture Engineer

#### Finding Solutions For...

- Develop bio-fuels and alternative energy sources
- Seek better ways to manage crop inputs and reduce environmental impacts through innovations like global positioning systems (GPS)
- Design storage systems and processes that improve food safety and quality

#### Job Forecast Looks Like...

- **Median Income:** \$71,090 per year
- **Job Outlook:** 9% growth from 2012-2022
- **Job Environment:** Office, lab and field, overtime hours related to weather impacts, growing seasons, etc.
- **Expected Growth Areas:** High-tech applications to agricultural products, water resource management, alternative energies

#### Skill Set Needed...

- **High School Courses:**
  - Math: algebra, trigonometry, calculus
  - Science: biology, chemistry, and physics
  - Specialized: drafting, computer science, engineering, robotics
- **Listening:** seek out information from clients, workers and other professionals.
- **Problem-solving:** apply engineering and technology to new circumstances.
- **Systems analysis:** propose solutions that work well with workers, equipment, machinery and the environment.
- **Teamwork:** design solutions involving biological, mechanical or environmental dimensions, work and receive feedback from a variety of backgrounds including agronomy, animal sciences, genetics and horticulture.

#### Education and Training Required...

- **Entry Level Jobs:** Require Bachelor's degree
- **Additional Training and Certifications:** a degree from an ABET-accredited engineering program, a passing score on the Fundamentals of Engineering (FE) exam, relevant work experience, typically at least 4 years, a passing score on the Professional Engineering (PE) exam



**THE OHIO STATE UNIVERSITY**  
COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



Sources:  
U.S. Department of Labor, Occupational Outlook  
Handbook, 2014-2015 Edition,  
[bls.gov/ooh](http://bls.gov/ooh)



# STEM PATHWAYS

## Cookie Prospecting **STEM** Challenge!

### The Problem

Buckeye Resources is looking for its next location to mine. They have failed on three previous attempts and will have to shut down if unsuccessful. Plus, the EPA (Environmental Protection Agency) is requiring them to minimize their mining impacts or face stiff penalties.

### The Challenge

As a team of geologists, your challenge is to go cookie prospecting . . . collect a sample, analyze it in the lab and determine the site's potential for mining.

### Find a Measurable Solution

**ASK:** What is your hypothesis?

**HYPOTHESIZE:** Identify independent & dependent variables.

**TEST:** Conduct an experiment.

**ANALYZE:** Results, draw conclusions, try again!

**COMMUNICATE:** Findings and make recommendations.

### Things to Consider

1. What things are important in selecting a new location?
2. What information will you need from your sample?
3. How can you minimize the impact of mining on the surrounding environment?
4. What costs will be associated with the mining operation?
5. How can the selected location impact those costs?

Authored by: Annie Davis, OSU Extension, Logan County, 4-H Youth Development Extension Educator, davis.2485@osu.edu, 937-599-4227  
[go.osu.edu/4HSTEMpathways](http://go.osu.edu/4HSTEMpathways)



What is your hypothesis?  
What are your variables?

- Independent?
- Dependent?

Record them on your data sheet with your analysis.



### Prospecting Expenses

\$1000 - Cookie Location

### Excavation Equipment

Round toothpicks - \$100

Flat toothpicks - \$75

Paper clips - \$150

Straw - \$100

Fork - \$200

### Labor

Each minute = \$50 per person

### Income

Standard chocolate chip mined = \$500

Combine partial chips to make a whole chip



### SAFETY ALERT:

Be mindful of allergies when working with any food products including cookies.



**THE OHIO STATE UNIVERSITY**

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



# STEM PATHWAYS

## Cookie Prospecting **STEM** Challenge!

Bring Your Samples Back to the Lab for Testing & Analysis



### TIME: 30 - 45 MINUTES

#### Materials and Supplies

- Straws
- Round toothpicks
- Flat toothpicks
- Paper clips
- Forks
- Paper/Paper Towels
- 3 different kinds of chocolate chip cookies (chunk, mini, soft, hard)
- GPS Units or GPS App (shows latitude & longitude coordinates)

#### Design Space

- Outdoor space to locate cookie mine locations
- Table space to mine chips from cookies
- Wi-Fi Access to Download Apps
  - Android apps are GPS Essentials and Latitude Longitude Coordinates by Proxit Apps and others.
  - iPhone Apps are GPS Coordinates and Find My Latitude and Longitude, but there are others.



**SAFETY ALERT:** Be mindful of allergies when working with any food products including cookies.

### Engage the Learner

- What factors are most important when choosing a location?
- How will the equipment you used impact the economics of the projects? (better equipment, more efficient workers, lower labor costs, more complete removal of the material, etc.)
- How will the softness or hardness of the bedrock (cookie) impact your decisions?
- What are your plans to protect the environment in and the around active mining location?

### Observations & Conclusions

- What worked? What didn't? Knowing what you know, what changes will you make?
- How would a different cookie selection change the equipment you decided to use?
- What factors impacted your profit?
- What did you do to protect the environment?

Refer to Career Focus Card for more details.

### STEM Career Path ... Geologist

- Who else might be involved? *Engineers, geophysicists, heavy equipment operators, environmental inspectors, the community – officials and residents.*
- Who benefits? *Depending on the mining operation it could be everyone. People use natural resources for anything from plastics to jewelry, from the roads we drive on to the electricity in our home.*
- What other issues are they helping to solve? *Water contamination/quality issues, finding oil/gas/mineral/resource alternatives for renewable & non-renewable resources, earthquake & other geo-hazard consultation (rock slides, volcanoes, flooding) understanding the Earth's history & using that information to help make policy and environmental decisions, assisting engineers with building sound and stable buildings, infrastructure, educating the public about Earth's history and natural wonder.*



**THE OHIO STATE UNIVERSITY**

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



# STEM PATHWAYS

## Cookie Prospecting **STEM** Challenge!



### Prospecting Area

- Place “rock” cookie samples for each group in a different location, note latitude and longitude of sites.
- Have each group navigate to locations using a GPS unit or GPS App to collect samples for analysis.
- Each group will select equipment to mine their prospecting site, determine project costs and purchase items from the adult in charge.
- Each group will begin mining their “rocks” (cookies) using the tools selected and keep track of how much time is used to calculate labor costs.
- Encourage geologists to keep their cookie on the paper during mining. We can’t turn the Earth’s surface upside down and the cookies are the Earth’s surface in this challenge.
- As a group finishes, the person in charge will count chips mined and assess any fines for damage to the environment. If damage is determined, the group will need to track time for remedial cleanup.
  - \$300 – each crumb outside prospecting area
  - \$2000 – illegal disposal of prospecting/mining material (eating crumbs, throwing them away before the inspector arrives).



**THE OHIO STATE UNIVERSITY**

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES





## STEM PATHWAYS Cookie Prospecting Analysis Data Sheet

Hypothesis: \_\_\_\_\_

\_\_\_\_\_ ☐ Accept ☐ Reject

Independent Variable: \_\_\_\_\_ Dependent Variable: \_\_\_\_\_

**Expenses**

Prospecting Location: \_\_\_\_\_

Equipment Used: \_\_\_\_\_

Labor: \_\_\_\_\_

Fines: \_\_\_\_\_

Total: \_\_\_\_\_

**Income**

Total Standard Sized Chocolate Chips Recovered: \_\_\_\_\_

Other Income: \_\_\_\_\_

**Total Income:** \_\_\_\_\_**Subtract Expenses:** - \_\_\_\_\_**Total Profit or Loss** \_\_\_\_\_

Sample Tested	Cookie Observations	Chocolate Chip Observations	Other Observations	Final Recommendation
Sample 1				
Sample 2				
Sample 3				



## STEM PATHWAYS

career

## Cooking Prospecting STEM Challenge

Did You Know? Geologists work to find earth's resources such as oil, natural gas, coal, precious metals and gemstones. This history of the Earth and past events in a specific location can determine whether a mineral resource is present, large enough, and high quality enough to be explored. They also learn about Earth's past to make our lives a better place to live and to teach others about our amazing planet.

## SCIENCE

Geologist



View a video about what geologists do.

**Where in the world would you look for these natural resource deposits knowing this information?**

**Oil** is a fossil fuel made over millions of years from the breakdown and gradual heating of marine organisms.

**Diamonds** are found in a special kind of igneous rock called a kimberlite. A kimberlite is like a pipe of magma that reaches the Earth's surface.

**Limestone** is a resource that is used for many different things like roads, agriculture, concrete, building stone, and other every day uses. Limestone is typically formed in warm, shallow, marine environments.

**Aluminum** comes from the rock bauxite. This rock forms in warm tropical climates where the silica has been removed from the soils.

## TECHNOLOGY

Geophysicists



**How can you see what is underground?**

- Use instruments that measure slight changes in gravity, use electrical properties, or seismic (or wave) energy to get a better image of what is under our feet. The technology used to pick up and record the vibrations are very sensitive microphones called geophones on land and hydrophones in the water. These vibrations travel through different layers (rock, oil, salt, water, etc.) at different speeds and can help the geophysicist determine where deposits can be found.

## ENGINEERING

Geologist

**How will the activity impact the environment around the site? How can we design the mining location to be the safest for our workers and enable us to get the most material?**

- Work with civil engineers and other professionals to determine the best materials for a job. They test soils, analyze hazards (earthquakes, landslides, etc.) They also work to ensure the environment around active wells and mines is not damaged.

## MATH

Economic Geologist

**How big is the mineral deposit and how long can we mine it? What are the costs of the land, equipment, labor and transportation needed to obtain it? What are the current market value and forecast for the resource?**

- Work with the others to determine whether the mineral or resource deposit is profitable enough to explore.



THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES

# STEM PATHWAYS

## Cookie Prospecting STEM Challenge

### Geologist

#### Finding Solutions For...

- Use of natural resources and policy development.
- Understand geo-hazards (volcanoes, earthquakes, landslides) and minimize.
- Climate and preserving our natural environment and water supply.

