South Dakota State University Extension

Speedboat Robotics Curriculum

Get Charged Up with 4-H Robotics!

Credits

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Table of Contents

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Introduction

Purpose

- Discover the exciting world of robotics with this Introduction to Robotics Program! Our hands-on program introduces youth to STEM concepts through fun, engaging projects.

Objectives

- Focus on fundamental concepts like:
  - Basic mechanics (gears, levers, motion)
  - Electronics (circuits, sensors, actuators)
  - Programming (block-based coding)
- Skills Youth Will Gain:
  - Basic robot building and design
  - Programming fundamentals
  - Using tools and materials safely
  - Troubleshooting and problem-solving
  - Working effectively in teams
  - Communicating ideas and findings

Target Audience

- Potential 4-H members (ages 8-18)

What is 4-H Robotics?

- A fun and hands-on program that introduces young people to the exciting world of robotics. Combines science, technology, engineering, and math (STEM) with teamwork and problem-solving. Emphasizes learning by doing, creativity, and innovation.

Why Robotics in 4-H?

- 4-H Robotics empowers young people to develop critical thinking and problem-solving skills. Encourages teamwork and collaboration. Promotes creativity and innovation. Build confidence and communication skills. Prepares youth for future careers in STEM fields. Aligns with the 4-H mission of developing youth to their fullest potential.

Items Needed

- Pencils
- Printed worksheets
  - What is a robot
  - Morning Routine Flowchart
  - Peanut Butter and Jelly
- Printed instructions for groups. Link listed on page 5.
- Robot Kits, I use EV3 kits
  - education.lego.com/en-us/products/lego-mindstorms-education-ev3-core-set/5003400/
- A computer or tablet that is compatible with the EV3 LEGO® Mindstorm Kits
- Certificates to be given out once the 4th session is completed.

Get Charged Up with 4-H Robotics!

Program can be facilitated using the EV3 LEGO® Mindstorm Kits or similar autonomous robots.

Session 1: Introduction to Robotics and Procedural Documentation (50 min)

- **Description:**
  - This session introduces fundamental concepts in robotics, including the definition, applications, diverse types, and core components of robots, along with the etymology of the term “robot.” Participants will engage in activities focused on writing sequential instructions, emphasizing the importance of precision and clarity in procedural documentation.
- **Facilitation Notes:**
  - Encourage active participation throughout the session. This foundational process prepares participants for robot programming by developing skills in precise instruction writing and execution towards a defined objective.

Session 2: Collaborative Robot Assembly (50 min)

