The SCALE Workforce Development Model

Kerrie A. Douglas[1], Tamara J. Moore[1], Melissa Dyehouse[1], Alejandro Strachan[2], and Peter Bermel[3]

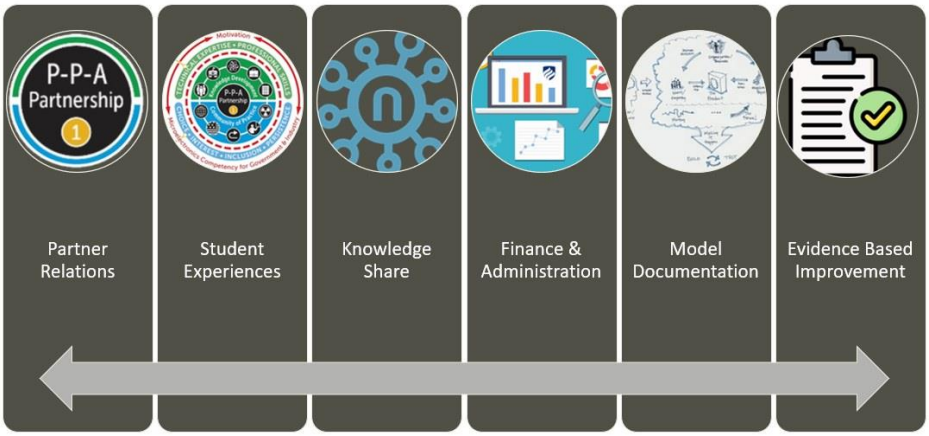
[1] School of Engineering Education, Purdue University, Neil Armstrong Hall of Engineering, 701 West Stadium Ave., West Lafayette, IN 47907

[2] School of Materials Engineering, Purdue University, Neil Armstrong Hall of Engineering, 701 West Stadium Ave., West Lafayette, IN 47907

[3] Elmore Family School of Electrical & Computer Engineering, Purdue University, 465 Northwestern Ave., West Lafayette, IN 47907

The Scalable Asymmetric Lifecycle Engagement (SCALE) microelectronics workforce development program is funded by the United States Department of Defense (DoD) to address the critical shortage of a capable microelectronics workforce. SCALE's innovative workforce development model includes a novel public-private academic partnership (PPAP), a tailored messaging approach that targets students from K-12 to Ph.D. levels, national curriculum standards in specialty areas, iterative adaptation of curriculum and standards, and systematic program evaluation to measure and ensure the program's effectiveness in meeting target benchmarks and objectives. SCALE's vertical integration of curriculum incorporates age-appropriate microelectronics curriculum and topics from the K-12 level to the graduate and professional level.

The SCALE Model is made up of five key components that enable the program to function effectively and as intended (Figure 1): Partner relations, student experiences, knowledge share, finance and administration, and evidence-based improvement. The model documentation component is addressed through this model documentation guide.



*1 - **Figure 1.** The SCALE Workforce Development Model*

The original prototype workforce development model was focused on developing and testing the model in a small number of technical areas. The prototype model proved successful in demonstrating the effectiveness of the methodologies that were used to produce a knowledgeable microelectronics workforce. The second phase of the SCALE workforce development model is the production phase of the model, which expanded the technical areas to include radiation hardening (RH), system on chip (SoC), heterogeneous integration/advanced packaging (HIAP), and embedded systems/trusted AI (ESS/AI). Other technical areas continue to be added (e.g., radio frequency and Optoelectronic microelectronics; RF/OE). The production model aims to expand and replicate the prototype model to attract, develop, obtain, and maintain a future microelectronics clearable workforce that will 1) increase the probability for successful recruitment, 2) produce a readier workforce, 3) advance knowledge share, 4) scale up, and 5) expand/replicate across additional microelectronic or other U.S. Industrial Base technology areas.

How to Use This Guide

The purpose of documenting the SCALE model is to: communicate the details, assumptions, and insights to others who may want to implement a similar program, enable others to reproduce the program's results, provide transparency into how the model was implemented, train new team members on how the program is implemented, serve as a means of quality control, and support decision-making by allowing users to evaluate the limitations and suitability of the model.

The main goal of this model documentation guide is to detail each component of the SCALE workforce development model so that it can be understood and implemented by those external to the program. Details about the model's components and implementation are provided, which include the work that has been taking place as well as lessons learned and recommendations. Supporting documents and additional details are included in the Appendices.

The guide is divided into five main sections: (1) Partner relations, (2) Student experience, (3) Knowledge share, (4) Finance and administration, and (5) Evidence-based improvement. Users of the guide may wish to explore only one or all of these sections. There is no particular order in which the sections should be read; however, those wishing to learn more about the SCALE workforce development program should read the student experience section. Information about SCALE partners is provided in

the partner relations section. The knowledge share section contains information about how findings and materials are shared and disseminated. The section on finance and administration provides details about the processes used to manage the program efficiently and successfully. Finally, evidence-based improvement provides information about how the program is evaluated and the types of evidence used to iteratively improve the program. At the end of each section, a list of recommendations and lessons learned is provided.

Links to Model Documentation

Partner Relations

The main goal of the Partner Relations component of the SCALE model is to leverage the expertise and capabilities of microelectronics partners from all sectors, including public, private, and academic institutions, to contribute to the scalability and replicability of the microelectronics workforce.

https://sway.cloud.microsoft/q7u8JKL8NEEvKEHn?ref=Link

Student Experience

The SCALE student experience aims to integrate microelectronics exposure and training from the K-12, undergraduate, graduate, and professional levels. The goal of the undergraduate and graduate-level SCALE student experience is to expose, motivate, and prepare students from diverse backgrounds in engineering and engineering technology with the skillset and mindset for careers in defense-related microelectronics.

https://sway.cloud.microsoft/i1KZVKzVAgbPDAid?ref=Link

Knowledge Share

The purpose of the SCALE knowledge share component is to disseminate the knowledge generated by the SCALE program both internally and externally, which includes technology transfer to industry to serve defense and security needs. This includes sharing technical knowledge, creating collaborative partnerships between the SCALE consortium members, and sharing the SCALE model with other external programs.

