Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025
Paper ID #46170

# CHIPS, Science, & Secondary Engineering Technology Education (Resource Exchange)

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Deana M. Lucas is a PhD student in the Technology Leadership and Innovation Department at Purdue University. Deana's background in Technology and Engineering Education drives her passion for working in spaces where disciplinary content converges. Her research spans both K-12 and higher education environments.

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Tori Constantine is a graduate research assistant pursing her Master's degree in Technology Leadership & Innovation at Purdue University. She currently works with the SCALE K12 research group in exploring microelectronics curriculum.

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Yubin Lee is a PhD student in STEM Education Leadership at Purdue University. Lee has served as a middle school technology teacher in South Korea and has a Master's Degree in Technology Education from Kongju National University.

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Tamara J. Moore, Ph.D., is a Professor of Engineering Education and University Faculty Scholar at Purdue University, as well as the Executive Co-Director of the INSPIRE Research Institute for Precollege Engineering. Dr. Moore's research is focused on the integration of STEM concepts in K-12 and postsecondary classrooms in order to help students make connections among the STEM disciplines and achieve deep understanding. Her work investigates engineering design-based STEM integration, computational thinking, and integration of high-level content in K-14 spaces. She is creating and testing innovative, interdisciplinary curricular approaches that engage students in developing models of real-world problems and their solutions.

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Dr. Morgan Hynes is an Associate Professor in the School of Engineering Education at Purdue University and Director of the FACE Lab research group at Purdue. In his research, Hynes explores the use of engineering to integrate academic subjects in K-12 cla

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**Dr. Rick Hill, University of Detroit Mercy**

Dr. Richard Hill is a Professor and Assistant Dean in the College of Engineering & Science at University of Detroit Mercy. Dr. Hill received a B.S. degree in Mechanical Engineering from the University of Southern California in 1998, and an M.S. degree in Mechanical Engineering from the University of California, Berkeley in 2000. He joined the faculty of Detroit Mercy in 2008 after receiving a Ph.D. degree in Mechanical Engineering and an M.S. degree in Applied Mathematics from the University of Michigan, Ann Arbor. His research interests lie in the areas of vehicle control, control and diagnosis of discrete-event systems, modular and hierarchical control, and engineering education. Dr. Hill also has a strong interest in diversifying the STEM pipeline and leads the innovating Detroit's Robotics Agile Workforce (iDRAW) program in partnership with underserved Detroit-area high schools.

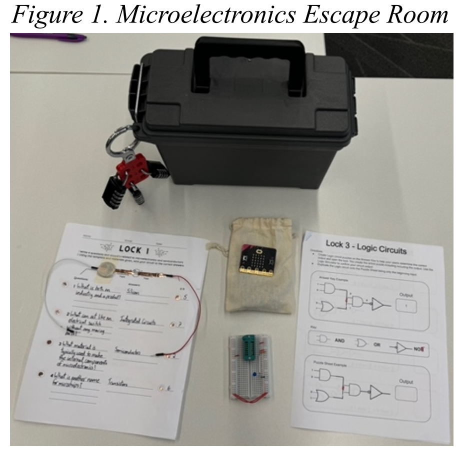
**CHIPS Act & Secondary Engineering Technology Education** (Resource Exchange)

In 2022, the *CHIPS (Creating Helpful Incentives to Produce Semiconductor) & Science Act* was passed, underscoring the United States' commitment to strengthening its capacity to develop and manufacture semiconductors. However, with these substantial investments in the semiconductor industry comes the need to cultivate a skilled workforce. This need then requires efforts to integrate semiconductor and microelectronics content/contexts into K-12 classrooms. Secondary engineering technology classrooms are particularly well-suited to this content given the concepts covered by, and the flexibility of, the subject area. Accordingly, this resource exchange will provide an in-depth exploration of two secondary engineering technology instructional units (one for middle school and one for high school) that were co-designed by teachers and university faculty/students as part of a multi-state semiconductor K-12 initiative.

This semiconductor K-12 initiative**,** referred to as **SCALE K-12,** is part of a program dedicated to equipping students with foundational knowledge for careers in defense-related microelectronics. It supports teachers and schools by providing resources to develop and deliver engaging, context-rich learning experiences that introduce students to key concepts in microelectronics design and production. Through this initiative, teachers collaborate in discipline-based cohorts, designing units that integrate microelectronics content within their subject areas, which they implement at various points throughout the academic year, bringing advanced technological concepts into the K-12 educational context. As a result of this initiative's curriculum development workshops, cohorts of secondary engineering technology educators collaborated to create, implement, and refine microelectronics-focused instructional units for both middle school and high school. These units engage students with real-world applications of microelectronics through hands-on design projects, exposing them to, and preparing them for, future opportunities in the semiconductor industry. Two of these units are presented in the following sections.

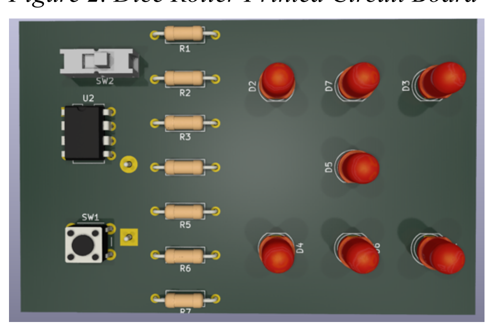
**What's in the Box (Middle School Unit):** In collaboration with a local "fictitious" escape room and a new microelectronics packaging company, this unit engages students in designing a four-level "escape room box or breakout box" (see Figure 1) that demystifies the inner workings of microchips (aka integrated circuits). Students work in teams to create puzzles that explore microelectronics basics, coding, digital logic, and testing for microchip counterfeits. Table 1 provides an outline for this unit.

