MODULE 10: INTELLIGENT TRANSPORTATION SYSTEMS: SMART WORK ZONES

LESSON 3: DEVELOPING SMART SUIT SENSOR TECHNOLOGY

Connected vehicle (CV) safety applications are designed to increase awareness of what is happening in the environment as people drive, walk, or bike within our transportation system. In this lesson, students will simulate the usage of ITS systems and connected vehicle sensors to alert drivers to upcoming work zone areas and the presence of highway personnel. Demonstrations will also include alerting work zone personnel of potential vehicle hazards.

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Lesson 3: Smart Suit Sensor Technology

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Grade Level: Adaptable to Grades 6-12	**Lesson in this Module: 3 of 4**
Time Required: 90 - 120 minutes	**Lesson Dependency:** This builds on lesson 2 and the materials listed in Lesson 1
Keywords: transportation engineering, intelligent transportation systems, e-textiles, 'smart suit' technology	

Materials List (From Lesson 1 of this Module)

LilyPad Arduino ProtoSnap Development Board, Highway Safety Attire (helmet, vest, pants, gloves), Mini USB cable, Felt, Fabric Marker, Needle Threader, Seam Ripper, Velcro

Pre-Requisite Knowledge

Must Complete Lessons 1 and 2

Lesson 3 Activities

In this lesson, students will simulate the usage of ITS systems and connected vehicle sensors to alert drivers to upcoming work zone areas and the presence of highway personnel. Demonstrations will also include alerting work zone personnel of potential vehicle hazards.

- **Activity 1: Smart Suit Groups (5 minutes)**

As a class, you will be developing different pieces of a "Smart Suit" that in conjunction with other ITS systems and connected vehicle technology, could alert both a driver to work zone personnel as well as to alert work zone personnel of a potential incoming hazard from a vehicle. Consider the different pieces of apparel worn by work zone personnel: helmets, vests, pants, and gloves. How could sensors in a "Smart Suit" work

with roadway sensors or Connected Vehicle sensors to make workers more visible to drivers, alert personnel to potential vehicle hazards, and alert drivers to both work zones and personnel in the area?

As a class, you will divide into teams and develop one piece of the "Smart Suit" using a LilyPad Arduino. As part of your "Smart Suit" design, you will have access to the components on the LilyPad ProtoSnap Development Board. How could you use these components to simulate how Connected Vehicle sensors and other Intelligent Transportation Systems could improve safety of both highway drivers as well as work zone personnel?

Divide into Smart Suit Teams

Helmet:

Vest:

Pants:

Gloves:

Teacher Directions: For this part of the lesson, students will be divided into teams and will take 1 piece of the "Smart Suit" to design. Students should be grouped into teams of 2-4 students. Students will use a LilyPad Arduino.

- **Activity 2: Planning ITS Work Zone Sensors (20 minutes)**

Now that you have had the opportunity to experiment with the LilyPad ProtoSnap Development Board and to learn basic programming skills, think about how the components of the board can be utilized with other ITS systems to improve safety of both drivers and work zone personnel.

*****Information included below is included in the student worksheet information***

LilyPad ProtoSnap Development Components To Be Used

Decide which components of the LilyPad ProtoSnap Board your group would like to incorporate into a "Smart Suit" Design. ***You can use up to 2 different components on each LilyPad.***

Students may have ideas for their "Smart Suit" that they cannot exactly replicate i.e. having a buzzer sound when a vehicle is too close to the work zone. If this is the case, encourage students to use and code similar components in their Smart Suit and use the description area to explain how this technology would work. For older students or students with more programming experience, consider allowing them to use more than 2 components.

1.

2.

3.

4.

5.

Description Of How Components Will Function

Explain how your Smart Suit will function with other ITS technologies to improve safety for both the work zone area personnel as well as oncoming drivers.

Based on experiments with the protosnap board and coding, students need to consider how they will create their "Smart Suit" and how it will function. Considering the coding level of the students, students need to know what codes will be needed to make their "Smart Suit" work. Students may use the coding examples found in the Github files as a starter.

