Planting with Precision

Provided by TryEngineering - www.tryengineering.org

Lesson Focus

Lesson explores agricultural and engineering and challenges students to engineer a system out of everyday materials that can drop a seed every 15 cm over a 60 cm distance. Students learn about seed drills and planters and consider the impact these inventions have had on farming and agriculture over the years. Students build and test their planters, evaluate their designs and those of classmates, and share observations with their class.

Lesson Synopsis

The "Planting with Precision" lesson explores how engineers work to solve the challenges of a society, such as efficient planting and harvesting. Students work in teams to devise a system using every day materials that can drop a sunflower or pumpkin seed every 15 cm over a 60 cm distance. Teams sketch their plans, build their system, test it, reflect on the challenge, and present their experiences to their class.

Age Levels

8-18.

Objectives

- Learn about engineering design and redesign.
- Learn about machinery and systems for planting crops.
- Learn how engineering can help solve society's challenges.
- Learn about teamwork and problem solving.

Anticipated Learner Outcomes

As a result of this activity, students should develop an understanding of:

- engineering design
- agricultural engineering
- teamwork

Lesson Activities

Students explore how engineers have solved societal problems such as increasing the effectiveness and efficiency of planting seeds. Students work in teams to devise a system using every day materials that can drop a sunflower or pumpkin seed every 15 cm over a 60 cm distance. They sketch their plans, build their system, test it, reflect on the challenge, and present to their class.

Resources/Materials

- Teacher Resource Documents (attached)
- Student Resource Sheet (attached)
- Student Worksheet (attached)

Alignment to Curriculum Frameworks

See curriculum alignment sheet at end of lesson.

Internet Connections

- TryEngineering (www.tryengineering.org)
- National Science Education Standards (www.nsta.org/publications/nses.aspx)
- The Seed Site (photos of 950 seeds sorted by size and shape) http://theseedsite.co.uk/seedpods.html
- ITEA Standards for Technological Literacy (www.iteaconnect.org/TAA)

Recommended Reading

- Farm Equipment of the Roman World (ISBN: 978-0521134231)
- Turn-of-the-Century Farm Tools and Implements (Dover Pictorial Archives) (ISBN: 978-0486421148)

Optional Writing Activity

- Write an essay or a paragraph how seed farming has changed over the past century: identify three major advances that have improved the economics of farming.

Optional Extension Activity

- Require students to incorporate a sensor or computer into their design.

Safety Notice

- Provide students with food quality, edible sunflower or pumpkin seeds for this lesson, not seeds actually intended for planting which may be coated with fertilizer.

For Teachers:
Teacher Resources

◆ **Lesson Goal**

The "Planting with Precision" lesson explores how engineers work to solve the challenges of a society, such as efficient planting and harvesting. Students work in teams to devise a system using every day materials that can drop a pumpkin or sunflower seed every 15 cm over a 60 cm distance. They sketch their plans, build their system, test it, reflect on the challenge, and present to their class.

◆ **Lesson Objectives**

- Learn about engineering design and redesign.
- Learn about machinery and systems for planting crops.
- Learn how engineering can help solve society's challenges.
- Learn about teamwork and problem solving.

◆ **Materials**

- Student Resource Sheets
- Student Worksheets
- Classroom Materials (pumpkin or sunflower seeds --use food quality, edible kind so that there is no risk of harm from fertilizers imbedded in seed intended for planting; cotton batting or towel to serve as "soil"; measuring tape)
- Student Team Materials: paper cups, plastic cups or bowls, empty cans or bottles, straws, paper towels, rubber bands, paper clips, tape, soda bottle, glue, string, foil, plastic wrap, pens, pencils, paper, bendable metal piping, hose or tubes, ruler, other items available in the classroom.

◆ **Procedure**

1. Show students the student reference sheets. These may be read in class or provided as reading material for the prior night's homework.
2. To introduce the lesson, consider asking the students how seeds are planted in cornfields. Ask them to think about the equipment and systems required to efficiently handle planting of seeds.
3. Teams of 3-4 students will consider their challenge, and conduct research into how seeding machines operate.
4. Teams then consider available materials and develop a detailed drawing showing their sower including a list of materials they will need to build it.
5. Students build their sower, and test it, and also observe the sowers developed and tested by other student teams.
6. Teams reflect on the challenge, and present their experiences to the class.

For Teachers:
Teacher Resources (Continued)

◆ **Alternative Method**
Alternatively, students could plant actual seeds (garden cress for example) either in an outdoor school garden or on cotton batting (garden cress grows well just about anywhere) so students can observe the growth of the seeds, opening discussions related to land use, efficiency of seed placement, over planting, or other topics related to land use.

