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| **Lesson Title :** Exploring Minimally Invasive Surgery | **Unit #:**  **1** | **Lesson #:**  **1** | **Activity #:**  **2** |
| **Activity Title:** Don’t Overdesign! |

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| **Estimated Lesson Duration:** | 4 days (45 min) |
| **Estimated Activity Duration:** | 2 days (45 min) |

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| **Setting:** | Classroom |

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| **Activity Objectives:** |

* The students will learn about the steps of the engineering design process
* The students will determine the limitations of devices used in minimally invasive surgery.
* The students will follow the engineering design process to design a device for use in minimally invasive surgery
* The students will analyze their devices and the device created by Ethicon EndoSurgery to determine the function of each part of the devices

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| **Activity Guiding Questions:** |

* What are the limitations on tools used for minimally invasive surgery?
* How do engineers design a new device to meet a need?
* How is customer data used in designing a device?

| **Next Generation Science Standards (NGSS)** | |
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| **Science and Engineering Practices (Check all that apply)** | **Crosscutting Concepts (Check all that apply)** |
| Asking questions (for science) and defining problems (for engineering) | Patterns |
| Developing and using models | Cause and effect |
| Planning and carrying out investigations | Scale, proportion, and quantity |
| Analyzing and interpreting data | Systems and system models |
| Using mathematics and computational thinking | Energy and matter: Flows, cycles, and conservation |
| Constructing explanations (for science) and designing solutions (for engineering) | Structure and function. |
| Engaging in argument from evidence | Stability and change. |
| Obtaining, evaluating, and communicating information |  |

| **Ohio’s New Learning Standards for Science (ONLS)** |
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| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| Demonstrating Science Knowledge **(D)** |
| Interpreting and Communicating Science Concepts **(C)** |
| Recalling Accurate Science **(R)** |

| **Common Core State Standards -- Mathematics (CCSS)** | |
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| **Standards for Mathematical Practice (Check all that apply)** | |
| Make sense of problems and persevere in solving them | Useappropriate tools strategically |
| Reason abstractly and quantitatively | Attendto precision |
| Construct viable arguments and critique the reasoning of others | Look for and make use of structure |
| Model with mathematics | Look for and express regularity in repeated reasoning |

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| **Unit Academic Standards (NGSS, ONLS and/or CCSS):** |

* Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
* Design criteria and constraints, which typically reflect the needs of the end-user of a technology or process, address such things as the product’s or system’s function (what job it will perform and how), its durability, and limits on its size and cost.
* Both physical models and computer models can be used in various ways to aid in the engineering design process.  Physical models, or prototypes, are helpful in testing product ideas or the properties of different materials.
* When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.

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| **Materials**: |

Paper and pens/pencils (at least one writing utensil per student and a few sheets of paper per student)

One project kit per group – each kit contains:

* Dowel rod (12 inches in length)
* Pipe cleaners (3 to 5 per kit)
* Paper lunch bag
* Plastic Ziploc bag (gallon size)
* Craft glue
* Sheet of stickers
* Roll of tape
* Scissors
* Plastic and/or wooden beads (various sizes, 3 to 5 per kit)
* Mailing labels (3 to 5 per kit)
* String (12 to 24 inches)
* Floral wire (12 to 24 inches)
* Balloons (2 or 3 per kit)

One testing set-up for every 3-4 groups – each testing set-up contains:

* Large plastic bowl filled with water
* Three small balloons filled with water
* Trocar

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| **Teacher Advance Preparation:** |

* Gather materials for project kits – it is recommended that each kit be contained in a plastic box
* Fill small balloons with water and place in large plastic bowl
* Fill large plastic bowl with water – enough so that the balloons are covered by at least an inch of water

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| **Activity Procedures:** |

**Day 1 – Introduction to Ethicon Engineering Process**

During the first day of this activity, students will hear a presentation from engineers at Ethicon EndoSurgery about what it means to be an engineer and how engineers design a product through the engineering design process. One of the main aspects of this presentation in an introduction to the design process used by Ethicon Engineers, known as DMADVV. This is an acronym for the following steps: Define the problem, Measure (understand the need), Anaylze (concept generation and selection), Design, Verify and Validate. Another important aspect of this presentation is an introduction to the trocar – a device used to introduce instruments into the body during minimally invasive surgery – as well as an explanation of what exactly minimally invasive surgery entails.

**Day 2 – Designing a Device for Minimally Invasive Surgery**

The purpose of this day is to introduce students to some of the challenges in designing a device for use in minimally invasive surgery. These challenges include: size limitations for the device due to the need to fit through a trocar, limited range of movement due to the trocar, need to remove the device through the trocar, need for sterile packaging, etc. Once students are introduced to this design challenge, they are given time to create their prototype. Approximately 10 minutes prior to the end of the class period, student teams present their device to the class. Following this, the actual device used by doctors for this task is shown to students. In most cases, student groups design a device significantly more complicated than the actual device, which is a stick with a round tip.

The following outline is based on a 45-minute class period.

Introduction to challenge – “Define” – 5 minutes

* “Work as a group to design a device to move tissue or organs during minimally invasive surgery, while keeping in mind the needs of the customer. At the end, you will present your device to a potential customer who will try out the device in a simulated environment.”
* Students are split into groups of 4-5
* Each group is given paper and pens/pencils

Brainstorming/Design Development – “Measure & Analyze” – 10 minutes

* Students brainstorm solutions to the problem, keeping in mind customer data
* Ethicon engineers act as ‘experts’ who are available to answer questions during this time
* By the end of this time, give students supplies and ask them to choose one of their designs to build a prototype

Designing device & building prototype – 20 minutes

* Student groups use the materials in their kit to create a prototype device to meet the requirements given for this challenge
* Groups should have access to a trocar during this time so they can test whether their device will fit through the trocar
* Students should be reminded that by the end of this time they must have a prototype completed and fully packaged

Device presentation & testing – 5 minutes

* Each group will give an informal presentation of their device, which includes:
  + Showing the device in its packaging and describing why they chose the packaging
  + Removing the device from the packaging
  + Placing the device through the trocar, which is held at the surface of the plastic bowl
  + Using the device to move the water balloons

Explanation of actual device & wrap-up – 5 minutes

* The actual device used is shown to students
* Students are solicited for their reactions to the actual device and how it differs from what they created
  + Note: if time allows, discuss questions found on Day 2 Reactions Worksheet

**Formative Assessments:**

Day 2 Reactions Worksheet

**Summative Assessments:**

None

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| **Differentiation:** |

No modification needed due to the small, homogeneous nature of the group of students (which includes no students with individualized education plans).

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| **Reflection:** |

Students did an excellent job designing simple devices to complete this task. One group even ended up creating a device nearly identical to the real thing. I think this activity was very valuable in helping students understand the challenges of using a trocar. One group even got a portion of their device stuck in the trocar when trying to remove the device. All students responded that they were surprised at the simplicity of the actual device and I think really understood the importance of avoiding over-designing.