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# LEARNING & CREATIVITY PLAN (L&C PLAN): Floppy Heart Valves

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## 1. Overview

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| Title | Floppy Heart Valves |
| Driving Question or Topic | What Do I Need to Know about Heart Valves?<br>Does My Model Valve Stack up to the Real Thing? |
| Ages, Grades, … | Ages: 9-12     Grade: 11 |
| Duration, Timeline, Activities | 5h and 45 min duration     Seven 50minutes class periods     2 lessons and 2 activities |
| Curriculum Alignment | Biology, Life Science, Science and Technology |
| Contributors, Partners | |
| Abstract - Synopsis | Students are presented with an engineering challenge that asks them to develop a material and model that can be used to test the properties of aortic valves without using real specimens. Developing material that is similar to human heart valves makes testing easier for biomedical engineers because they can test new devices or ideas on the model valve instead of real heart valves, which can be difficult to obtain for research. To meet the challenge, students are presented with a variety of background information, are asked to research the topic to learn more specific information pertaining to the challenge, and design and build a (prototype) product. After students test their products and make modifications as needed, they convey background and product information in the form of portfolios and presentations to the potential buyer. |
| References, Acknowledgements | TeachEngineering<br>https://www.teachengineering.org/curricularunits/view/van_floppy_unitdoc<br>The contents of this digital library curriculum were developed under National Science Foundation RET grant nos. 0338092 and 0742871. |

## 2. STEAME Framework*

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| Teachers' Cooperation | 1st Teacher: Biologist<br>2nd Teacher: Healthcare Professional<br>(the two teachers can work together during both lessons) |
| STEAME in Life (SiL) Organization | Student groups are challenged to develop a material that mimics the behavior and mechanical properties of aortic valves. To do this, students study the problem, learn as much about heart valves as they can, and apply their knowledge towards the design, building and testing of a material and model that meets the buyer's needs. |
| Action Plan Formulation | **Action Plan Overview:**<br>**STAGE I:** Generation of ideas and gathering of multiple perspective information by students.<br>**STAGE II:** Lesson 1 and associated activity Plan formulation<br>**STAGE III:** Lesson 2 and associated activity Plan formulation |

## 3. Objectives and Methodologies

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| Learning Goals and Objectives | By the end of the L&C Plan, students should be able to be familiar with all the steps that are needed for developing a material that mimics the behavior and mechanical properties of aortic valves. |
| Learning Outcomes and expected Results | Once the plan is completed, students will be able to know the basics about heart valves forces that act on heart valve tissue, as well as elasticity, stress, strain, Young's modulus and how to calculate Young's modulus for materials. design and test their prototype heart valve models. |
| Prior Knowledge and Prerequisites | Students should be familiar with the components of the cardiovascular system and the basic structure of the heart, including the names and positions of the four chambers. |
| Motivation, Methodology, Strategies, Scaffolds | The main methodologies are inquiry-based learning and problem-based learning. Engineers investigate ways to improve problems that humans face by developing solutions, and then researching, building, testing and redesigning those solutions to improve upon the initial design. Often what is needed does not exist, so it is up to engineers to develop novel materials, structures or procedures to solve the problems. Bioengineers perform all these tasks, but with a focus on biological materials, processes or chemicals. In this case, student groups are challenged to develop a material that mimics the behavior and mechanical properties of aortic valves. To do this, students study the problem, learn as much about heart valves as they can, and apply their knowledge towards the design, building and testing of a material and model that meets the buyer's needs. |

## 4. Preparation and Means

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| Preparation, Space Setting, *Troubleshooting Tips* | Model Heart Valves - Student teams follow the engineering design process to design, build, test and redesign a functioning model heart valve. Each group also creates a brochure explaining how its heart valve functions. Teams present their designs to the teacher and class, showing a demonstration of their model heart valve, explaining their brochure, and describing how their design could be a solution to this unit's Grand Challenge question. |
| Resources, Tools, Material, Attachments, Equipment | • Lesson 1: What Do I Need to Know about Heart Valves? https://www.teachengineering.org/lessons/view/van_floppy_lesson01<br>• Lesson 2: Elasticity & Young's Modulus for Tissue Analysis(https://www.teachengineering.org/lessons/view/van_floppy_lesson02)<br>• *Lesson: Blood Pressure Basics* https://www.teachengineering.org/lessons/view/van_heartvalves_lesson02<br>• *Lesson: Heart to Heart* https://www.teachengineering.org/lessons/view/van_heartvalves_lesson01 |
| *Safety and Health* | |