#### Job Forecast Looks Like...

- **Median Income:** \$90,890, highest salaries in petroleum and mining, lowest in government
- **Job Outlook:** 16% growth from 2012-2022
- **Job Environment:** Field work: sample collection and observations in the environment,. Lab: Sample analysis with microscopes, chemicals, and other testing methods. Office: Computers to make and test models based on field observation, to make maps and reports.
- **Expected Growth Areas:** The need for energy, environmental protection, and responsible land and resource management will spur demand. New jobs will be in management, scientific, and technical consulting services and to replace the growing number of retirees.

#### Skill Set Needed...

- **High School Courses:**
  - Math: algebra and calculus
  - Science: earth science, biology, chemistry, and physics
- **Survival skills:** ability to work in any environment and weather.
- **Problem solving:** observation skills, ability to take those and apply general rules to specific problems to produce sensible answers.
- **Interpersonal:** ability to get along and work well with others.
- **Communication:** excellent written and verbal

#### Education and Training Required...

- **Entry Level Jobs:** Require Bachelor's degree
- **Additional Training and Certifications:** HAZMAT training and computer certifications. Advanced degrees Master's and doctorate increase jobs.



**THE OHIO STATE UNIVERSITY**  
COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



Sources:  
U.S. Department of Labor, Occupational Outlook  
Handbook, 2014-2015 Edition,  
[bls.gov/ooh](http://bls.gov/ooh)

Association of Women Geologists <http://awg.org/>

American Geosciences Institute,  
<http://www.agiweb.org/workforce/careers/html>



# STEM PATHWAYS

## Corny Polymer Balls **STEM** Challenge!

### The Problem

The 4 Clovers Toy Company is looking to change the formula they use to make a popular bouncing ball. Market studies show that consumers want to purchase disposable bio-friendly toys. The company's senior chemist has requested that biodegradable ingredients be studied for their practical use in the bouncing ball's new formula.

### The Challenge

To develop and test an hypothesis to determine the practical use of glue, borax and corn starch to enhance the bounce factor for a children's disposable toy ball.

### Find a Measurable Solution

ASK: What is your hypothesis?

HYPOTHESIZE: Identify independent & dependent variables.

TEST: Conduct an experiment.

ANALYZE: Results, draw conclusions, try again!

COMMUNICATE: Findings and make recommendations.

### Things to Consider

1. What properties do you want your corny polymer ball to possess?
2. What properties do you think each ingredient offers to the corny polymer ball?
3. How will you test for the various properties and compare product formulations for desired end product?



### What Properties Should Your Ball Have?

- Slimy?
- Bouncy?
- Sticky?
- Stretchy?
- Goopy?

### What Ingredient(s) Impacts Which Property?

### What is Your Hypothesis?

### Identify Independent & Dependent Variables

- Glue (white, clear, all-purpose, school, wood, washable, different brands, etc.)
- Borax (laundry-booster)
- Cornstarch
- Ration of ingredients
- Mixing time
- Ingredient order
- Water temperature



#### SAFETY ALERT:

Don't eat the materials used to make the ball or the ball itself. WASH YOUR HANDS!

Authored by: Patty House, OSU Extension, Clark County,  
4-H Youth Development Extension Educator, house.18@osu.edu  
937-521-3865. [go.osu.edu/4HSTEMpathways](http://go.osu.edu/4HSTEMpathways)



**THE OHIO STATE UNIVERSITY**

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



# STEM PATHWAYS

## Corny Polymer Balls **STEM** Challenge!



- Did you accept or reject your hypothesis?
- What changes will you make?
- What questions do you still want to explore?

### TIME: 15 - 30 MINUTES

#### Materials & Supplies

- Glue (different types)
- Cornstarch
- Food Coloring
- Measuring spoon/cup
- Water (warm)
- Plastic cups or zipper-type bags
- Plastic spoon or craft stick to stir
- Borax (laundry booster found in detergent section)

#### Design Space

- Table space sufficient for each group to work.
- Cover tables for easy clean-up.
- Ingredients in labeled containers; small amounts can reduce waste.
- Basic formula.



**SAFETY ALERT: DON'T EAT the materials used to make the ball or the ball itself. WASH YOUR HANDS!**

### Engage the Learner

- How do scientists come up with their experiment?
- What do you already know about the properties of your variables? What might you need to research?
- How can you test for various properties?
- What safety considerations are needed in mixing chemicals?
- How would you report your findings to consumers, the toy company or other scientists?

### Observations & Conclusions

- Observe your corny polymer ball. What changes would you like to make?
- How will you test for that change?
- What do you think would happen?
  - ☛ if you left an ingredient out;
  - ☛ used more or less of one ingredient;
  - ☛ used cold water;
  - ☛ did not stir; etc.

### STEM Career Path... Polymer Scientist

- Who else might be involved? *Chemist, engineer, electrical technician, quality control manager*
- Who benefits? *Consumers and future generations with more alternative products to petroleum fuel based products, agriculture producers with more market options for commodities, and science community through new discoveries.*
- What other industries might benefit from this work? *Water treatment, soil erosion, horticulture, any industry that uses a plastic for product development or packaging*

Refer to Career Focus Card for more details.



**THE OHIO STATE UNIVERSITY**

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



# STEM PATHWAYS

## Corny Polymer Balls **STEM** Challenge!

### Working in Groups of 4 to 6...

Step 1: Make Borax Solution in Cup A.

- Place 2 T of warm water into Cup A.
- Add ½ tsp. of Borax powder and stir until borax dissolves.
- Add a drop of food coloring.

Step 2: Make Ball Mixture in Cup B

- Place 1 T of glue into Cup B.
- Add a ½ tsp. of the borax solution from Cup A on top of the glue.
- Add 1 T of cornstarch.
- **DO NOT STIR YET!** Wait 15 to 20 seconds to allow ingredients to interact. Then **STIR!**

- Step 3: Mixing Together
- Stir materials together in cup B until the mixture is impossible to stir.
- Take mixture out of Cup B and start molding the ball with your hands.
- Ball will be sticky and messy at first, but kneading will form it into a solid.

- Step 4: Test It and Make Observations
- Bounce your ball on the table. How bouncy is it?
- What would you like to change?
- How can you test for that change?
- What is your hypothesis and independent and dependent variables?

Step 5: Store Ball with Safety Reminder in a zipper type bag.



**DO NOT EAT THE BALL or the ingredients to make the ball!**  
Wash hands with soap and water!

### Test Your Hypothesis

### Record Your Findings

### Share Your Results



**What is your hypothesis?**

**What are your variables?**



**THE OHIO STATE UNIVERSITY**

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES





## STEM PATHWAYS Corny Polymer Ball Lab Analysis Data Sheet

Hypothesis: \_\_\_\_\_

☐ Accepted ☐ Rejected

Independent Variable: \_\_\_\_\_ Dependent Variable: \_\_\_\_\_

Glue Tested	Describe Bounce Factor	Height of Bounce	Length of Bounce	Ball Diameter, Elasticity, Texture, etc.
All-Purpose Glue Brand:				
White School Glue Brand:				
Clear School Glue Brand:				
Wood Glue Brand:				
Washable Glue Brand:				

Your Recommendation to 4 Clover Toy Company





## STEM PATHWAYS

career

## Corny Polymer Ball STEM Challenge

Did You Know? Polymers are what helps keep your hair in place when you use hairspray, a gel or mousse. There are both natural and synthetic polymers used in hundreds of products we use everyday. View: : <http://science360.gov/obj/tkn-video/1267e29c-f852-4cbd-bb01-331c72bb4fb4>

## SCIENCE

Polymer Scientist

## What causes the mixture to become a bouncy ball?

- Polymers are molecules made up of repeating units connected by chemical bonds. How those chains are put together determines how the product acts – some are rubbery, some are hard and tough while others are sticky and gooey.
- For the polymer ball, if you add more glue, the ball is slimy, add more corn starch, the ball becomes more stretchy or add less borax and the ball will be goopier. None of which is optimal for a ball the consumer wants to bounce.
- There are natural polymers like DNA, proteins and cellulose as well as synthetic polymers like nylon, silicone, neoprene and polystyrene.

## TECHNOLOGY

Electrical  
Mechanical  
Technician

## What factors need to be considered when designing, maintaining and monitoring machines to manufacture polymer products?

- Improper ratios of ingredients or inadequate mixing time will lead to a poor or inconsistent product.
- Understanding of the product and the equipment used in making the product is essential.
- Many on-line and computer based systems allow for automation of monitoring, but require technicians with diagnostic and analysis skills to troubleshoot and interpret data collection.
- Not all STEM jobs require a college degree! Technical training is in high demand as well.

## ENGINEERING

Polymer Engineer

## How can this polymer be modified to make a different ball?

- If you used salt, sugar, baking soda, corn meal, flour or oatmeal in place of the corn starch, would you be able to create a different type of ball? What if you used liquid starch instead of borax? That's what polymer engineers do, look for ways to modify polymers to improve performance or make new products.
- Polymer engineers not only design new products and modify existing ones, but make process changes to improve efficiency.

## MATH

Quality Manager

## Why is quality control important to a polymer manufacturer and the consumer?

- Competitive edge comes when polymer properties are consistent over the entire production process, maximizing production performance while keeping safety regulations.
- Manufacturers and customer satisfaction happens when quality managers assure product performance.



THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



# STEM PATHWAYS

## Corny Polymer Ball STEM Challenge

### Polymer Scientist

#### Finding Solutions For...

- Fine-tune existing polymers, create new polymers that cost less and perform better and create special application plastics.
- Plastics and synthetic fibers; agricultural chemicals; paints and adhesives; and biomedical applications such as artificial skin, prosthetics, and the nicotine patch to name a few.
- Environmental friendly polymers that biodegrade.

#### Job Forecast Looks Like...

- **Median Income:** \$88,990 per year
- **Job Outlook:** 6% growth from 2012-2022
- **Job Environment:** Laboratories, offices, production sites.
- **Expected Growth Areas:** As many as 50% of all chemists, will work in polymers sometime in their careers. Industries where adhesives, coatings, synthetic rubber, synthetic fibers, agricultural chemicals, packaging, automotive, aircraft, aerospace, biomedical industries.

