CTE Workcell Teacher Facilitation Guide

Unit 2 - Using the Teach Pendant

A Note about Implementing VEX CTE STEM Lab Units:

STEM Lab Units are designed to be an interactive Unit of instruction that you can use with your students to implement the CTE 6-Axis Robotic Arm in your setting. STEM Lab Units are student-facing content that is designed for students to directly interact with the videos, resources, and instructional materials to complete the activities. This Facilitation Guide is the teacher-facing companion, like a teacher's manual, providing the resources, materials, and information needed to be able to plan, teach, and assess with the VEX CTE 6-Axis Robotic Arm. For more detailed information about implementing STEM Lab Units in your classroom, visit VEX PD+ for videos, expert tips, and more.

Unit Overview

In this Unit, students will learn about the Teach Pendant – what it is, and how to use its features and functionality to control the movement of the 6-Axis Arm by jogging it to different locations. They will also learn about end effectors, like the Magnet Pickup Tool and Pen Holder Tool, so that they can use the 6-Axis Arm to pick up a Disk. Students will apply their learning to complete an activity and move three Disks to new locations on the CTE Tile, using the Teach Pendant.

Unit Essential Questions - *These open-ended, thought-provoking questions are designed to guide inquiry and encourage deeper understanding. They can provide context and relevance for students, and help them to see the bigger picture or the real-world applications of what they're learning.*

- What is the role of a Teach Pendant in controlling robotic movements, and how does it impact automation in various industries?
- How do end effectors extend the functionality of robotic arms, and in what ways can they be utilized to interact with objects?
- What are the principles behind accurately controlling a robotic arm's movement along the x, y, and z-axes using a Teach Pendant?
- In what ways does understanding and applying the features of the Teach Pendant contribute to efficiency and precision in automated tasks?

Unit Enduring Understandings - *These understandings reflect the big ideas you want students to understand and be able to use several years from now, as well as identify predictable misunderstandings.*

- Students will understand that Teach Pendants are key for precise robotic arm control, enabling complex tasks in various industrial settings.
- Students will know that the use of different end effectors enables a robotic arm to be more versatile and accomplish more types of tasks.
- Students will grasp that skill in navigating a robotic arm along the x, y, and z-axes is essential for precision and spatial task management.
- Students will recognize that executing tasks effectively with a robotic arm requires technical skill with the Teach Pendant and strategic task planning.

Lesson Overview

- The **Introduction** gives students an overview of what students will be doing and learning about in the Unit, with real world context for things like the Teach Pendant and end effectors. The page also covers key vocabulary and required materials. Additionally, guidance for students on how to co-create learning targets for the Unit is provided.

- The **Power and Connect the 6-Axis Arm** Lesson reminds students how to connect the cables of the 6-Axis Arm to a power source and a computer. It also reviews how to connect the 6-Axis Arm to both web-based and app-based VEXcode EXP. Students can skip this page if they do not need these reminders.
- **Lesson 1: Introduction to the Teach Pendant** teaches students about what a Teach Pendant is and how it is used in an industrial setting. Students are introduced to key features of the Teach Pendant in VEXcode EXP, like the jogging function, and practice jogging the 6-Axis Arm to different locations.
- In **Lesson 2: End Effectors** students learn about what end effectors are, and they enable the 6-Axis Arm to interact with its environment, so that they can use the Magnet on the 6-Axis Arm to pick up and move a Disk on the Tile.
- The **Putting It All Together** activity challenges students to apply their skills in jogging the 6-Axis Arm and using the Magnet to move three Disks to new locations on the Tile without causing collisions.

Materials Needed for this Unit (per group)

- CTE 6-Axis Robotic Arm or CTE Workcell Kit
- 3 Disks
- VEXcode EXP
    - Students can download the app-version of the software to their Windows or Mac device at code.vex.com.
    - Students can also use the web-based version on a Google Chrome or Microsoft Edge browser at codeexp.vex.com
- A Computer
- Engineering Notebook (per student)

All Materials needed for this Unit can also be found in the Master Materials List.