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***Special Note: The coding sketches for the LilyPad ProtoSnap Development Board in which the components are already wired together may use hidden pins that are not located directly on the petals of the LilyPad Arduino. Students will need to use the pins located directly on the LilyPad petals when sewing circuits into their Smart Suit. The GitHub account includes a couple of example codes for sewn circuits. Students can use these sketches as starters to developing their own code.*

- **Activity 3: Sewing With E-Textiles (60-75 minutes)**

Understanding E-Textile Videos

**Teacher Directions: The following are videos that explain how to setup soft circuits and sew with conductive thread. If your students have no sewing or e-textiles experience, these videos would be useful as an introduction. After viewing the videos, students should have a basic understanding of how e-textiles work and should be able to design and sew the LilyPad circuits.*

Video 1 – Getting Started With E-textiles: Threading A Needle

https://www.youtube.com/watch?v=TfB5L4qwsJA

Video 2 – Getting Started With E-Textiles: Basic Stitches

https://www.youtube.com/watch?v=_VhLwGwpk9A

Video 3 – Starting To Sew An E-Textiles Circuit

https://www.youtube.com/watch?v=boaIQvO-8MU

Video 4 – Finishing Stitches On An E-Textiles Circuit

https://www.youtube.com/watch?v=XC8BaN-uKFw

Video 5 – Getting Started With E-Textiles: Basic Circuit With A PCB LED

https://www.youtube.com/watch?v=vBTLDH_3NoM

***Special Note: is very It important that students plan how the circuits will be laid out. When using conductive thread, you will not be able to cross stitches unless they are insulated. In addition, the end of threads on the back of the felt cannot touch or there will be a short circuit. NOTE: TO KEEP STITCHES FROM TOUCHING, HOT GLUE CAN BE USED TO SECURE STITCHES.*

*****Information below is included in the student worksheet information***

Now that you have learned some basic information about e-textiles and the Arduino coding language, you are ready to map out your LilyPad Arduino circuits. To create your Smart Suit, you will be sewing the components of the LilyPad onto felt fabric pieces and then attaching the felt circuit to the suit garments.

STEPS For Designing Sewn Circuits

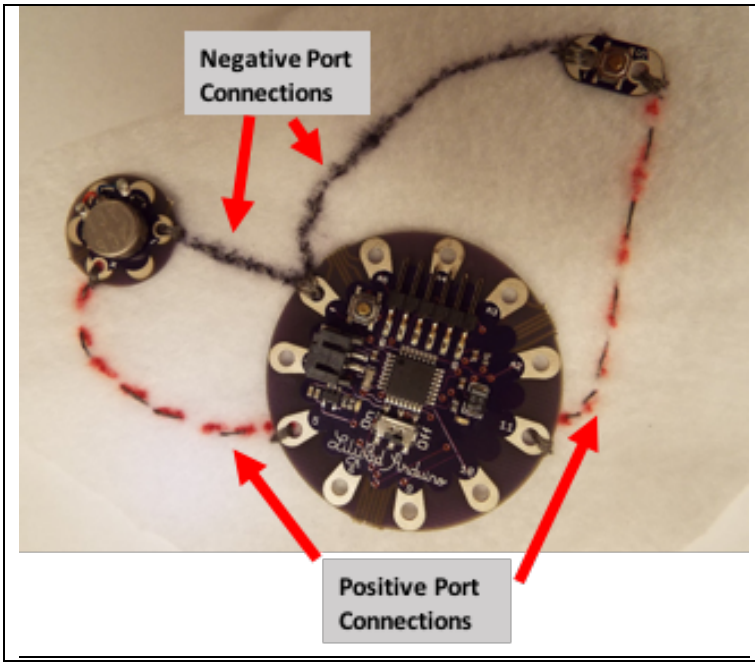
1. **Consider where each component will be located in relation to other components that will be used.**

2. **Consider which pins will be used for each component on the LilyPad Arduino relative to other components being used.**

3. **Decide what size piece of felt will be needed for your design –test the felt piece inside the garment it will be sewn into to ensure proper fit.**