#### Skill Set Needed...

- **High School Courses:**
  - Math: algebra, calculus
  - Science: biology, chemistry, and physics
- **Critical-thinking:** analytical and problem-solving skills to conduct precise and accurate scientific experiments to develop new and improved products, processes and materials
- **Communication:** writing and speaking skills to share experiments and results
- **Teamwork:** to motivate and work well with others on a research group

#### Education and Training Required...

- **Entry Level Jobs:** Require Bachelor's degree
- **Additional Training and Certifications:** most polymer scientists have a Ph.D. and were trained as organic chemists. Only a few colleges and universities have a degree in polymer science, internships provide useful training.



**THE OHIO STATE UNIVERSITY**  
COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



Source:  
American Chemistry Society:  
<http://www.acs.org/content/acs/en.html>

# STEM PATHWAYS

## Eggstraordinary Eggs STEM Challenge!

### The Problem

Sunny Side Eggs wants to reach a new market with a four pack to go egg carton. You have been contacted to work with a team to create and test a prototype.

### The Challenge

Using the materials provided, your challenge is to design an egg carton prototype capable of protecting its contents from breakage under applied pressure.

### Find a Solution

ASK: What are some possible ideas?

PLAN: Test out your ideas

CREATE: Put your ideas into action.

TEST: How well did your idea work?

IMPROVE: Review results & make changes.

### Things to Consider

1. How will egg size affect the materials you choose?
2. How will design materials chosen impact shock absorption, support and separation to protect eggs from breaking?
3. What structural shape(s) do you predict will work the best? Why?

Authored by: Patty House, OSU Extension, Clark County,  
4-H Youth Development Extension Educator, [house.18@osu.edu](mailto:house.18@osu.edu)  
937-521-3865 [go.osu.edu/4HSTEMpathways](http://go.osu.edu/4HSTEMpathways)



### Choose Your Design Materials

Large Sandwich Foam Container (1 per team)

Cotton Balls

Tooth Picks

Craft Sticks

Cotton Swabs

Cosmetic Sponges/Pads

3 oz. paper cups

Cardstock Strips

Toilet Paper

Paper Towels

Packing Peanuts

Straws

Masking tape

Bubble Wrap



**SAFETY ALERT:** Always wash hands with soap and water after handling eggs to prevent salmonella exposure!



**THE OHIO STATE UNIVERSITY**

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



# STEM PATHWAYS

## Eggstraordinary Eggs STEM Challenge!

### Egg Structure Exploration

- Lead youth in exploring the power packed in the structure of eggs before they design their egg carton prototypes.
- Give each youth an egg or if large group ask for a few volunteers. Have youth place egg in the palm of their hand and wrap their hand around the egg and squeeze. What happens?
- Have the youth hold the end's of the egg between their thumb and index finger and squeeze. What happens?
- Ask for a volunteer who would like to do the ultimate egg power test by standing on eggs. View the Eggstraordinary Power Challenge video for instruction.

### TIME: 20-30 MINUTES

#### Materials and Supplies

- Large Sandwich Foam Container
- Cosmetic Sponges/Pads
- Cotton Balls
- Craft Sticks
- 3 oz. paper cups
- Toilet Paper
- Packing Peanuts
- Bubble Wrap
- Large Eggs
- Garbage Bags
- Tooth Picks
- Cotton Swabs
- Cardstock
- Paper Towels
- Straws
- Masking Tape
- Hand Sanitizer



**SAFETY ALERT:** Always wash hands with soap and water after handling eggs to prevent salmonella exposure!

### Design & Test Space

- Table Space for Each Team to Build Prototype
- Floor Space Covered with Garbage Bag for Teams to Test Prototype
- 2 Prototypes Must Be Tested at the Same Time with One Test Subject

### Engage the Learner

- What affect will the number of eggs placed in the egg carton have on the outcome?
- How will egg orientation impact your design?
- How would your design elements change if using different size or type of eggs?



*Do you think our design worked?*

### Observations & Conclusions

- How well did your egg carton protect the eggs inside?
- What worked? What didn't? Knowing what you know, what changes will you make to your egg carton prototype?
- If you could select any other materials to use, what would you choose and why?

Post who designed the most powerful egg carton. What features do you like about the design? What features would you change? (tamper resistance, cost effectiveness, etc.)

### STEM Career Path... Packaging Engineer

Who else might be involved? *Food scientist, materials scientist, logistics specialist, industrial designer, marketer, etc.*

Who benefits? *Consumers: packaging that protects food from contamination, spoilage and/or breakage. Environment: use or recycled materials. Companies: reduction in product loss and waste.*

What other issues are Packaging Engineers helping to solve? *Tamper evident methods, re-use of product materials to reduce waste, robotics application, thermal & structure analysis.*

Refer to Career Focus Card for more details.



**THE OHIO STATE UNIVERSITY**

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES





# STEM PATHWAYS

## Glucose Detective **STEM** Challenge!

### The Problem

Jason has diabetes, which means his blood contains abnormal levels of glucose, a sugar. If Jason were to experience low blood sugar, he would need to eat or drink something with a high level of glucose immediately, so he does not pass-out.

### The Challenge:

Help Jason identify which of the items he should consume containing the highest level of glucose.

### Find a Measurable Solution

ASK: What is your hypothesis?

HYPOTHESIZE: Identify your variables.

TEST: Conduct an experiment.

ANALYZE: Results, draw conclusions, try again!

COMMUNICATE: Findings & make recommendations.

### Things to Consider

1. Glucose is a major source of energy for cells in our body. Hormones made in the body, such as insulin, help control blood glucose levels.
2. Hypothesis: Which item do you think will contain the most glucose? Why?
3. Why would Jason need a food high in glucose rather than a food containing more complex sugars, if his blood sugar is low?
4. A digital glucose meter helps people gauge their glucose levels. The meter measures glucose in mg/dL or milligrams of glucose per deciliter of solution.

Authored by: Dustin Homan, Program Manager for Bio-product Education, Ohio Bio-Products Innovation Center  
614-247-1940 [go.osu.edu/4HSTEMpathways](http://go.osu.edu/4HSTEMpathways)



What is Your Hypothesis?

What are the variables in your hypothesis?

### Identify the Independent and Dependent Variables

- Fruit juice (orange, lemon, apple)
- Fresh produce (apple, pear, pineapple, cucumber, tomato)
- Processed foods and beverages (soda, sports drinks, salad dressings, sauces, peanut butter, chips)
- Level of Glucose



#### SAFETY ALERT:

Be aware of food allergies! Ask participants if they are allergic to any foods before beginning.



THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



# STEM PATHWAYS

## Glucose Detective **STEM** Challenge!



- Did you accept or reject your hypothesis?
- What changes will you make?
- What questions do you still want to explore?

**TIME: 30 MINUTES**

### Materials & Supplies

- 3 ounce disposable cups
- Food and beverage samples
- Water
- Plastic Spoons
- Pipets
- Aluminum Foil
- Digital glucose meters with test strips or paper glucose test strips
- Graph paper and pens or pencils
- Hand sanitizer



**SAFETY ALERT:** Be aware of food allergies! Ask participants if they are allergic to any foods before beginning.

### Design Space

- One table for each group, cover tables for easy clean-up.
- Glucose meter: Read instructions for proper set-up and use.
- Food & Beverage samples: add 1 to 2 T of a different sample to a cup. Add water to dry food or thick liquids and stir to make the consistency of blood, dissolving the dry food. Include water in a cup as your control.
- Results Card: Record each food and beverage sample with the corresponding number on a card.
- Keep food & beverage containers for reference later by the groups.

### Engage the Learner

- Which foods can contribute to weight gain? *Foods high in fat, sugar and carbohydrates*
- What sugary foods could you remove from your diet to reduce your caloric intake?
- Where can you locate the sugar content of a food? *Food labels and dietary references*
- What agricultural crops high in sugar could be used to produce ethanol, a renewable fuel source? *Most ethanol is produced by breaking down the starch into simple sugars and fermenting.*

### Observations & Conclusions

- What other foods may have high glucose levels that could be tested?
- Which foods that you have tested should Jason eat if his blood glucose levels are becoming too high?
- How might you test for more complex sugars?

**Note:** People with diabetes also suffer from high blood glucose levels.

### STEM Career Path... Nutritionist

- Who else might be involved? *Agricultural producers, endocrinologist, food scientist, biomedical engineer, and marketers.*
- Who benefits? *People with diabetes, current and future consumers with more nutritional food options, governments and businesses incurring less health-related costs through preventative care.*
- What other issues are nutritionists helping to solve? *Preventing & treating illnesses, increasing life span; enhancing bodily development in babies & children; and improving health of pregnant women and older people.*

Refer to Career Focus Card for more details.



**THE OHIO STATE UNIVERSITY**

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



# STEM PATHWAYS

## Glucose Detective **STEM** Challenge!

### Each group will ...

Step 1: Create a bar graph to capture your data on your experiment record. Label the y-axis "Glucose content", range 0-600 mg/dL in 50 mg/dL intervals. Label the x-axis with each mixture's number.

Step 2: Place a strip of aluminum foil in front of each numbered cup.

Step 3: Using the glucose meter, test your control – the water. Remove test strip from vial immediately and insert the strip into the meter. The meter should turn on depending on the meter's manufacturer.

Step 4: Using the pipet, place a few drops of water on the aluminum foil strip in front of the water cup. Gently touch the tip of the strip to the water and allow the water drop to be drawn into the strip. Some meters may beep to indicate the meter has received the mixture and is analyzing the water. Record your water glucose reading, which should be near 0.

Step 5: Now test each sample with the glucose meter. Use a new strip for each test. Remove test strip from vial, recap vial immediately, and insert the strip into the meter. Using the pipet, place a few drops of the sample on the aluminum foil strip. Gently touch the tip of the strip to a drop of the mixture and allow the drop to be drawn into the strip. Read the glucose meter result displayed on the meter and record it on the graph in the appropriate column.

Step 6: Analyze and compare results. Guess the contents of the cups based on your results. Ask the facilitator to share the food or beverage in each cup.

Step 7: Look at the sugar content of the foods and beverages you tested. Read the labels on the foods and beverage containers. Were your predictions and results close?



