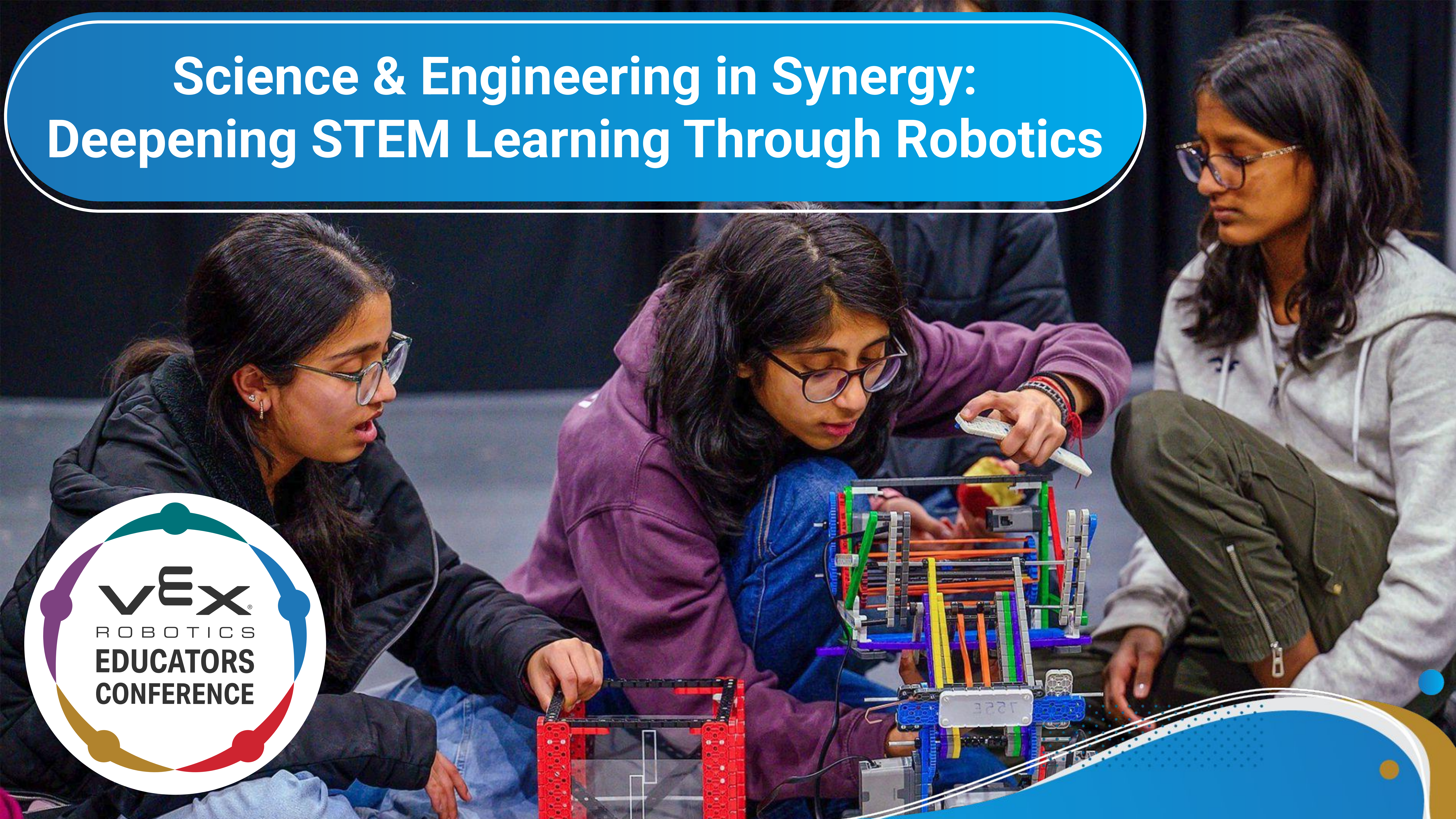
Science & Engineering in Synergy: Deepening STEM Learning Through Robotics