https://sway.cloud.microsoft/foGVkck25Mo9umkU?ref=Link

Finance and Administration

The primary goal of SCALE's finance and administration component is to enable smooth and efficient program operations both internally at the prime institution and with the academic partners external to Purdue. Finance and administration are key components of the SCALE program as they permit the efficient management of SCALE's resources.

https://sway.cloud.microsoft/BM1bxFRXq6LheG6d?ref=Link

Evidence-Based Improvement

The goal of SCALE's evaluation is to provide a holistic evaluation leading to evidence-based improvement. The SCALE evaluation uses a holistic approach to evaluation, including outcome-based metrics, process evaluation, external evaluation, site-specific evaluation, and financial return on investment to provide a comprehensive understanding of the program.

https://sway.cloud.microsoft/nYz3HSHBN0YDFuIc?ref=Link

Contact

For questions, please contact scale@purdue.edu.

1. Partner Relations

1.1. Goal

The main goal of **the Partner Relations component** of the SCALE model is to leverage the expertise of microelectronics partners from all sectors, including public, private, and academic institutions, to contribute to the scalability and replicability of the microelectronics workforce. This section provides information about SCALE partners; the end of this section includes "Lessons Learned" and "Recommendations" sections to provide more insight into what we have learned over the course of implementing the SCALE model.

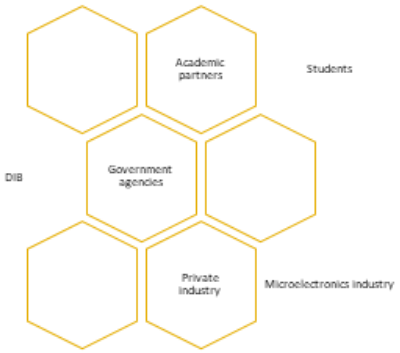
1.2. Features

A key feature of SCALE within the Partner Relations component of the model is the partnerships between the public, private, and academic institutions. The SCALE program relies on the interactions and collaborations between these partners, including various groups that focus on different aspects of the program. These partners and groups include a government oversight committee, partner relations advisory board, a core leadership team, a management team, the SCALE university consortium, leadership in each technical area, DoD/GOV/DIB partnership leads, and an external evaluation team. Currently, SCALE's public-private-academic partnership brings together 20 higher education organizations and 50 partners within the defense industry and government.

1.3. Partnerships

SCALE partners include academic institutions, government agencies, private companies, and defense industrial base (DIB) partners. Academic partners are selected based on a number of criteria, one of which is that they must offer students opportunities in SCALE's key technical areas. These technical areas include radiation hardening (RH), heterogeneous and advanced packaging (HI/AP), System on Chip (SoC), trusted and secure artificial intelligence (ESS/AI), and radio frequency optical electronics (RF/OE). Other SCALE areas include the Center for Secure Microelectronics Ecosystem (CSME). Additional technical areas may be added in the future depending on interest as part of SCALE's goals of expanding as necessary. Secondly, university/college partnerships are evaluated based on bolstering the type of partners SCALE may be lacking; for example, HBCUs and community colleges will receive a higher priority.

The partner industries, both government and private, are those with interests in hiring students skilled in microelectronics, particularly within SCALE's technical areas. One of the critical motivations for students joining SCALE is to gain an edge in acquiring an internship or future full-time position from some of these organizations.



1 - Figure 1. Public, private, and government partnerships

1.3.1. College/University Partners

As of Spring 2024, the SCALE program consisted of 20 higher education institutions (Table 1) with over 300 students participating. Not only do the institutions vary by type (e.g., R1 institutions) but there is also a wide range in the number of students participating from each. For example, only a small number of students participate at Brigham Young University, while Purdue University has over 200 SCALE students currently enrolled. The majority of the universities are large, public institutions with R1 classifications. However, SCALE leadership has made a concerted effort to include more diverse colleges and universities. Notably, Morgan State University (joined in 2023) is a Historically Black College/University (HCBU). Other universities have high levels of minority student enrollment; for example, in fall 2022 over 46% of Arizona State University's incoming first-year students came from minority backgrounds. Other unique universities include the Air Force Institute of Technology and private, faith-based institutions such as Notre Dame University and Brigham Young University.

Table 1. Academic Partners and Technical Verticals

University Partners	ESS/TAI	CSME	HI/AP	RFOE	RH	SoC
1. Air Force Institute of Technology					X	
2. Arizona State University		X	X		X	
3. Brigham Young University					X	
4. Georgia Institute of Technology			X		X	X
5. Indiana University	X				X	
6. Indiana University-Purdue University (IUPUI)	X					
7. Morgan State University						X
8. New Mexico State University					X	
9. Notre Dame University	X					
10. Ohio State University						X
11. Purdue University		X	X		X	X
12. Saint Louis University					X	
13. SUNY-Binghamton			X			
14. Texas A&M University		X				
15. Tulsa University	X					
16. University of California-Berkeley						X
17. University of Colorado-Boulder				X		
18. University of Florida		X				
19. University of Maryland					X	
20. University of Tennessee-Chattanooga					X	
21. Vanderbilt University					X	

ESS/TAI: Embedded Security Systems/Trusted AI; CSME: Center for Secure Microelectronics Ecosystem; HI/AP: Heterogeneous Integration and Advanced Packaging; RH: Radiation Hardening; RFOE: Radio Frequency- & Opto-Electronics; SoC: System on Chip

An important consideration when bringing in new partners is to ensure that they are selected strategically and are onboarded carefully. Growing partnerships too quickly can result in partners that are not engaged fully in program activities and that do not implement the program as intended. Having clear and set expectations from the onset of the onboarding process should facilitate a smoother program experience.

1.3.2. Federal Employers

There are a total of 17 government agencies that have partnered with SCALE (Table 2). These partners seek employees who have the knowledge, skills, and abilities that are needed in the microelectronics defense industry. These agencies provide internships and research experiences to qualified SCALE students. Their partnership with SCALE can help create a pipeline of trained students with experience and security clearance.

