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Pre-College Microelectronics Curriculum Units Developed Using an Integrated Microelectronics Framework (Resource Exchange)

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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.

Siddika Selcen Guzey, Purdue University at West Lafayette (PWL) (COE)

Dr. Guzey is a professor of science education at Purdue University. Her research and teaching focus on integrated STEM Education.

Dr. Greg J Strimel, Purdue University at West Lafayette (PPI)

Greg J. Strimel, Ph.D., is an assistant professor of Technology Leadership and Innovation and coordinator of the Design and Innovation Minor at Purdue University. Dr. Strimel conducts research on design pedagogy, cognition, and assessment as well as the pre

Dr. Morgan M Hynes, Purdue University at West Lafayette (COE)

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

Dr. Kerrie A Douglas, Purdue University at West Lafayette (PWL) (COE)

Dr. Douglas is an Associate Professor in the Purdue School of Engineering Education. Her research is focused on improving methods of assessment in engineering learning environments and supporting engineering students.

Dr. Molly H Goldstein, University of Illinois Urbana-Champaign

Dr. Molly H. Goldstein is a Teaching Assistant Professor and Product Design Lab Director in Industrial and Enterprise Systems Engineering at the Grainger College at the University of Illinois. She is also courtesy faculty in Mechanical Science and Engineering, Curriculum & Instruction (College of Education) and Industrial Design (School of Fine and Applied Arts). Dr. Goldstein's research focuses on student designers through the study of their design actions and thinking.

Dr. Rick Hill, University of Detroit Mercy

Dr. Richard Hill is a Professor and Associate 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.

Imani Adams, Purdue University at West Lafayette (COE)

Imani Adams is a Ph.D. student at Purdue University in Engineering Education. Prior to starting her Ph.D., Imani worked in industry for ten years after completing her M.S. in Mechanical Engineering from The Ohio State University and B.S. in Mechanical Engineering from North Carolina Agricultural and Technical State University. Imani's research interest is in African American youth engagement with engineering in formal and informal spaces. Apart from academics, Imani is involved with Purdue's Engineering Education Graduate Student Association and the Black Graduate Student Association.

Vanessa Blas, University of Illinois at Urbana - Champaign
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Emily M. Haluschak is a PhD student in the school of Engineering Education at Purdue University. Emily is interested in leveraging integrated curriculum development in K-12 settings to positively impact underserved populations in the field of engineering. She utilizes past experiences in STEM program evaluation, education policy, and chemical engineering research.

Miss Rachel E. Higbee, Purdue University at West Lafayette (PWL) (COE)

Rachel is an NSF Graduate Research Fellow pursuing her PhD in Engineering Education at Purdue University. She has earned a BS in Civil Engineering from LeTourneau University and MS in Environmental Engineering from Purdue. Rachel's current research focuses on assessment of K-12 environmental justice curriculum, but she also has experience in curriculum writing, K-12 microelectronics, photochemistry, water quality, PFAS remediation, and disinfection.

Joshua E. Katz, University of Illinois at Urbana - Champaign

Joshua E. Katz is a Ph.D. student in the Department of Curriculum and Instruction, DELTA program, at UIUC, where his research centers on collaborative learning in engineering education and other STEM disciplines. He obtained his B.S. in Technology and Engineering Education in 2019 and his M.S. in STEM Education and Leadership in 2021 from Illinois State University. Additionally, he holds a professional educator license for secondary education in Technology and Engineering Education in Illinois.

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Deana Lucas, Purdue University at West Lafayette (COE)

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.

Christine H. McDonnell, Purdue University at West Lafayette (PWL) (COE)

Christine is a PhD student in the school of Engineering Education at Purdue University. Christine is interested in exploring the connections between integrated STEM education in K-12 classroom settings and the impact on student learning, career interests, and reducing premature departure from STEM pathways.

Ms. Azizi Penn, Purdue Engineering Education

Azizi Penn is a professional software engineer, a professor at California State University, Sacramento, and an engineering education Ph.D. student. Prior to and during her graduate work, she developed a passion for providing engineering practice experiences to pre-college students.

Brian Povilus, University of Illinois at Urbana - Champaign
Mr. Bruce Wellman, Purdue University at West Lafayette (COE)

Bruce Wellman is a National Board Certified Teacher (NBCT, Chemistry) who taught high school chemistry and engineering for 22 years. He is currently a doctoral student in the Engineering Education Department at Purdue University

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Jennifer Heap is a Project Manager for SCALE K-12 at Purdue University's School of Engineering Education. With a background in education, she is passionate about leveraging her experience to enhance STEM learning in K-12 classrooms. Jennifer is dedicated to fostering innovative approaches that inspire the next generation of learners and educators in the STEM fields.

