XRP Robotics Curriculum Design (Supplementary Kit)

Jialing Wu | April 20, 2025

TOC

- Project Background
- Course Feedback So Far
- Problem Identification (7 Smart Teaching Principles)
- Proposed Solutions
- Conclusion
- Other Supporting Materials

Project Background

Engineering for US All (e4usa) is a nationwide NSF-funded program that introduces high school students to engineering through a year-long, accessible, and inclusive course—covering topics such as engineering design process, community-based design, water filter, wind energy etc.

(XRP Robotics Curriculum)

e4usa + FIRST combines the e4usa classroom curriculum with hands-on robotics activities from the FIRST program, giving students a richer STEM experience while expanding access in underserved schools.

e4usa Curricular + FIRST Extracurricular

e4usa + FIRST Sequential Curricular

e4usa + FIRST Concurrent Curricular

e4usa + FIRST Co-curricular and Extracurricular

Course Feedback So Far

- The lesson lacks sufficient scaffolding to support student understanding (compared to e4usa curriculum).

↓ To clarify the issue

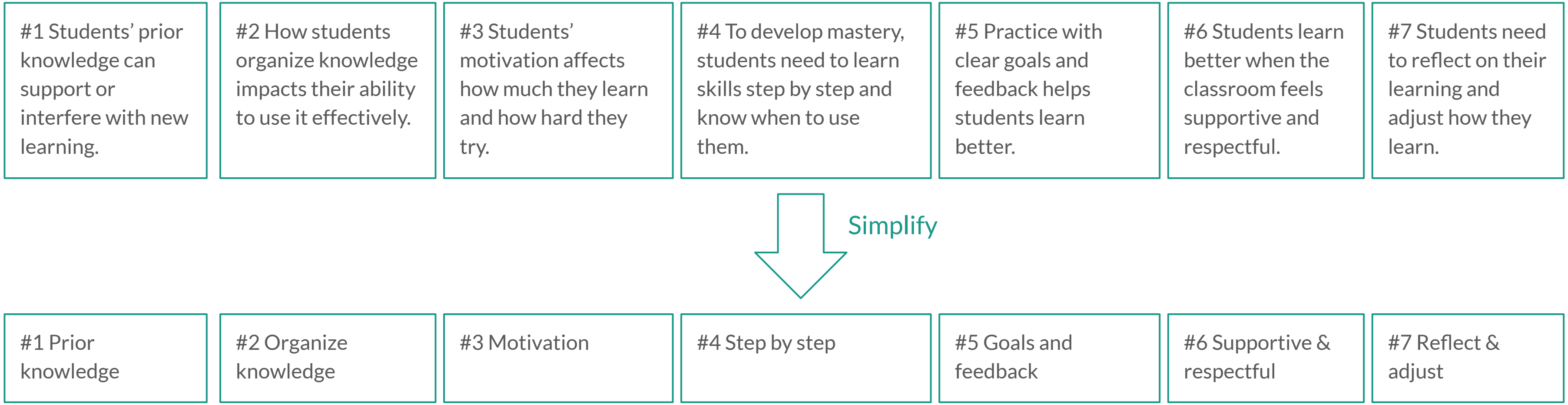
Problem Identification

01 | How e4usa curriculum echoes *7 Smart Teaching Principles*

02 | How XRP curriculum echoes *7 Smart Teaching Principles*

03 | Review XRP curriculum and see what could be added on

Problem Identification (7 Smart Teaching Principles)



#1 Students' prior knowledge can support or interfere with new learning.

#2 How students organize knowledge impacts their ability to use it effectively.

#3 Students' motivation affects how much they learn and how hard they try.

#4 To develop mastery, students need to learn skills step by step and know when to use them.

#5 Practice with clear goals and feedback helps students learn better.

#6 Students learn better when the classroom feels supportive and respectful.

#7 Students need to reflect on their learning and adjust how they learn.