◆ **Time Needed**
Two to three 45 minute sessions.

◆ **Testing Tip**
Lay towel or cotton batting onto table surface with a ruler or measuring tape along the edge. Cotton will prevent the seed from bouncing as it would on smooth surface.

Student Resource: Seed Drills and Planters

◆ Seed Drill

A seed drill is a sowing device that precisely positions seeds in the soil and then covers them. Before the introduction of the seed drill, the common practice was to plant seeds by hand. This proved to be very wasteful, as planting was imprecise poorly distributed -- so there was much waste of seeds and usable soil.

In older methods of planting, a field was prepared with a plough which dug rows, or furrows. The field was then seeded by throwing the seeds over the field, sometimes called "manual broadcasting." Some seeds landed in the furrow and were protected, which others might be left exposed…not very efficient! The use of a seed drill can boost the ratio of crop yield by up to nine times, by placing seeds just where they are needed.

◆ Planter

Like a seed drill, a planter is towed behind a tractor. Planters lay the seed down in precise manner along rows. The seeds are distributed through devices called row units that are spaced along the back of the planter (the one to the right has the ability to 4 rows at a time. At the moment, the biggest in the world has a 48-row capacity: the John Deere DB120.

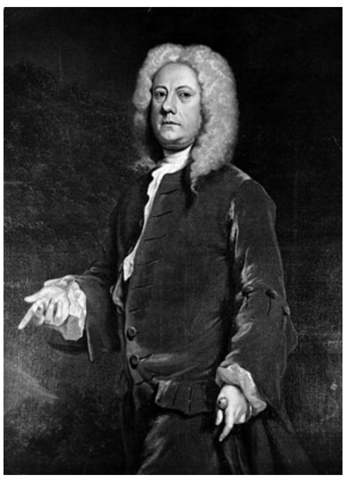
Older planters might have a seed bin for each row and a fertilizer bin for two or more rows. In each seed bin plates with "teeth" are installed to correspond to the size of the type of seed to be sown and how quickly seed should be able to come out. The amount of space between each "tooth" would be just big enough to allow one seed in at a time to get through, but not big enough for two.

Student Resource:
Planting History and Precision

◆ History

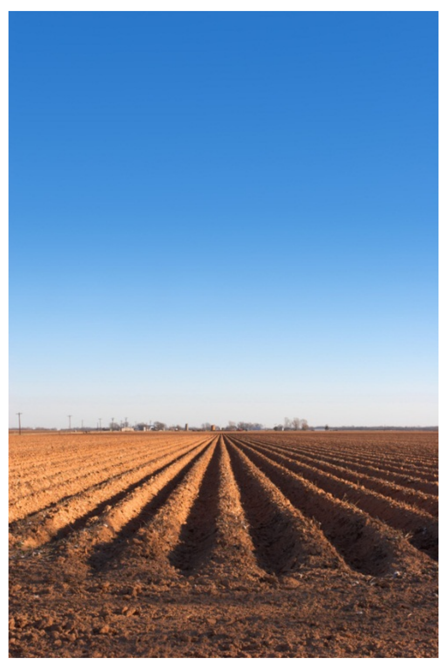
The Sumerians used primitive single-tube seed drills around 1500 BC, and tube-based seed drills were invented by the Chinese in the 2nd century BC. Some believe that the seed drill was introduced in Europe after contacts with China. The illustration to the right shows a Chinese double-tube seed drill, published by Song Yingxing in the Tiangong Kaiwu encyclopedia of 1637.

The earliest European seed drill was attributed to Camillo Torello and patented by the Venetian Senate in 1566. And, a seed drill was described in detail by Tadeo Cavalina of Bologna in 1602.



In England, the seed drill was further refined by Jethro Tull, who was said to have perfected a horse-drawn seed drill in 1701 that economically sowed the seeds in neat rows. However, seed drills would not come into widespread use in Europe until the mid-19th century.

◆ Advanced Technology



Over the years seed drills have become more advanced and sophisticated. For example, many companies and universities that focus on research on agriculture are now recommending the use of electronic measuring systems to accurately measure seed spacing.

Some use a system called "PhotoGate" that uses a light emitter with a sensor where seeds fall from a seeder. When a seed passes the opening, it blocks the light from one or more of the sensors and sends a signal to a computer indicating that a seed has dropped. Software then tracks the placement and timing of seed placement and can very accurately report the space between individual seeds.