**Make Your Predictions**

**Test Your Samples**

**Record Your Results**

**Share Your Findings**



**What are your independent & dependent variables?**

**What is your hypothesis?**



**THE OHIO STATE UNIVERSITY**

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES





## STEM PATHWAYS Glucose Detective Challenge Bar Graph Data Sheet

Hypothesis: \_\_\_\_\_

\_\_\_\_\_ ☐ Accepted ☐ Rejected

Independent Variable: \_\_\_\_\_ Dependent Variable: \_\_\_\_\_

600 mg/dl

Glucose Level

0 mg/dl

Number of Mixture Tested

Your Recommendation for Jason:



# STEM PATHWAYS

## Glucose Detective STEM Challenge

career

**Did You Know?** For processed foods, the labels on most products list total sugar, which is a mixture of the following sugars: sucrose, fructose and glucose.

### SCIENCE

Food Scientist

**How can foods be produced that are healthier, safer, more abundant and less expensive?**

- Calories are a tool used to measure the energy content from a food's or beverage's carbohydrates, fats and proteins. Boys and girls between the ages of 9-13 years old need at least 1600-1800 calories a day.
- Adding fats and sugars during processing can make a food or beverage more appealing, but it also adds calories.
- Salt is used to preserve and modify the flavor of foods, but too much salt in the diet increases the risk of high blood pressure, which raises the odds of heart disease and stroke.

### TECHNOLOGY

Endocrinologist

**What new technologies can be designed to treat diabetes?**

- An endocrinologist is a doctor focusing on the internal function of the body, especially our body's production and use of hormones.
- The pancreas makes the hormone insulin, which the body typically releases while eating to help the body use the glucose it gets from food.
- Diabetes is a group of diseases characterized by high blood glucose levels that result from the body's inability to produce and/or use insulin.
- Insulin is delivered to diabetics through injections and pumps. What other methods could be pursued to help control glucose levels and/or deliver insulin to diabetics?

### ENGINEERING

Biomedical Engineer

**How might a meter be engineered that measures glucose, but does not require a drawing blood?**

- Currently, many people with diabetes measure the amount of glucose in their blood by pricking or lancing their finger and squeezing out a drop of blood. Sometimes a diabetic may have to measure their glucose levels multiple times a day, including before and after meals.
- Glucose can also be measured through urine, but it is not as accurate as blood glucose levels.
- Things to consider when designing a glucose meter include cost, functions, size, memory or ability to store results, and accuracy.

### MATH

Nutritionist

**What combination of physical activity and nutrition could help prevent diabetes or reduce its severity in a person?**

- Approximately 79 million people in the United States, or 25% of the population, may have pre-diabetes.
- The American Diabetes Association suggests that a non-pregnant adult with diabetes should aim for a blood glucose target of 154 mg/dL.
- Someone in the United States is diagnosed with diabetes every 17 seconds. Estimate how many people will be diagnosed with diabetes in the next minute.



THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES

# STEM PATHWAYS

## Glucose Detective STEM Challenge

### Nutritionist

#### Finding Solutions For...

- Healthy lifestyles
- Achieving specific health-related goals

#### Job Forecast Looks Like...

- **Median Income:** \$55,240 per year
- **Job Outlook:** 21% growth from 2012-2022
- **Job Environment:** Nutritionists work in many settings including hospitals, cafeterias, nursing homes and schools. Some are self-employed with their own practice.
- **Expected Growth Areas:** employment of dietitians and nutritionists is expected to increase faster than the average of all occupations.

#### Skill Set Needed...

- **High School Courses:**
  - Math: algebra and calculus
  - Science: biology, chemistry
  - Specialized: health and food science
- **Analytical:** interpret and communicate research
- **Organizational:** balance nutritional needs and food costs
- **Interpersonal:** motivational and trustworthy to help people achieve goals
- **Communication:** good written and speaking skills to help educate people

#### Education and Training Required...

- **Entry Level Jobs:** Require Bachelor's degree, participation in internships. Most states require a license or certification requiring passing an exam.
- **Additional Training and Certifications:** Advanced degrees to enhance earning potential and management roles.



THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



Sources:  
U.S. Department of Labor, Occupational Outlook  
Handbook, 2014-2015 Edition,  
[bls.gov/ooh](http://bls.gov/ooh)

American Diabetes Association



# STEM PATHWAYS

## Hay Swift Kick **STEM** Challenge!

### The Problem

Baler Logistics needs to design a kicker, bale ejection system, for one of their latest square balers. You have been contracted to work with a team to create a prototype.

### The Challenge

Using the materials provided, design a model that is accurate and reliable for moving the bale to the target.

### Find a Solution

ASK: What are some possible ideas?

PLAN: Test out your ideas

CREATE: Put your ideas to the test

IMPROVE: Review results & make changes

### Things to Consider

1. What are the anticipated bale specs for the kicker to handle?
2. What component(s) drive the kicker's accuracy and precision (reliability)?
3. How will design materials chosen be impacted by environmental conditions?

Authored by: Patty House, OSU Extension, Clark County,  
4-H Youth Development Extension Educator, [house.18@osu.edu](mailto:house.18@osu.edu)  
937-521-3865, <http://www.ohio4h.org/STEM-Pathways>



### Choose Your Design Materials

Rubber Bands (various sizes)

Craft Sticks (various sizes)

Plastic Utensils (spoons, forks)

Plastic or Metal Bottle Caps

Masking Tape

Bales (mini-marshmallows, square shaped cereal,  
toy building blocks, make your own bales)

Masking Tape



#### SAFETY ALERT:

You are making a projectile device! Do not  
take aim at anyone when testing!



THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



# STEM PATHWAYS

## Hay Swift Kick **STEM** Challenge!



*Note:  
Have each  
team select  
a bale or  
test their  
prototype  
with the  
same or  
different  
bales.*



### TIME: 20-30 MINUTES

#### Materials and Supplies

- Craft Sticks (various sizes)
- Rubber bands (various sizes)
- Plastic Utensils (spoons, forks)
- Plastic or Metal Bottle Caps
- Hay Bale (mini-marshmallows, toy building blocks/hay bales, square shaped cereal, design your own bale)
- Masking Tape or Glue Gun

#### Design Space

- 4 ft. x 4 ft. table space per team
- Set parameters # of craft sticks, # of rubber bands, # of bottle caps, plastic utensils, bale types, etc.
- Target for testing accuracy and reliability.

View How A Baler Makes A Square Bale:  
[http://www.youtube.com/watch?v=\\_BVtirYc6Pc](http://www.youtube.com/watch?v=_BVtirYc6Pc)



**SAFETY ALERT:** You are making a projectile device! Do not take aim at anyone when testing!

### Engage the Learner

- What climatic and growing conditions might impact material choice?
- How will bale size and weight affect kick pan or lever materials selected?
- What affects does leverage and spring have on the bale kicker's accuracy and precision (reliability)?

### Observations & Conclusions

- Did your hay kicker work as you intended? What's your model's accuracy percentage? reliability percentage?
- What worked? What didn't? Knowing what you know, what changes will you make to improve accuracy & precision?
- If you could choose another material, what would it be? How would you use this material?

Post who designed the most accurate, most reliable or both accurate & reliable over time.

### STEM Career Path ... Agriculture Systems Technologists

- Who else might be involved? *Climatologists, agronomists, agriculture safety specialists, agriculture and mechanical engineers, economists, etc.*
- Who benefits? *Agriculture producers through reduced labor costs, farm-related injuries, uniformed hay bales for sale, competitive edge of manufacturers, etc.*
- What other industries might benefit from this work? *Food processing and manufacturing, toy companies, sports equipment, etc.*

Refer to Career Focus Card for more details.



**THE OHIO STATE UNIVERSITY**

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



## STEM PATHWAYS

career

## Hay Swift Kick STEM Challenge

Did You Know? The first hay baler was designed in 1932. Today's hay baler is highly mechanized with many parts working simultaneously. View: <http://www.youtube.com/watch?v=BVtirYc6Pc> What does the hay ejector (kicker) remind you of when in operation?

## SCIENCE

Agronomist

## What characteristics determine hay's feeding value and quality?

- Grass/forage species, year in production, maturity when cut and harvested.
- Growing and weather conditions
- Weed and foreign debris
- Insect and disease damage
- Moisture content, feed value analysis, storage conditions

## TECHNOLOGY

Agriculture Systems  
Technologists

## How can improved baler mechanization and operation improve hay quality and profitability?

- Bale uniformity for ease of transport and handling
- Environmental conditions impact equipment reliability, performance and product quality
- The baler's hay kicker reducer handling time and labor costs.

## ENGINEERING

Mechanical Engineer

What other labor intensive tasks have improved with new technologies?  
What task or chore do you have that you wish there was a machine to do it for you?

- Mechanical engineering is the broadest engineering field. They design, develop, build and test mechanical devices, including tools, engines and machines.

## MATH

Agriculture  
Equipment Dealer

## What determines the number and type of hay balers stocked by a local equipment dealer?

- Type of agricultural production in the area (crop type, livestock produced, irrigation, etc.)
- Farm size and age of agriculture producers and farm operators
- Local and national weather conditions (drought, flood, etc.)
- Agriculture commodity and market prices determine dollars available to purchase new equipment or replace existing equipment.



THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES

# STEM PATHWAYS

## Hay Swift Kick STEM Challenge

### Agriculture Systems Technologist

#### Finding Solutions For...

- Agricultural equipment, water quality and water management, bio-renewables and biofuels, biological products, livestock facilities, food processing and more.
- Maximizing production, minimizing costs and optimizing social, economic and environmental benefits.