Simplify

#1 Prior knowledge

#2 Organize knowledge

#3 Motivation

#4 Step by step

#5 Goals and feedback

#6 Supportive & respectful

#7 Reflect & adjust

Problem Identification

e4usa Engineering is Creative - Unit 2 (Water Filter)

2.1 Introduction to Teaming
2.2 Potable Water in the Community
2.3 Introduction to the Engineering Design Process
2.4 Problem Definition
2.5 Brainstorming
2.6 Design Selection & Mathematical Modeling
2.7 Sketching a Design
2.8 Prototype Creation
2.9 Prototype Testing
2.10 Design Iteration
2.11 Design Communication Through Posters
2.12 Product, Process, and Team Evaluation

XRP Curriculum - Unit 1 (Gate Maze)

Lesson # 1 - Intro to Robotics
Lesson # 2 - Building your XRP
Lesson # 3 - Intro to Block Coding and the Gate Maze
Lesson # 4 - Coding the Gate Maze in Blockly
Lesson #5 - Intro to Python Coding
Lesson # 6- Coding the Gate Maze in Python

Problem Identification (7 Smart Teaching Principles)

	#1 Prior knowledge	#2 Organize knowledge	#3 Motivation	#4 Step by step	#5 Goals and feedback	#6 Supportive & respectful	#7 Reflect & adjust
e4usa	Connect the water treatment process to students’ community experiences.	Introduce the engineering design process and refer back to it throughout the later activities.	Students can decide the testing criteria for their designs.	Students engage with the engineering design process step by step.	Students can refine their designs based on the results of the water treatment tests.	Students have freedom to design their own product.	Students present and share their work through a final poster session.
XRP				Start with block-based (graphical) programming, then transition to Python programming.	Students are required to complete a final maze challenge.		Students present and share their work through a final poster session.

Problem Identification (7 Smart Teaching Principles)

	#1 Prior knowledge	#2 Organize knowledge	#3 Motivation	#4 Step by step	#5 Goals and feedback	#6 Supportive & respectful	#7 Reflect & adjust
e4usa	Connect the water treatment process to students' community experiences.	Introduce the engineering design process and refer back to it throughout the later activities.	Students can decide the testing criteria for their designs.	Students engage with the engineering design process step by step.	Students can refine their designs based on the results of the water treatment tests.	Students have freedom to design their own product.	Students present and share their work through a final poster session.
XRP	There is limited connection to students' prior knowledge or experiences.	Students need scaffolding to understand how to solve problems through programming.	The project offers limited student autonomy, which may lead to low engagement.	Start with block-based (graphical) programming, then transition to Python programming. For students with no programming experience, block-based programming is still challenging, and Python can be difficult to understand.	Students are required to complete a final maze challenge. Feedback on programming issues is not very intuitive.	Students have little freedom in defining their project goals.	Students present and share their work through a final poster session.

Problems to solve

1. How can the project content be connected to students’ prior experiences and knowledge?

2. How can student autonomy be increased in the project?

3. How can the curriculum be scaffolded to make the programming learning curve less steep？

Proposed Solutions

● A handbook based on the 7 smart teaching principles, listing three course-improvement activities under each principle, to help the XRP Curriculum Design Team improve the activities in the classroom .

Target audience

01 | XRP Curriculum Design Team

02 | e4usa+FIRST Teachers

03 | e4usa+FIRST Team

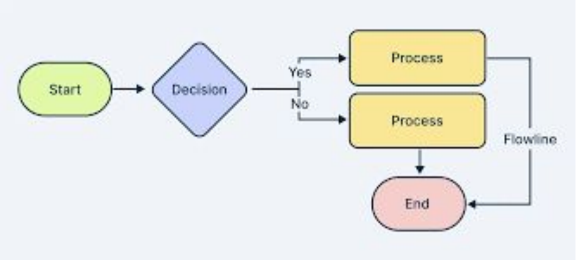
Proposed Solutions

#1 Prior knowledge

- Allowing students to identify robots in life and describe programming tasks encountered in daily life (such as mobile phone automation and sweeper behavior).
- Guide students to share their views on "programming" to activate and clarify previous knowledge.
- Introduce the "You Know I Don't Know" wall to encourage students from different backgrounds to share experiences and blind spots.

#2 Organize knowledge

- Design a visual flowchart of "from problem to solution" to teach students how to decompose problems, select commands, and assemble logical structures.
- Create a common bug prompt card, such as "What to do if the robot doesn't move", "It may be because the turning angle is wrong", etc.
- Encourage students to write pseudo-code/annotations next to the code and explain their ideas in natural language.



