Integrating Engineering Design and Robotics in Pre-College Education: A Hands-On Approach with Lego Robotics (Resource Exchange)

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Norman Philipp is a licensed engineer and a tenured faculty member at Pittsburg State University in the College of Technology with over 12 years of experience in higher education, specializing in pre-college STEM outreach and innovative engineering education. As the co-coordinator of the Adventures in Robotics program, Prof. Philipp focuses on hands-on, project-based learning that engages middle and high school students in engineering concepts through the use of robotics. Their work is designed to foster critical thinking, problem-solving, and collaboration among young learners, with the goal of inspiring the next generation of engineers and STEM professionals. Prof. Philipp holds degrees from the University of Kansas, the University of Nebraska, and Pittsburg State University.

Prof. Randy Winzer, Pittsburg State University

Randy Winzer is a Professor in the Engineering Technology department at Pittsburg State University in Pittsburg, KS; he served as the EET program coordinator from 2002 until 2007. He holds both BS and MS degrees in Engineering Technology and has several years of experience supporting various information technology infrastructure projects; primarily those in support of educational content delivery and K-12 education. The past twenty-one summers Professor Winzer has conducted a STEM outreach effort titled 'Adventures in Robotics' which has had over 1,000 local K-12 participants.

Introduction to Scratch Programming and Motor Control with LEGO Spike Prime

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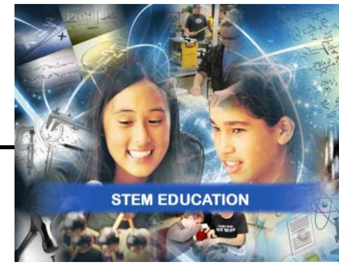

Lesson Length: _30-45______min **Audience:__4^{th} – 7^{th} Grade_**

Description: Students will learn the fundamentals of programming using Scratch with the LEGO Spike Prime kit. By the end of the lesson, students will be able to write a program to control the robot's motors, enabling it to move while avoiding obstacles toward a target without knocking it over. Students will also develop problem-solving skills by calibrating motor power and distance settings to achieve precise movement.

Lesson Objective: Upon completion the student should be able to:

- Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. **NGSS**: MS-ETS1-4
- Recommend improvements to the design of computing devices, based on an analysis of how users interact with the devices. **CSTA**: 2-CS-01 (6-8)
- Write arguments to support claims with clear reasons and relevant evidence. **Common Core:** CCSS.ELA-LITERACY.W.6.1

Tools and Materials Needed:

- LEGO Spike Prime kits
- Computers or tablets with the LEGO® Education SPIKE™ App installed
- Pre-built targets for the robot
- Scratch programming blocks (available in the app)

References:

https://spike.legoeducation.com/prime/lobby/

Key Contents:

1. Prepare
- Read through the student material in the LEGO® Education SPIKE™ App.
  - *Competition Ready – Training Camp 1: Driving Around*
- Plan a preliminary lesson (if needed) using the getting-started materials in the app to familiarize students with LEGO Spike Prime.

2. Engage (5 Minutes)
- Discussion Prompts: Navigating through obstacles on robotics competition fields is a key to success. Engage your students in a discussion by asking them to:
  - "Why do you think programming is important in robotics?"
  - Describe a field tactic associated with their favorite sport.
  - List all the movements they think their Driving Base should be able to perform.
  - "How do you think a robot can measure distance to reach a target precisely?"
- Use a video or demonstration of a LEGO Spike Prime robot to introduce the activity.

3. Explore (20 Minutes)
- Activity:
  - Students work in pairs to build the Practice Driving Base model.
  - Provide pre-made programming stacks in the LEGO SPIKE App for basic movements. *(Included in Training Camp 1: Driving Around)*
  - Students modify parameters (e.g., speed, distance) and observe how changes affect movement.

- Building Tips: A simple driving base
    - Use the simple Driving Base model with no sensors.
    - Remember to use the cable clips.

4. Explain (5 Minutes)

- Facilitate a discussion on:
    - Planning each program step.
    - The concept of pseudocode and its role in structured problem-solving.
- Example: Show how pseudocode can help map the program logic for moving the robot.

5. Elaborate (15 Minutes)

- Challenge:
    - Program the robot to move through a field of obstacles to a target without knocking it over.
    - Encourage iterative testing to refine motor power and distance settings.
- Optional:
    - Learn about Velocity: Have students determine the velocity of the robot by measuring how far it moves in 5 sec. Remove the obstacles and have them control when the robot stops based on a time input for a given distance from the target.
- Allocate time for cleanup and reorganization.

6. Evaluate

- Suggested Assessment Criteria:
    - Ability to build and program the robot.
    - Precision of robot movement.
    - Understanding of programming concepts and pseudocode.
    - Teamwork and problem-solving skills.
    - Successfully programs the robot to meet the challenge.
    - Demonstrates collaboration and iterative problem-solving.
    - Understands and applies programming concepts effectively.
- Provide constructive feedback and encourage reflective discussion:
    - "What did you learn about programming and precision?"
    - "What would you do differently next time?"

Assessment Opportunities:

Teacher Observation Checklist

- Create a scale that matches your needs, for example:
    - Partially accomplished
    - Fully accomplished
    - Overachieved
- Use the following success criteria to evaluate your students' progress:
    - Students can select appropriate blocks for making controlled movements.
    - Students can change the parameters of blocks in iterative ways.
    - Students can stack appropriate move blocks together to create programs.

Self-Assessment

- Have each student choose the brick that they feel best represents their performance:
    - **Blue:** I've made the Driving Base move in different ways.
    - **Yellow:** I've created different programs to move the Driving Base in a square.
    - **Violet:** I've combined different types of motor movements to successfully navigate around obstacles.

Peer-Assessment

- Encourage your students to provide feedback to others by:
    - Having one student score the performance of another using the colored brick scale above.
    - Asking them to present constructive feedback to each other so that they can improve their group's performance during the next lesson.

Differentiation:

Simplify this lesson by:

- Spending extra time explaining what is being controlled by each parameter of the program blocks.

Take this lesson to the next level by:

- Asking your students to use the Gyro Sensor to program their Driving Base to drive in a square.
- Practicing speed and precision on a larger surface, like a competition table