One Letter at a Time: Integrating Microelectronics in Pre-College Classrooms Using Client Letters (Resource Exchange)

Prof. Tamara J Moore, Purdue University – West Lafayette (College of Engineering)

Tamara J. Moore, Ph.D., is the Crowley Family Professor of Engineering Education at Purdue University. 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 – West Lafayette (College of Engineering)

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

Dr. Morgan M Hynes, Purdue University – West Lafayette (College of Engineering)

Dr. Morgan Hynes is an Assistant 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. Greg J Strimel, Purdue University

Greg J. Strimel, Ph.D., is an associate professor and interim department head in the Department of Technology Leadership and Innovation at Purdue University, where he coordinates the Design and Innovation Minor, prepares future K–12 Engineering Technology Teachers, and supports the graduate student program in STEM education leadership.

Dr. Molly H Goldstein, University of Illinois at 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 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.

Imani Adams, Purdue University – West Lafayette (College of Engineering)

Imani Adams is a Ph.D. candidate 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.

Amiah Clevenger
Yash Ajay Garje, Purdue University – West Lafayette (College of Engineering)

Yash is a Ph.D. student at the School of Engineering Education at Purdue University. His research aims at broadening student participation in STEM through robotics education. His research focuses on enhancing STEM participation through robotics education, employing learning technologies and storytelling to craft inclusive educational experiences that foster student belonging.

Emily M. Haluschak, Purdue University – West Lafayette (College of Engineering)

Emily M. Haluschak is a PhD candidate in the school of Engineering Education at Purdue University. Her research focuses on student and teacher troubleshooting of physical computing systems. 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.

Dr. Rachel E. Higbee, Purdue University – West Lafayette (College of Engineering)

Dr. Rachel Higbee is a postdoctoral scholar in the School of Engineering Education at Purdue University. She holds a BS in Civil Engineering, MS in Environmental Engineering, and PhD in Engineering Education, during which she was an NSF Graduate Research Fellow. Rachel's current research focuses on integrating microelectronics content into K-12 classrooms as part of the SCALE K-12 project. She also has experience researching curriculum development and assessment, photochemistry, and PFAS remediation.

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

Joshua E. Katz is a Ph.D. candidate 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.

Yubin Lee, Purdue University at West Lafayette (COE)

Yubin Lee is a Ph.D. student at Purdue University.

Julia Lipman, Purdue University – West Lafayette (College of Engineering)
Deana Lucas, Purdue University at West Lafayette

Deana M. Lucas is a PhD candidate 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 – West Lafayette (College of Engineering)

Christine H. McDonnell is a PhD candidate 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.

Silas Owen, Purdue University at West Lafayette (COE)
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.

Mr. Bruce E Wellman, Purdue University – West Lafayette (College of Engineering)

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

Tugba Abanoz, Purdue University – West Lafayette (College of Engineering)
JaKobi Burton, Purdue University – West Lafayette (College of Engineering)
Anne DeLion, Purdue Engineering Education
Jennifer Heap, Purdue Engineering Education

Jennifer Heap is the Communications Lead 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 Sterrett, Purdue Engineering Education

Rena Sterrett is the Lead Project Manager for SCALE K–12 at Purdue University. With a BS in Elementary Education and a Master of Education, Rena brings more than two decades of experience across K–12 education, community-based programming, and higher education. Her work focuses on translating research into practice through large-scale professional development, curriculum design, and cross-sector partnerships. A former classroom teacher, she remains committed to supporting educators and expanding student access to engaging, high-quality learning experiences.

SCALE K-12 Curriculum

Project Description

SCALE K-12, a workforce development initiative, aims to build a robust U.S. talent pipeline to support the nation's microelectronics (ME) manufacturing sector. Leveraging partnerships with districts in Indiana, Illinois, and Michigan, SCALE K-12 integrates ME concepts and careers through K-12 systems using real-world applications. Teacher Fellows collaborate to design, pilot, and refine integrated curriculum units with ongoing coaching. The instructional materials and resources are available on nanoHUB through the QR above or the following link: https://www.scalek12.org

Contact Information

PI - Tamara J. Moore
tamara@purdue.edu

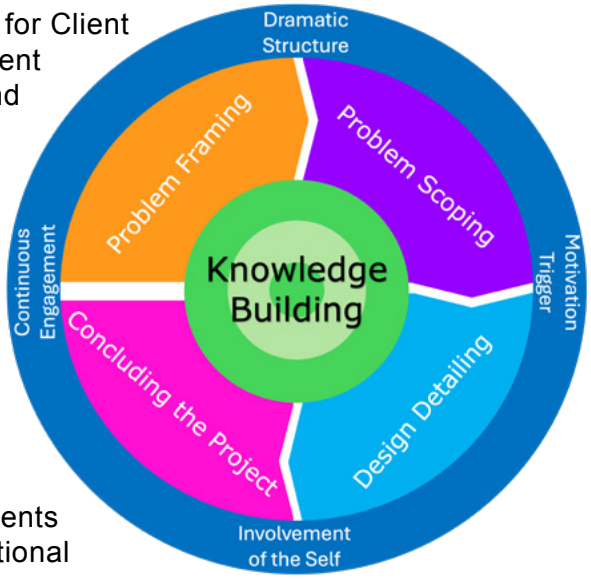
Project Manager - Rena A. Sterrett
rsterret@purdue.edu