#### Job Forecast Looks Like...

- **Median Income:** \$71,090 per year
- **Job Outlook:** 5% growth from 2012-2022
- **Job Environment:** Indoor and outdoor field experiences testing equipment and designs
- **Expected Growth Areas:** Precision agriculture, bio-renewables and biofuels, water quality and management, food processing

#### Skill Set Needed...

- **High School Courses:**
  - Math: algebra, geometry, calculus
  - Science: biology, chemistry, and physics
  - Specialized: drafting, computer science, engineering, robotics
- **Problem-solving:** apply engineering and technology to new circumstances
- **Teamwork:** design solutions involving biological, mechanical or environmental dimensions, work and receive feedback from a variety of backgrounds
- **Communication:** actively listen, writes and speaks well
- **Initiative:** attention to detail, willingness to take on challenges and responsibilities

#### Education and Training Required...

- **Entry Level Jobs:** Require Bachelor's degree
- **Additional Training and Certifications:** Increased earning potential for those that seek advanced training, masters and doctorates



**THE OHIO STATE UNIVERSITY**

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



Sources:  
U.S. Department of Labor, Occupational Outlook  
Handbook, 2014-2015 Edition,  
[bls.gov/ooh](http://bls.gov/ooh)



# STEM PATHWAYS

## Natural Glue **STEM** Challenge!

### The Problem

Glue is used to help manufacture furniture and typically made from petroleum. Emily owns a furniture store and is looking for ways to make her company more environmentally-friendly by using a glue made from renewable agricultural materials.

### The Challenge

Help Emily by formulating a glue using known bio-friendly ingredients then comparing the glue's performance against a standard wood glue for drying time, strength and adhesion.

### Find a Measurable Solution

ASK: What is your hypothesis?

HYPOTHESIZE: Identify your variables.

TEST: Conduct an experiment.

ANALYZE: Results, draw conclusions, try again!

COMMUNICATE: Findings & make recommendations.

### Things to Consider

1. Why do we use glue and for what applications?
2. What performance features need to be in glue in order for customers to purchase it?
3. What type of experiment will you design to test the strength of your glue mixture?

Authored by: Dustin Homan, Program Manager for Bio-product Education, Ohio Bio-Products Innovation Center  
614-247-1940 [go.osu.edu/4HSTEMpathways](http://go.osu.edu/4HSTEMpathways)



What is Your Hypothesis?



What are your variables?

### Identify Independent and Dependent Variables

- Types of Flour
- Ratio of Ingredients
- Amount of Water
- Mixing Time
- Drying Time
- Amount of Adhesive Applied
- Adhesion
- Strength



#### SAFETY ALERT:

Do not eat the adhesive glue and wash your hands after handling the glue.



THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



# STEM PATHWAYS

## Natural Glue **STEM** Challenge!



**TIME: 30 MINUTES**

### Materials & Supplies

- Craft sticks
- Large plastic cups or zipper type bags
- Wooden stir stick
- Measuring tools; cups & spoons
- Stopwatch to measure drying times
- Standard Wood glue
- Different Flours
- Sugar
- Vinegar
- Water

### Design Space

- Table space for teams of two.
- Table covers for easy clean-up
- Ingredients measured out in labeled containers.
- Basic formula



**SAFETY ALERT:** Do not eat the adhesive glue and wash your hands after handling the glue.

- Did you accept or reject your hypothesis?
- What changes will you make?
- What questions do you still want to explore?

### Engage the Learner

- What environmental factors could affect the glue's ability to bond materials together?
- How might the materials being bonded affect the glue's hold?
- What are the positives and negatives of using an agricultural-based glue versus a petroleum-based glue?
- Identify objects in nature that are naturally "sticky"?

### Observations & Conclusions

- How might you alter the ingredients next time to improve the glue's adhesiveness?
- What other experiments could you design to test the glue's bonding ability under different conditions?
- What other agricultural materials could be substituted in the ingredients' list to make the glue?
- Why is it beneficial to make natural glue that does not contain harmful chemicals, which are found in some petroleum-based glues?

### STEM Career Path... Chemist

- Who else might be involved? *Agricultural producers, processing operator, materials engineer, manufacturer and marketer*
- Who benefits? *Consumers with more sustainable choices, agricultural producers with expanded commodity market opportunities, and new jobs.*
- What other issues are chemists helping to solve? *Producing lighter and stronger materials for vehicles to increase fuel mileage and safety, creating more nutritious foods, and discovering new medicines to treat illness.*

Refer to Career Focus Card for more details.



**THE OHIO STATE UNIVERSITY**

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



# STEM PATHWAYS

## Natural Glue **STEM** Challenge!

### Each group of 2 will ...

Step 1: Gather two craft sticks, a wooden stirring stick and a plastic cup or zipper type bag.

Step 2: Place 1 cup flour of your choice into the plastic cup or zipper type bag.

Step 3: Add

- ☛ 1 ½ cups water
- ☛ 1/3 cup sugar
- ☛ 1 teaspoon vinegar

Step 4: Using the stir stick, mix the contents very thoroughly.

- Step 5: Now design an experiment to test the glue's adhesiveness. An example may include using the stir stick to apply the mixture to the end of one craft stick. Place the end of another craft stick on top of the mixture to adhere them together.
- Step 6: Allow a few moments for the adhesive to dry; use the stopwatch to time drying length.
- Then develop a series of different tests to determine the adhesive's strength.
- Repeat experiment and alter variables to test.
- Record and discuss procedures, results and observations.



### Test Your Hypothesis

### Analyze Your Findings

### Communicate Your Results



What is your hypothesis?

What is your independent and dependent variables?



THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



## STEM PATHWAYS Natural Glue Lab Analysis Data Sheet

Hypothesis: \_\_\_\_\_

\_\_\_\_\_ ☐ Accepted ☐ Rejected

Independent Variable: \_\_\_\_\_ Dependent Variable: \_\_\_\_\_

Glue Tested	Drying Time Record Time	Amount Applied Record Measurement	Describe Adhesive Bond	Describe Strength Test Conducted
Wood Glue				
Natural Glue Record Flour Type Used				
Natural Glue Record Flour Type Used				
Natural Glue Record Flour Type Used				
Natural Glue Record Flour Type Used				

Your Recommendation to Emily





## STEM PATHWAYS

career

## Natural Glue STEM Challenge

Did You Know? Nature produces many kinds of glues/adhesives including tree sap, mud, mussel byssus, and spider silk. Can you think of other sticky things that occur in nature?

## SCIENCE

Chemist

## What causes the mixture to become adhesive?

- Grinding grains, such as wheat, makes flour and releases starches and proteins.
- Starch molecules are long polymer chains of simple sugars linked head to tail by chemical bonds.
- Proteins are more complex- a single protein contains amino acids strung together like beads on a necklace.
- When water is added to flour and mixed, the proteins form a tough elastic substance called gluten.

## TECHNOLOGY

Computer  
Programmer

## What factors need to be considered when designing machines to manufacture the adhesive on a large scale?

- An incorrect ratio of ingredients or inadequate mixing time will not produce a consistent product and cause irregular adhesion.
- The temperature of the mixture will affect its viscosity, or ability to flow throughout the manufacturing plant.
- Varying particle sizes will cause the glue to have mixed properties, so machines need to be able to detect particle size and adjust mixing accordingly.
- Agricultural inputs, such as wheat and sugar, need to be stored in cool, dry environments to reduce spoilage.

## ENGINEERING

Materials Engineer

## What other performance characteristics should the glue possess to be purchased by consumers?

- The vinegar in the glue serves as a mild natural preservative to reduce rate of spoilage.
- Mixtures made from higher protein content flour are harder and stronger. Soybean flour is higher in protein than wheat flour.
- The natural glue produced through this activity is non-toxic in case of ingestion or skin contact.

## MATH

Logisticians

## How will the ingredients be acquired and stored? How and when will the glue be delivered to customers?

- Agricultural inputs, such as wheat and sugar, have shelf lives and need to be used within a specified time to avoid spoiling.
- It is critical to monitor ingredient sources to optimize production to meet demand and keep costs low.
- Streamlining transportation of ingredients to the manufacturer and glue to the consumer will reduce costs and make the business more profitable.



THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES

# STEM PATHWAYS

## Natural Glue STEM Challenge

### Chemist

#### Finding Solutions For...

- Cheaper, safer and more sustainable materials
- Reducing pollution
- Improving energy efficiency and alternative sources of energy
- Treatment of diseases and illnesses

#### Job Forecast Looks Like...

- **Median Income:** \$73,060 per year
- **Job Outlook:** 6% growth from 2012-2022
- **Job Environment:** Full-time and regular hours in laboratories and offices
- **Expected Growth Areas:** materials research, environmental research, alternative energy sources research, and pharmaceutical/drug research

#### Skill Set Needed...

- **High School Courses:**
  - Math: algebra and calculus
  - Science: biology, chemistry, and physics
- **Critical thinking:** analytical and problem-solving skills to conduct precise and accurate scientific experiments to develop new and improved products, processes and materials
- **Communication:** writing and speaking skills to share experiments and results
- **Teamwork:** to motivate and work well with others on a research group

#### Education and Training Required...

- **Entry Level Jobs:** Require Bachelor's degree
- **Additional Training and Certifications:** Chemists with advanced degrees, particularly those with a Ph.D., tend to experience better opportunities through senior research, upper-management and faculty positions.



THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



Sources:  
U.S. Department of Labor, Occupational Outlook  
Handbook, 2014-2015 Edition,  
[bls.gov/ooh](http://bls.gov/ooh)

# STEM PATHWAYS

## Please Just Contain It **STEM** Challenge!

### The Problem

The County's Emergency Management Board is developing a plan to improve containment and clean up of chemical spills. They have contacted your team of scientists to investigate the use of the super absorbent material found in diapers (Hydrogel). You have been given the product to test and establish recommendations for use by the EMA board.

### The Challenge

To develop and test an hypothesis to determine hydrogel's absorption capacity for different liquid wastes.

### Find a Measurable Solution

ASK: What is your hypothesis?

HYPOTHESIZE: Identify independent & dependent variables.

TEST: Conduct an experiment.

ANALYZE: Results, draw conclusions, try again!

COMMUNICATE: Findings and make recommendations.

### Things to Consider

1. What are the chemical and physical differences between water and oil ?
2. Which type of spill do you predict the product will best contain or least contain? What is the basis for your prediction?
3. How will you determine the product's effectiveness in containing a spill?