4. **Sketch the circuit to plan the layout of the stitching. Ensure that stitches do not cross. Crossing stitches can cause a short circuit. If stitches must cross, they will need to be insulated.**
   - ***a.*** *Positive ports on the components need to be connected to the various pins on the LilyPad.* ***BE CAREFUL!!!! Positive stitches from one port cannot contact positive stitches on another port. If it is necessary to have stitches cross, make sure to insulate the stitches from each other using a small piece of felt.***
   - *b. Negative ports will be connected to the negative port on the LilyPad to create the ground of the circuit. Negative ports can be connected in one continuous circuit or directly to the negative port of on the LilyPad*

Example of a Sewn Circuit



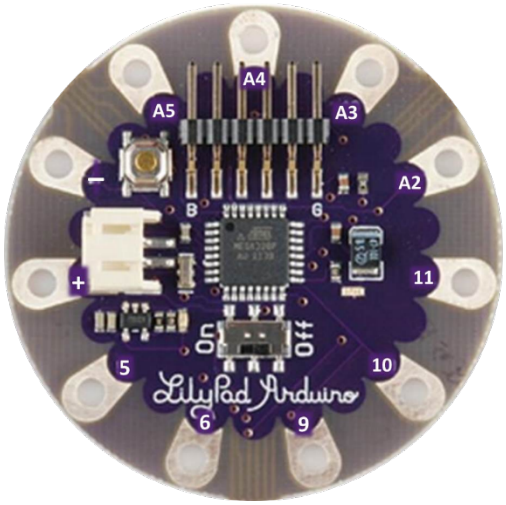
This circuit uses a button attached to pin 11 to control the buzzer attached to pin 5. The buzzer and button are grounded individually on the negative port.

- **Activity 4: Designing the Circuit**

CIRCUIT SKETCH

Please use the space below to design how your circuit will be constructed. Include all components that will be used and stitching leads. If you have more than one circuit, please sketch all circuits being used.

