Summary
In these lessons, students will learn about the pediatric airway and the difficulties doctors face with regard to its assessment and treatment. Students will learn about medical imaging techniques currently being used to assess the airway and gain an understanding of the benefits associated with three-dimensional modeling. Students will also be introduced to engineering, as a creative problem solving method. Students will have the opportunity to apply the knowledge gained of problem solving techniques and pediatric airway assessment through a challenge activity in which they will be asked to develop a kid-friendly process for developing patient-specific airway models. Students will also have the opportunity to enhance their oral and written communication skills through a short presentation and the development of a professional proposal.

Learning Objectives
Following participation in this interactive lesson plan, students should be able to:
- Distinguish between textbook illustrations and realistic anatomy
- Convey an understanding of medical imaging techniques discussed
- Identify the airway and other important anatomical structures from medical images
- Explain the concept of rapid prototyping and create a list of associated medical applications
- Recognize the need for and apply creative problem solving in various situations
- Work efficiently in a team environment
- Communicate ideas effectively through project proposal and presentation mediums (optional)

Lesson Plan
The lesson plan detailed below is divided into three 60-minute class sessions. Appropriate adjustments may be made for the 90-minute lesson period. Each lesson includes a set of brief lecture notes, one or two interactive activities, and a writing/discussion prompt. The dissection lab and presentation/written proposal are optional, but highly recommended, supplemental components to this lesson plan. Only the first lesson, in this three-lesson series, has been developed. Condensed versions of the other lessons have been included.

Lesson 1 – Introduction to Human Airway Anatomy and Medical Imaging
Lesson Pre-requisites: Students should have a preliminary understanding of the structure and function of the respiratory system, prior to this lesson’s commencement.

A Note to the Instructor: This lesson is recommended for students who have completed or are currently completing a life science or biology course, at the middle school level or above, that covers basic anatomy of the human body. It is highly recommended that this lesson be accompanied by a dissection laboratory, in which students are required to identify anatomy, and make investigative conclusions based on textbook illustrations.
Activity 1: Airway Anatomy Review

Time Allotted: 15 minutes

Materials: Copy paper, markers, airway model, and anatomy textbook (or airway textbook illustration)

Preparation: None

Instructions: Place students into groups of two or three, providing each group with a sheet of 8 ½ x 11 in. copy paper, three different colored markers, and an airway model. Request that each group choose a member who will draw throughout the duration of the activity. Once groups have been formed, ask that each group draw and label, in detail, the airway from the model provided. After 7 minutes, provide each group with an anatomy textbook and ask that they verify their results. Two minutes should be sufficient for this part of the activity. Invite the class to come back together, and begin a discussion, using the questions below or your own, regarding the differences between textbook illustration and actual human anatomy, emphasizing what is lost in creating 2-D illustrations and introducing the concept and advantages of three-dimensional medical modeling.

Discussion Questions:

- What were some of the difficulties your group encountered in drawing the model? How did you overcome these difficulties? Did you feel as if there was any part of the model that couldn’t be captured in your drawing?
- How did your drawing compare to the illustrations shown in the textbook? Does the model compare in the same way?
- What are the advantages to having a three-dimensional model available as opposed to the drawings provided in textbooks? What might be some disadvantages?

Lecture Break: Introduction to Medical Imaging

Time Allotted: 20 minutes

Description: Students should be asked to identify how doctors are able to visualize internal structures of the actual human body, particularly the airway. A list should be written on the board with space for writing between each idea. Common answers may include surgery, cutting the body open or medical imaging. Students may need prompting for medical imaging and instruction should focus on introducing them to medical imaging techniques including x-ray, endoscopy, ultrasound, computed tomography, and magnetic resonance imaging. Students should then be asked to identify, as a class, some of the pros and cons of each method and come to an agreement within their group as to which imaging method is the most ideal when looking at the airway. Each group should be given the opportunity to share and defend their choice, before computed tomography is identified as being the most ideal. A maximum of twenty minutes should be spent on this section of the lesson. More time can be allotted based on the instructor’s choice of emphasis. It may be helpful to develop a short worksheet describing the imaging techniques for student reference and/or notes. Students should be clear as to the slice-by-slice nature of computed tomography prior to beginning the next activity.