Authored by: Patty House, OSU Extension, Clark County,  
4-H Youth Development Extension Educator, [house.18@osu.edu](mailto:house.18@osu.edu)  
937-521-3865 [go.osu.edu/4HSTEMpathways](http://go.osu.edu/4HSTEMpathways)



### What is Your Hypothesis?

#### Identify Independent and Dependent Variables

- Color
- Odor or Smell
- Water Base
- Oil Base
- Hydrogel Amount



#### SAFETY ALERT:

You can touch this "hydrogel", but **PLEASE** don't put any chemical, even a safe, non-toxic one like this, into your eyes, nose or mouth!



**THE OHIO STATE UNIVERSITY**

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



# STEM PATHWAYS

## Please Just Contain It **STEM** Challenge!



- Did you accept or reject your hypothesis?
- What changes will you make?
- What questions do you still want to explore?

### Materials & Supplies

- Polymer Compounds
  - Baby Diapers (mine the hydrogel) OR
  - Hydrogel (purchase from science source)
  - Corn Based Polymer (contact Ohio Corn Growers Association)
- Water Base Items (vinegar, ketchup, water, tempera paint, juice, milk, syrup, salt water, etc.)
- Oil Base Items (vegetable oil, baby oil with coloring, mineral oil, soy ink, oil based paint, etc.)
- 1 Gallon Plastic Zipper Type Bag, Scissors (if mining the polymer from diapers)
- Single serve plastic cup, ½ teaspoon for each polymer type, 1 tablespoon for each water and oil base sample, plastic spoons



**SAFETY ALERT:** You can touch this “hydrogel”, but PLEASE don’t put any chemical, even a safe, non-toxic one like this, into your eyes, nose or mouth!

**TIME: 30 - 45 MINUTES**

### Design Space

- Table space sufficient for each group to work.
- Cover tables for easy clean-up.
- Supplies to diaper mine for each group or hydrogel.

### Engage the Learner

- What do you already know about the test compound? What might you need to research?
- What other variables could be tested?
- How should product application be factored into your recommendations?
- How will you report your findings to consumers, emergency management board and other scientists?

### Observations & Conclusions

- Observe the rate of absorption and the amount absorbed... successful, somewhat, not at all?
- How does the volume change in each sample tested?
- How does the product standup to masking an odor or soaking up color?
- What might be some other uses for this product by consumers, industries, agriculture producers, etc.?

What other variables would you like to test?  
Post your findings and challenge others to find hydrogel's contain it limits!

### STEM Career Path... Materials Scientist

- Who else might be involved? *Chemists, engineers, health specialists, hydrologists, soil scientists, physicians, marketers*
- Who benefits? *Environmental and human health benefits are extensive – protection of drinking, surface and ground water sources, soil, wildlife, animal and plant life*
- What other industries might benefit from this work? *Manufacturers of any chemical, health care, homeland security, oil and gas, transportation, government, etc.*

Refer to Career Focus Card for more details.



**THE OHIO STATE UNIVERSITY**

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES





# STEM PATHWAYS

## Please Just Contain It **STEM** Challenge!

### Working in Groups of 4 to 6...

#### FIRST! Mine Your Polymer

Step 1: Carefully use the scissors to cut through the inside lining of the diaper and remove the cotton-like material.

Step 2: Put the stuffing and the plastic lining into a clean, 1 gallon zipper-type bag.

Step 3: Scoop up any powdery material from the table; place it in the bag and seal the bag.

Step 4: Shake the bag to remove the powdery polymer from the stuffing.

Step 5: Remove the stuffing and plastic lining from the bag; **THROW IT AWAY**. You should have the mined polymer remaining in the bag.

#### SECOND! Test the Polymer for Spill Containment

Step 6: Use water as your control test. Place 1 T. of water in a plastic cup and add ½ teaspoon of the hydrogel polymer. Wait a few seconds and stir with a spoon.

Step 7: Now choose two water-base products and two oil-base products to test.

Step 8: Repeat step 6 by placing 1 T of each water base and oil base product chosen in a separate plastic cup and adding ½ teaspoon of the hydrogel to each cup. Wait a few seconds and stir with a spoon.

How effective was the hydrogel polymer?

- ☛ In absorbing the spill
- ☛ In neutralizing the odor
- ☛ In soaking up the color

**Note:** Compare each test to the water control. What are the similarities and differences to volume change indicating the spill is binding with the polymer?



#### THIRD! OPTIONAL Compare Petroleum-Based to Corn-Based Polymer

Step 9: Place 1 T of water in a cup and add ½ teaspoon of the corn-based polymer to the water. Wait a few seconds and stir.

Step 10: Place 1 T of the same water and oil base samples that you used in Step 8 in separate cups and add ½ teaspoon of the corn-based polymer to each cup.

What differences did you observe between the effectiveness of the hydrogel petroleum-based polymer and the corn-based polymer in containing or cleaning up the spill, neutralizing odor or absorbing color?

**What is your hypothesis?**  
**Will results find you accepting or rejecting your hypothesis?**

**What are your independent and dependent variables?**



**THE OHIO STATE UNIVERSITY**

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



## STEM PATHWAYS Please Just Contain It Analysis Data Sheet

Hypothesis: \_\_\_\_\_

\_\_\_\_\_ ☐ Accept ☐ Reject

Independent Variable: \_\_\_\_\_ Dependent Variable: \_\_\_\_\_

Sample Tested	Describe Rate of Absorption	Describe Change in Volume	Describe Ability to Mask Odor	Describe Ability to Soak up Color
Control Solution				
Water Based Sample 1				
Water Based Sample 2				
Oil Based Sample 1				
Oil Based Sample 2				

Your Recommendation to the EMA Board:



# STEM PATHWAYS

## Please Just Contain It STEM Challenge

Did You Know? Some polymers can absorb 500 times their weight in water increasing in volume by 30 to 60 times.

### SCIENCE

#### Materials Scientist

#### What other product benefits could result from incorporation of hydrogels?

- Hydrogels are polymers, long chain molecules that are superabsorbent used to make millions of disposable diapers and to improve water holding capacity in container gardens.
- New hydrogels are being used in drug delivery systems, soft contact lenses, wound dressing, replacement cartilage and scaffold for tissue engineering – medical advances improving the health care of all ages.
- Some hydrogels are environmentally sensitive having the ability to sense changes in pH, temperature or the concentration of a metabolite.

### TECHNOLOGY

#### IT Specialist

#### Why is computer modeling important in the design process of new materials and products?

- 3-D computer modeling software is used to study the structure and properties of complex molecules.
- Sophisticated testing equipment supports modeling, simulation and analysis of experimentation.

### ENGINEERING

#### Chemical Engineer

#### Why would comparing natural versus synthetic polymers be important in designing new products?

- Green products are growing in demand as consumers are looking to do their part to reduce global impact and the carbon footprint.
- Savings in production costs, worker safety, shrinking natural resources are strong reasons for using one polymer source over another or seeking alternative polymer sources.

### MATH

#### Marketing Specialist

#### Why is it important for your team to understand what the consumer wants from your product?

- Trends in the market place are important to creating new products.
- Challenges or problems manufacturers or consumers have had with a product enables tests to be run to fine-tune materials or focus on new product development.
- Every product requires a marketing plan highlighting the products safety and consumer benefits.



THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



# STEM PATHWAYS

## Please Just Contain It STEM Challenge

### Materials Scientist

#### Finding Solutions For...

- New products, processes and testing methods through applied research.
- Safer products and higher quality with a focus on more environmentally friendly alternatives.
- Make materials that make life better from sun lotions to prosthetic limbs, race cars to snowboards.

#### Job Forecast Looks Like...

- **Median Income:** \$88,990 per year
- **Job Outlook:** 5% growth from 2012-2022
- **Job Environment:** Laboratories and offices where they conduct experiments and analyze data.
- **Expected Growth Areas:** Electronics, energy and transportation, environmental research to reduce pollution and improve efficiency.

#### Skill Set Needed...

- **High School Courses:**
  - Math: geometry, algebra, calculus, statistics
  - Science: biology, chemistry, and physics
  - Specialized: computer science
- **Initiative:** curiosity, perseverance, great focus for hands-on experimenting.
- **Critical-thinking:** analytical and problem-solving skills to conduct precise and accurate scientific experiments to develop new and improved products, processes and materials
- **Communication:** writing and speaking skills to share experiments and results
- **Teamwork:** to motivate and work well with others on a research group

#### Education and Training Required...

- **Entry Level Jobs:** Require Bachelor's degree in chemistry, biology, engineering or other related field
- **Additional Training and Certifications:** master's or doctorate degrees preferred, HAZMAT training



THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



Sources:  
U.S. Department of Labor, Occupational Outlook  
Handbook, 2014-2015 Edition,  
[bls.gov/ooh](http://bls.gov/ooh)



# STEM PATHWAYS

## Submarine Exploration **STEM** Challenge!

### The Problem

Jack is an aquatic scientist exploring the lifecycle of the Pacific Seahorse. He needs a vessel to help him travel to the area between the surface and the ocean bed.

### The Challenge

Design a vehicle to help Jack capture video of Pacific Seahorses in their native habitat.

### Find a Solution

ASK: What are some possible ideas?

PLAN: Test out your ideas

CREATE: Put your ideas into action.

TEST: How well did your idea work?

IMPROVE: Review results & make changes.

### Things to Consider

1. How will the material you choose for your submarine affect its ability to float under the surface?
2. What material properties must you consider before adding them to your submarine?
3. What type of submarine will minimize the disturbance of the ocean life environment?

Authored by: Travis West, OSU Extension, Vinton County,  
4-H Youth Development Extension Educator, west.222@osu.edu  
740-596-5212, go.osu.edu/4HSTEMpathways



### Choose Your Design Materials

Plastic Egg (submarine)

Marbles

Coins

Wood Pieces

Beads

Cork

Washers

Paper Clips

Popsicle Sticks

#### SAFETY ALERT:

You don't want water to be leaking inside your submarine or on your internal materials.  
Check your seal before launching into the ocean.



THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



# STEM PATHWAYS

## Submarine Exploration **STEM** Challenge!



**TIME: 30 MINUTES**

### Materials and Supplies

- Plastic eggs (one for each participant)
- Variety of small and heavy objects (craft sticks, marbles, coins, wood pieces, beads, cork, washers, paper clips)
- Tubing Plastic Container (3-5 gal. size – deep enough to accommodate floating, hovering in water & sitting on the bottom)
- Water (optional salt to add to water)
- Tape (to seal submarine shell from leaks)
- Record sheet & pen

### Design Space

- Table space with plastic eggs and design materials.
- Testing area with container half filled with water.
- Optional: 2<sup>nd</sup> container half filled with salt water for comparisons.



**SAFETY ALERT:** You don't want water to be leaking inside your submarine or on your internal materials. Check your seal before launching into the ocean!

### Engage the Learner

- How many ways are there to construct the submarine to accomplish the challenge?  
*Multiple*
- What forces are acting on the object? *Buoyancy – Force pushing up, Pressure – pulls sub to ocean floor, Drag – resistance of water pressure on outside of submarine*
- How might the material's selected affect the submarine's ability to float? *Dense materials like metal nuts will increase the effect of pressure on sub; less dense materials like wood pieces and craft sticks will increase buoyancy of submarine*

### Observations and Conclusions

- What materials seemed to move the submarine lower in the water? *Dense materials like metal nuts, etc. They are heavier (more mass) and therefore increase effect of pressure on submarine.*
- Does the submarine work in both salt and fresh water? *Salt water is more dense than fresh water, so submarine should float higher in the water.*

Reference: "Design a Submarine" by the Museum of Science in Industry; Chicago, IL.

### STEM Career Path ... Marine Engineer

- Who else might be involved? *Marine biologist, biological technicians, naval architects*
- Who benefits? *Improved safety for recreational boaters, naval officers, cruise ship travelers, ocean explorers and scientists. Ability to map uncharted waters, discovering new plant and animal life, tracking changes, retrieving sunken ships, etc.*
- What other issues are marine engineers helping to solve? *Designing vessels from aircraft carriers to submarines. More efficient propulsion and steering of aquatic vessels.*

Refer to Career Focus Card for more details.



**THE OHIO STATE UNIVERSITY**

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



# STEM PATHWAYS

## Submarine Exploration STEM Challenge

career

Did You Know? Some of the largest submarines can stay submerged underwater for six months.

### SCIENCE

Marine Biologist

What conclusion can you draw from observing seahorses in their natural habitat?

- They are bad swimmers.
- They are fish.
- Male seahorses give birth.
- They eat almost constantly.

### TECHNOLOGY

Biological  
Technicians

How can studying with a submarine assist in preserving seahorse populations?

- Seahorses mate with their partner for life.
- Fifty-three species of seahorses are spread across the world.
- Sometimes seahorses stay on one plant for days because they are not good swimmers.

### ENGINEERING

Marine Engineers

What materials will help reduce the friction of a submarine?

- Buoyant materials are necessary to keep the submarine off the ocean bed.
- Submarines must be able to rise to the surface and float in the water.

### MATH

Naval Architects

What factors must be considered when designing an aquatic vessel?

- Computer specifications to establish basic characteristics of a ship, such as size, weight, and speed.
- Develop sectional and waterline curves and angles of the hull to establish the center of gravity and ideal hull form.
- Calculating the static and dynamic stability of a given vessel.
- Determining the force of buoyancy imposed on the vessel by the materials.



THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



# STEM PATHWAYS

## Submarine Exploration STEM Challenge

### Marine Engineer

#### Finding Solutions For...

- Vessels from aircraft carriers to submarines
- More efficient propulsion and steering of aquatic vessels

#### Job Forecast Looks Like...

- **Median Income:** \$88,100 per year
- **Job Outlook:** 10% growth from 2012-2022
- **Job Environment:** Offices with access to computers, software and design tools, some time is spent at sea testing and maintaining vessels
- **Expected Growth Areas:** ships and systems to transport energy products, global transportation for liquefied natural gas

#### Skill Set Needed...

- **High School Courses:**
  - Math: algebra, trigonometry and calculus
  - Science: biology, chemistry, and physics
  - Specialized: drafting
- **Problem-solving:** apply engineering and technology to new circumstances
- **Teamwork:** design solutions involving biological, mechanical or environmental dimensions, work and receive feedback from a variety of backgrounds
- **Communication:** give clear instructions and explain complex concepts to teams
- **Ingenuity:** operations analysis to create a design and use critical thinking to anticipate and correct deficiencies.

#### Education and Training Required...

- **Entry Level Jobs:** Require Bachelor's degree
- **Additional Training and Certifications:** An exam to obtain a mariner's license from the U.S. Coast Guard. Cooperative engineering programs can provide valuable practical experience which is important to employers.



**THE OHIO STATE UNIVERSITY**  
COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



Source:  
U.S. Department of Labor, Occupational Outlook  
Handbook, 2014-2015 Edition,  
bls.gov/ooh



# STEM PATHWAYS

## Watersheds at Work **STEM** Challenge!

### The Problem

Heavy seasonal rains are causing multiple sources (point & non-point) contaminants to enter our waterways. Everybody who lives in our watershed has a responsibility to help control where it goes & how fast it gets there.

### The Challenge

To create a solution that diverts, reduces and manages the flow of contaminants through your watershed.

### Find a Solution

ASK: What are some possible ideas?

PLAN: Test out your ideas

CREATE: Put your ideas to the test

IMPROVE: Review results & make changes

### Things to Consider

1. What are some potential engineered or natural solutions to controlling contaminated water in your watershed?
2. How does topography impact flow rate and management solutions?
3. What is the correlation between land use and volume of run-off?

Authored by: Patty House, OSU Extension, Clark County  
4-H Youth Development Extension Educator  
house.18@osu.edu 937-521-3865  
Dr. Bob Horton, Ohio 4-H, State STEM Specialist  
horton.2@osu.edu 614-247-8150  
<http://www.ohio4h.org/STEM-Pathways>



### Design Your Watershed

#### Select 3 Different Land Uses

*One must be agricultural and one urban*

- **Agricultural** – corn and soybean cropland, pasture or hay field, livestock, fruit and vegetable production
- **Urban** – Commercial lawn application, waste water treatment, car wash, new construction, water treatment plant, residential housing, golf course, roads.

#### Select 3 Different Water Management Solutions

*One must be engineered and one natural*

- **Engineered**– retention pond or catch basin, field tile, storm drain, filter strip, wetlands
- **Natural** – Tree buffer, grass waterways or filter strips, reduce till practice, wetlands

#### Select 2 Water Sources

*One is rain and the other major body of water for the watershed (stream, river, lake)*



**SAFETY ALERT:** You can touch the water polymer crystals, but do not put them in your nose, mouth or eyes!



**THE OHIO STATE UNIVERSITY**

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



# STEM PATHWAYS

## Watersheds at Work **STEM** Challenge!

### Set-Up & Testing Considerations For Each Team of 4

- 4 ft. x 4 ft. Engineer Challenge Area**
- Base Materials:**
  - Two - 30 gallon trash bags – one for challenge mat and one for topography.
  - Disposable bowls, cups, newspaper modeling clay to create topography between the two gallon trash bags and a surface water source.
- Land Use Materials:** Select materials to represent three types of land uses and add to the topography.
- Engineered and Natural Barriers & Diverters:** Select three materials to reduce flow of pollutants through the watershed.
- Point & Non-Point Sources:** Apply appropriate point and non-point sources to appropriate land use areas.

### TIME: 30 MINUTES

#### Materials and Supplies

- |                             |                              |
|-----------------------------|------------------------------|
| • Masking Tape              | • Activated Charcoal         |
| • Cotton Swabs              | • Paper Cups                 |
| • Tissue Paper              | • Sand                       |
| • Paper Bowls               | • Peat Moss                  |
| • 20-30 gallon Garbage Bags | • Mulch                      |
| • Straws                    | • Felt Interfacing           |
| • Gravel                    | • Muslin                     |
| • Cotton Balls              | • Sponges                    |
| • Water Polymer Crystals    | • Corn Packing Peanuts       |
| • Cheesecloth               | • Powdered Drink (chemicals) |
|                             | • Cocoa (soil)               |
|                             | • Spray Bottle with Water    |



**SAFETY ALERT:** You can touch the water polymer crystals, but do not put them in your nose, mouth or eyes!

### Engage the Learner

- What do you know about water quality in your watershed?
- What are some realistic management solutions to agricultural land?
- What natural solutions would work in urban areas?
- What will accelerate water flow in your watershed? How can you manage it?

### Observations & Conclusions

- Observe the water flow rate in your watershed. How much chemical was absorbed? How much soil was diverted?
- Which land modifications had the greatest impact?
- How does the rate of rainfall impact your solutions?
- Which solutions performed the best engineered or natural and why?
- Which is more devastating a cup of water poured on or a cup of water sprayed on? How does it impact a single point versus the entire watershed?
- What recommendations would you make based on your findings?

### STEM Career Path ...

#### Water Management Specialist

Who else might be involved? Urban planner, civil and environmental engineers, soil conservationist, meteorologist, hydrologist, biologist, agronomist.

Who benefits? Improved water quality for everyone, economic benefits to farmers, municipalities and taxpayers, environmental protection to ecosystems.

What other issues are water management specialists helping to solve? wetland restoration, groundwater contamination, water quality and quantity issues – dams, flooding, levies, etc.

Refer to Career Focus Card for more details.



THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



# STEM PATHWAYS

Thank You For Participating!

We would like you to answer some questions about your experience in facilitating STEM Pathways. We are surveying facilitators to better understand our program's impact on facilitation preparation.

**This survey is...**

- **VOLUNTARY:** You can choose to fill it out or not.
- **PRIVATE:** No one will know which answers are yours.
- **NOT A TEST:** There are no right or wrong answers.





