Robots – The next generation innovative teaching tool

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**Problem**: Today we are living in a very promising technology world where virtual reality and augmented reality have become a reality and how it can change our lives. Even telepresence and Robo-teachers in classrooms are transforming learning experiences. As the innovation of technology advances and arises it is important that we prepare our students to be innovative. The physics and math classes often fail to understand the interdisciplinary relationship and their relevance of learning in real life. The high school students are becoming less interested in physics as they cannot visualize how their learning is applied in real world. The current and the next generation classrooms should be able to provide and expose students to experience new interesting learning opportunities where facts and ideas become building blocks with which they can construct innovative applications, products, and inventions. The students have a real purpose inherent in bringing their idea to fruition: from the brainstorming phase to execution phase that have real world value.

**Abstract**

This is an interdisciplinary technology driven project based lesson which will provide a great opportunity to crystallize the difficult and abstract concepts in physics. The students will build different robots that can demonstrate a variety of topics in physics mechanics, light, sound and electricity. The lesson uses robots to contextualize the teaching of physics, mechanical and electrical engineering concepts. Throughout the whole process the lesson emphasizes on creative problem solving skills and a deeper insight into the complexity how different engineering and physics disciplines interlace in the process. This approach which promotes hands-on experience and the linking of concepts between the different branches of physics and across other like math and engineering during the learning process help students understand and retain what they learned. This kind of learning not only provides an engaging experience for students but also lays the foundation for proficient independent learning not just in formal education, but throughout life. This lesson plan is easily expandable as they already come with a few resources for the classrooms like the LEGO EV3 Mindstorms.

**Tag Standards/NAGC**

3.1. Curriculum Planning. Students with gifts and talents demonstrate growth commensurate with aptitude during the school year.

3.2. Talent Development. Students with gifts and talents become more competent in multiple talent areas and across dimensions of learning.

3.3. Talent Development. Students with gifts and talents develop their abilities in their domain of talent and/or area of interest.
3.4. Instructional Strategies. Students with gifts and talents become independent investigators.

3.5. Culturally Relevant Curriculum. Students with gifts and talents develop knowledge and skills for living and being productive in a multicultural, diverse, and global society.

3.6. Resources. Students with gifts and talents benefit from gifted education programming that provides a variety of high quality resources and materials.

**Georgia performance standards.**

**SCSh3. Students will identify and investigate problems scientifically.**
- a. Suggest reasonable hypotheses for identified problems.
- b. Develop procedures for solving scientific problems.
- c. Collect, organize and record appropriate data.
- d. Graphically compare and analyze data points and/or summary statistics.
- e. Develop reasonable conclusions based on data collected.
- f. Evaluate whether conclusions are reasonable by reviewing the process and checking against other available information.

**SCSh4. Students will use tools and instruments for observing, measuring, and manipulating scientific equipment and materials.**
- a. Develop and use systematic procedures for recording and organizing information.
- b. Use technology to produce tables and graphs.
- c. Use technology to develop, test, and revise experimental or mathematical models.

**SCSh5. Students will demonstrate the computation and estimation skills necessary for analyzing data and developing reasonable scientific explanations.**
- a. Trace the source on any large disparity between estimated and calculated answers to problems.
- b. Consider possible effects of measurement errors on calculations.
- c. Recognize the relationship between accuracy and precision.
- d. Express appropriate numbers of significant figures for calculated data, using scientific notation where appropriate.
- e. Solve scientific problems by substituting quantitative values, using dimensional analysis and/or simple algebraic formulas as appropriate.

**SP3. Students will evaluate the forms and transformations of energy.**
- a. Analyze, evaluate, and apply the principle of conservation of energy.
- g. Analyze and measure power.

**SP4. Students will analyze the properties and applications of waves.**
- a. Explain the processes that results in the production and energy transfer of electromagnetic waves.
- b. Experimentally determine the behavior of waves in various media in terms of reflection, refraction, and diffraction of waves.
- c. Explain the relationship between the phenomena of interference and the principle of superposition.
- d. Demonstrate the transfer of energy through different mediums by mechanical waves.
- e. Determine the location and nature of images formed by the reflection or refraction of light.
SP5. Students will evaluate relationships between electrical and magnetic forces.
   a. Describe the transformation of mechanical energy into electrical energy and the transmission of electrical energy.
   b. Determine the relationship among potential difference, current, and resistance in a direct current circuit.
   c. Determine equivalent resistances in series and parallel circuits.
   d. Determine the relationship between moving electric charges and magnetic fields.