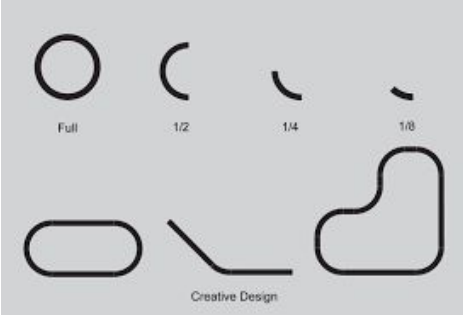
Proposed Solutions

#3 Motivation

- Before the maze challenge, students are allowed to choose the path style and design their own maze challenge story background (such as "robot delivery" and "jailbreak escape").
- Introduce the role of "maze creator", let some students try to design the maze, and others to solve it.
- Set up an achievement system (such as "Creator Badge" and "Most Stable Navigation Award") to improve motivation.

#4 Step by step

- Use a scaffolded transition: natural language → pseudocode → block-based → Python.
- Create a coding progression ladder with tiered challenges: e.g., first “Drive Forward,” then “S-curve,” then full maze.
- After each new skill, add a brief recap session to reinforce integration.



Proposed Solutions

#5 Goals and feedback

- Provide a structured feedback form (e.g., “What’s working / What needs fixing / Suggested next step”).
- Use peer review and debugging exchanges: students test each other’s code and give suggestions.
- Include quick mini debug challenges to model how feedback can guide immediate learning.

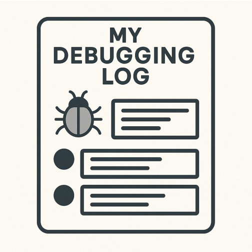
#6 Supportive & respectful

- Set up "non-technical communication tasks" in the first two lessons, such as role-playing robot action flow, to reduce technical anxiety.
- Provide differentiated learning resources: basic students use block diagrams, and advanced students consult API.
- Design hierarchical group tasks to let experienced people drive inexperienced people and create a mutual learning environment.

Proposed Solutions

#7 Reflect & adjust

- Introduce the three reflection questions at the end of each lesson (what did you learn today, what problems you encountered, and what you will do next time).
- Add "My Debugging Log" at the project stage to record failure cases and resolution strategies.
- Encourage students to set and adjust individual goals, such as "I hope the robot can avoid three obstacles this time".



Conclusion

Implementation Considerations

The activities should be introduced progressively and matched to students' readiness. Flexibility is key—activities must accommodate diverse backgrounds and learning needs. Teachers will need time, support, and resources to prepare and deliver these activities successfully, and class time should include space for reflection and feedback.

Implications on Stakeholders

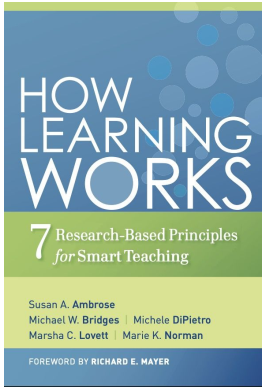
This approach benefits all stakeholders. Students become more motivated, engaged, and self-aware learners. Teachers gain deeper insight into student thinking and can tailor instruction more effectively. Curriculum designers are guided by a research-based framework, and schools may see improved learning outcomes and a more inclusive classroom environment.

Conclusion

Integrating the seven learning principles into robotics or STEM education enhances both instructional quality and student experience. While each principle targets a different aspect of how learning works, their combined application creates a cohesive, supportive, and empowering learning environment. This handbook provides a list of practical activities for translating theory into classroom practice, ensuring that all learners are equipped to thrive.

Other Supporting Materials

How Learning Works: Seven Research-Based Principles for Smart Teaching



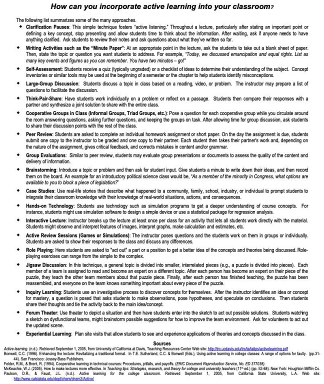
HOW LEARNING WORKS

7 Research-Based Principles *for* Smart Teaching

Susan A. Ambrose
Michael W. Bridges | Michele DiPietro
Marsha C. Lovett | Marie K. Norman

FOREWORD BY RICHARD E. MAYER

How can you incorporate active learning into your classroom?