*Figure 1. Microelectronics Escape Room*




**Roll the Dice (High School Unit):** This unit introduces students to microchip fabrication and packaging through the design and creation of a printed circuit board that functions as a digital dice roller (see Figure 2). Students learn to design circuits using electronic design automation tools, mill circuit pathways using a CNC router, program microchips, and solder components before presenting their prototypes to a specified client.  Table 2 provides an outline for this unit.

*Figure 2. Dice Roller Printed Circuit Board*




**Resource Exchange:**  Each of the units share here are designed to actively engage students with semiconductor-related concepts and microelectronics production, fostering hands-on learning experiences with an important and in-demand workforce context. Both secondary engineering technology units are provided, free-of-charge, through this resource exchange and accessible through the initiative's website at [www.scalek12.org](http://www.scalek12.org).

**Table 1. Middle School Unit Overview**

| | |
|---|---|
| Lesson 1 | Students are introduced to their client and the escape box project. They will learn about the semiconductor industry, how microchips are made, and how microelectronics are important to their lives. Students then apply what they learned about microelectronics and to create a puzzle for the "first lock" of their escape box. The puzzle will require students to use knowledge of circuits to create an interactive experience that helps the "escape box players" learn about microelectronics. |
| Lesson 2 | Students are introduced to sensors in microelectronics. They will use micro:bits as a platform for investigating how programming connects sensors and microelectronics. They will use what they learn to create a micro:bit-based puzzle that uses a sensor to provide an input into a program and produces a displayed output with the combination for the "second lock" on their escape box. |
| Lesson 3 | Students get a glimpse what happens inside a microchip. They will learn how to draw logic gates with appropriate symbols and how to follow inputs through logic circuits to get an output. They will use breadboards with logic gate chips to see how digital logic works in a circuit. Once they understand the basics of logic gates, they will design a puzzle for their escape box that requires them to create a set of 4 logic circuits that players need to navigate to discover the next lock combination. |
| Lesson 4 | Students learn about the societal effect of counterfeit products in a variety of spaces. They will connect those effects to how counterfeit microelectronics can cause harm. They gain more experience with breadboards by following a schematic to build a microchip tester to check for "counterfeit" chips. This tester will form the final puzzle in their escape box. |
| Lesson 5 | Students work together to test and recommend the top three escape boxes to send to their client. Each team will test at least one box from a different team. They will record their findings as they test. Students will use their testing data, as well as their knowledge of microelectronics and circuits, as evidence for justifying their escape box selections. |

**Table 2. High School Unit Overview**

| | |
|---|---|
| Lesson 1 | Students are introduced to the microelectronics industry through a real-world scenario involving a new microelectronics packaging company in their community. The lesson begins by exploring the critical role microelectronics play in everyday products and the variety of careers available in this rapidly growing field. Students will then engage with a client design brief, where they are tasked with creating an electronic dice roller as a promotional item for the company. Through this project, students will learn about the fundamental processes of microelectronics packaging and the design and manufacturing of Printed Circuit Boards. |
| Lesson 2 | Students will dive into the practical aspects of circuitry by creating and testing simple series and parallel circuits using breadboards. Guided by a client brief, they will prototype circuits that light multiple LEDs, which will later be used in their electronic dice roller project. |
| Lesson 3 | Students will advance from creating simple circuits to integrating microcontrollers, specifically the micro:bit, into their designs. This lesson focuses on coding and programming the micro:bit to control the circuits they have previously built, enabling them to create interactive electronic projects. The micro:bit, a programmable microcontroller, acts as a crucial testing platform for the code that will eventually be used to control the microchip in their final electronic dice roller project. |
| Lesson 4 | Students will transition from breadboard prototyping to designing the Printed Circuit Board for their electronic dice roller. After exploring Electronic Design Automation software, students will lay out the circuit pathways for the printed circuit board, ensuring that each component (LEDs, resistors, microcontroller, etc.) are properly connected. |
| Lesson 5 | Students will transition from designing their printed circuit boards to physically creating their boards using a CNC mill. The lesson will introduce students to G-code, the programming language used to instruct CNC machines. Students will learn how to generate G-code for their Printed Circuit Board designs and operate the CNC mill to mill the circuit pathways for their electronic dice roller. |
| Lesson 6 | Students will learn how to solder electrical components to a printed circuit board to complete their electronic dice roller project. By the end of the lesson, students will have a fully assembled Printed Circuit Board for their electronic dice roller, ready for testing and final assembly. |
| Lesson 7 | Students will focus on preparing and delivering a technical presentation of their electronic dice roller prototype. This presentation will cover the design process, key design decisions, and market analysis, simulating a real-world client pitch. |

We acknowledge support from the U.S. Department of Defense [Contract No. W52P1J-22-9-3009], Indiana Economic Development Corporation [Contract No. A281-3-IPF-1028 424208], and U.S. Department of Defense through Applied Research Institute [Contract No. SA-22036.001].