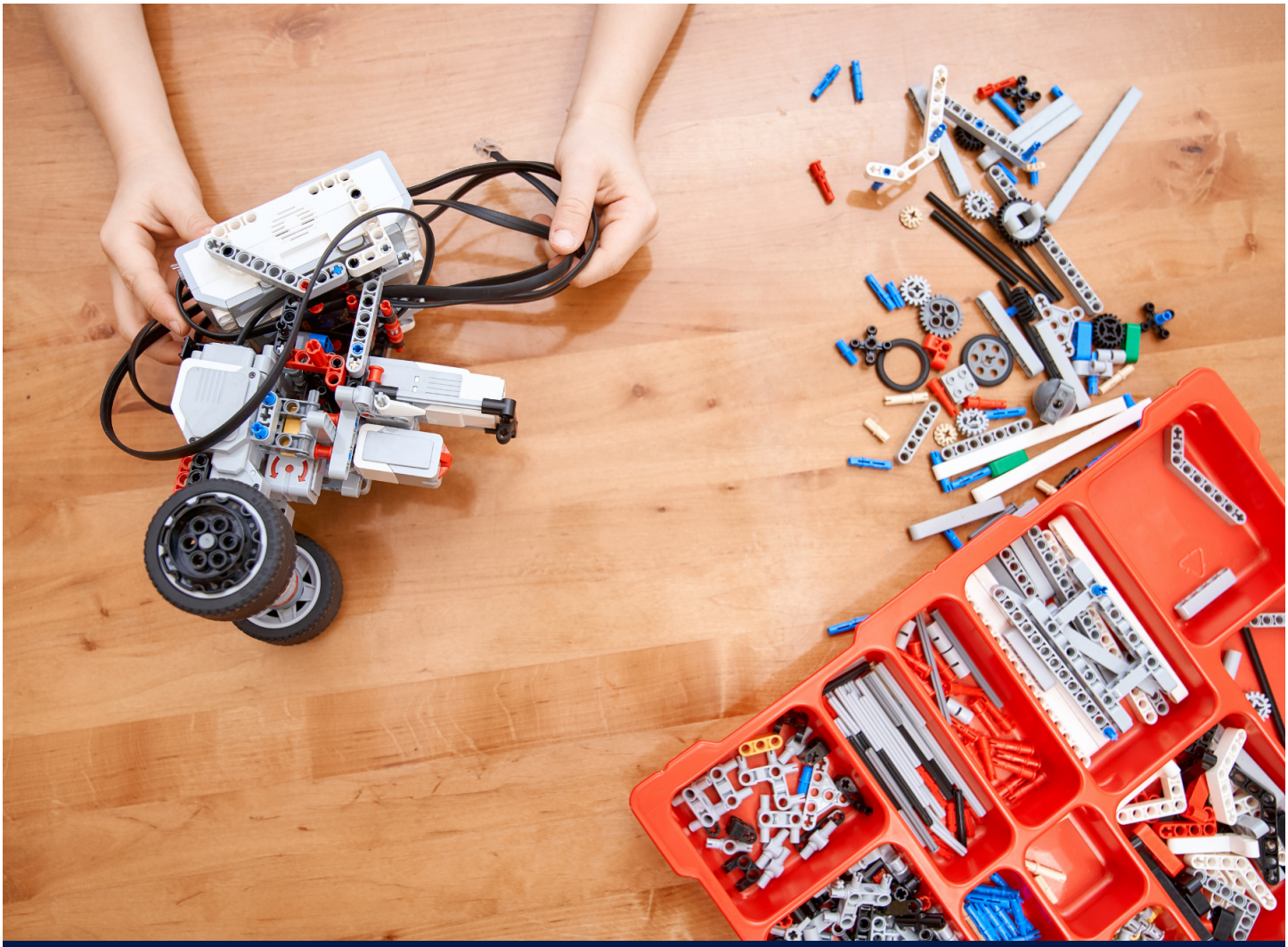
- **Description:**
  - Participants will collaborate in small groups (ideally 3, maximum 5) to assemble a robot. The session will begin with a discussion on effective teamwork principles. Groups will then collaboratively plan and execute the robot assembly, aiming to complete the build. The LEGO® Mindstorm EV3 speed boat instructions will be utilized for a standardized build across all groups.
- **Facilitation Notes:**
  - Utilize the provided LEGO® Mindstorm EV3 speed boat instructions (link: assets.education.lego.com/v3/assets/blt293eea581807678a/blt7bddc6ee7e97c774/5f88046f25f8972408a0301a/speed-bot.pdf).
  - Ensure all groups assemble the same robot to facilitate instructor guidance and verification of correct construction. Providing step-by-step instructions in color is recommended.

Session 3: Introduction to Basic Robot Programming (Geometric Shapes) (50 min)

- **Description:**
  - This session introduces the fundamentals of robot programming and develops understanding of robot functionality. Participants will practice programming their robots to create basic geometric shapes with varying angles. The emphasis is on achieving accuracy in programming rather than simply completing the shapes, serving as preparation for the subsequent advanced programming session.
- **Facilitation Notes:**
  - Frame this session as a practical exercise for developing precise programming skills essential for the more complex tasks in Session 4.

Session 4: Advanced Robot Programming (Maze Navigation) and Certification (50 min)

- **Description:**
  - Building upon the skills acquired in previous sessions, participants will engage in a more complex challenge involving robot navigation through a designated maze or course. Clear instructions will be provided for the task. The session will conclude with the awarding of certificates of completion and potentially small tokens of recognition.
- **Facilitation Notes:**
  - This session is designed to be an engaging culmination of the learning experience. Prepare clear instructions for the maze navigation task. Consider providing certificates and small mementos to acknowledge participants’ achievements.