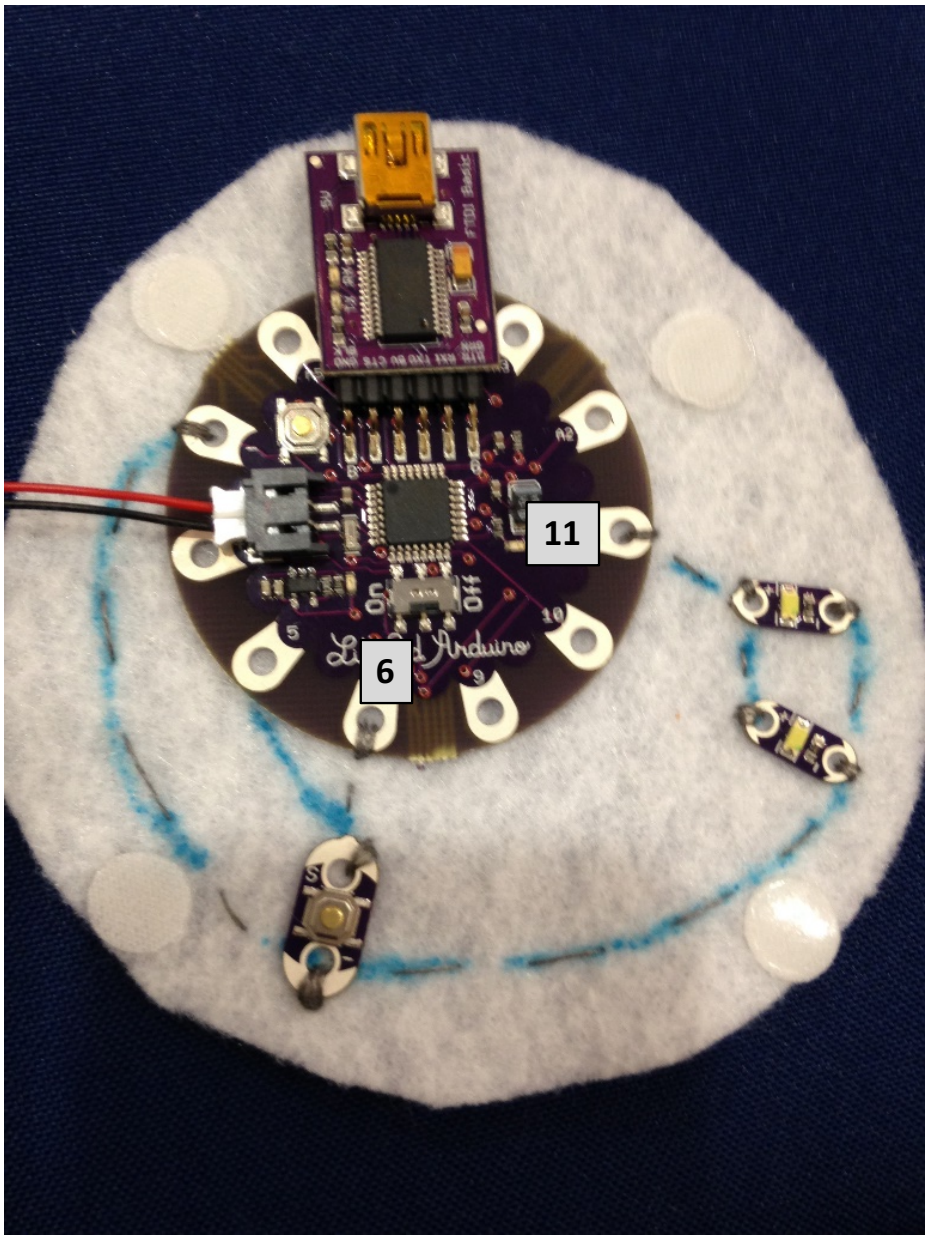
Teacher Directions: *This is a very important part of the lesson where students will consider how every component in their circuit will be constructed. It is very important that students map out exactly where each component will be connected on the LilyPad and the stitching that will be used. If any of the stitching will need to cross, students will need to insulate the stitches from each other to prevent a short circuit. After students have planned how their circuit will be constructed, they can then map the circuit out on the felt pieces (Task 4) and begin writing the coding sketch to control the various components. There are 2 different pages in the student worksheets to sketch 2 individual circuits.*



Below are examples of sewn circuits. (These are not included in the student edition).