Teacher as Facilitator in this Unit

This Unit is designed to be student-facing so that students can directly interact with the Unit content. This places the teacher in the role of facilitator of learning, rather than a supplier of information, in the classroom. As such, you can choose how you want the students to move through the Unit content, based on the needs and interests of your students, and the places where you think they may need more or less direct instruction. You know your students best, so tailor your teaching and implementation to best suit your students.

Troubleshooting Tips for this Unit

- Students will need to have access to VEXcode EXP on their computers. For more information about accessing VEXcode EXP, go to code.vex.com.
- Remind students to keep an eye out for cables as they move about the classroom to avoid tripping hazards.

Group Size

- A group size of 2-4 students per VEX CTE 6-Axis Robotic Arm or VEX CTE Workcell Kit is recommended for all Unit activities. This recommendation can vary depending on the needs of your classroom.

- View this article to learn more about how to support students to organize their roles within groups throughout the Unit.

Unit Vocabulary

The suggested vocabulary for this Unit is meant to offer teachers a vehicle for establishing a shared language in the classroom when working with VEX CTE. Encourage students to work vocabulary words into their conversations throughout the Unit, so that they can use the terms confidently and correctly not only in this Unit but also in future VEX CTE experiences. You can use these words as a base list, and adapt them to best meet the needs of your students.

- **End Effector -** The device at the end of a robotic arm designed to interact with the environment; also known as the End of Arm Tooling (EOAT).
- **Jogging -** The process of incrementally moving a robotic arm in specific directions using a control interface (like the Teach Pendant), typically in small, precise movements.
- **Teach Pendant -** A device used to manually control the actions of a robotic arm.

Preparing Your Classroom

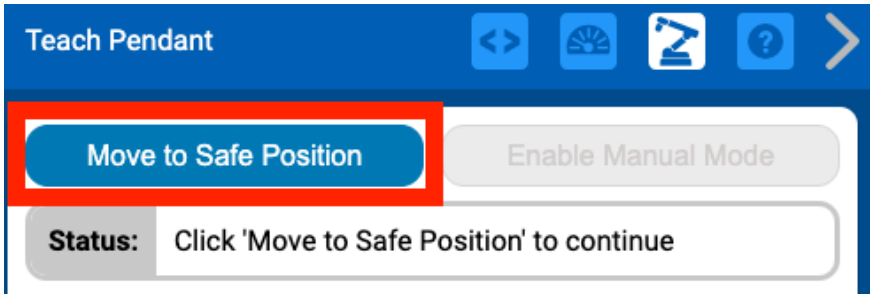
- All students must have access to VEXcode EXP on their device before beginning the Unit.
    - The app-version of the software can be downloaded to Windows or Mac devices at code.vex.com.
    - The web-based version is available on Google Chrome or Microsoft Edge browsers at codeexp.vex.com.
- In order to use the Teach Pendant, the 6-Axis Arm and computer must have a wired connection.
    - Make sure that each group is in a space where the 6-Axis Arm can be plugged into a power source and have a wired USB-connection to a computer with VEXcode EXP access.
    - To further support students as they are getting started and connecting their 6-Axis Arm to VEXcode EXP, you can use the following resources.
        - For help connecting the 6-Axis Arm to web-based VEXcode EXP, select the article that matches your device:
            - Windows
            - Mac
            - Chromebook
        - For help connecting the 6-Axis Arm to app-based VEXcode EXP, see this article.
- Each 6-Axis Arm should have had its firmware updated prior to beginning the Unit. However, if a message in VEXcode EXP appears when the 6-Axis Arm is connected to update the firmware, follow the steps here.
    - App-based VEXcode EXP
    - Web-based VEXcode EXP