Table 2. Government Partners

Government Partners
1. Air Force Life Cycle Management Center (AFLCMC)
2. Air Force Nuclear Weapons Command (AFNWC)
3. Air Force Research Lab-Space Vehicles Directorate (AFRL/RV)
4. Cornerstone OTA
5. Department of Energy National Nuclear Security Administration (DOE/NNSA)
6. Missile Defense Agency (MDA)
7. Naval Research Laboratories
8. NSWC-Crane
9. National Aeronautics and Space Administration (NASA)
10. Office of the Secretary of Defense for Research and Engineering – Trusted & Assured Microelectronics Program
11. Trusted & Assured Microelectronics
12. Sandia National Laboratory
13. Space Systems Command (SSC)
14. U.S. Navy Strategic Systems Program
15. U.S. Air Force & Air Force Materiel Command
16. U.S. Army Combat Capabilities Development Command
17. White Sands Missile Range (SVAD)

1.3.3. Microelectronics Industry Companies

SCALE partnered with 33 private companies (Table 3). These partners have interests in recruiting students with skills in certain technical areas of microelectronics and work with SCALE leadership to advertise internship or research positions to students.

Table 3. Industry Partners

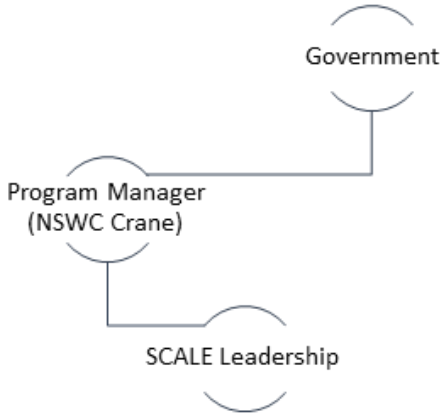
Industry Partners
1. Aerospace Corporation
2. Amentum
3. Analog Devices
4. Applied Materials
5. BAE Systems
6. Blue Origin
7. Boeing Corporation
8. Calumet Electronics
9. Cobham Advanced Electronic Solutions
10. Draper Labs
11. General Dynamics
12. GlobalFoundries
13. IBM
14. Innovative Scientific Solutions Inc. (ISSI)
15. Integra Technologies
16. Intel
17. In-Q-Tel
18. Johns Hopkins Applied Physics Laboratory
19. KBR
20. Keysight
21. L3 Harris
22. Mercury Systems
23. Milanowski & Assoc.
24. MIT Lincoln Labs
25. Northrop Grumman
26. Reliable Microsystems
27. Renesas Electronics
28. Science Systems and Applications Inc. (SSAI)
29. Silicon Technologies
30. SkyWater
31. Taiwan Semiconductor Manufacturing Co.
32. Trusted Semiconductor Solutions
33. Western Digital

1.4. SCALE Groups

The SCALE partners form different groups that help facilitate the overall management and functioning of the program.

1.4.1. Government Oversight Committee

The Government Oversight Committee (GOC) is responsible for overseeing the SCALE workforce development efforts, including those related to the Department of Defense (DoD) program management. The GOC provides feedback, approval, and direction for the SCALE program. The Program Manager for SCALE, based at the Naval Surface Warfare Center, Crane Division, works closely with the SCALE core leadership team to monitor the budget, evaluate the alignment to DoD needs, and provide regular reports to government authorities regarding the program's status. The Program Manager communicates with other members of government to report on SCALE's progress and provide any feedback to the SCALE core leadership.



2 - Figure 2. High-level oversight

1.4.2. Core Leadership Team

The core leadership team consists of Purdue faculty and professionals who lead key components of the program. Each component of the SCALE model (i.e., Partnerships, Student Experience, Knowledge Share, Finance & Administration, Evidence-Based Improvement) has an individual responsible for coordinating those efforts. For example, the SCALE Student Experience Program Lead coordinates student experiences across universities and is responsible for integrating and aligning student experiences across all academic partners. A subset of the team (e.g., the core leadership team) meets regularly to discuss high-level program planning and administration.

3 - Figure 2. Core leadership team structure

1.4.3. SCALE University Consortium

SCALE is made up of a consortium of several academic partners, which provide faculty mentors for SCALE students at each of the universities. Each university has at least one PI who leads SCALE at their university. As part of SCALE, university partners have responsibilities that they must fulfill. These fall under three broad roles of 1) management, 2) knowledge/skills/abilities and curriculum development, and 3) recruiting, research experiences, and mentoring. These roles are described in Section 1.8.

1.4.4. Management Team

The management team includes the core leadership team at Purdue with the addition of the Principal Investigators (PIs) at the academic partner academic institutes. The PIs lead or coordinate the SCALE program at each university site. There is typically one PI for each technical area at each university site. In some instances where there is more than one technical area at a site, there are two or more leads.

1.4.5. Technical Area Leadership

There are one or more technical area leads for each SCALE technical area. Currently, there are leads for RH, SoC, HI/AP, and ESS/AI. The technical area leads are primarily responsible for reviewing and overseeing university programs within the technical area and ensuring that they are following the SCALE model as articulated in each Statement of Work. More information about the responsibilities of the SCALE technical area leads is described in Section 1.7.

1.4.6. GOV/DIB/Industry Partnership Leads

The partnership leads of government and industry work with SCALE leadership to provide information about internships and full-time opportunities that qualified SCALE students can opt to apply for. They also provide information to SCALE leadership about the types of knowledge, skills, and abilities that are needed so that the SCALE program can develop curriculum and training opportunities accordingly. These partners participate in the Career Pathways Working Group (see Section 2 for more details) and provide an appropriate point of contact to the SCALE program to provide current information. The expectation is that the government and industry partners will coordinate with SCALE leadership to provide knowledge/skills/abilities expectations and internship opportunities for SCALE students.

1.4.7. External Evaluation Team

SCALE has a team of external evaluators that serve as an independent source for evaluating the effectiveness of SCALE and aid in determining whether the contractual obligations are being met (Figure 3). The external evaluation team is responsible for evaluating the implementation of the program, consortium functioning, outcomes, and equity and diversity. To do this, they review internal data, conduct case studies, administer a student exit survey, assess symposium participation via a post-event survey, and conduct focus groups/interviews of SCALE PIs/faculty. The external evaluation team submits their findings in a report presented biannually to the funding agency. They also work on other tasks as needed or requested. The external evaluators submit an updated statement of work annually.