Resources: The information required for this lecture can be found at: http://www.fda.gov/Radiation EmittingProducts/RadiationEmittingProductsandProcedures/MedicalImaging/default.htm

Activity 2: Reading a CT Scan

Time Allotted: 20 minutes

Materials: four handouts each containing one axial and one sagittal chest CT scan slice; four answer sheets; anatomy textbook

Preparation: make two copies of each handout for this activity

Instructions: Place students into eight groups of two or three (different groups than in the previous activity are preferred) and provide each group with one of the handouts supplied. Ask students to identify the orientation of the body in the slice and the anatomical structures shown in the image. After seven minutes, invite the groups with matching numbers (found in the upper right-hand corner of the handout), to meet, for
five minutes, to discuss their findings and ideas. After ample time has been left for discussion, provide each group of students with the labeled answer sheet associated with the group’s data. Allow two minutes for the groups to look at the correct assignments, and then invite the class to come back together. A discussion should then be initiated regarding the students’ results and perspectives. The general line of questioning to be followed is provided below. The conclusion of this discussion coincides with the conclusion of the lesson.

Discussion Questions:

- How did everyone do? Did anyone find it difficult to identify the orientation of the body in their slices? Once you had figured out the orientation of the body, was it easier to identify or understand what the anatomical structures were?
- For students who were able to identify structures and orientation fairly easily: what sort of clues did you use to determine which structure was which? Did you ever doubt your assignment or conclusions?
- Following the above questions, the point should be made that doctors use similar, though undoubtedly more complex, context clues to assess and diagnose diseases and defects in humans, from medical images; particularly those diseases and defects of the pediatric airway.
- What could be some of the consequences of diagnosing or treating patients based on what is seen in medical images? Can anyone think of a way doctors could make diagnosing patients a more exact science? (Encourage all ideas here as no idea is incorrect and the goal of this component is for students to think in a creative, problem-solving manner)
- The idea, but not the concept of, additive manufacturing should be introduced as one method that could be chosen, after all ideas have been shared. An emphasis should be placed on the idea that each student will have a different way of solving the problem and that each method is equally possible.

A Note to the Instructor: The following two lessons have not yet been fully developed. Ideally, these lessons would educate students on the rest of the “Three-dimensional modeling of pediatric airways” research project.

Lesson 2 – Introduction to Additive Manufacturing and Engineering Challenge
Lesson Pre-Requisites: Lesson 1

Activity 1: Build Me a Model

Time Allotted: 25 minutes (20 minutes to build with 5 minute discussion). Objective: Students will learn about additive manufacturing by developing their own model in a way similar to that of additive manufacturing machines. Description: Students will build a model using single sheets of cardstock (available in most craft or office supply stores) cut to a given shape and pasted one directly on top of another. Assigning shapes (such as cylinders, hearts, stars, cubes, etc.) to be modeled is highly recommended due to the time-consuming nature of this activity.

Lecture Break: What is Additive Manufacturing?


Challenge Brainstorm

Time Allotted: 20 minutes. Objective: Students will assimilate all information learned in previous discussions in a team effort to brainstorm ideas for creating a kid-friendly method for clinical modeling of pediatric airways. Students will learn to assess the relevant factors as often considered in an engineering design process. Description: Students will be presented with the challenge of creating a method for clinical
modeling of pediatric airways. Students will first be asked to list all the important factors that will affect their project and need to be considered. Important factors include kid-friendliness, patient safety, parental consent, physician acceptance of technology, time constraints, etc. Students will then brainstorm ideas for how they will accommodate for such factors. The brainstorming session may need to be finished outside of class due to time constraints. Instructors can opt to have students share their plans next class, informally, or to have students develop a 5-minute oral presentation and/or written proposal, given a week-long preparation period.

Lesson 3 – The Engineer in Me (Optional)

Lesson Pre-requisites: Lesson 2

Overview: Students will share their ideas from Lesson 2, either formally or informally as indicated in the previous lesson. The instructor will then open up a discussion on engineering, by asking students how they would define engineering and how many of them have considered engineering as a future career option. Connections should then be made between engineering principles (teamwork, problem-solving, innovative thinking, creativity, etc.) and the activities/discussions of previous lessons. The instructor should then highlight some applications of engineering expertise that apply to the demographic of the students in the classroom. Further discussion should commence, as appropriate.

CT Scan Images
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Orientation: 1. Axial (Head-to-Toe); 2. Sagittal (Shoulder-to-Shoulder)
CT Scan Images
Orientation: 1. Axial (Head-to-Toe); 2. Coronal (Front-to-Back)
CT Scan Images
Orientation: 1. Coronal (Front-to-Back); 2. Axial (Head-to-Toe)

Pharynx  Larynx

Lungs  Bronchi  Bone

Trachea  Heart
CT Scan Images
Orientation: 1. Sagittal (Shoulder-to-Shoulder); 2. Axial (Head-to-Toe)

Endotracheal Tube

- Spine
- Lungs
- Trachea
- Heart