Teacher Tips

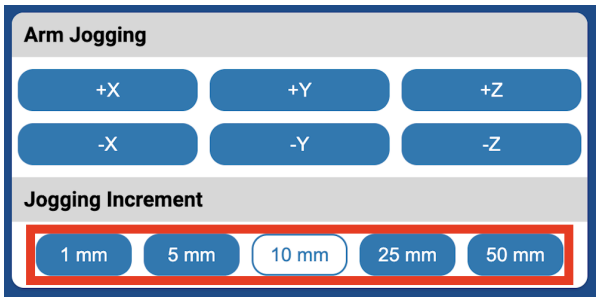
Support student collaboration in this Unit: [View this article to learn more about how to support students to organize their roles within groups throughout the Unit.]

Lesson 1: Introduction to the Teach Pendant

- This Lesson highlights some key features of the Teach Pendant in VEXcode EXP that will enable students to complete the activities in the Unit successfully and safely. There is additional functionality in the Teach Pendant, but this Lesson is designed to focus students' attention on specific elements as an introduction.
- Be sure that students select **Move to Safe Position** to enable the jogging functionality of the Teach Pendant. This will be the only button available upon connection to the 6-Axis Arm.



- Remind students that they can change the Movement Increment in the Teach Pendant, so they can jog the 6-Axis Arm for larger or smaller increments, as needed.
    - The default increment is 10mm.
- There are many features of the Teach Pendant, not all of which are covered in this introductory Lesson. [To learn more about using the Teach Pendant in VEXcode, see this article.]



Lesson 2: End Effectors

- To move a Disk successfully in this Lesson, students will need to move the 6-Axis Arm, enable the Magnet, and release the Magnet in a particular order. Ask students to describe the process of moving a Disk with the 6-Axis Arm to you in detail, to help them think about and better understand that order matters when completing a task with the 6-Axis Arm.
- Connect the action of jogging the 6-Axis Arm to what students have learned previously about the Cartesian coordinate system used with the 6-Axis Arm. Encourage students to estimate the distance they think they will have to jog the 6-Axis Arm on a particular axis. Ask them which movement increments they can use to travel that distance effectively, to help them consider how they can be strategic about the increments. Remember that each square on the Tile is 50mm by 50mm.

Putting It All Together

- If students complete the activity early and need an additional challenge, have them try to accomplish the same task by moving the Disks in a different order to reinforce that there are multiple ways to solve the challenge.

Engineering Notebooks

Incorporating engineering notebooks into your classroom offers a dynamic and collaborative way for students to document their learning journey in engineering and robotics. As a facilitator, encourage students to regularly use their notebooks to record self-assessments and note coordinates during activities. This tool not only aids in project management and problem-solving but also prepares students with essential life skills in documentation and collaboration, pivotal in both academic and future professional settings.

Using Engineering Notebooks

- If you have not done so already, view the video in the Teacher Portal and read this article to learn more about using engineering notebooks as a learning tool in your classroom.
- Make sure that students are continuing in the **same** Engineering Notebook from Unit 1, whether it is a physical notebook or the CTE Digital Engineering Notebook.
- Use the following links only if you need to create a **new** CTE Digital Engineering Notebook for a student.
    - CTE Digital Notebook template (Google Slides) (Microsoft PowerPoint)
    - Digital CTE Parts (Google Slides) (Microsoft PowerPoint)
    - CTE Digital Notebook instructions (Google Slides) (Microsoft PowerPoint)
        - If using the Google Slides version, you will be required to make a copy when opened.

- For more information on customizing resources view these two articles from the STEM Library:
    - Customizing Resources Using Google Drive
    - Customizing Resources Using Microsoft Office

- **Documenting in this Unit:** Students should use their engineering notebook to record notes about jogging the 6-Axis Arm and moving Disks, answers to the Check Your Understanding questions, and to complete the Wrap-Up Reflection.
    - Encourage students to keep track of their work, questions, and any reflecting or rethinking they do throughout the Unit in their engineering notebook. This will make it easier for them to justify their answers in the Wrap-Up Reflection on the Putting It All Together page.