4 - Figure 3. Role of external evaluation

1.5. Leadership Structure

The SCALE program is led by faculty at Purdue University with a Principal Investigator (PI), Co-PIs, and key team members who oversee and lead components of the program. There are also PIs at each of the partner academic institutions who lead activities at their universities, delegate responsibilities, and participate in working groups and other meetings as needed.

There are also PIs at each of the partner academic institutions who lead activities at their universities, delegate responsibilities, and participate in working groups and other meetings as needed.

Over time, the SCALE team at Purdue has grown to the extent that several main roles are needed to ensure the effective functioning of the program (Figure 4). These roles are listed below with a brief description.

- **Integrator**: The role of Integrator is held by the Co-Director of SCALE. The Integrator is responsible for overseeing and coordinating the overall operations of SCALE as well as facilitating communication, coordination, and activities between internal and external partners. The Integrator provides oversight to all aspects of the program and ensures the program runs as planned.
- **Partner relations**: This role is led by the other Co-Director of SCALE with the main responsibilities of responding to DoD requests and requirements, recruiting industry, academic, and government partners, and tracking and approving finances, sub-awards, and technology transfer.
- **Model Lead**: The Model Lead is responsible for documenting the model, ensuring that the model is transferable to other subject areas, and overseeing processes of determining how the model is replicated across university sites. The Model Lead also conducts design-based research to document how and why the model undergoes any changes and/or improvements.

- **Career Development Lead**: The Career Development Lead is tasked with translating workforce needs from the DoD, federal government, and DIB into educational needs within four components of the workforce development model: curriculum, research, internships, and full-time employment.

- **Work Experience Lead**: The role of the Work Experience Lead is to better understand the needs of the microelectronics workforce by interviewing employees and collaborating with technical leads to understand the technical skills needed. This individual also collaborates with the Curriculum Lead to transfer workforce needs into the curriculum and to develop learning goals based on the findings. This role also involves creating and maintaining a streamlined and up-to-date system for gathering internship information from both SCALE partner members and students, and overseeing the implementation of this system.

- **Student Experience Program Lead**: This individual coordinates student experiences across universities and is responsible for integrating and aligning student experiences across all academic partners in the consortium. This is achieved by developing standards and processes for student programs, including curriculum for working in defense, mentor training, and student longitudinal engagement. The Student Experience lead also develops and implements scalable mentoring programs that are flexible enough to be adapted across university sites.

- **Knowledge Share Lead**: The Knowledge Share Lead coordinates dissemination of SCALE curriculum, activities, and news via the nanoHUB platform. The Knowledge Share Lead also conducts research on the technical and educational aspects of the tools and learning that takes place as a result of platform usage. This individual also oversees a SCALE group as well as a SCALE PI group on nanoHUB. More information about nanoHUB and these groups is provided in Section 3: Knowledge Share.

> *The **nanoHUB** platform serves over 1.6 million visitors annually and was founded in 2002 at Purdue University as an open and free online platform for computational education, research, and collaboration in nanotechnology, materials science, and related fields. nanoHUB is home to thousands of resources including teaching materials, courses, presentations, and workshops. This platform allows website and app hosting with settings from public to private with limited access, depending on SCALE's needs.*

- **Simulation/Data Tools Lead**: As part of dissemination via nanoHUB, the role of the Simulation/Data Tools Lead is to work with the Technical Leads and faculty to create the technical tools and simulations needed for microelectronics content delivery.

- **Education Coordinator**: The role of the Education Coordinator is to oversee SCALE group management on nanoHUB, including advertising internship opportunities, overall website design, managing access restrictions to SCALE material, and working with SCALE instructors to deploy curriculum materials in nanoHUB. Another key role is working with the curriculum development team to match knowledge, skills, and abilities (KSA) with material and activities and to document SCALE student interventions.

- **Communication and Marketing Specialist**: This individual's role is to provide communications material for SCALE's academic consortium members and help generate and update materials for partners and external organizations with potential interests in SCALE. For example, the Communication

and Marketing Specialist produces the SCALE website and newsletter and determines the frequency and type of content disseminated on social media websites.

- **Business Managers**: These individuals typically work at academic institutions. They are in charge of creating and managing subcontracts with the university consortium members.

- **Managing Director**: The finance and administration components of SCALE are led by a Managing Director who monitors spending and sub-award agreements, manages the consortium, executes the SCALE program according to the specified model, supports SCALE leadership, and leads business management aspects of the program. This role also includes implementing a project management strategy for SCALE and improving and monitoring key programmatic processes, including collecting metric data.

- **Program Specialist**: The Program Specialist serves as the lead administrative assistant. In this role, the individual organizes SCALE meeting times and invitations, coordinates logistics for events, and develops new administrative processes. Another role of this position is to help develop and distribute student recruitment materials and provide support to partner academic sites.

- **Curriculum Lead**: The Curriculum Lead is tasked with developing curriculum, technologies, and pedagogies to recruit and retain engineering students in microelectronics. This includes leading the training of faculty in research-based pedagogies, developing curriculum with microelectronics contexts, developing modules to communicate engineering challenges associated with workforce development needs, and designing and building digital learning technologies to enact microelectronics curriculum successfully.

- **Curriculum Specialist**: The Curriculum Specialist's role is to write and edit curriculum with microelectronics contexts while ensuring that the curriculum is aligned with evidence-based practices.

- **Evaluation/Assessment Working Group Lead**: The role of the Evaluation/Assessment Working Group Lead is to coordinate the internal evaluation of the program, including collecting formative and summative data to inform the program. This individual also coordinates with external evaluators and shares evaluation findings with relevant stakeholders.