Cross curriculum

SAP3. Students will assess the integration and coordination of body functions and their dependence on the endocrine and nervous systems to regulate physiological activities.
   a. Interpret interactions among hormones, senses, and nerves which make possible the coordination of functions of the body.
   b. Investigate the physiology of electrochemical impulses and neural integration and trace the pathway of an impulse, relating biochemical changes involved in the conduction of the impulse.
   c. Describe how the body perceives internal and external stimuli and responds to maintain a stable internal environment, as it relates to biofeedback.

AP Physics

Enduring Understanding 6.E: The direction of propagation of a wave such as light may be changed when the wave encounters an interface between two media.

Essential Knowledge 6.E.1: When light travels from one medium to another, some of the light is transmitted, some is reflected, and some is absorbed. (Qualitative understanding only.)
Learning Objective 6.E.1.1: The student is able to make claims using connections across concepts about the behavior of light as the wave travels from one medium into another, as some is transmitted, some is reflected, and some is absorbed.

Essential Knowledge 6.E.2: When light hits a smooth reflecting surface at an angle, it reflects at the same angle on the other side of the line perpendicular to the surface (specular reflection); this law of reflection accounts for the size and location of images seen in mirrors.
Learning Objective 6.E.2.1: The student is able to make predictions about the locations of object and image relative to the location of a reflecting surface. The prediction should be based on the model of specular reflection with all angles measured relative to the normal to the surface.

Essential Knowledge 6.E.4:
The reflection of light from surfaces can be used to form images.
   a. Ray diagrams are very useful for showing how and where images of objects are formed for different mirrors and how this depends upon the placement of the object. Concave and convex mirror examples should be included.
   b. They are also useful for determining the size of the resulting image compared to the size of the object.
   c. Plane mirrors, convex spherical mirrors, and concave spherical mirrors are part of this course. The construction of these ray diagrams and comparison with direct experiences are necessary.
Learning Objective 6.E.4.1: The student is able to plan data collection strategies and perform data analysis and evaluation of evidence about the formation of images due to reflection of light from curved spherical mirrors.

Learning Objective 6.E.4.2: The student is able to use quantitative and qualitative representations and models to analyze situations and solve problems about image formation occurring due to the reflection of light from surfaces.

Objectives

- To Measure the intensity of reflected light.
- To Compare electrical light sensors to human eyes.
- To determine the threshold value for different colors.
- To understand how light sensors work and the underlying concepts of light and reflectivity, color and perception (human verses light sensor, reflectivity of different wavelengths.)
- To enhance their STEM skills.

Anticipated Learner Outcomes

The students should be able to

- Measure the intensity of reflected light for different colors.
- Use the color sensor to stop the robot when a line is detected.
- Set a threshold value for the sensor.
- Program the LEGO MINDSTORMS EV3 robot or use any other robot with the light sensor to follow a line.
- Describe how light sensors work.
- Gain a good understanding of the application of physics in real life.
Assessment and Rubrics

**Pre lab Activity Questions:**

1. How many sensors or senses to humans have? List them

2. Give examples of sensors in robot that are similar to at least 2 human senses.

3. How do humans sense light?


5. Give some examples of light sensors in engineering systems.

**Post lab Activity Questions:**

1. How does the LEGO EV3 light sensor work?

2. Provide an example “stimulus-sensor-coordinator-effector-response” framework using the EV3 light sensor.

3. What is the difference between the ambient light mode and the reflected light mode?

4. What are some of the readings you obtained in different areas of the room? (Listen to student answers.) What were readings by the window, under a table, in a corner?

5. What can the light sensor detect?
Background

Robots are not just revolutionizing industries but our world by increasingly aiding and integrating into roles where we once relied solely on human operators. Initially the use of robots were limited to certain fields like military, manufacturing, service law enforcement, First responders, industrial chores, healthcare but now we see a new generation coming, prepared to do household chores, maintenance work, leisure activities or engage in educational activities and are completely autonomous. They are now designed to empower us. It has become a great tool across the educational spectrum. The LEGO EV3 system offers a wide range of hands-on- project- based learning experiments that can be used repeatedly throughout the curriculum as new concepts are introduced. The robotics set can be used to teach different concepts of physics and engineering with the use of different type of sensors either by constructing the given models in the manual or by designing a complete different structure.
As the students explore the principles that make light sensors work. We will review stimulus-sensor-coordinator-effector-response" framework using the human eye as a sensor. Understand the eye anatomy and function of the human sense of sight. Discuss specifically about the sensing elements in the eye—the rods and cones—and how signals from the rods and cones are sent to the brain. Make sure Explain the human sensing process of the eye: Incoming light is refracted or made to change direction by the cornea, the outermost part of the eye. This light is directed through the pupil, which is a hole through which it can pass. The surrounding muscular tissue in the iris (the colored part of the eye) controls the pupil size. The light that enters the back of the eye through the pupil is redirected by the eye’s lens, to receptors in the back of the eye that convert light into electrical signals. Emphasize the "conversion" or "transduction" function of this human sensor to understand the sensing technology in robots. Also explain about the 2 bulbs in the light/color sensor that the one on top is a phototransistor that measures light intensity. The one on the bottom is a light-emitting diode (LED) transmitter, which sends out a bright red light. At the end of the activity with the sensors they will gain a deeper understanding of the principles of light, and how the stimulus response framework which is used commonly in several engineering systems and envision the application of applications in real life.

