Module 3
Sensor Development – Designing for Need

Teacher

60 minutes

Purpose of this lesson

- Investigate the engineering design process
- Reason about the design criteria for the SENSE IT temperature sensor
- Reason about the design criteria for additional SENSE IT sensors

Materials
Copy of the lesson
Copy of the Student Worksheet
Access (print or electronic) to the instructions for constructing the sensors

Background
Engineering Design Process
The engineering design process is a series of steps that engineering teams use as a guide to solve problems. To determine how to build something (skyscraper, sensor), engineers gather information and conduct research to understand the needs of the challenge. They brainstorm many possible solutions and select the most promising idea, embark upon creating a design for the product, make analytical decisions on the materials and construction, manufacturing and fabrication. The team creates and tests many prototypes, making improvements until the product design meets the design criteria.

The team considers many factors before implementing a design: Cost of construction, testing, manufacturing, use and maintenance, quality, reliability, environmental consideration, safety, functionality, ease of use, aesthetics, ethics, social and cultural impact. Engineers now also consider sustainability - how the development, use and ultimate disposal of the product might impact people and our planet.

There are several steps to the engineering design process:

Defining the problem
What is the problem? What do we want to accomplish? What are the project requirements? What are the limitations? Who is the end-user of the product? What data needs gathering to answer the questions?

Brainstorming, Researching and Generating Ideas
Imagine and brainstorm ideas and designs. Be creative and open to suggestions from others. Investigate existing technologies and potential methods to use. Explore, research, compare and analyze many possible solutions.

Identifying Criteria and Specifying Constraints
Identify and specify the requirements and limitations of a design, such as cost, efficiency, which can sometimes compete with each other.

Exploring Possibilities
Developed ideas are shared with the team and discussed, with the pros and cons of each idea identified.

Selecting an Approach
Based on the needs and constraints identified, select the most promising idea.

Developing a Design Proposal
Draw a diagram of the idea. How will it work? What is the testing procedure? What materials and tools are needed? What analyses must be conducted?

Build a Model or Prototype
Build a prototype and test it against the design objectives. Analyze and discuss what works, what doesn't and what could be improved.

Testing and Evaluating
Does it work? Does it meet the original design constraints?

Refining the Design
Discuss product improvements, make revisions. Draw new designs if needed. Iterate the previous steps in the design process to create an optimal product.

Creating or Making
Manufacture the final product based upon the results of the design process.

Communicating Process and Results
Present the final product and include a discussion of how the solution(s) best meets the needs of the initial problem, opportunity or need.

Other factors to consider in the design phase are: human factors (e.g., human abilities, behavior, psychology, physiology, safety); sustainability (e.g., longevity of the product, sustainability and availability of components, environmental impact of obtaining components, environmental impact of disposal of the product).

Assessment

1) Deconstruct the SENSE IT Temperature Sensor Design Process
    a) Review the steps of the design process outlined above.
    b) Brainstorm several of the criteria you think were considered while the SENSE IT project staff moved through the first three steps of the design process to create the temperature sensor you built as part of the SENSE IT project:
        - *Defining the problem*
        - *Brainstorming, Researching and Generating Ideas*
        - *Identifying Criteria and Specifying Constraints*

For example:
Why measure water temperature?
What temperature ranges would be necessary to measure?
How accurate does the sensor need to be for the purpose?
How complicated could the assembly/components be?
Could the components be recycled for additional student use?
Could the design solution be expensive to build?

How will the sensor be used/deployed? Are there special considerations for use?
How will one obtain the reading/measurement? Are there special considerations for use?
What other parameters besides temperature (in addition to temperature) would be helpful to gain a more accurate understanding of the quality of water tested?
Can the temperature sensor be integrated with other sensors?

c) List the questions/criteria on the student worksheet.
d) Discuss with entire class to create a full list of criteria.

Assessment Extension

1) The SENSE IT project includes the design instructions for three additional sensors:

- Turbidity
- Conductivity
- Depth

For each of the sensors, repeat the steps above (your teacher may choose to split your class and have one group focus on one sensor and share the results):
Deconstruct the SENSE IT Sensor Design Process

a) Review the steps of the design process outlined above.
b) Brainstorm several of the criteria you think were considered while the SENSE IT project staff moved through the first three steps of the design process to create the sensors you built as part of the SENSE IT project:

- *Defining the problem*
- *Brainstorming, Researching and Generating Ideas*
- *Identifying Criteria and Specifying Constraints*

For example:
Why measure turbidity, conductivity and depth?
What ranges would be necessary to measure?
How accurate does the sensor need to be for the purpose?
How complicated could the assembly/components be?
Could the components be recycled for additional student use?
Could the design solution be expensive to build?
How will the sensor be used/deployed? Are there special considerations for use?
How will one obtain the reading/measurement? Are there special considerations for use?
Can the sensors be integrated?

c) List the questions/criteria on the student worksheet.
d) Discuss with entire class to create a full list of criteria.

2) Based on the research conducted to answer the questions above or as part of your course, is there a need to measure additional water quality parameters? If so, which parameters and why?

Dissolved oxygen, nutrients – although the sensor is too complicated to attempt in this project, the DO measurement coupled with the SENSE IT sensor data could be very valuable to assess overall water quality.