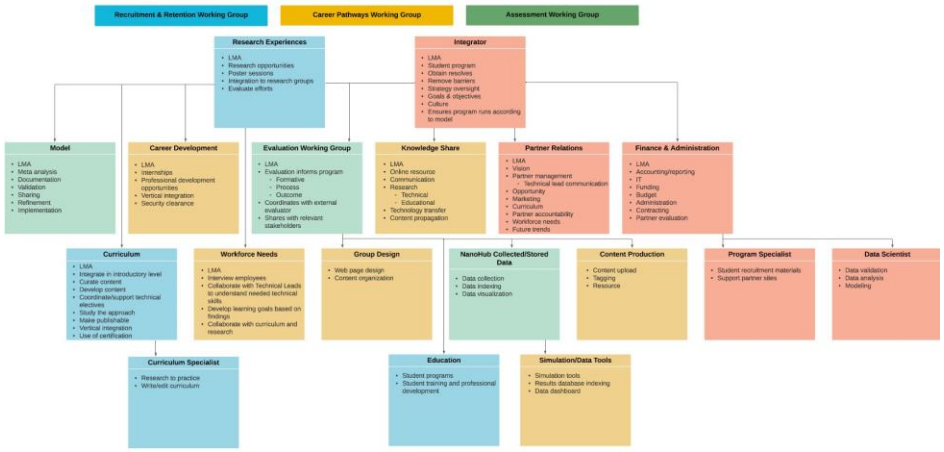
To enact the program successfully, the following roles are recommended:

- Program Director(s)
- Managing director
- Student experiences lead
- Administrative and business support leads
- Knowledge share lead
- Admissions support/processing
- Evaluation lead
- Work experience lead

- Curriculum lead

At the top of Figure 4, there are three main working groups listed: Recruitment and Retention Working Group, Career Pathways Working Group, and Assessment Working Group. These working groups serve to connect and inform the different Leads and Partners on various aspects of the program. The working groups will be discussed in more detail in Section 1.10.3.

In addition to the SCALE team at Purdue, the leadership of the academic partners is key to the successful implementation of the program. Details about the roles of academic partners are described in the following sections.



*5 - **Figure 4. SCALE Leadership Structure and Organization***

1.6. Technical Leadership Roles and Responsibilities

For each technical area (e.g., RH, SoC, ESS/AI, HI/AP), there are one or two PIs that serve the role of Technical Lead. The Technical Leads have the responsibility of ensuring that the following tasks are implemented:

- Review statements of work and spending plans for each PI in the technical area before the new contract. Ensure that there is consistency and consensus within the technical area regarding the experiences and opportunities that students have access to and that there is adequate integration of the students into the SCALE community, in particular with DoD/DIB and quantitative metrics.
- Review and oversee university programs within the technical area to ensure that they are following the SCALE model as articulated in SOWs, including meeting student metrics. Provide feedback and develop plans for improvement when needed.
- Review spending plans for each PI in the technical area with SCALE management quarterly, or as needed, and provide feedback to the PI.
- Coordinate SCALE seminars, workshops, information sessions, and annual meetings for the technical area across the partners.

- Collaborate with SCALE working groups (or delegate to one of the PIs) to develop a Knowledge, Skills, and Abilities (KSA) portfolio for students and strategize its delivery (although the Workforce Needs Group is leading this effort, they will still require input).
- Hold regular meetings with SCALE PIs in the technical area to discuss student experiences, program implementation, and facilitate information sharing.
- Ensure PIs from the technical area are active in the working groups (e.g., Assessment Working Group) and communication about activities is shared appropriately and effectively across the technical area.
- Make recommendations to Purdue SCALE directors for funding allocation based on performance, capacity, and needs/opportunities.

1.7. Consortium PI Roles and Responsibilities

For each university, there are approximately one to two PIs. Generally, if there is more than one PI at a university it is because there is more than one technical area represented there. The main responsibilities of SCALE PIs fall within four areas: 1) management, 2) KSA and curriculum (e.g., formal and informal learning) development, 3) recruiting, research experiences and mentoring, and 4) metrics collection/target achievement (Figure 5). These responsibilities ensure that the program is implemented with fidelity at each academic partner institution and that the important components of the SCALE program are not omitted. Details about each responsibility are provided below.

6 - Figure 5. PI roles and responsibilities

1.7.1. Management

- Execute sub-awards based on DoD financial guidelines of April 1 – March 31 fiscal years.
- Execute sub-awards based on commitments in SOWs and modify SOWs based on feedback from the SCALE Sponsor, SCALE leadership, and Technical Lead(s).
- Work with other universities in the Technical Vertical to create and share content, share and implement best practices for SCALE cohort support and mentoring, share mentoring and programs, and publish resources on nanoHUB.
- Provide quarterly reports by the requested deadline.

1.7.2. KSA and Curriculum (e.g., formal and informal learning) Development

- Collaborate with SCALE curriculum and pedagogy faculty to integrate the identified KSAs into classes and/or develop new classes.
- Develop and maintain a list of offerings at each university to deliver KSAs.
- Develop and deliver microelectronics content in introductory level and upper-disciplinary courses as modules.
- Post at least one new curriculum unit or tool on the nanoHUB website each year for others to use.

1.7.3. Recruiting, Research Experiences and Mentoring

- Help recruit students into SCALE by giving presentations to student organizations, particularly identity-based engineering organizations (e.g., women in engineering; minorities in engineering).
- Work with SCALE leadership to determine whether recruitment efforts are successful and develop an orientation process for new SCALE students.
- Provide microelectronics research opportunities starting at the first year or second year undergraduate (whether on a paid basis or for course credit) and continuing through graduation.
- Provide effective mentoring for the students across the board (by faculty, graduate students, peer mentors, class instructors, and/or advisors). Provide assessments of the quality of the mentoring of SCALE students and for the graduate students mentoring the SCALE students.
    - Mentoring includes working with individual students on career counseling and developing plans to meet KSAs for the technical area.
    - Connect students with the Department of Defense and defense industrial base in seminars, research, and internships.
    - Help students obtain internships between the first and second year at DoD partner companies, government laboratories, partner universities, or Summer Undergraduate Research Fellowship (SURF).
- Attend the annual SCALE Symposium.