## 5. Implementation

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| Instructional Activities, Procedures, Reflections | Unit Overview<br>This "legacy cycle" unit is structured with a contextually based Grand Challenge followed by a sequence of instruction in which students first offer initial predictions (Generate Ideas) and then gather information from multiple sources (Multiple Perspectives). This is followed by a Research and Revise phase as students integrate and extend their knowledge through a variety of learning activities. The cycle concludes with formative (Test Your Mettle) and summative (Go Public) assessments that lead students towards answering the Challenge question. See below for the progression of the legacy cycle through the unit. Research and ideas behind this way of learning may be found in How People Learn: Brain, Mind, Experience and School (Bransford, Brown |

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| | & Cocking, National Academy Press, 2000); see the entire text at https://www.nap.edu/read/9853/chapter/1.<br><br>The legacy cycle is similar to the engineering design process in that they both involve identifying an existing societal need, applying science and math to develop solutions and using the research conclusions to design a clear, conceived solution to the challenge. Though the engineering design process and the legacy cycle both result in viable solutions, each focuses differently on how the solution is devised and presented. See an overview of the engineering design process in the engineering design handout in the final activity, or at https://www.nasa.gov/audience/foreducators/plantgrowth/reference/Eng_Design_5-12.html#.VDSAGvldUnE.<br><br>In What Do I Need to Know about Heart Valves?(lesson 1), students are introduced to the challenge question and exposed to some basic information relevant to the topic of heart valve tissue. This supplies the Challenge, Generate Ideas, and Multiple Perspective portions of the legacy cycle. Students wrap up the lesson by researching heart valve mechanics and valve tissue anatomy and details. These activities represent the Research and Revise portion of the legacy cycle. In The Mighty Heart associated activity, student groups dissect sheep hearts to see and feel its structure, including valves, and learn more in-depth information about valves.<br><br>In Elasticity & Young's Modulus for Tissue Analysis (lesson 2), students learn about the forces that act on heart valve tissue, as well as elasticity, stress, strain, Young's modulus and how to calculate Young's modulus for materials. They complete some practice problems to solidify their understanding. In the Does My Model Valve Stack up to the Real Thing? associated activity, students research materials suitable for their model valves. They test possible materials to evaluate them for similarities to real heart valves. Then they design and test their prototype heart valve models. Students refine their models after testing and before presenting the information to the teacher and class as an information packet. The work accomplished in this activity represents the Test Your Mettle and the Go Public portions of the legacy cycle. |
| Assessment - Evaluation | Assessment<br>Pre-Lesson Assessment<br><br>Engineering and the Body Class Discussion: Ask students if they believe engineering has anything to do with the health of the human body. Begin a class discussion to assess how familiar students are with engineering's involvement in the medical industry by asking the following questions:<br><br>Do you think engineers play any role in our health? (Answer: Yes)<br>What is an example of an engineer whose work might affect our health? (Possible answers: Biomedical engineers work with doctors and surgeons to design medical technologies, tools, equipment and procedures, chemical engineers design medicines, and civil and environmental engineers create infrastructure that provides drinking water treatment, waste water treatment and air quality, which all have a direct influence on public health.)<br>What type of engineer might work hand in hand with a doctor to help a patient with heart disease? (Answer: A biomedical engineer designs technologies that doctors can use, such as stents to open arteries clogged by plaque build-up, artificial heart valves to replace deteriorated or injured heart valves, and artificial hearts that pump blood through the body during surgeries and even after a person's biological heart fails.)<br>Post-Introduction Assessment |