- **Using Engineering Notebooks in Student Self-Assessment:** Engineering notebooks are an important tool for student self assessment. They provide a record of students' learning over time, making their progress visible to both you and the students. In this Unit, students will use their Engineering Notebooks as they self-assess by:
    - Recording their learning targets
    - Recording answers to Check Your Understanding questions
    - Recording their reflective rating in the Wrap-Up Reflection
    - Using them to support their answers as they discuss their progress with you in the Debrief Conversation

Read the following section for more information on how engineering notebooks are an important part of assessment and reflection.

Assessment and Reflection

Check Your Understanding Questions (CYU)

At the end of each Lesson, a set of CYU questions are provided as formative assessment to check student understanding before moving on with the rest of the Unit.

- The Answer Key for the questions can be found here. (Google Doc / .docx / .pdf)
- If you have not done so already, read this article to learn more about incorporating CYU questions into your teaching practice, and making the most of the formative assessment opportunities they present.

Two types of Check Your Understanding Questions are provided for students to answer in their engineering notebooks throughout the Unit.

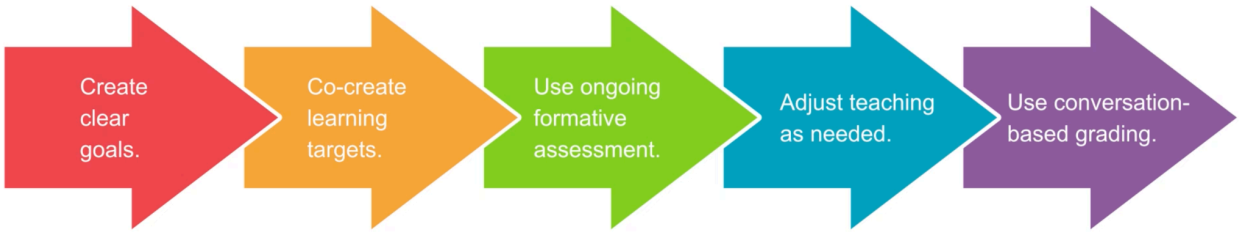
- **Content-Related Questions**: Students can use these questions to determine how well they understand the essential concepts of each Lesson, and you can use their answers to be sure students have grasped the material fully before moving on. As the Lessons in this uUnit are sequential, be sure to reteach any concepts or knowledge gaps prior to having students continue to progress through the Lessons.
- **Student Engagement Questions:** These questions prompt students to reflect on whether or not they are reaching their learning targets and how they are feeling about their learning throughout the Unit. They help students to remain active participants in their learning process. They should be used as discussion prompts as you are facilitating the Unit and during the Debrief Conversation, as students' answers to these questions can help you make decisions about how to best support them moving forward.

For more information on formative assessment, view these videos from the VEX Video Library:

- Connecting Research and Teaching: The Purpose of Formative Assessment
- Connecting Research and Teaching: Formative Assessment Strategies
- Connecting Research to Practice: Eliciting Student Understanding

    - To view additional CTE videos as well as a wealth of professional development resources, join PD+! Find out more and become a PD+ subscriber here.

Student Self-Assessment



Student self-assessment has been shown to intrinsically motivate students and keep them engaged. It is woven throughout each Unit, following the process depicted in the graphic above. To learn more about student-self assessment, see this article.

- In the Introduction Lesson, you will establish a shared goal with students, and co-create learning targets.
- Ongoing formative assessment occurs throughout each Lesson in the form of Check Your Understanding Questions that allow you to check students' conceptual understanding and progress towards their learning targets, allowing you to adjust your teaching to meet student needs as needed throughout each lesson.
- In the "Putting it all Together" section, formative assessment continues with the Wrap Up Reflection, which encourages students to consider their engagement and learning across the whole Unit.
- The Debrief Conversation provides an opportunity for conversation-based grading as you discuss the Wrap Up Reflection with student groups along with the rubric provided.
- Students' Engineering Notebooks are used throughout the Unit to document their learning process, and are a rich source of information about students' evolving thinking and learning.