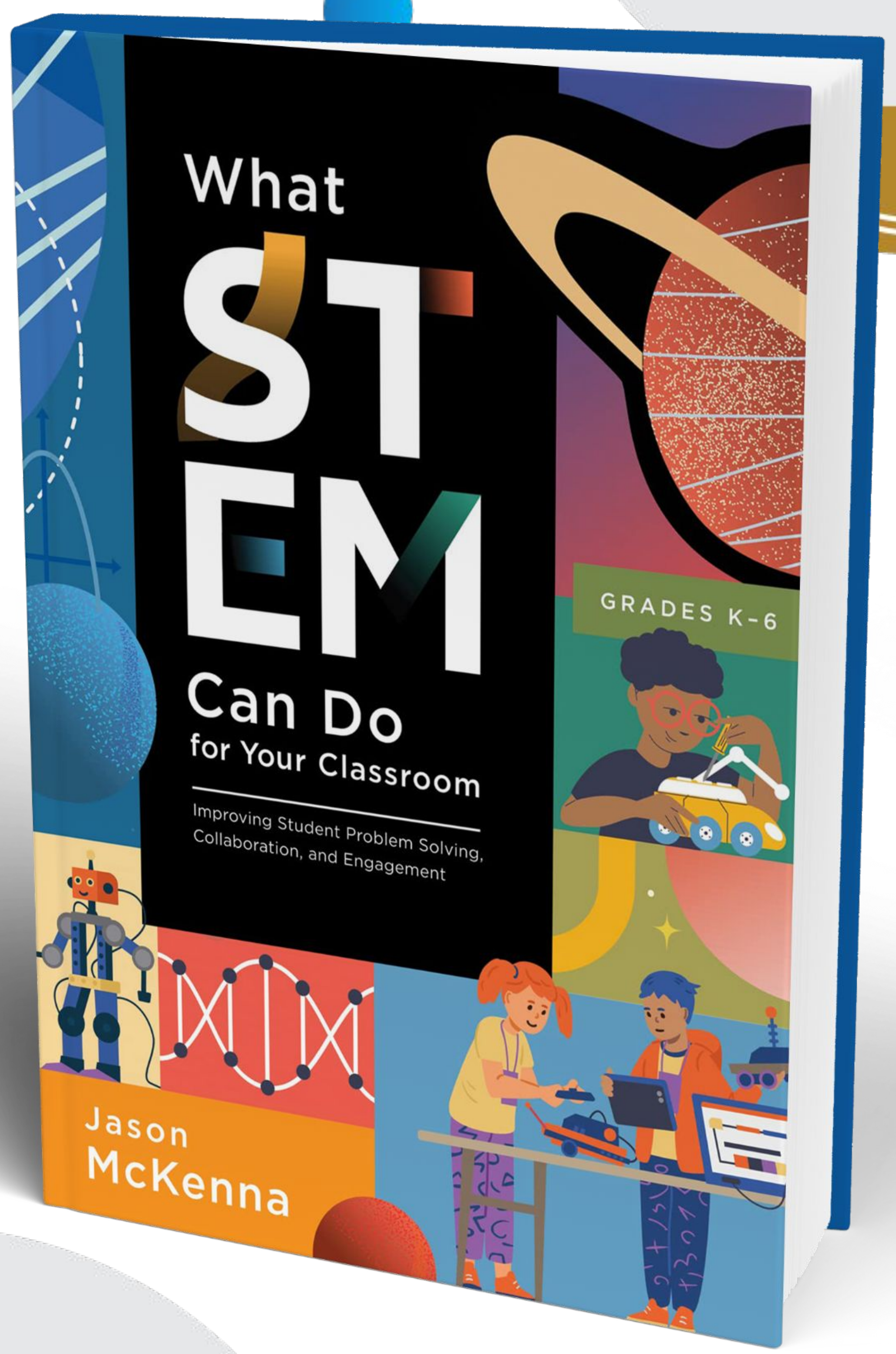


VEX ROBOTICS
EDUCATORS CONFERENCE

Jason McKenna

VP of Global Educational Strategy,
VEX Robotics, Top 100 Education Influencers

What STEM Can Do for Your Classroom:
Improving Student Problem Solving, Collaboration, and Engagement



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Computational Thinking

"Computational thinking captures the concepts and practices associated with using computational tools to help solve problems."

- **Dr. David Weintrop**

How has Computational Thinking changed Math and Science?

"A primary motivation for introducing computational thinking practices into science and mathematics classrooms is the rapidly changing nature of these disciplines as they are practiced in the professional world."

(Bailey and Borwein 2011; Foster 2006; Henderson et al. 2007)

"In the last 20 years, nearly every field related to science and mathematics has seen the growth of a computational counterpart."

(Weintrop et al. 2016)

The Growing Role of Computation in Mathematics and Science

Macro Level

Complex patterns and relationships emerge that require computation to simulate.

Micro Level

Students may have intuitive understandings of scientific phenomena.

From a pedagogical perspective, the thoughtful use of computational tools and skill sets can deepen learning of mathematics and science content.

(Guzdial 1994; Eisenberg 2002; National Research Council 2011a, b; Redish and Wilson 1993; Repenning et al. 2010; Sengupta et al. 2013; Sherin 2001; Wilensky 1995; Wilensky et al. 2014 Wilensky and Reisman 2006)

The landscape of education is changing. Recent advances in high-speed computation and analytical methods have created powerful tools for understanding a myriad of STEM subjects. In some scientific fields, such as molecular biology and chemistry, the advent has been recent but rapid.

(Weintrop et al. 2016)

Vets Make House Calls for Killer Whales

Researchers used a drone to attempt to collect samples from Southern Resident killer whales by steering it into plumes of their exhaled breath in water off the San Juan Islands of Washington State.

"Other researchers had used drones to collect breath samples from large whales, like humpbacks, which produce big plumes. Orca exhalations are smaller and harder to collect. But using **computational modeling**, experts in conservation technology at the San Diego Zoo Wildlife Alliance discovered that if they mounted a petri dish on a drone in the right place, air currents generated by the propellers would help funnel the respiratory droplets onto the dish."