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| | Brainstorming: Assess students' prior knowledge based on their brainstorming session feedback with the Challenge Question Brainstorm Worksheet. Gauge what they already know about the heart from their responses.<br><br>Lesson Summary Assessment<br><br>Heart Disease and Defects Research: Have students conduct Internet research to learn more about heart diseases as well as various defects. Require students to research at least 10 different types of heart diseases, including at least one disease of the heart valves, take notes, and write brief summaries (two paragraphs) about each disease to turn in for grading. Have them incorporate the vocabulary words—such as left and right atria, left and right ventricle, tricuspid valve, mitral valve, interventricular septum, aorta, aortic valve, superior and inferior vena cava, pulmonary arteries and pulmonary veins—in the summaries. |
| Presentation - Reporting - Sharing | Students present their work to the teacher and class as an information packet. |
| *Extensions - Other Information* | |

**STAGE I: Generation of ideas and gathering of multiple perspective information by students (STEPS 1-3)**

1. First stage is structured with a contextually based *Grand Challenge* followed by a sequence of instruction in which students first offer initial predictions (Generate Ideas) and then gather information from multiple sources (Multiple Perspectives).
2. This is followed by a *Research and Revise* phase as students integrate and extend their knowledge through a variety of learning activities.
3. The stage concludes with formative (Test Your Mettle) and summative (Go Public) assessments that lead students towards answering the Challenge question. Research and ideas regarding this way of learning may be found in *How People Learn: Brain, Mind, Experience and School (Bransford, Brown & Cocking, National Academy Press, 2000);* see the entire text at https://www.nap.edu/read/9853/chapter/1.

   This stage is similar to the engineering design process in that they both involve identifying an existing societal need, applying science and math to develop solutions and using the research conclusions to design a clear, conceived solution to the challenge. Though the engineering design process and the legacy cycle both result in viable solutions, each focuses differently on how the solution is devised and presented. See an overview of the engineering design process in the engineering design handout in the final activity, or at https://www.nasa.gov/audience/foreducators/plantgrowth/reference/Eng_Design_5-12.html#.VDSAGvldUnE.

**STAGE II: Lesson 1 and associated activity Plan formulation (2 steps)**

1. In **What Do I Need to Know about Heart Valves?** (lesson 1), students are introduced to the challenge question and exposed to some basic information relevant to the topic of heart valve tissue. This supplies the Challenge, Generate Ideas, and Multiple Perspective portions of this stage. Students wrap up the lesson by researching heart valve mechanics and valve tissue anatomy and details. These activities represent the *Research and Revise* portion of this stage.

2. In **The Mighty Heart** associated activity, student groups dissect sheep hearts to see and feel its structure, including valves, and learn more in-depth information about valves.

**STAGE III: Lesson 2 and associated activity Plan formulation (2 steps)**

1. In **Elasticity & Young's Modulus for Tissue Analysis** (lesson 2), students learn about the forces that act on heart valve tissue, as well as elasticity, stress, strain, Young's modulus and how to calculate Young's modulus for materials.

2. They complete some practice problems to solidify their understanding. In the **Does My Model Valve Stack up to the Real Thing?** associated activity, students research materials suitable for their model valves. They test possible materials to evaluate them for similarities to real heart valves. Then they design and test their prototype heart valve models. Students refine their models after testing and before presenting the information to the teacher and class as an information packet. The work accomplished in this activity represents the Test Your Mettle and the Go Public portions of the legacy cycle.

**Learning and Creativity Action Plan Schedule**

Plan on the unit taking seven 50-minute class periods, according to the following schedule (Table I). Further resources on Lessons and Activities learning material can be accessed in the following links:
https://www.teachengineering.org/lessons/view/van_floppy_lesson01
https://www.teachengineering.org/lessons/view/van_heartvalves_lesson01
https://www.teachengineering.org/lessons/view/van_floppy_lesson02
https://www.teachengineering.org/lessons/view/van_heartvalves_lesson02

**Table I (Action Plan Schedule)**

| Day | Document | Curricular Document Title | Time required |
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| 1-2 | Lesson 1 | What Do I Need to Know about Heart Valves? | 100 minutes (2*50 minutes) |
| 3 | Activity 1 | The Mighty Heart | 45 minutes |
| 4 | Lesson 2 | Elasticity & Young's Modulus for Tissue Analysis | 50 minutes |
| 5-7 | Activity 2 | Does My Model Valve Stack up to the Real Thing? | 150 minutes (3*50 minutes) |