1.7.4. Metrics Collection/Target Achievement

- Achieve targets for metrics as agreed upon by the SCALE sponsor, SCALE leadership, the Technical Vertical lead, and the PIs in the technical vertical.
- Respond to metrics data collection/assist with collection of metric data as requested.
- Attend SCALE working groups.

1.8. SCALE Faculty Roles and Responsibilities

There are typically one or more SCALE faculty members at each university who are funded by SCALE and who are neither PIs nor technical leads. These SCALE faculty members have certain responsibilities as part of the SCALE program. It is the responsibility of the PIs at each institution as well as SCALE leadership to oversee the faculty and ensure that faculty meet the following obligations, as applicable.

- Participate in SCALE seminars and information sessions, develop a KSA portfolio for students, and translate KSAs into classes, research, and mentoring for the students at the top level.
- Develop and deliver microelectronics content in First Year Engineering and disciplinary courses as modules.
- Help recruit students into SCALE and follow up with recruited students to identify opportunities for them.
- Provide microelectronics research opportunities starting at the first year or second year undergraduate (paid or for credit) and continuing through graduation.
- Obtain funding for research (SCALE pays for undergraduate researchers and selected quarter-time research assistants for US citizen graduate students).
- Provide mentoring of SCALE students and for the graduate students mentoring the SCALE students.
- Help students obtain internships between the first and second year at DoD partner companies, government laboratories, partner universities, or other undergraduate student research experience programs.
- Work with Engineering Education faculty to determine whether programs are effective and how to change them.
- Work with other universities in the Technical Vertical to create and share content, share and implement best practices for SCALE cohort support and mentoring, and share mentoring and programs.
- Connect students with the Department of Defense and defense industrial base in seminars, research, and internships.

1.9. Partner Management

Effectively managing the diverse array of partners from various institutions, each with distinct technical requirements and areas of expertise, is a crucial responsibility within the SCALE program. One goal of SCALE is that the program structure is consistent across academic institutions. To achieve this, each university should have a management process in place to execute the program with fidelity. KSA and curriculum development should take place within the technical areas at each academic institution, while recruitment, research experiences, and mentoring should be similar across institutions. SCALE academic

partners need to provide and meet certain metrics providing evidence of fidelity and whether specified targets were met.

1.9.1. Production Method

The SCALE program is unique because while the client that SCALE reports to is the DoD, the program must also be responsive to the needs of other key stakeholders that it serves, such as students. SCALE leadership identified a need for an internal, experienced managing director with expertise in large-scale engineering project management. After an individual who met those qualifications was hired, a lean project manufacturing system[1], along with other management strategies, was incorporated into SCALE. The goal of the lean manufacturing process is to streamline processes and procedures to eliminate waste and maximize productivity. See Appendix 1 for details about this system.

[1] Lander, E., and J. K. Liker. 2007. "The Toyota Production System and Art: Making Highly Customized and Creative Products the Toyota Way." International Journal of Production Research 45 (16): 3681–3698.

1.9.2. Partner Support and Program Participation

With an ever-growing list of university partners spanning throughout the U.S., as well as leadership's experiences with varied participation and adherence to the SCALE model among partners, a method was needed to more systematically assess how each partner was performing. To do this a rubric was developed to rate SCALE partnerships to enable the identification of strengths and weaknesses, focus on addressing any weaknesses, and have a more systematic and fair process for assessing and comparing partners. The rubric can be found in Appendix 2. The rubric covers the following topics that were deemed important by the funding agency and SCALE leadership (Figure 6).

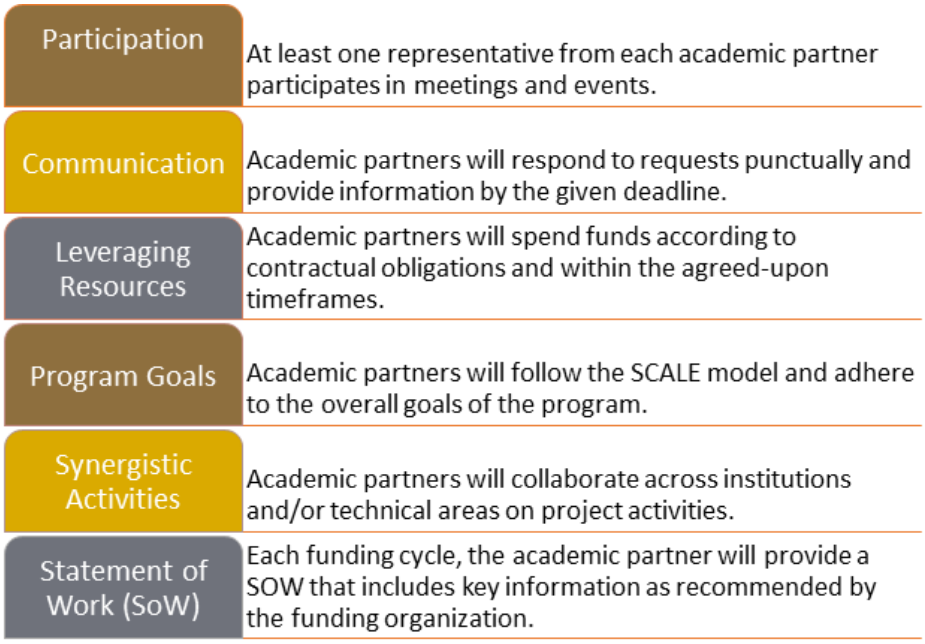


Figure 6. *Key Elements of an Effective Partnership in SCALE*

1.10. Synergistic Activities

The SCALE consortium holds events and meetings to provide members the opportunity for SCALE team members and leaders to collaborate, share content, learn more about SCALE processes and outcomes, and enable the external evaluators to collect important formative program information. The main events are the SCALE Symposium, vision building day, quarterly meetings with key members of the leadership team and technical leads/PIs, and the SCALE working groups.

1.10.1. SCALE Symposium

The largest event that SCALE holds is the SCALE Annual Symposium. This event takes place annually in May and all leadership, including PIs, technical leads, and funding agency representatives are invited. The event is typically held over one and a half to three days at Purdue University. All travel costs including meals are provided by the grant funds. The event usually consists of a day of presentations about SCALE, including metric data, results of surveys, plans for the future, the SCALE model, and any new initiatives or updates. There are also opportunities for the external evaluators to hold focus groups or interviews with PIs, roundtable discussions for various groups, and collaborative working time. For example, a major part of day 2 for the May 2023 meeting included technical leads and PIs in groups to develop a Quad Chart of activities they are working on, barriers or challenges, and work they want to accomplish in the future. After completing the quad charts, they will begin developing statements of work to submit in the following month which outlines their plans for the upcoming year.

1.10.2. Vision Building Day

One unique feature of the SCALE program is that there is one client, the DoD, yet there are many different stakeholders whose needs must also be prioritized for effective program functioning (e.g., students, technical leads). To better meet these expectations, SCALE held a one-day Vision Building Day to accomplish three key tasks: prioritize a list of challenges that SCALE is facing with strategies to overcome the challenges, create a shared team calendar, and select a list of core values for SCALE. Vision building day is described in greater detail in Section 4: Finance and Administration.

1.10.3. Working Groups

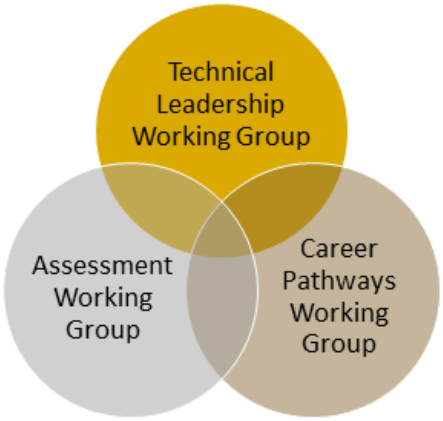
SCALE holds monthly working groups for PIs, technical leads, and other interested stakeholders to meet and discuss issues relevant to the working group. The working groups are: the Technical Leadership Working Group, the Assessment Working Group, and the Career Pathways Working Group. A description of each group follows.

Technical Leadership Working Group – This TLWG is led by the project's Director. The group consists of the technical leads of each area. The purpose of the TLWG is to enable the technical leads to work more directly with their PIs and to address workforce development programming that is across the technical area. This group meets monthly.

Assessment Working Group (AWG) – The AWG group meets once per month with SCALE PIs and technical leads. The purpose of the group is to share updates and news related to evaluation and assessment, including data collection, results, and metrics. The meeting also promotes discussion around evaluation and emphasizes the importance of collecting information to inform the program.

The Assessment Working Group meets monthly to share updates and discuss evaluation results with SCALE PIs and technical leads.

Career Pathways Working Group (CPWG): The CPWG consists of representatives of the Public- Private-Academic Partnership (PPAP) and is tasked with translating workforce needs from the DoD, federal government, and DIB to align with employer needs assessments, professional and technical certifications, and the workforce development model (i.e., curriculum, research, and internships). Members provide information about workforce needs and facilitate undergraduate and graduate internships in their corresponding technical areas of need. This includes leveraging existing relationships with US DoD agencies and their contractors, as well as offering internships at the SCALE partner university, where possible. Identified career paths will include employment after completion of a bachelor's degree as well as employment after completion of graduate education (MS or PhD). The CPWG meets at least once per academic term generally by teleconference.



*7 - **Figure 7.** SCALE Working Groups*

1.11. Key Successes

There were several noteworthy successes within the area of Partnerships for the SCALE program. These successes included:

- Engagement: There was a high level of engagement from many of the PIs and technical leads in working groups, the symposium, and other SCALE events. Because SCALE should be replicated with fidelity across academic institutions, engagement in SCALE meetings and events is essential to stay informed.
- Collaboration: SCALE has had several cross-area projects and inter-university research collaborations. SCALE leadership has also formed partnerships with diverse intuitions.
- Lean management system: A managing director was hired to improve SCALE's processes and efficiency and ensure that the project could function at the highest capacity.

1.12 Key Challenges

There were several barriers and challenges that SCALE experienced at varying times throughout the project. The barriers can be categorized into two main areas: 1) cross-institution issues and 2) SCALE processes.

Cross-institution issues:

- Because of the diversity of the academic partners in SCALE, there are sometimes inequities and inequality of opportunities from site to site.
- It can be difficult to develop content for SCALE courses due to restrictive university policies regarding course ownership. There may also be university policies regarding content sharing and conflicts of interest.
- Sharing course content across institutions may not be possible due to policies limiting or prohibiting cross-university credits for students.
- Time and scheduling can cause issues because each academic institution has varying course schedules and semester start/end dates.
- There was no individual in charge of coordination and collaboration between academic institutions that could help with some of these issues.

SCALE processes:

- In some instances, PIs are not aware of forms or surveys that need to be submitted and deadlines are missed. Because communications arrive via email, sometimes these forms or surveys are overlooked.
- Data management requires a lot of hands-on work to clean and get into a format suitable for analysis.

1.13 Recommendations

Based on our experiences with the partnership component of the SCALE Workforce Development model, we offer the following recommendations for large workforce development programs regarding partnerships.

- Define roles and develop an organizational structure at the beginning of the project.
- Provide opportunities to develop buy-in and understanding of the organizational structure.
    - Include time for team building in order to better understand everyone's role and enable mutual respect.
- Develop conventions and processes to facilitate communication and sharing across organizations and team members.

    - Designate a person to serve as a communications hub to organize and disseminate information.

- There should be a careful and strategic onboarding of new partners, particularly university partners.
- The project functions cannot be done in silos – everyone must be aware of what others are doing to ensure efficiency and that efforts are not duplicated.
- The administrative side of SCALE is critically important to ensure important work gets done. There should be individuals who can fill these roles not only for the lead institution but a designee at each institution.
- Create opportunities for the team to share research, literature, and occasions to build knowledge about the different aspects of the project.
- Create opportunities for the team to develop and discuss processes to improve the efficiency of the project and overcome barriers.