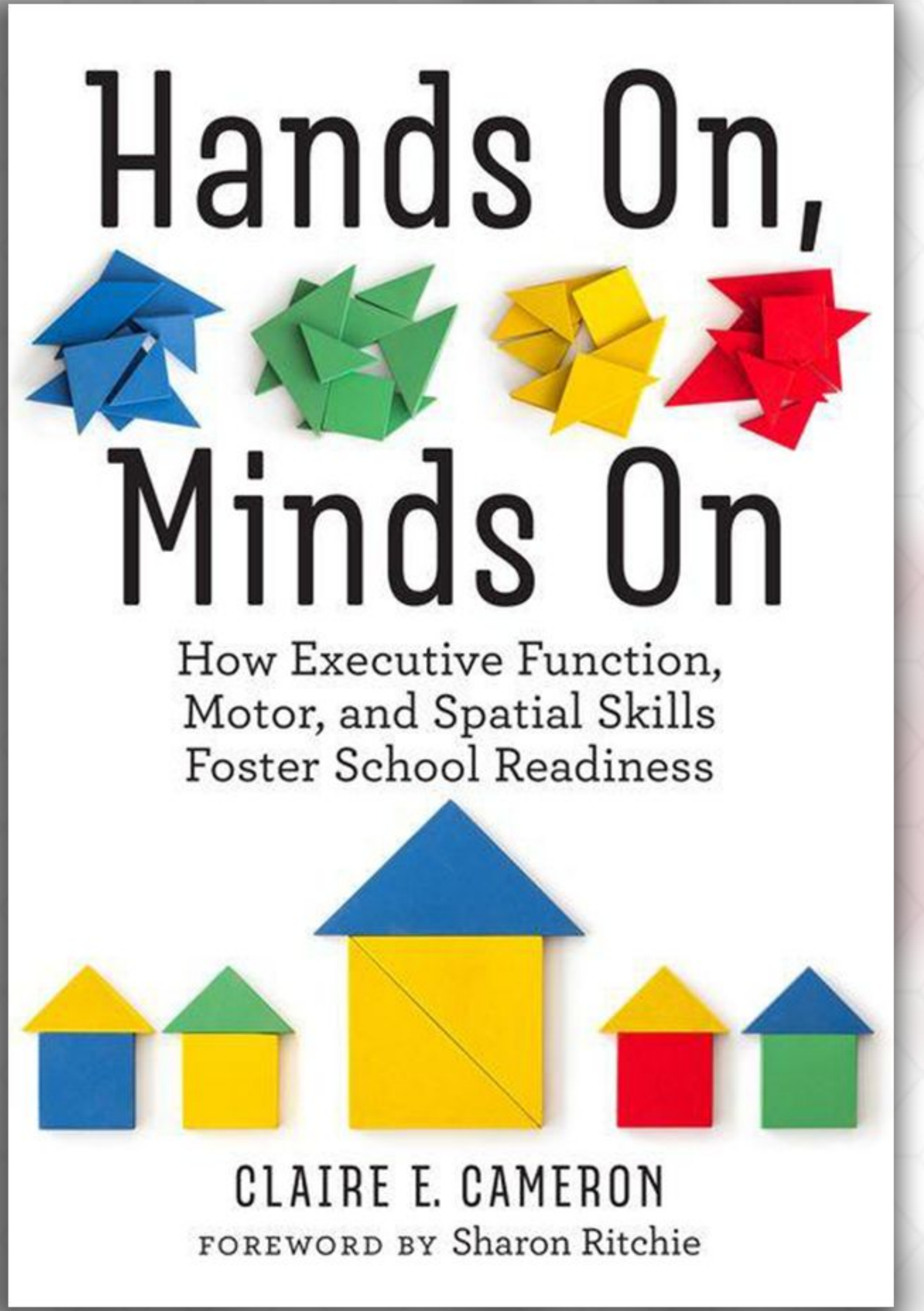
These Vets Make House Calls for Killer Whales

STEM teachers face a fundamental challenge - they want to create **deeply engaging learning experiences**, but struggle to do so in educational systems that push standardized approaches.

Teaching CS and Computational Thinking

Learning CS relies upon learning symbols and that students recognize and turn those symbols into meaning. This meaning then has to be interpreted within a particular context.

How do we enable students to do this?

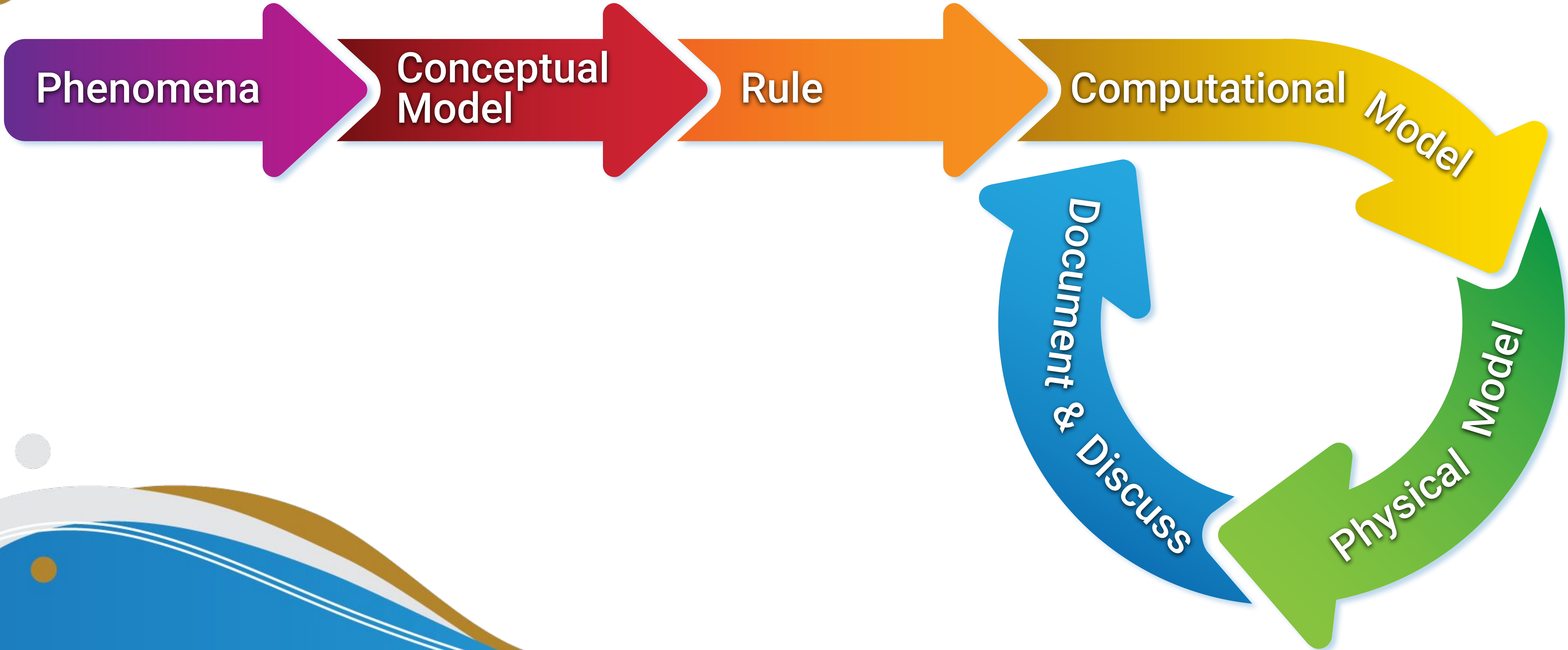

Hands On,
Minds On
How Executive Function,
Motor, and Spatial Skills
Foster School Readiness
CLAIRE E. CAMERON
FOREWORD BY Sharon Ritchie

Introduce Synergistic Learning

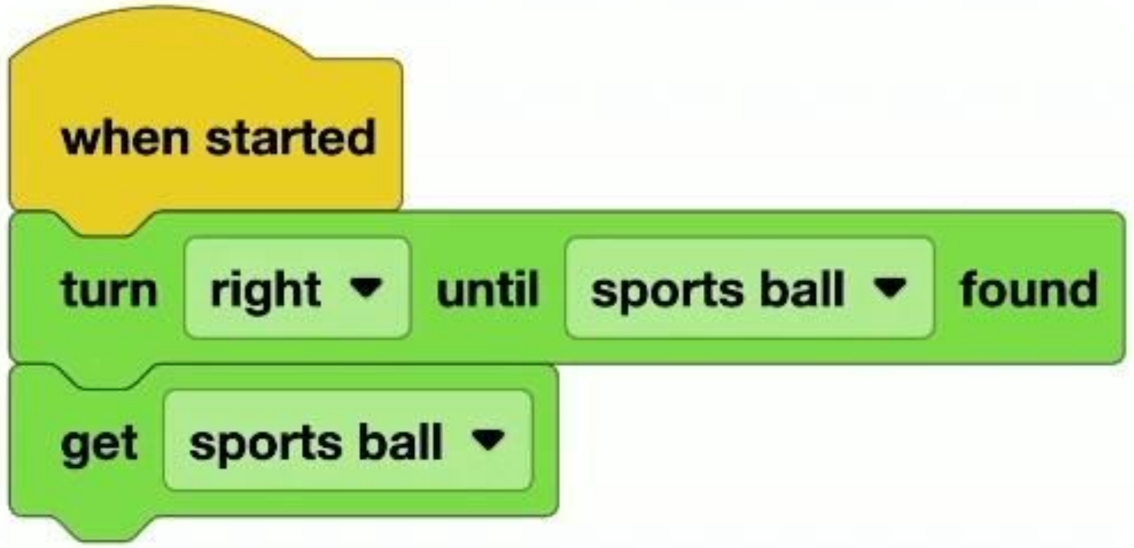
"Synergistic learning combining **computational thinking (CT)** and **STEM** has proven to be an effective method for advancing learning and understanding in a number of STEM domains and simultaneously helping students develop important CT concepts and practices."

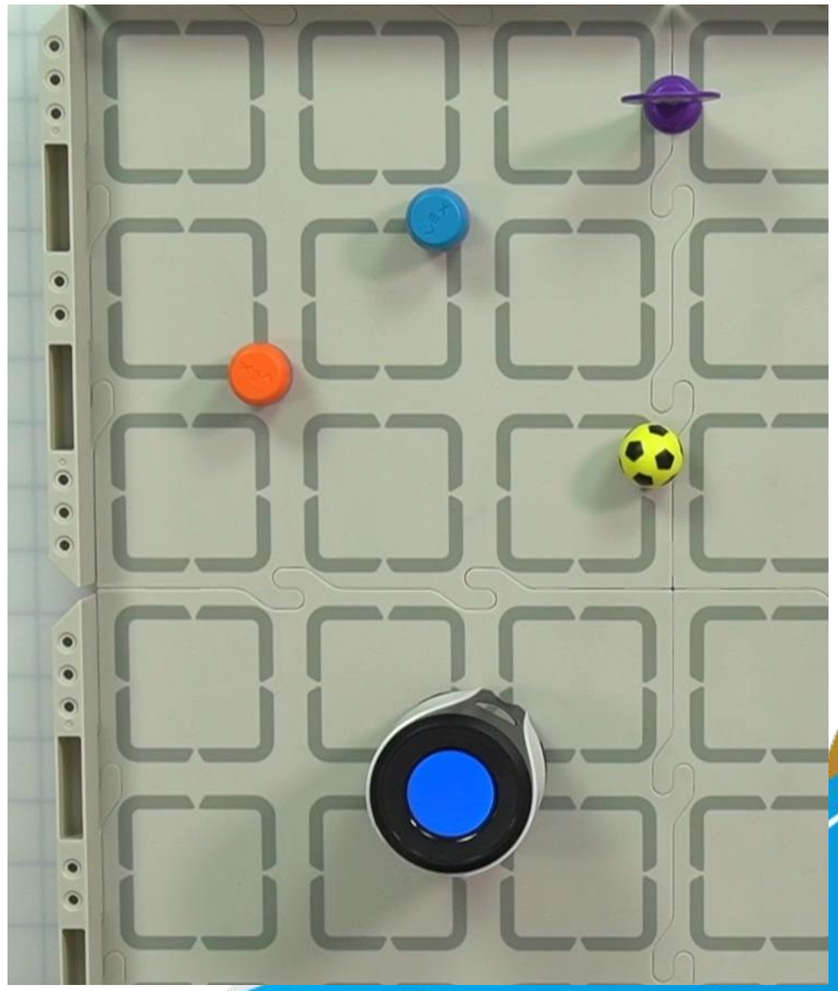
Source: https://eric.ed.gov/?id=EJ1246440

Synergistic Learning



VEX AIM


when started
turn right until sports ball found
get sports ball



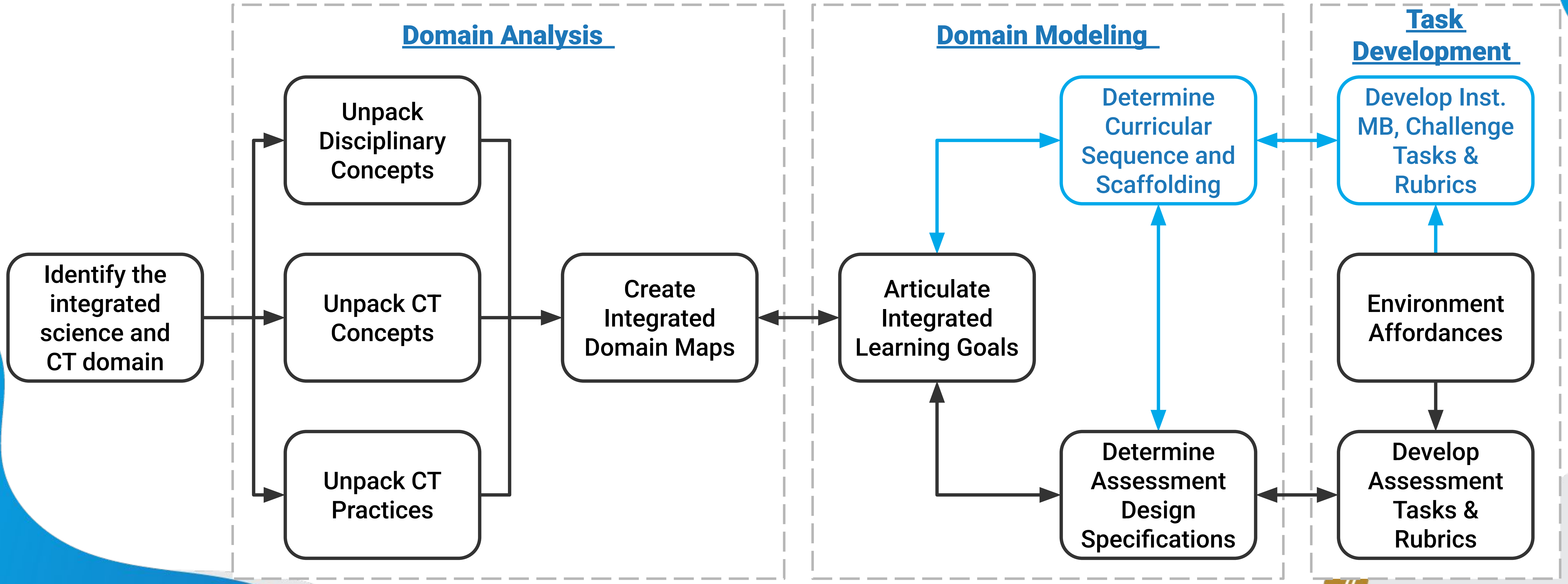

VEX
Classroom Series
VEX AIM
Bringing Computer Science to Life!
123 GO AIM IQ
EXP V5 CTE AIR VR
Your First
VEXcode AIM Project

Creating A Rule

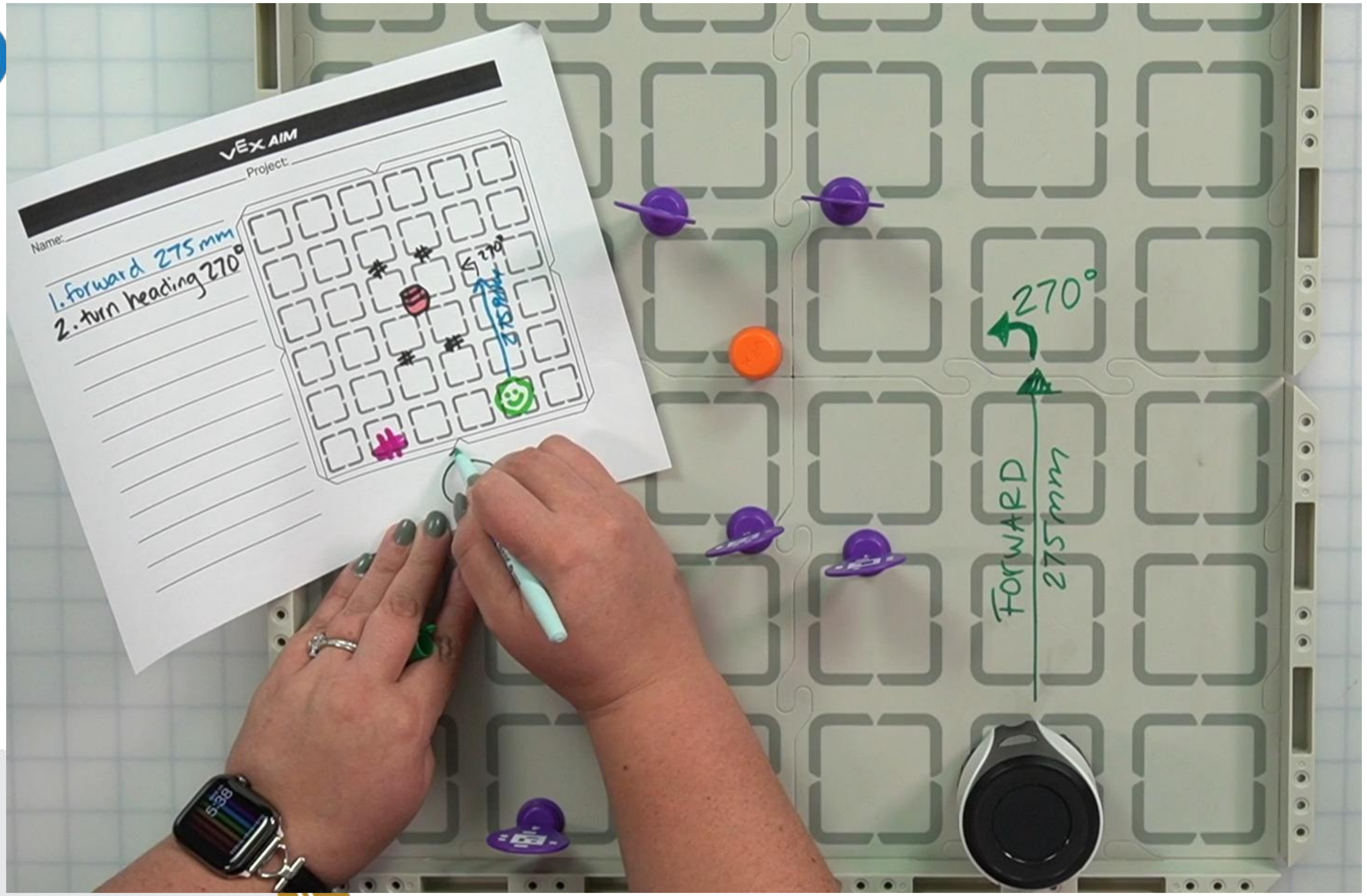
Now that you have watched the video, capture your thoughts in your journal. Answer these questions to guide your thinking and help you prepare for a whole-class discussion:

- What do you notice about moving the robot with Button Coding compared to driving? Write at least three observations.
- What did you see in the video to support your ideas?
- List at least two questions you have about using Button Coding to move the robot to a location.
- How did the order of the button presses change the actions of the robot?
- What is a skill you have that you think will help you be successful with Button Coding?

Curriculum and Assessment Design Process



Computational Model



VEX AIM Intro Course - Unit 5: Lesson 3 Drive

Practice Task: Drive the robot around the obstacles, and deliver both barrels to AprilTag ID 4. Document your driving and plan how to code that movement.

Discussion Questions As You Drive

- How are you planning your route?
- How are you making sure not to knock over the AprilTag obstacles?
- How are you documenting your driving so that it will be precise enough to be helpful when you start to code?

Practice Checklist

- ☐ Deliver both barrels to AprilTag ID 4
- ☐ Did not hit any obstacles
- ☐ Document the robot's movement
- ☐ Create a plan for how you will build a project to mimic that movement

Feeling stuck? *Use a ruler, Robot Protractor, and/or Path Planning Sheet to help you create a detailed and precise plan. Have a group member read your plan and see if they understand it. Not quite? Try adding more detail to your plan.*

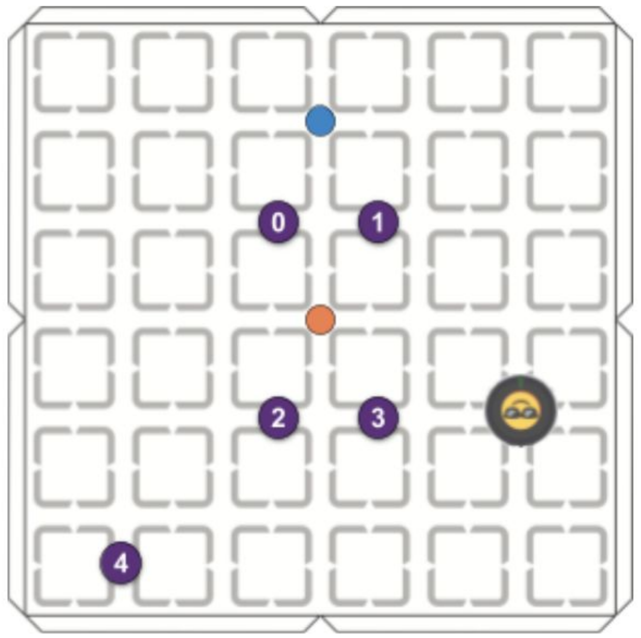
Success Criteria:

- ☐ All group members explain their path plan to the teacher.
- ☐ All group members share how they contributed to driving, documenting, and planning.

Document Your Practice

Use this space to share your learning. You can plan and draw the robot's path, write the robot's movement, and/or record your planned path for your coding project.

I learned ________________ from my group while collaborating on a path.



Physical Model

Step 4: Explore! Move between driving and coding to iterate on your project and improve your solution.

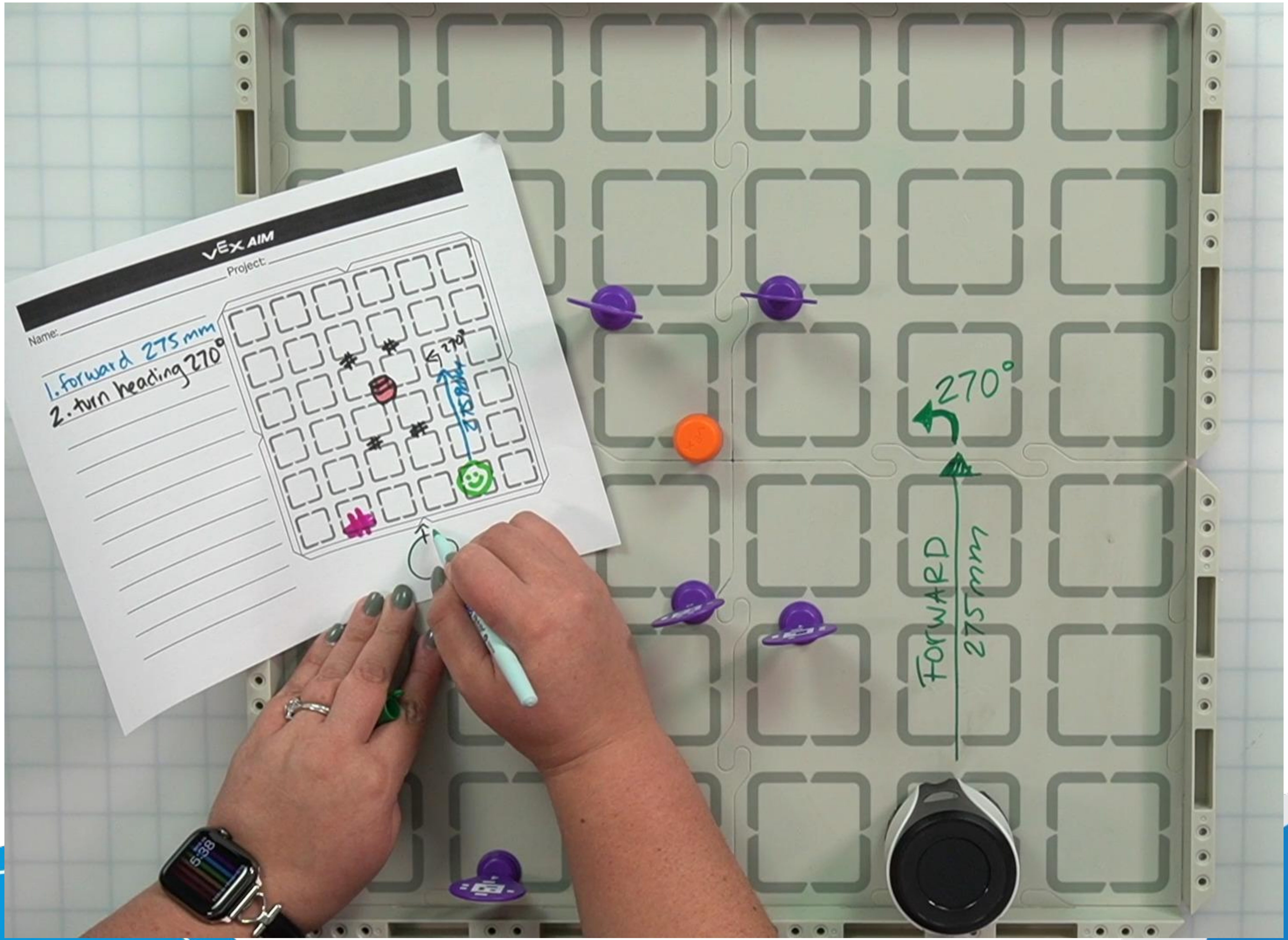
- Together with your group, brainstorm ways to make your project better.
- Drive the robot to test out your ideas, and choose one to start with.
- Iterate on your project to make it match the new driven behaviors.
- Continue to move between driving and coding to iterate on your project and find the best strategy to complete the task!

VEX AIM Driving with Controller

When students both drive the robot (physically experience input/output relationships) and code the robot (construct abstract logical sequences), they engage in a bi-directional, reinforcing process: Synergistic Learning.

This **hands-on + minds-on synergy** makes computational thinking more accessible and meaningful.

Document and Discuss Throughout



Task Cards

Step 2: Model the movements of the robot needed to complete the task using Drive mode.

- Your task is to drive the robot from the blue barrels to the orange barrels passing between each set. Document your planned path from driving, then, make a plan for how to code that movement.
- Use this task card (Google / .docx / .pdf) to guide your practice.
  - Pro Tip: Make sure that each member of the group has a turn to both drive and record, so that you can have meaningful collaborative discussions as you create a shared plan.

VEX AIM — Intro Course - Unit 3: Lesson 1 Drive

Practice Task: Drive the robot from the blue barrels to the orange barrels, passing between each set. Document your driving and plan how to code that movement.

Discussion Questions As You Drive

- Does the robot end in exactly the same position each time you drive? Why or why not?
- Is there another way to drive the robot to complete the task? Why or why not?
- How are you documenting the path of your driving so that it will be helpful when you start to code?
- What do you think will help you recreate your driven movement in code?

Practice Checklist

- ☐ Drive the robot between the barrels
- ☐ Document the robot's movement
- ☐ Create a plan for how you will build a project to mimic that movement
- ☐ Check in with your teacher to share your plan

Feeling stuck? *Ask other groups about how they are documenting their robot's movement. Is there different information that they noted that could help your group strengthen your plan?*

Success Criteria:

- ☐ All group members explain their plan to the teacher.
- ☐ All group members share how they contributed to driving, documenting, and planning.

Document Your Practice

Use this space to share your learning. You can plan and draw the robot's path, write the steps of the robot's movement, and/or record your plan for your coding project.

One thing I understand better or differently after talking with my group is ___________.