Rena Ann Sterrett, Purdue Engineering Education

SCALE K-12 Curriculum

SCALE K-12 Project

SCALE K-12 is part of the SCALE workforce development project focused on preparing a skilled workforce in the U.S. to strengthen microelectronics (ME) manufacturing capabilities. SCALE K-12 collaborates with Indiana, Illinois, and Michigan school districts to integrate ME content and contexts across their school systems. Teacher Fellows in these districts help co-create and test curricular units with coaching support. The units can be found on nanoHUB with supporting resources for broader access through the QR above or the following link: https://www.scalek12.org

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SCALE K-12
SCalable Asymmetric Lifecycle Engagement
Precollege Microelectronics Workforce Development

Pre-College Microelectronics Curriculum Units Developed Using an Integrated Microelectronics Framework

Curricular Units Overview: Using the Microelectronics (ME) Integration Curriculum Development Framework, K-12 instructional units were co-developed and implemented with 68 participating teachers to introduce ME-related content, contexts, and careers into pre-college classrooms. SCALE K-12 curriculum is aligned to national and state standards and covers a variety of content areas in primary and secondary education including science, mathematics, art, engineering/technology, and English/language arts.

ME Integration Curriculum Development Framework Summary:

Component	Description
Motivating and Engaging Context	• Leverages students' personal knowledge and experiences • Provides compelling, realistic purposes for learning
Meaningful Integration of ME	• Seamless integration of essential ME content • Every lesson within the unit connects to ME • Promotes understanding of ME careers/pathways
A Realistic Client	• Provides realistic client and end-user needs • Develop field-related tech to solve client problems
Integration of Disciplinary Content	• Aligns with learning objectives and state standards • Developmentally appropriate concepts • Promotes coherent conceptual understanding
Instructional Strategies	• Student-centered and asset-based pedagogies • Evidence-based reasoning and argumentation • Multiple modes of representation
Teamwork	• Collaboration & individual responsibility • Encourage positive team interactions & co-learning
Communica-tion	• Communicates disciplinary concepts • Presents solutions to client's problems • Encourages multiple modes of representation
Organization	• Measurable learning objectives and clear goals • Logical, sequential flow of activities/lessons • Provides teacher guidance
Performance & Formative Assessment	• Aligns assessments with learning objectives/goals • Meaningful connections to state standards • Opportunities for evidence of understanding through performance tasks

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SCALE K-12 Curriculum

1	**Trekking Through the Periodic Table** (8th – 10th, Science)
ME Fuse: semiconductors, materials used in microchips, circuits using breadboards and micro:bits Goal: Students build a radio-frequency scanner to identify materials while on a space exploration mission.	
2	**Stay Cool** (4th, Elementary Education)
ME Fuse: microchips in microelectronics, simple circuits Goal: The ESphere team uses energy transfer, circuits, and programming to keep a device from overheating.	
3	**Microelectronic Masterpieces: Hello Dali** (4th – 6th, Art)
ME Fuse: coding, use of microcontrollers, system inputs/outputs Goal: Students design Dalí-inspired surrealist clocks, integrating electronics with coding for interactive art.	
4	**What's in the Box** (6th – 8th, TechEd)
ME Fuse: semiconductor production, coding, digital logic, testing integrated circuits, counterfeit microchips Goal: Develop a four-level escape room box (breakout box) that demystifies the inner workings of microchips.	
5	**The Day the Lights Went Out** (6th – 12th, English)
ME Fuse: radiation hardening, block coding and programming Goal: Students create fictional narratives describing a world with limited ME saved by radiation-hardening.	
6	**Rolling the Dice** (9th – 12th, TechEd)
ME Fuse: automation design, programming, microchip packaging, printed circuit board, and soldering Goal: Create a fully functional digital dice roller on a printed circuit board for a ME packaging company.	
7	**Lights, Parade, Action** (1st, Elementary Education)
ME Fuse: automation, GPS, light sensors, self-driving cars, security systems Goal: Students design a town center with streetlights and a celebration parade with push-button robots.	
8	**Guardians of the Grid** (9th – 12th, TechEd)
ME Fuse: trusted and assured ME, logic gates on breadboard, programming, sensors, hardware security Goal: Students design a counterfeit-proof programmable door lock after learning about microchips.	
9	**This Circuit is on Fire** (8th, Algebra)
ME Fuse: Ohm's law, simple circuits, cell phone microelectronics, use of microcontrollers, coding Goal: Students explore a solution to prevent cell phones from overheating using linear algebra and graphs.	
10	**Cirrus-ly Spectacular: Wave Explorations** (6th, Science)
ME Fuse: circuits using breadboards, redundancy to circuits for radiation hardening in space Goal: Complete different space missions while exploring the electromagnetic spectrum and its waveforms.	
11	**Microelectronic Viking Adventure** (5th, Math)
ME Fuse: circuits, programming microcontrollers, programmable robot Goal: Using the book "Sir Cumference and the Viking's Map", students learn different aspects of ME.	
12	**Who Let the Dogs Out** (3rd, Elementary Education)
ME Fuse: microelectronics applications, simple circuits, use of microcontrollers, coding Goal: Students use technology and ME to design a secure play zone for their four-legged dog friends.	

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