SESSION 1

Session 1: Introduction to Robotics and Procedural Documentation

SKILL LEVEL

Ages 8-18

KEY TERMS

- Robot
- Precise Instruction

EDUCATION STANDARDS

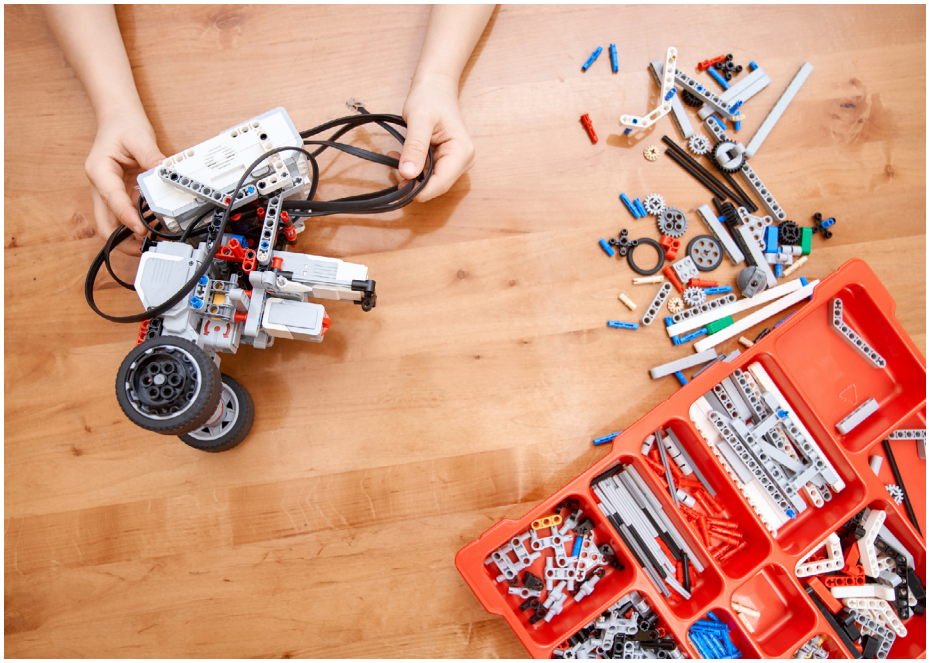
SD Computer Science:
- K-2.IC.02
- 3-5.CS.01

TIME NEEDED

50 Min

MATERIAL LIST

- Whiteboard or projector
- Markers/Pens
- Handouts (Optional)



EXPECTED LEARNER OUTCOMES

By the end of this session, participants will be able to:
- Define “robot” and discuss what the word means.
- Identify diverse applications and types of robots.
- Recognize core components common to most robots.
- Understand the importance of writing clear and precise directions.
- Write a clear, sequential set of instructions to achieve a defined objective.

BACKGROUND

This session introduces fundamental concepts in robotics, including the definition, applications, diverse types, and core components of robots, along with the etymology of the term “robot.” Participants will engage in activities focused on writing sequential instructions, emphasizing the importance of precision and clarity in procedural documentation.

VOCABULARY

Robot: a machine capable of carrying out a complex series of actions automatically, especially one programmable by computer.

ACTIVITY PREPARATION

Gather materials and prepare participants by leading the "Robot Brainstorm" activity outlined below.

ACTIVITY INSTRUCTIONS

Introduction (5 minutes)

- Activity: "Robot Brainstorm"
  - Ask participants: "When you hear the word 'robot,' what comes to mind? Where have you seen robots?"
  - Jot down their ideas on the whiteboard.
  - Transition: "Today, we're going to dive into the fascinating world of robotics and discover what makes robots work, and how we can effectively communicate with them."