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

One Letter at a Time: Integrating Microelectronics in Pre-College Classrooms Using Client Letters

Curricular Units Overview: Guided by the *Conceptual Framework for Client Letter Development*, a set of four instructional units were collaboratively designed by and embedded in nine teachers' classrooms to introduce microelectronics concepts, applications, and career connections to 6th-12th grade students. In addition, ten 3rd-5th grade educators utilized the same framework to create unique curriculum units that connect microelectronics and engineering with literacy instruction through the use of a novel-based context. All units are aligned with relevant state and national standards across multiple disciplines, including science, mathematics, business, English/language arts, and engineering/technology.

Conceptual Framework for Client Letter Development



The Conceptual Framework for Client Letter Development uses client letters as an instructional and narrative tool to create a guided, immersive learning environment that fosters student engagement while scaffolding learning through engineering design-based STEM integration curricula. The framework centers knowledge building as the core curricular objective, ensuring that narrative elements work in synergy with instructional goals. The engineering design process underpins curricular progression, moving through problem framing, problem scoping, design detailing, and project completion, while allowing flexibility to support the evolving storyline.

The curricula highlighted on the back were developed using this framework. To see this in action, download the curricular units from the URL or QR code to the left. To learn more about how client letters are used in engineering design-based STEM integration curricula, see McDonnell et al. (2025).

McDonnell, C. H., Adams, I. N., Hynes, M. M., Guzey, S. S., Pilotte, M. K., Strimel, G. J., Tank, K. M., & Moore, T. J. (2025). From context to connection: Client letters in STEM integration curricula. *STEM Synergies Special Issue of Education Sciences, 15*(6), 696. https://doi.org/10.3390/educsci15060696

SCALE K-12 Curriculum

1	**Dustbusters!** (6th – 8th grade, Science)
Engineers working for FONES (Fabrication of Nanoscale Electronics and Semiconductors) help product manager Phil Turret design a cleanroom air filtration system that protects microchips from microscopic contaminants. Students learn why even a single dust particle can compromise product reliability. They apply concepts of filtration and metric measurement to design, build, and test a multi-layer filter model that removes contaminants while meeting size and material constraints.	
2	**Chips & Charms** (6th – 12th grade, Tech-Ed, Engineering, and Business)
Fabiola Wyre and her product team at Chips & Charms are looking for partners to help prototype a promotional item to give away at the Consumer Electronics Show that showcases their ME capabilities. Using design software, students develop a circuit prototype, code a custom microchip, and create schematics for the promotional item. After assessing the business risk of outsourcing vs. in-sourcing materials, students present the prototype circuit board design to Fabiola and her team.	
3	**From Sand to Circuits** (9th – 12th grade, Chemistry)
Part 1: Krystal Boule, the project manager of an R&D group at a National Lab, is seeking chemistry consultants to help identify the various jobs and chemical processes involved in manufacturing microchips from raw materials. As consultants, students work with Kohl Valant, a materials engineer, to learn about the chemical bonding and crystal growth involved in the formation and doping of a wafer. Part 2: Students work with Kat A. List, the electrical engineer, and a lab technician as they continue to learn about the chemistry behind the photolithography and etching processes through hands-on activities, culminating in presentations of their functioning macro-scale prototypes.	
4	**RAMbunctious Recall** (9th – 12th grade, Computer Science)
Banks Memory Ltd. develops products to assist in the memory care of individuals with cognitive impairments, such as dementia. For their new product, they want to develop an electronic memory game to assist with short-term memory recall. Mae Marie Banks, the CEO, wants to learn more about how memory functions in electronics to better understand the types of products that could meet this need. Students code a memory game, that functions similarly to Simon Says or a sequencing memory activity, while learning about the different types and functions of memory in ME.	
5	**Novel Engineering** (K – 5th grade, Elementary Engineering and Literacy)
Through Novel Engineering, students identify engineering problems faced by characters in a variety of teacher-selected novels. Student teams develop prototypes using ME (micro:bits) to solve the characters' problems. The novel text and teacher-generated client letters help guide instruction as students tailor their solutions to the needs and wants of the characters and to the novel's setting and context. Students deepen their literacy engagement with the books and engage in the Engineering Design Process. Example books include: Tales of Fourth Grade Nothing, by Judy Blume (4th grade), The Hundred Dresses, by Eleanor Estes (3rd grade), and Tiger Rising, by Kate DiCamillo (4th grade).	

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