How can you incorporate active learning into your classroom?

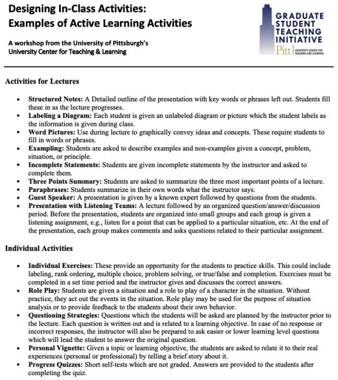
The following list summarizes some of the many approaches.

- **Clarification Pauses**: This simple technique fosters "active listening." Throughout a lecture, particularly after stating an important point or defining a key concept, stop presenting and allow students time to think about the information. After waiting, ask if anyone needs to have anything clarified. Ask students to review their notes and ask questions about what they've written so far.
- **Writing Activities such as the "Minute Paper"**: At an appropriate point in the lecture, ask the students to take out a blank sheet of paper. Then, state the topic or question you want students to address. For example, "*Today, we discussed emancipation and equal rights. List as many key events and figures as you can remember. You have two minutes – go!*"
- **Self-Assessment**: Students receive a quiz (typically ungraded) or a checklist of ideas to determine their understanding of the subject. Concept inventories or similar tools may be used at the beginning of a semester or the chapter to help students identify misconceptions.
- **Large-Group Discussion**: Students discuss a topic in class based on a reading, video, or problem. The instructor may prepare a list of questions to facilitate the discussion.
- **Think-Pair-Share**: Have students work individually on a problem or reflect on a passage. Students then compare their responses with a partner and synthesize a joint solution to share with the entire class.
- **Cooperative Groups in Class (Informal Groups, Triad Groups, etc.)**: Pose a question for each cooperative group while you circulate around the room answering questions, asking further questions, and keeping the groups on task. After allowing time for group discussion, ask students to share their discussion points with the rest of the class.
- **Peer Review**: Students are asked to complete an individual homework assignment or short paper. On the day the assignment is due, students submit one copy to the instructor to be graded and one copy to their partner. Each student then takes their partner's work and, depending on the nature of the assignment, gives critical feedback, and corrects mistakes in content and/or grammar.
- **Group Evaluations**: Similar to peer review, students may evaluate group presentations or documents to assess the quality of the content and delivery of information.
- **Brainstorming**: Introduce a topic or problem and then ask for student input. Give students a minute to write down their ideas, and then record them on the board. An example for an introductory political science class would be, "*As a member of the minority in Congress, what options are available to you to block a piece of legislation?*"
- **Case Studies**: Use real-life stories that describe what happened to a community, family, school, industry, or individual to prompt students to integrate their classroom knowledge with their knowledge of real-world situations, actions, and consequences.
- **Hands-on Technology**: Students use technology such as simulation programs to get a deeper understanding of course concepts. For instance, students might use simulation software to design a simple device or use a statistical package for regression analysis.
- **Interactive Lecture**: Instructor breaks up the lecture at least once per class for an activity that lets all students work directly with the material. Students might observe and interpret features of images, interpret graphs, make calculation and estimates, etc.
- **Active Review Sessions (Games or Simulations)**: The instructor poses questions and the students work on them in groups or individually. Students are asked to show their responses to the class and discuss any differences.
- **Role Playing**: Here students are asked to "act out" a part or a position to get a better idea of the concepts and theories being discussed. Role-playing exercises can range from the simple to the complex.
- **Jigsaw Discussion**: In this technique, a general topic is divided into smaller, interrelated pieces (e.g., a puzzle is divided into pieces). Each member of a team is assigned to read and become an expert on a different topic. After each person has become an expert on their piece of the puzzle, they teach the other team members about that puzzle piece. Finally, after each person has finished teaching, the puzzle has been reassembled, and everyone on the team knows something important about every piece of the puzzle.
- **Inquiry Learning**: Students use an investigative process to discover concepts for themselves. After the instructor identifies an idea or concept for mastery, a question is posed that asks students to make observations, pose hypotheses, and speculate on conclusions. Then students share their thoughts and tie the activity back to the main idea/concept.
- **Forum Theater**: Use theater to depict a situation and then have students enter into the sketch to act out possible solutions. Students watching a sketch on dysfunctional teams, might brainstorm possible suggestions for how to improve the team environment. Ask for volunteers to act out the updated scene.
- **Experiential Learning**: Plan site visits that allow students to see and experience applications of theories and concepts discussed in the class.

Sources

Active learning. (n.d.). Retrieved September 1, 2005, from University of California at Davis, Teaching Resources Center Web site: http://trc.ucdavis.edu/trc/ta/tatips/activelearning.pdf
Bonwell, C.C. (1996). Enhancing the lecture: Revitalizing a traditional format. In T.E. Sutherland, C.C. & Bonwell (Eds.), Using active learning in college classes: A range of options for faulty. (pp.31-44). San Francisco: Jossey-Bass Publishers.
Felder, R.M., & Brent, R. (1994). Cooperative learning in technical courses: Procedures, pitfalls, and payoffs. (*ERIC Document Reproduction Service, No. ED 377038*).
McKeachie, W.J. (2005). How to make lectures more effective. In *Teaching tips: Strategies, research, and theory for college and university teachers* (11th ed.) (pp. 52-68). New York: Houghton Mifflin Co.
Paulson, D.R., & Faust, J.L. (n.d.). *Active learning for the college classroom*. Retrieved September 1, 2005, from California State University, L.A. Web site: http://www.calstatela.edu/dept/chem/chem2/Active/

Designing In-Class Activities: Examples of Active Learning Activities



Designing In-Class Activities:
Examples of Active Learning Activities

A workshop from the University of Pittsburgh's
University Center for Teaching & Learning

GRADUATE STUDENT TEACHING INITIATIVE
Pitt | UNIVERSITY CENTER FOR TEACHING AND LEARNING

Activities for Lectures

- **Structured Notes:** A Detailed outline of the presentation with key words or phrases left out. Students fill these in as the lecture progresses.
- **Labeling a Diagram:** Each student is given an unlabeled diagram or picture which the student labels as the information is given during class.
- **Word Pictures:** Use during lecture to graphically convey ideas and concepts. These require students to fill in words or phrases.
- **Exampling:** Students are asked to describe examples and non-examples given a concept, problem, situation, or principle.
- **Incomplete Statements:** Students are given incomplete statements by the instructor and asked to complete them.
- **Three Points Summary:** Students are asked to summarize the three most important points of a lecture.
- **Paraphrases:** Students summarize in their own words what the instructor says.
- **Guest Speaker:** A presentation is given by a known expert followed by questions from the students.
- **Presentation with Listening Teams:** A lecture followed by an organized question/answer/discussion period. Before the presentation, students are organized into small groups and each group is given a listening assignment, e.g., listen for a point that can be applied to a particular situation, etc. At the end of the presentation, each group makes comments and asks questions related to their particular assignment.

Individual Activities

- **Individual Exercises:** These provide an opportunity for the students to practice skills. This could include labeling, rank ordering, multiple choice, problem solving, or true/false and completion. Exercises must be completed in a set time period and the instructor gives and discusses the correct answers.
- **Role Play:** Students are given a situation and a role to play of a character in the situation. Without practice, they act out the events in the situation. Role play may be used for the purpose of situation analysis or to provide feedback to the students about their own behavior.
- **Questioning Strategies:** Questions which the students will be asked are planned by the instructor prior to the lecture. Each question is written out and is related to a learning objective. In case of no response or incorrect responses, the instructor will also be prepared to ask easier or lower learning level questions which will lead the student to answer the original question.
- **Personal Vignette:** Given a topic or learning objective, the students are asked to relate it to their real experiences (personal or professional) by telling a brief story about it.
- **Progress Quizzes:** Short self-tests which are not graded. Answers are provided to the students after completing the quiz.

Thank you.

Jialing Wu
wu.6489@buckeyemail.osu.edu