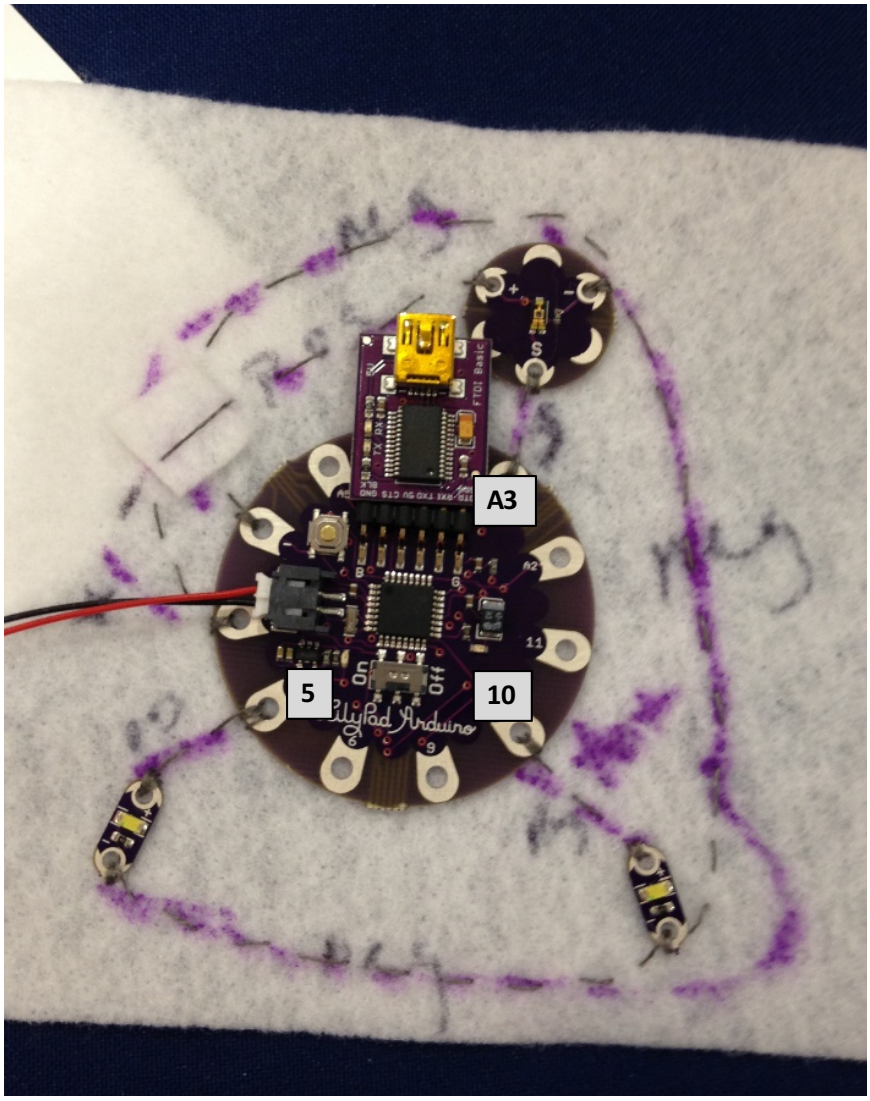
Button & 2 LEDs

2 LED lights connected in a parallel circuit to pin 11. Button connected to pin 6. Button and both LEDs grounded in 1 circuit to negative port on LilyPad.



Light Sensor & 2 LEDs

2 LED lights connected on pins 5 & 10. Light sensor connected on Signal port connected on pin A3, positive port connected to positive port on LilyPad. LED lights and light sensor grounded in 1 circuit to the negative port on LilyPad.



- **Activity 5: Sewing & Coding Circuits (60 minutes)**

*****Information below is included in the student worksheet information***

After designing the layout of the circuit, you are ready to map out the circuit on the felt pieces that will be attached to your Smart Suit.

**A coding reference guide and component hook up guide is included in the teacher edition of the lesson worksheet.*

ENSURE THAT ALL COMPONENTS ARE DISCONNECTED FROM THE COMPUTER. YOU CAN NOW BREAK APART YOUR LILYPAD PROTOSNAP DEVELOPMENT BOARD ☺ BE CAREFUL!!!!! THE LILYPAD COMPONENTS ARE VERY SMALL AND CAN BE EASILY LOST.

Sewing Directions:

1. Using the individual components from the LilyPad ProtoSnap Board, arrange them on the felt pieces.

2. Using markers, sketch the stitching out on the felt. ***(Red can be used for positive stitching leads – black can be used for negative stitching leads)***.

Important Information:

   a. *Positive ports on the components need to be connected to the various pins on the LilyPad.* ***BE CAREFUL!!!!! Positive stitches from one port cannot contact positive stitches on another port.***

   b. *Negative ports will be connected to the negative port on the LilyPad to create the ground of the circuit. Negative ports can be connected in one continuous circuit or directly to the negative port of on the LilyPad.*

3. After mapping out the circuit, sew the circuit components together.

4. Once all sewing is complete, check the stitching to ensure that no conductive thread pieces are touching. ***If needed, use hot glue to secure stitching to felt***.

Coding Directions:

1. You may use any of the coding structures found at https://github.com/gilescountystem

2. Develop your own code to control the components of your "Smart Suit." ***If using code sketches from the GitHub account, check that pin numbers for components are correct***.

3. Once the code is written, verify the code to make sure there are no mistakes. If there are mistakes go back and fix those and then verify again.

4. When you are able to verify your code with no mistakes and the circuits are sewn together, upload the code to the LilyPad Arduino and see if components work properly.