What is a Robot? (10 minutes)

- **Definition and Origin:**
  - Introduce a formal definition of a robot (e.g., "a machine capable of carrying out a complex series of actions automatically, especially one programmable by computer").
  - Explain the origin of the word "robot" (from the Czech word "robota," meaning "forced labor". Discuss how this origin relates to the function of robots.
  - Discussion:
    - Ask: "Why do we create robots? What problems do they solve?"
    - Briefly touch upon the concept of robots performing repetitive, dangerous, or difficult tasks.

Applications, Types, and Components (15 minutes)

- **Applications:**
  - Lead a discussion on diverse applications of robots:
    - Manufacturing (assembly lines); Healthcare (surgery, rehabilitation); Exploration (space, underwater); Logistics (warehousing, delivery); Domestic (vacuum cleaners, lawnmowers); Entertainment/Education; Encourage participants to share examples they know.
- **Types of Robots** (Brief Overview):
  - Mention a few broad categories:
    - Industrial Robots (e.g., robotic arms); Mobile Robots (e.g., AGVs, drones); Humanoid Robots; Service Robots
- **Core Components:**
  - Explain the fundamental components of most robots:
    - Body: What holds it all together.
    - Actuators: What makes it move (motors, hydraulics, pneumatics).
      - Types of movement: wheels, feet, propellers
    - Sensors: How it perceives its environment (cameras, touch sensors, ultrasonic sensors).
    - Controller/Processor: The "brain" that processes information and makes decisions.
    - Power Source: How it gets energy.
    - Wires: connecting the brain to other parts of the robot
    - Gears: transmit rotational motion and power, as well as to modify speed and torque
  - Relate these components to the applications discussed (e.g., a robot vacuum needs wheels (actuators), a bumper sensor, and a mapping system (controller).

The Importance of Procedural Documentation (15 minutes)

- **Introduction:** "Now that we know what robots are and what they're made of, how do we tell them what to do? This is where precise instructions come in.
- Activity: Robot Instructions:
  - Peanut Butter and Jelly Sandwich (if time/materials allow)
    - Instructions: Choose one volunteer to be the "robot." The rest of the participants must verbally instruct the "robot" on how to make a peanut butter and jelly sandwich, one precise step at a time. Emphasize that the robot will only do exactly what it's told, no assumptions.
    - Facilitation: Let the "robot" make humorous mistakes due to unclear instructions (e.g., "put the knife in the peanut butter" without specifying how to open the jar first).

REFLECTION

Debrief:

- After the activity, bring the group back together.
- Ask: “What did you learn from that activity?”
- Key takeaways to emphasize:
    - The importance of precision and clarity in instructions.
        - » Breaking down complex tasks into smaller, manageable steps.
        - » Anticipating potential doubts and addressing them.
        - » How this directly relates to programming robots – robots follow instructions literally.

Wrap-up and Preview:

- Summary: “Today, we’ve explored the world of robotics, from its definition and history to its diverse applications and core components. Most importantly, we’ve practiced the essential skill of writing clear and precise instructions, which is fundamental to communicating with robots.”
- Q andA: Open the floor for any lingering questions.

EXTENDED LEARNING

Go to the following session.

SESSION 2

Session 2: Robot Assembly and Teamwork

SKILL LEVEL

Ages 8-18

KEY TERMS

- Technical Diagrams
- Assembly

EDUCATION STANDARDS

SD Computer Science:

- 3-5. AP.07
- 6-8. AP.06

TIME NEEDED

50 Min

MATERIAL LIST

- Robot Kits (one complete, unassembled kit per group)
- Assembly Instructions

EXPECTED LEARNER OUTCOMES

By the end of this session, participants will be able to:

- Work effectively in small teams.
- Successfully assemble a basic robot or significant portions of it, following provided instructions.
- Apply critical reading and interpretation skills to follow technical diagrams and sequential steps.
- Identify key physical components of their robot during the assembly process.
- Practice problem-solving and trouble shooting in a hands-on environment.

BACKGROUND

Participants will collaborate in small groups (ideally 3, maximum 5) to assemble a robot. The session will begin with a discussion on effective teamwork principles. Groups will then collaboratively plan and execute the robot assembly, aiming to complete the build. The LEGO® Mindstorm EV3 speed boat instructions will be utilized for a standardized build across all groups.

VOCABULARY

None.

ACTIVITY PREPARATION

Gather materials and ready participants by discussing the "Welcome, Recap, and Connection" section below.

ACTIVITY INSTRUCTIONS

Welcome, Recap, and Connection (5 minutes)

- **Facilitator:** Welcome back, aspiring roboticists! Last session, we dove into the world of robots – what they are, where we find them, and their essential parts like sensors, actuators, and controllers. We also talked about the absolute necessity of precise instructions when communicating with anything, especially robots. Remember our Peanut Butter and Jelly activity? What did that teach us about giving instructions?
  - *Allow participants to share key takeaways (e.g., be specific, sequential, assume nothing).*
- **Facilitator:** Today, you're going to put those precise instruction-following skills to a very tangible test! You'll literally be bringing a robot to life, one piece at a time.

Group Formation and Team Brief (5 minutes)

- **Facilitator:** From this point forward, you will be working in consistent teams. Robotics is a highly collaborative field, and learning to work effectively with others is just as important as understanding the technology itself.
- **Activity:** Divide the class into groups.
  - *Method: You can pre-assign groups for balance or allow participants to self-select with guidance to ensure even numbers. Emphasize that these will be their ongoing project teams.*
- **Facilitator:** Please find your group members. These are your teammates for the coming sessions!
- **Facilitator:** Your group will work together on a single robot kit. This means shared responsibility, shared problem-solving, and shared success. Communication within your group will be key!

Introduction to Robot Assembly (10 minutes)

- **Facilitator:** Each group will now receive a robot kit and its assembly instructions. Think of these instructions as the robot's DNA – they tell you exactly how it's built, piece by piece.
- **Activity:** Distribute one robot kit and its instruction manual to each group.
- **Key Instructions and Expectations for Assembly:**
  - **Read Before You Build:** Before touching any pieces, have *everyone* in your group look through the entire instruction manual. Notice the diagrams, the part lists, and the sequence of steps. This is your blueprint!
  - **Precision is Paramount:** Just like the instructions we tried to give last time, these assembly steps must be followed exactly. Skipping steps or guessing can lead to issues later on.
  - **Collaborate Actively:** Decide on roles within your group. One person can read the current step, another can find the parts, and on can perform the assembly. Rotate these roles frequently so everyone gets hands-on experience.
  - **Identify Components:** As you assemble, try to identify the major components.
  - **Troubleshooting First:** If you get stuck, your first step is to *re-read the instructions together*. Often, the answer is there. If you're still stuck after careful review, then you can call me over.
  - **Safety:** Be mindful of small parts and handle tools carefully if your kit requires them.
- **Facilitator:** My role will be to circulate, observe, and offer guidance if you truly get stuck, but I encourage you to work through challenges as a team.

Hands-on Robot Assembly Activity (25 minutes)

- **Facilitator:** Alright teams, you have 25 minutes to make as much progress as you can on assembling your robot. Remember to work together, follow the instructions precisely, and have fun! Ready, set, build!
- **Activity:** Participants begin the hands-on assembly of their robots.
- **Facilitator Role during activity:**
  - **Circulate:** Constantly move among the groups, observing their progress and interactions.
  - **Observe Teamwork:** Note how groups are collaborating, communicating, and dividing tasks.
  - **Offer Guiding Questions:** Instead of giving direct answers, ask questions like: What does the diagram show for this step? Are all the pieces oriented correctly? Did you check the part count for this step?
  - **Prompt Component Identification:** What part are you attaching right now? What do you think its function will be?
  - **Troubleshoot (when necessary):** If a group is genuinely stuck after attempting to troubleshoot themselves, help them identify the precise step where they went wrong or how to re-interpret a diagram.
  - **Manage Time:** Give a 10-minute and 5-minute warning before the end of the assembly time.

REFLECTION

Facilitator: Alright everyone, please pause your building, no matter how far you've gotten. Fantastic work today, teams!

- **Debrief:**
  - What was the most challenging part of assembling your robot today?
  - How did the lessons from our first session about precise instructions help you in this hands-on task? (Reinforce the link between theoretical understanding and practical application).
  - What did you learn about working in a team during this assembly process?
  - Take a quick look at your robot (or what you've assembled so far). Can you point out any of the core components we discussed last time, like a motor or a sensor mount?
- **Preview:** Excellent progress today! Assembling the robot is a huge step. In our next session, we'll move from building the physical robot to giving it intelligence – we'll start learning how to program your robots to move, sense, and interact with the world!

Instructions: Guide groups on how to carefully store their partially or fully assembled robots and kits for the next session.

EXTENDED LEARNING

Go to the following session.

SESSION 3

Session 3: Programming Your EV3 Speedboat – Making Basic Movements

SKILL LEVEL

Ages 8-18

KEY TERMS

- Programming
- Commands
- Debugging

EDUCATION STANDARDS

SD Computer Science:
- 3-5. AP.06
- 3-5. AP.07

TIME NEEDED

50 Min

MATERIAL LIST

- LEGO® Mindstorms EV3 Speedboat robots (fully or mostly assembled from Session 2), one per group
- Computers/Laptops/tablets with LEGO® Mindstorms EV3 Software installed, one per group
- Charged EV3 Intelligent Bricks (ensure they are powered on)
- USB cables for connecting EV3 Bricks to computers (or ensure Bluetooth connectivity is configured)
- Large, clear, flat floor space for robot testing (e.g. gym floor)
- Masking tape (optional)

EXPECTED LEARNER OUTCOMES

By the end of this session, participants will be able to:
- Connect their LEGO® Mindstorms EV3 Software.
- Navigate the basic program of the LEGO® Mindstorms EV3 Software.
- Identify and use fundamental programming blocks for motor control.
- Write a simple program to make their EV3 Speedboat move forward.
- Program their Speedboat to turn left and right using different angles.
- Combine movement and turn commands to program the Speedboat to “draw” a basic shape.
- Practice debugging simple EV3 programs.

BACKGROUND

This session introduces the fundamentals of robot programming and develops understanding of robot functionality. Participants will practice programming their robots to create basic geometric shapes with varying angles. The emphasis is on achieving accuracy in programming rather than simply completing the shapes, serving as preparation for the subsequent advanced programming session.

VOCABULARY

None.

ACTIVITY PREPARATION

Gather materials and verify all components are working correctly.

ACTIVITY INSTRUCTIONS

Welcome, Recap, and Hook (5 minutes)

- **Facilitator:** Welcome back, amazing robotics teams! Last session, you did an incredible job assembling your LEGO® Mindstorms EV3 Speedboats. You took all those parts and followed precise instructions to build a real robot!
- **Facilitator:** Now that your Speedboat has a body, what's missing to make it do something? How do we make it 'smart' and move on its own?
  - *Take answers like: 'instructions,' 'telling it what to do,' 'programming it,' 'giving it a brain.'*
- **Facilitator:** Exactly! Today is the day you become robot programmers! You'll learn how to write the instructions that bring your EV3 Speedboat to life and make it move!

Introduction to EV3 Programming Software (10 minutes)

- **Concept of Programming:**
  - **Facilitator:** Programming is like writing a very detailed recipe or a set of step-by-step instructions that your robot's 'brain' – the EV3 Brick – can understand and follow. Robots don't 'know' anything until we tell them.
  - Every app on your phone, every smart device, every self-driving car – they all run on programs, on instructions written by programmers like you.
- **Launching and Connecting:**
  - **Facilitator:** Please have one team member open the LEGO® Mindstorms EV3 Software on your computer. While they do that, another team member should turn on your EV3 Brick.
  - **Guided Demo (Projector):** Show students how to:
    - Open the EV3 Software.
    - Navigate to a new project.
    - **Connect the EV3 Brick:** Show how to connect the EV3 Brick via USB cable (or explain Bluetooth pairing if applicable). Emphasize checking the connection status icon in the software. You need to see the green checkmark or connected icon!
- **Software Interface Overview:**
  - **Facilitator:** Let's take a quick tour of our programming environment.
    - **Programming Palette (Left Side):** This is where all the command blocks are. We'll mostly use the 'Action' blocks (pink tab) today.
    - **Programming Canvas (Middle):** This is where you drag and connect your blocks to build your program, like a puzzle.
    - **Hardware Page (top of programming canvas):** This shows your connected EV3 Brick and what motors/sensors are plugged into which ports (A, B, C, D). Crucial: Ensure motors are plugged into the correct ports for your Speedboat build, typically B and C for drive motors.

Essential Movement Blocks (15 minutes)

- **Facilitator:** Today, we'll focus on making our Speedboat move. Our Speedboat uses motors to drive. The EV3 has special blocks to control these motors.
- **Introducing Move Steering (or Move Tank):**
  - **Facilitator:** "Look in the 'pink 'Action' palette for the first and second pink blocks. This is the most common way to make your robot drive and turn."
  - **Explain Move Steering Parameters:**
    - **Motors:** Explain that this block controls two motors (e.g., B and C for the Speedboat's drive wheels).
    - **Forward:** the robot will drive forward
    - **Form of duration used:** On for Seconds, On for Degrees, On for Rotations. Explain that On for Rotations or On for Degrees are good for precise movements, while On for Seconds is simpler to start.
    - **Steering:** explain where the steering wheel is embedded, how to use it and how the chosen form of duration affects their turn.
- **Guided Practice - Drive Forward and Stop:**
  - **Facilitator:** Let's make your Speedboat drive forward for a short distance.
    - Drag a first pink block under the gold start block

    - » Set the duration to On for Rotations (e.g., 1 rotation) or On for Seconds (e.g., 2 seconds).
  - **Upload and Test:** Now, let's upload this program to your EV3 Brick. Click the 'Download' button (usually bottom right). Once uploaded, press the 'Play' button on your EV3 Brick and see what happens!
  - *Circulate, assist with block parameters, and troubleshoot connection/upload issues. Emphasize: 'Program it, download it, run it!'*

Programming Challenge: Small Shapes - A Square (15 minutes)

- **Facilitator:** Now that we can go straight, how do we make our Speedboat turn? We need to combine straight movements with turns to create shapes.
- **Logic Discussion:** To make this shape, your robot needs to drive forward, turn, drive forward, turn, and so on.
- **Guided Programming for a shape:**
  - **Facilitator:** "Let's start building your shape. You'll need:
    - » Move Steering (straight, for a side).
    - » Move Steering (turn, for a corner).
    - » You will download one block at a time, accuracy is the key. Facilitator will give the okay to drag more blocks down
  - **Focus on Turns:** For turning, use 2 second pink block with a Steering value (e.g., -50 for left, 50 for right) and a small Rotations or Degrees value for the turn.
    - » *Note: 90-degree turns are often not exactly 90 degrees of motor rotation due to friction/traction. Tell students it's about experimentation.*
- **Facilitator Role:**
  - Circulate constantly, observing.
  - Ask guiding questions: How many degrees will your robot turn with that setting? If your shape isn't closing, is it turning too much or too little?
  - Help troubleshoot inconsistent turns or straight lines. Reinforce: This is what real engineers do – they test, adjust, and re-test!

REFLECTION

Wrap-up and Next Steps

- **Sharing and Celebration:**
  - **Facilitator:** Alright teams, time to pause! No matter how perfect your shape is, you've just programmed your robot to follow complex instructions – that's amazing!
  - Did any groups get their Speedboat to complete the shape? Or at least close to one? (Allow a few quick demonstrations).
- **Summary:** Today, you've taken your first exciting steps into robot programming! You learned how to tell your EV3 Speedboat to move forward and turn using the EV3 software. You even tackled the challenge of making it 'draw' a shape by combining these movements.
- **Discussion:**
  - What was the most challenging part of programming today?
  - How did the concept of 'precise instructions' from Session 1 apply to your programming?
  - What did you learn about debugging – finding and fixing errors in your program?
- **Preview:** Fantastic work! Next time, we'll make your Speedboats even smarter by exploring a new obstacle course for you to complete.
- **Housekeeping:** Instruct groups to close your program, power off their EV3 Bricks, disconnect USB cables, and store their robots and components neatly.

EXTENDED LEARNING

Go to the following session.

SESSION 4

Session 4: Programming Your EV3 Speedboat – Course Navigation and Celebration

SKILL LEVEL

Ages 8-18

KEY TERMS

- Debugging
- Turning Blocks
- Precise Movement Control

EDUCATION STANDARDS

SD Computer Science:
- 3-5. AP.06
- 3-5. AP.07

TIME NEEDED

50 Min

MATERIAL LIST

- LEGO® Mindstorms EV3 Speedboat robots (fully functional), one per group
- Computer/Laptops with LEGO® Mindstorms EV3 Software installed (with saved programs), one per group
- Charged EV3 Intelligent Bricks
- USB cables (or confirmed Bluetooth connectivity)
- Course Materials: Masking tape and/or Printed course that can be used repeatedly
- Certificates of Completion (one per participant)

EXPECTED LEARNER OUTCOMES

By the end of this session, participants will be able to:
- Design a simple course for their EV3 Speedboats to navigate.
- Apply their knowledge of movement and turning blocks to program their robot to follow the course.
- Use more precise movement control (e.g. Move Steering with Degrees or Rotations) for accurate course navigation.
- Practice debugging and refining their programs through iterative testing.
- Demonstrate teamwork and problem-solving skills in a more complex programming challenge.
- Celebrate their achievements in robotics and programming!

BACKGROUND

Building upon the skills acquired in previous sessions, participants will engage in a more complex challenge involving robot navigation through a designated maze or course. Clear instructions will be provided for the task. The session will conclude with the awarding of certificates of completion and potentially small tokens of recognition.

VOCABULARY

None.

ACTIVITY PREPARATION

Gather materials and verify all components are working correctly.

ACTIVITY INSTRUCTIONS

Welcome, Recap, and Course Introduction (10 minutes)

- **Facilitator:** Welcome back, robot navigators! In our last session, you programmed your EV3 Speedboats to move and turn and even draw a shape. Today, we're going to put those skills to the test in a real navigation challenge!
- **Review Previous Concepts:** Briefly recap the key movement blocks (going forward and turning), emphasizing the importance of precise control using Degrees or Rotations for accurate turns and distances.
- **Introduce the Course Challenge:**
  - **Facilitator:** Your mission today is to program your EV3 Speedboat to navigate a course. The course will have turns, straight sections, and possibly some obstacles. You'll need to work together as a team to design your program and make it work!
  - **Course Design:**
    - **Team-Based:** Each team will have to complete the course on their own.

Programming the Course Navigation (25 minutes)

- **Teamwork Time:** Teams work together to program their EV3 Speedboats to navigate the course.
- **Facilitator Role:**
  - Circulating and observing team progress.
  - Encourage teamwork and collaboration.
  - Ask guiding questions: How many degrees do you need to turn for that corner? Is your robot turning too much or too little? How can you make your robot drive straight for a specific distance?
  - Remind students to test their programs frequently and debug any issues.
  - Offer assistance as needed but encourage teams to solve problems independently.

Course Navigation and Testing (10 minutes)

- **Testing and Refinement:** Teams test their programs on the course, adjusting as needed to improve accuracy and reliability.
- **Facilitator Role:**
  - Observe the testing process.
  - Provide feedback and suggestions for improvement.
  - Ensure all teams have a chance to test their programs.
  - Celebrate successes and encourage perseverance.

REFLECTION

- Awards Ceremony:
  - Congratulations to all participants on their hard work and accomplishments in the robotics program.
  - Hand out Certificates of Completion to each participant.
  - (Optional) If time allows, each team demonstrates their final course navigation program.
- Wrap-up and Farewell:
  - Summarize the key concepts and skills learned throughout the program.
  - Encourage participants to continue exploring robotics and programming.
  - Thank participants for their enthusiasm and participation.

EXTENDED LEARNING

None