Materials and Supplies

- LEGO Mindstorms EV3 kit :45544 (1 kit per lab group and 3-4 students per group suggested)
- Build instructions (included in the kit ) and online.
- Computer/smart phones are tablets with the software installed.
- Zip-lock bags are highly recommended to keep the LEGO parts organized.
- Different Colored paper or half Inch electrical sticky tapes and scissors.

Plan

It is important that the students complete the elements survey which will help them understand the different types of elements in the kit.

The first block there are 3 types of elements the number 3 represents the type of element and 1X means you need one of that kind. The second block shows how to put together.

Since this lesson is on reflection of light once the class completes energy we will work on this.

Lab time : 4 class periods of 55 minutes or 2 class periods of 90 minutes periods. A tablet /smart phone or computer to view the build instruction pdf is helpful since you won’t have to get printed copies to hand to the students.
Day 1 : **Introduction to the EV3 System and Pre lab activity**:

1. Let the students complete the Pre lab activity questions.
2. Review the answers and explain the steps involved in stimulus to response process.
3. Discuss the two main types of sensing elements in the eyes.
4. Take students to a computer lab and let them explore the “Getting started,” “Software Overview.” and “Content Editor” videos found on the home screen of the LEGO Mindstorms EV3 Home Edition Software. (The videos take only 10 minutes). You should allow them another 15 -20 minutes to explore the software.

Day 2 : **Build**

1. Pass out the kits and copies of the build instructions (if online pdf is not an option). Or make the students look at their electronic copy.
2. Go over the build instructions. Students need to be told how to read this type of diagram/instruction in the build guide.
3. Give them a few minutes to complete the elements survey which will give a very good idea of all the elements in the kit.
4. Click on the link [http://robotsquare.com/wp-content/uploads/2013/10/45544_educator.pdf](http://robotsquare.com/wp-content/uploads/2013/10/45544_educator.pdf) to view the build instructions online or you can also find it at the end of the document.
5. The build instructions are in color- grouped sections, so each student can be working on a different part of the robot.
6. Once the robot is complete, inspect it.

Day 3 : **Programming**

1. Direct student groups to follow the instructions to experiment with the 1) reflected light mode, 2) ambient light mode.
2. Have them test the brightness of various colors and surfaces that they can find in the classroom.
3. Have them test the ambient light in different areas of the classroom.
4. Record the data from the sensor which will help them determine the threshold value.
5. Tell them that in order to get a consistent reading or for best accuracy the sensor must be held perpendicular and close to, but not touching the surface.
6. Provide or show students how to determine the threshold value make them record readings when it is outside the line on either sides and exactly on the line. The average of the 2 the light and the dark is the threshold value.
Day 4 : Testing, Presentation and Post lab activity.

1. Have each group to identify a threshold value for different colors.
2. Tell them how they should determine the direction the robot has to move if it goes out of the line.
3. Have 2 groups use single light sensor and 2 groups /or accelerated group use 2 light sensors if available.
4. After they determine the threshold value they can program it to make it either stop when it sees a particular line or follow a colored line.
5. Wrap up the activity by asking the class to complete the post lab activity questions provided in the Assessment section.

Summary

Students have a stronger understanding of how the LEGO MINDSTORMS EV3 light sensor detects the brightness of light it receives and converts it to a numerical value as a percentage of the maximum brightness it can detect. Students learnt the concept of "stimulus-sensor-coordinator-effector-response" to describe the human and electronic sensory processes and how the human sensor, converts light to electrical impulses that are sent via the nerves (optic nerve in this case). Explain stimulus-to-response pathways, sensor fundamentals, details about the LEGO light sensor, including its two modes of gathering data and what its numerical value readings mean, and the principle behind the light sensors that the LEGO EV3 only senses brightness and not specific colors. Students will complete the pre/post lab questions. This lesson and its associated activity enable students to gain a deeper understanding of how robots can take sensor input and use it to make decisions via programming and how sensors are used in several other engineered technologies.
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References


Sensors and Reflection: https://www.teachengineering.org/lessons