County: \_\_\_\_\_ Hours of Facilitation: \_\_\_\_\_

Setting: ☐ After-School ☐ Camp ☐ Club ☐ School

☐ Other \_\_\_\_\_

# of Youth \_\_\_\_\_ # of Times Facilitating: \_\_\_\_\_

## Facilitator Survey

BEFORE Facilitating STEM Pathways					AFTER Facilitating STEM Pathways			
Strongly Disagree	Disagree	Agree	Strongly Agree	Please share to what extent you agree or disagree with each statement <u>BEFORE</u> and <u>AFTER</u> your facilitation of a STEM Pathways program. STEM = Science, Technology, Engineering and Math	Strongly Disagree	Disagree	Agree	Strongly Agree
								
1	2	3	4	EXAMPLE: I like learning along with youth. <i>This response shows that <u>BEFORE</u> the program, the facilitator agrees with this statement and <u>AFTER</u> being a facilitator with this program they strongly agree.</i>	1	2	3	4
1	2	3	4	1. I am comfortable teaching STEM.	1	2	3	4
1	2	3	4	2. I'm afraid I will mess up science experiments.	1	2	3	4
1	2	3	4	3. I can connect STEM careers to real-world problems.	1	2	3	4
1	2	3	4	4. I am comfortable leading activities with multiple end results.	1	2	3	4
1	2	3	4	5. I can solve a problem using the engineering design process.	1	2	3	4
1	2	3	4	6. I enjoy helping others learn from mistakes as much as successes.	1	2	3	4
1	2	3	4	7. I'm intimidated by the application of new technology.	1	2	3	4
1	2	3	4	8. I am interested in STEM career opportunities.	1	2	3	4
1	2	3	4	9. I can lead group problem solving through active questioning.	1	2	3	4
1	2	3	4	10. I use STEM information to help me make decisions.	1	2	3	4



**As a result of facilitating a STEM Pathways Program, please answer the following questions.**

**What did you discover about yourself?:** \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**What did you discover about the youth you engaged in the Stem Pathways Program?:** \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**What would you change to improve your ability to facilitate STEM Pathways?** \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

### **Tell Us About Yourself:**

**I am:** ☐ Male ☐ Female

**I am a:** ☐ teen volunteer ☐ adult volunteer ☐ youth professional

**I am:** ☐ American Indian or Alaskan Native

☐ Asian

☐ Black or African American

☐ Native Hawaiian or Pacific Islander

☐ Hispanic or Latino

☐ Multi-Racial

☐ White

**I live:** ☐ On a Farm ☐ Rural Non-Farm ☐ Town ☐ Suburb ☐ City over 50,000

**My career is:** \_\_\_\_\_

**My highest level of education is:** \_\_\_\_\_



# STEM PATHWAYS

Thank You For Participating!

We would like you to answer some questions about your experience.

**This survey is...**

- **VOLUNTARY:** You can choose to fill it out or not.
- **PRIVATE:** No one will know which answers are yours.
- **NOT A TEST:** There are no right or wrong answers.

County: \_\_\_\_\_ Program Date: \_\_\_\_\_





Setting: ☐ After-School ☐ Camp ☐ Club ☐ School

☐ Other \_\_\_\_\_

## BEFORE Participating in STEM Pathways

## Participant Survey

## AFTER Participating in STEM Pathways

Strongly Disagree 	Disagree	Agree	Strongly Agree 	Please share to what extent you agree or disagree with each statement <u>BEFORE</u> and <u>AFTER</u> your participation in STEM Pathways.  STEM = Science, Technology, Engineering and Math	Strongly Disagree 	Disagree	Agree	Strongly Agree 
1	<b>2</b>	3	4	EXAMPLE: I like science <i>This response shows that <u>BEFORE</u> the program, the participant disagrees with this statement and now, <u>AFTER</u> participating in the program they agree.</i>	1	2	<b>3</b>	4
1	2	3	4	1. I get excited about new discoveries.	1	2	3	4
1	2	3	4	2. I like to see how things are made.	1	2	3	4
1	2	3	4	3. I like testing ideas.	1	2	3	4
1	2	3	4	4. I can work with others to solve problems.	1	2	3	4
1	2	3	4	5. I believe there is only one right answer in science.	1	2	3	4
1	2	3	4	6. I can create a model from my idea to solve a problem.	1	2	3	4
1	2	3	4	7. I am confident in sharing my observations.	1	2	3	4
1	2	3	4	8. I want to learn more about STEM.	1	2	3	4
1	2	3	4	9. I think STEM information can help me make better decisions.	1	2	3	4
1	2	3	4	10. I would like to have a STEM related job someday.	1	2	3	4

CFAES provides research and related educational programs to clientele on a non-discriminatory basis.  
For more information: <http://go.osu.edu/cfaesdiversity>



**As a result of your participation in STEM Pathways, please share with us...**

**Three Things You Learned:** \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**Two Things You Still Have Questions About:** \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**One Thing You Plan to Explore:** \_\_\_\_\_

\_\_\_\_\_

**Tell Us About Yourself:**

**I am:** ☐ Male ☐ Female

**I am:** ☐ American Indian or Alaskan Native  
☐ Native Hawaiian or Pacific Islander

☐ Asian  
☐ Hispanic or Latino

☐ Black or African American  
☐ Multi-Racial ☐ White

**I live:** ☐ On a Farm ☐ Rural Non-Farm ☐ Town ☐ Suburb ☐ City over 50,000

**My grade in school:** \_\_\_\_\_

**My age:** \_\_\_\_\_

# STEM PATHWAYS

What did you learn today?



# STEM PATHWAYS

What did you learn today?



# STEM PATHWAYS

What did you learn today?



# STEM PATHWAYS

What did you learn today?



# STEM PATHWAYS

How will your experience today impact your pursuit of a STEM job?



# STEM PATHWAYS

How will your experience today impact your pursuit of a STEM job?



# STEM PATHWAYS

How will your experience today impact your pursuit of a STEM job?



# STEM PATHWAYS

How will your experience today impact your pursuit of a STEM job?





# STEM PATHWAYS

How would you describe your STEM experience today?



# STEM PATHWAYS

How would you describe your STEM experience today?



# STEM PATHWAYS

How would you describe your STEM experience today?



# STEM PATHWAYS

How would you describe your STEM experience today?



# STEM PATHWAYS

How will you use STEM in the future to help you make decisions?



# STEM PATHWAYS

How will you use STEM in the future to help you make decisions?



# STEM PATHWAYS

How will you use STEM in the future to help you make decisions?



# STEM PATHWAYS

How will you use STEM in the future to help you make decisions?



# STEM PATHWAYS

STEM Pathways has helped me discover...



# STEM PATHWAYS

STEM Pathways has helped me discover...



# STEM PATHWAYS

STEM Pathways has helped me discover...



# STEM PATHWAYS

STEM Pathways has helped me discover...



# STEM PATHWAYS

When my first plan or idea did not work, I felt...



# STEM PATHWAYS

When my first plan or idea did not work, I felt...



# STEM PATHWAYS

When my first plan or idea did not work, I felt...



# STEM PATHWAYS

When my first plan or idea did not work, I felt...





# STEM PATHWAYS

When I see a new problem, my first step is...



# STEM PATHWAYS

When I see a new problem, my first step is...



# STEM PATHWAYS

When I see a new problem, my first step is...



# STEM PATHWAYS

When I see a new problem, my first step is...



# STEM PATHWAYS

When I have questions about STEM, I ...



# STEM PATHWAYS

When I have questions about STEM, I ...



# STEM PATHWAYS

When I have questions about STEM, I ...



# STEM PATHWAYS

When I have questions about STEM, I ...



# STEM PATHWAYS

STEM Pathways challenged me to...



# STEM PATHWAYS

STEM Pathways challenged me to...



# STEM PATHWAYS

STEM Pathways challenged me to...



# STEM PATHWAYS

STEM Pathways challenged me to...



# STEM PATHWAYS

STEM Pathways opened my eyes to...



# STEM PATHWAYS

STEM Pathways opened my eyes to...



# STEM PATHWAYS

STEM Pathways opened my eyes to...



# STEM PATHWAYS

STEM Pathways opened my eyes to...





# STEM PATHWAYS

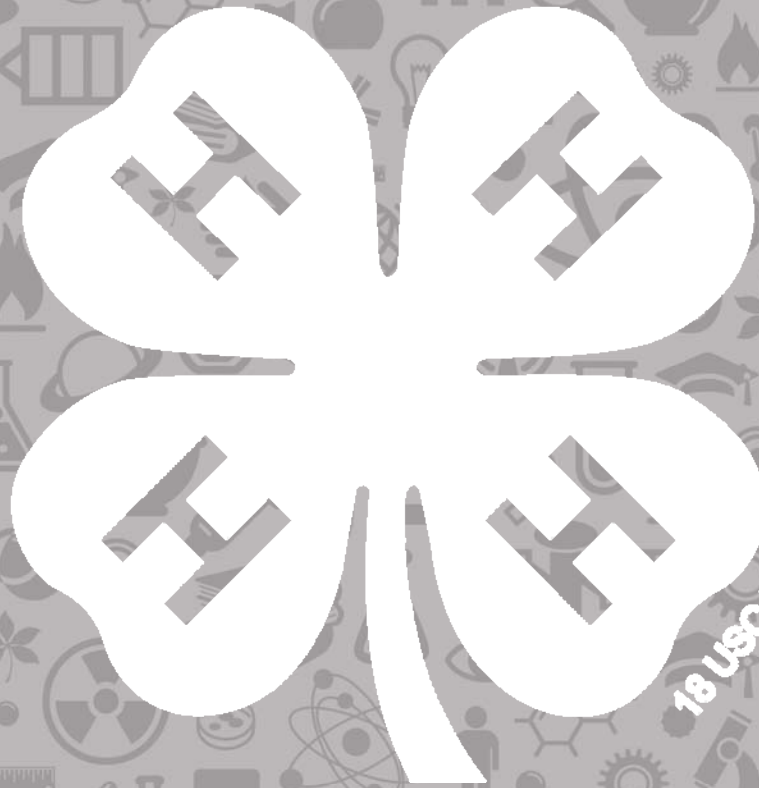
Engagement + Problem Solving = Learning



SCIENCE • TECHNOLOGY • ENGINEERING • MATHEMATICS



<http://www.ohio4h.org/STEM-Pathways>



18 USC 707

## Design Challenge Learning in Action!



THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES