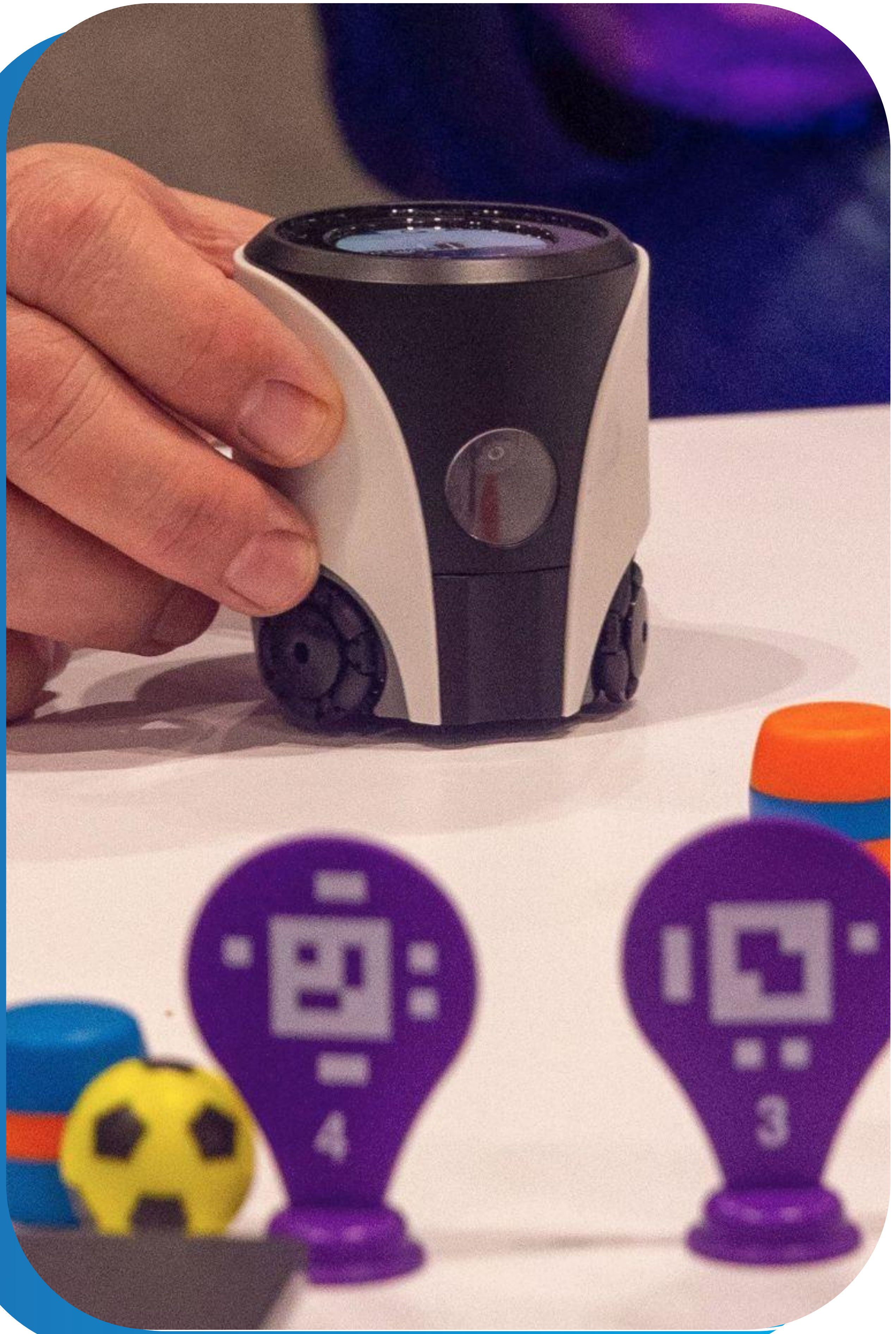
Learner Variability is the Rule

Steps for Co-Creating Learning Targets with your Students:

- Establish shared goal based on Introduction page
- Determine essential knowledge students need to be successful in the Unit Challenge
- Co-create learning targets based on the fundamental unit understandings
- Be sure students record process of creating learning targets in their notebooks to refer throughout the unit

What do I need to learn and do during the Unit to successfully complete the Unit activities with my group?

Learning Target Category	Learning Targets
Knowledge Targets *What do I need to know and understand in order to be successful in the Unit?*	☐ ☐ ☐
Skill Targets *What can I demonstrate to show I understand the concepts and skills needed to be successful in the Unit?*	☐ ☐ ☐
Product Targets *What can I record in my developer notebook to demonstrate and expand my knowledge about the concepts and skills needed to be successful in the Unit?*	☐ ☐ ☐



Learning Targets

Knowledge - What do I need to know and understand in order to be successful in the unit?

- Example: *"I can identify the buttons on the controller and what they do in Drive mode."*

Reasoning - What can I do with what I know and understand in order to be successful in the unit?

- Example: *"I can describe how the strengths of the kicker differ."*

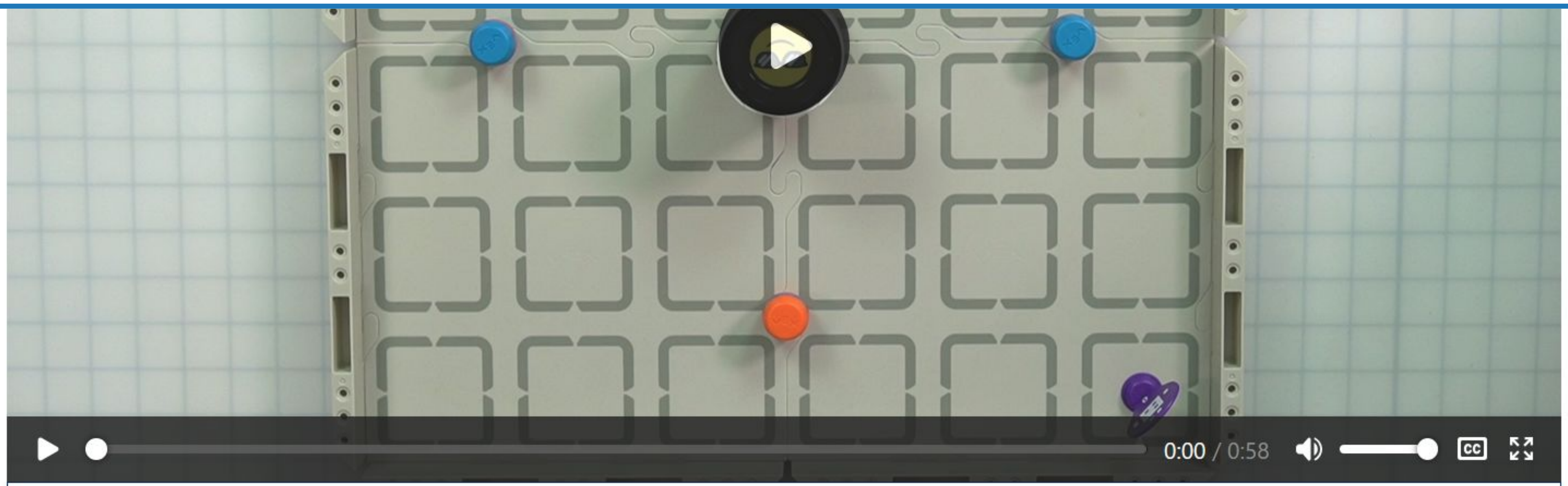
Skills -What can I demonstrate to show I understand the concepts and skills needed to be successful in the unit?

- Example: *"I can drive the robot to kick a ball through a goal."*

Products - What can I record in my developer notebook to demonstrate and expand my knowledge about the concepts and skills needed to be successful in the unit?

- Example: *"I can record the observation from the video in my developer notebook."*

Student Centered Curriculum



Transcript

After you have watched the video, you will have a class discussion about it. Record your answers to the following questions in your journal, so you are ready to share during the discussion:

- Compare the movements in this video to the movements of the robot in previous lessons. When does the direction the robot is facing matter? When does that direction not matter? How is the robot picking up and placing the barrels?
- Does precision matter for this challenge? Explain your thinking.
- What are some questions you have about coding the robot to face specific directions with VEXcode AIM?
- What skills and understandings will you need to develop to complete the challenge?

Co-Creating Learning Targets

Now that you have watched the video, you know that you will be coding the robot to transport barrels using VEXcode AIM. Think about what you will need to know and learn to do this. You will co-create learning targets with your group and your teacher so that you have a shared understanding of your learning goals for this unit.

Record your learning targets in your journal. You will return to these learning targets later in the unit to reflect on your progress and plan for future learning.

Summary

- Synergistic learning is a framework, not a script
- Have students explore both computational and physical models
- Productive student discourse
- Begin with learner variability

Questions?

Chat with me and a community of amazing educators in the PD+ Community!