CLAAS and HORSCH Set World Record in Maize Drilling

Since 28 April 2012, the two companies CLAAS and Horsch have jointly held the world record in the precision drilling of maize. Inside 24 hours, a total area of 448.29 hectares was tilled and fertilised simultaneously by means of a XERION 5000 and a Maestro 24.70 SW single-grain seed drill. The goal of the combined bid was to sow 24 rows of maize at a high speed averaging 14.7 km/h and with a very good coefficient of variation. It is the first world record of this kind in which maize drilling was carried out with underground fertilisation.

The Maestro 24.70 SW single-grain seed drill manufactured by Horsch drills 24 seed rows with a spacing of 70 cm and a sowing depth of between 1.5 and 9.0 cm. For the world record attempt, the depth was set to 6 cm. The seeds are fed by a “Seed on Demand” system, which ensures easy filling and shortens filling times. The central tank has a seed and fertiliser capacity of 2,000 litres and 7,000 litres respectively.

The Maestro permits sowing speeds of 15 km/h and above, depending on the placement accuracy required. At 15 km/h, the machine achieves absolutely precise single-grain results. For this purpose, the chute features an integral grain sensor, which detects not only the number of grains but also their spacing. The sensor sends data to the driver's control terminal, which informs the driver row-by-row of missing and double spots and displays the coefficient of variation. This enables the driver to react promptly to changing situations and to produce optimum work results.

Throughout the 24 hours, all machine and sowing parameters were monitored and documented constantly by CLAAS TELEMATICS and the grain sensor of the seed drill.

In total, 10 tonnes of seed and 47 tonnes of fertiliser were consumed. As a result, 10 pit stops had to be made to fill the seed drill. Each stop was also used as an opportunity to refuel the tractor.

The world recor d team of Horsch and CLAAS was 16 men strong. Truck drivers maintained supplies of seed, fertiliser and diesel. Two persons were tasked with ensuring a smooth and, above all, speedy pit stop for quick seed drill refills and tractor refuelling. The machine combination was driven by four drivers on rotation. Technical support was provided by a team of three technicians.

(Press Release and Photo Source from CLAAS Group: www.claas.com/cl-pw/en/press/mitteilungen/start,cid=918208,bpSite=51524,lang=en_EU.html)
More details at http://app.claas.com/2012/weltrekord-maissaat.en/)

Student Resource: Land Use and Productivity

◆ Contributions of Norman Borlaug

Norman Ernest Borlaug was an American agronomist, humanitarian, and Nobel laureate who has been called "the father of the Green Revolution." Borlaug received his Ph.D. in plant pathology and genetics from the University of Minnesota in 1942. He took up an agricultural research position in Mexico, where he developed semi-dwarf, high-yield, disease-resistant wheat varieties. During the mid-20th century, Borlaug led the introduction of these high-yielding varieties combined with modern agricultural production techniques to Mexico, Pakistan, and India. As a result, Mexico became a net exporter of wheat by 1963. Between 1965 and 1970, wheat yields nearly doubled in Pakistan and India, greatly improving the food security in those nations. These collective increases in yield have been labeled the Green Revolution, and Borlaug is often credited with saving over a billion people worldwide from starvation. He was awarded the Nobel Peace Prize in 1970 in recognition of his contributions to world peace through increasing food supply.

◆ The Green Revolution

Green Revolution refers to a series of research, development, and technology transfer initiatives, occurring between the 1940s and the late 1970s. The effort increased agriculture production around the world, beginning most markedly in the late 1960s. The initiatives involved the development of high-yielding varieties of cereal grains, expansion of irrigation infrastructure, modernization of management techniques, distribution of hybridized seeds, synthetic fertilizers, and pesticides to farmers. The Green Revolution spread technologies that had already existed before, but had not been widely used outside industrialized nations.

◆ High Yield Crops

Cereal production more than doubled in developing nations between the years 1961–1985. Yields of rice, maize, and wheat increased steadily during that period. The production increases can be attributed roughly equally to irrigation, fertilizer, and seed development. While agricultural output increased as a result of the Green Revolution, the energy input to produce a crop has increased faster, so that the ratio of crops produced to energy input has decreased over time. Green Revolution techniques also heavily rely on chemical fertilizers, pesticides and herbicides, some of which must be developed from fossil fuels, making agriculture increasingly reliant on petroleum products. Between 1950 and 1984, as the Green Revolution transformed agriculture around the globe, world grain production increased by over 250%.

Student Worksheet:

◆ Engineering Teamwork and Planning

You are part of a team of engineers given the challenge of developing a system out of everyday materials that can drop a pumpkin or sunflower seed every 15 cm over a 60 cm distance.

You have a wide range of materials to use and you can power your device in any way you wish as long as your hands do not touch the seed as it drops.

◆ Research Phase

Read the materials provided to you by your teacher. If you have access to the internet, consider different types of seeding machines and determine a design you think will work best in your classroom setting.

◆ Planning and Design Phase

Draw a diagram of the seeder design on the back of this paper, and in the box below make a list of all the parts you think your team will need to build it.

Materials you will need:

◆ **Presentation Phase**
Present your plan and drawing to the class, and consider the plans of other teams. You may wish to fine tune your own design.

◆ **Build it! Test it!**
Next build your seeder and test it. You may share unused building materials with other teams, and trade materials too. Be sure to watch what other teams are doing and consider the aspects of different designs that might be an improvement on your team's plan.

◆ **Reflection**
Complete the reflection questions below:

1. How similar was your original design to the actual seeder your team built?

2. If you found you needed to make changes during the construction phase, describe why your team decided to make revisions.

3. Which seeder system that another team made proved to be the most precise? What about their design made it more precise?

4. Do you think that this activity was more rewarding to do as a team, or would you have preferred to work alone on it? Why?

5. If you could have used one additional material (tape, glue, a computer, sensors -- as examples) which would you choose and why?

6. How would you have to adjust your seeder if you were instead planting corn? How about orchids?

7. How did advances in equipment impact the "Green Revolution?"

For Teachers:
Alignment to Curriculum Frameworks

Note: Lesson plans in this series are aligned to one or more of the following sets of standards:

- U.S. Science Education Standards (http://www.nap.edu/catalog.php?record_id=4962)
- U.S. Next Generation Science Standards (http://www.nextgenscience.org/)
- International Technology Education Association's Standards for Technological Literacy (http://www.iteea.org/TAA/PDFs/xstnd.pdf)
- U.S. National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (http://www.nctm.org/standards/content.aspx?id=16909)
- U.S. Common Core State Standards for Mathematics (http://www.corestandards.org/Math)
- Computer Science Teachers Association K-12 Computer Science Standards (http://csta.acm.org/Curriculum/sub/K12Standards.html)

◆National Science Education Standards Grades K-4 (ages 4-9)

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- ✦ Abilities necessary to do scientific inquiry
- ✦ Understanding about scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of the activities, all students should develop an understanding of

- ✦ Properties of objects and materials
- ✦ Position and motion of objects

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- ✦ Abilities of technological design
- ✦ Understanding about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- ✦ Types of resources
- ✦ Science and technology in local challenges

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- ✦ Science as a human endeavor

◆National Science Education Standards Grades 5-8 (ages 10-14)

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- ✦ Abilities necessary to do scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop an understanding of

- ✦ Properties and changes of properties in matter
- ✦ Motions and forces

CONTENT STANDARD E: Science and Technology

As a result of activities in grades 5-8, all students should develop

- ✦ Abilities of technological design

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- ✦ Populations, resources, and environments
- ✦ Risks and benefits
- ✦ Science and technology in society

For Teachers:
Alignment to Curriculum Frameworks (cont.)

◆**National Science Education Standards Grades 5-8 (ages 10-14)**

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- ✦ Science as a human endeavor
- ✦ History of science

◆**National Science Education Standards Grades 9-12 (ages 14-18)**

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- ✦ Abilities necessary to do scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop understanding of

- ✦ Motions and forces
- ✦ Interactions of energy and matter

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- ✦ Abilities of technological design
- ✦ Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- ✦ Environmental quality
- ✦ Natural and human-induced hazards
- ✦ Science and technology in local, national, and global challenges

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- ✦ Historical perspectives

◆**Next Generation Science Standards Grades 3-5 (Ages 8-11)**

Engineering Design

Students who demonstrate understanding can:

- ✦ 3-5-ETS1-1.Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- ✦ 3-5-ETS1-2.Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- ✦ 3-5-ETS1-3.Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

◆**Next Generation Science Standards Grades 6-8 (Ages 11-14)**

Engineering Design

Students who demonstrate understanding can:

- ✦ MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- ✦ MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

For Teachers:
Alignment to Curriculum Frameworks (cont.)

◆Standards for Technological Literacy - All Ages

The Nature of Technology

- Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Technology and Society

- Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology.
- Standard 5: Students will develop an understanding of the effects of technology on the environment.
- Standard 6: Students will develop an understanding of the role of society in the development and use of technology.
- Standard 7: Students will develop an understanding of the influence of technology on history.

Design

- Standard 8: Students will develop an understanding of the attributes of design.
- Standard 9: Students will develop an understanding of engineering design.
- Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities for a Technological World

- Standard 11: Students will develop abilities to apply the design process.
- Standard 13: Students will develop abilities to assess the impact of products and systems.

The Designed World

- Standard 15: Students will develop an understanding of and be able to select and use agricultural and related biotechnologies.