Read more about the student self-assessment components in the Unit below.

Co-creating Learning Targets

Co-creating learning targets helps students to feel a sense of ownership and responsibility towards their learning, leading to a more engaged and motivated classroom environment. You will co-create learning targets with students in their groups in the Introduction Lesson of the Unit. You will then use them to guide students to monitor and reflect on their progress and learning throughout the Unit, and to reflect on them during the Debrief Conversation as well. Read this article to learn more about co-creating learning targets with your students.

Follow these steps with your students when co-creating learning targets:

- **Step 1: Establish a shared goal.** A video in the Introduction Lesson provides information about what students will be learning and doing in this Unit. Use this video as a basis for establishing a shared goal with students. This is a crucial first step - without a shared goal it will be difficult for students to create learning targets that are guiding them towards the essential understandings of the Unit.

- **Step 2**: **Help students to determine the essential knowledge they need in order to be successful in reaching that shared goal.** What things will students need to learn and do in order to successfully complete the Putting It All Together Activity at the end of the Unit? Guide students to brainstorm a list and record them in their Engineering Notebooks. Because students will be using the Teach Pendant to

move three Disks to new locations in a specific order without collisions, their lists will likely include things like:
    - Jog the 6-Axis Arm along the x-axis.
    - Enable the Magnet Pickup Tool on the 6-Axis Arm.
    - Document the features of the Teach Pendant in my engineering notebook.
    - Work together with my group to complete the activity collaboratively.

- **Step 3**: **Co-create learning targets based on the brainstormed list.** Guide students to take each of the list items and frame them into a learning target. Students can phrase them in the form of "I can" statements, such as "I can identify how to enable and release the Magnet with the Teach Pendant." This template (Google Doc / .docx / .pdf) has been provided to students to help them write their learning targets in their Engineering Notebooks.

It is important to encourage students to create learning targets that address all of the following domains, to ensure that they are creating targets that address deeper learning as well as surface level knowledge:

- **Knowledge** - What do I need to know in order to successfully complete the Putting it All Together Activity?
    - Example: "I can identify how to enable and release the Magnet with the Teach Pendant."
- **Reasoning** - What can I do with what I know and understand about a concept in order to successfully complete the Putting it All Together Activity?
    - Example: "I can use the Teach Pendant to jog the 6-Axis Arm along the x, y, and z-axes."
- **Skills** - What can I demonstrate to show that I understand the concept and will be able to use it to successfully complete the Putting it All Together Activity?
    - Example: "I can use the Teach Pendant to move a Disk with the Magnet on the 6-Axis Arm."
- **Products** - What can I make to demonstrate my learning of the concept?
    - Example: "I can record the process of using the Teach Pendant to move a Disk with the 6-Axis Arm in my engineering notebook."

The Wrap Up Reflection

A Wrap Up Reflection is included at the end of the "Putting It All Together" page in the Unit. This reflection prompts students to reflect on their learning and self-assess their understanding. During the Wrap Up Reflection, students will rate themselves as novice, apprentice or expert on each of the essential concepts covered in the Unit in their Engineering Notebooks. Then they will reflect on the progress they made towards the learning targets they co-created with you at the beginning of the Unit.

The Debrief Conversation

The Debrief Conversation at the end of the "Putting It All Together" page is an opportunity for students and teachers to sit down together to discuss the student's progress towards the co-created learning targets over the course of the Unit, using the Debrief Conversation Rubric (Google Doc / .docx / .pdf) provided as a tool. Students should support their assertions in the Debrief Conversation with documentation from their engineering notebooks. Read this article to learn more about having effective Debrief Conversations with students.