Links to Model Documentation

Partner Relations

The main goal of the Partner Relations component of the SCALE model is to leverage the expertise and capabilities of microelectronics partners from all sectors, including public, private, and academic institutions, to contribute to the scalability and replicability of the microelectronics workforce.

https://sway.cloud.microsoft/q7u8JKL8NEEvKEHn?ref=Link

Student Experience

The SCALE student experience aims to integrate microelectronics exposure and training from the K-12, undergraduate, graduate, and professional levels. The goal of the undergraduate and graduate-level SCALE student experience is to expose, motivate, and prepare students from diverse backgrounds in engineering and engineering technology with the skillset and mindset for careers in defense-related microelectronics.

https://sway.cloud.microsoft/i1KZVKzVAgbPDAid?ref=Link

Knowledge Share

The purpose of the SCALE knowledge share component is to disseminate the knowledge generated by the SCALE program both internally and externally, which includes technology transfer to industry to serve defense and security needs. This includes sharing technical knowledge, creating collaborative partnerships between the SCALE consortium members, and sharing the SCALE model with other external programs.

https://sway.cloud.microsoft/foGVkck25Mo9umkU?ref=Link

Finance and Administration

The primary goal of SCALE's finance and administration component is to enable smooth and efficient program operations both internally at the prime institution and with the academic partners external to Purdue. Finance and administration are key components of the SCALE program as they permit the efficient management of SCALE's resources.

https://sway.cloud.microsoft/BM1bxFRXq6LheG6d?ref=Link

Evidence-Based Improvement

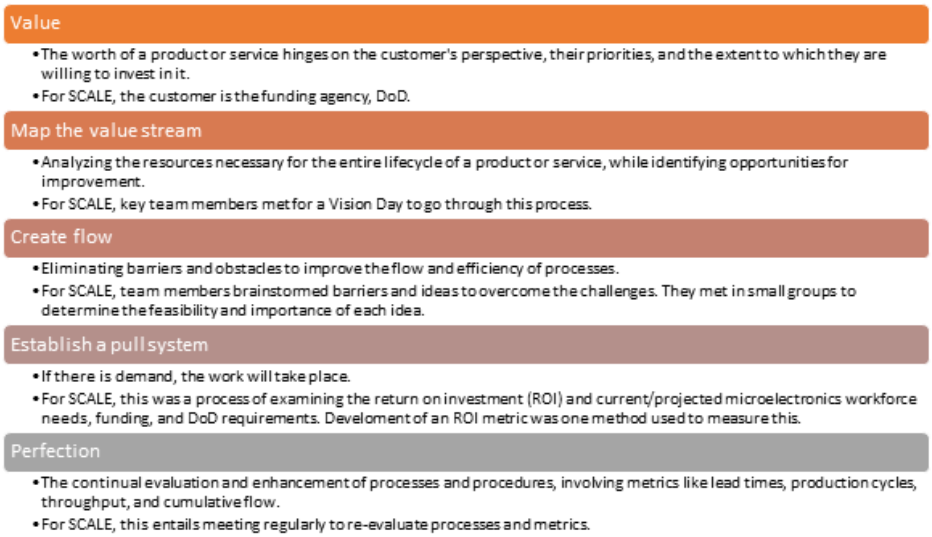
The goal of SCALE's evaluation is to provide a holistic evaluation leading to evidence-based improvement. The SCALE evaluation uses a holistic approach to evaluation, including outcome-based metrics, process evaluation, external evaluation, site-specific evaluation, and financial return on investment to provide a comprehensive understanding of the program.

https://sway.cloud.microsoft/nYz3HSHBN0YDFuIc?ref=Link

Appendices

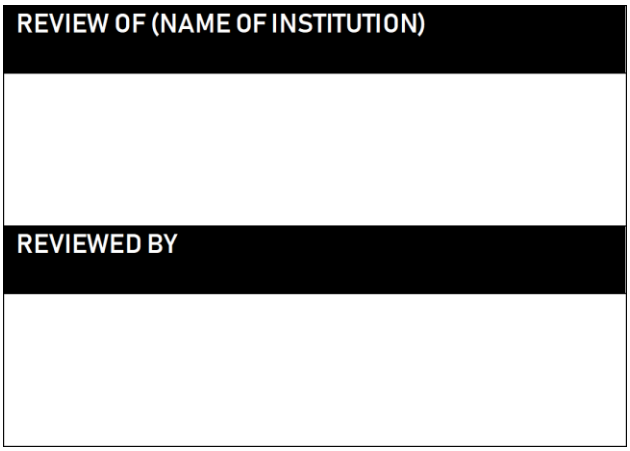
Appendix 1. SCALE Management Structure

This system operates based on five principles:



This management structure allows for a focus on processes and efficiency. Leadership by an experienced project director is critical to success as well as meeting in small groups to ideate and determine how to move forward.

Appendix 2. SCALE Partnership Rubric



INSTRUCTIONS

The purpose of this rubric is to provide a rating of the SCALE university partnership on several key aspects of the partnership for evaluation purposes. The rubric contains five aspects of a quality partnership, including participation, communication, leveraging resources, program goals, and synergistic activities. Finally, the rubric also contains a category for rating each university's Statement of Work (SOW) to ensure that each one contains the necessary components for the workforce development partnership. Each category contains a description of the broad category, followed by the specific objectives that are rated.

Ratings are given on a Yes/No basis; either there is evidence that a university met the objective or the evidence shows that the university did not meet that objective. If no evidence can be obtained to determine whether a particular objective was met or not, then an explanation can be included in the Comments section and the objective should not be given a rating. The Comments section can be used to justify the rating or include any relevant comments for the objective. If a university exceeded expectations toward a specific objective, such achievements can be acknowledged in the Comments section.

Scoring Rubric

Category	Category Description	Objectives	Yes	No	Comments
Participation	At least one representative from each university participates in meetings and events. If more than one technical area is represented at a university, someone from each technical area should be present. Representative contributes ideas and suggestions or asks questions.	Attends at least 80% of working group meetings annually	Yes	No	
		Attends SCALE symposium in person (may attend virtually if approved beforehand)	Yes	No	
		Actively participates in meetings/events	Yes	No	
Communication	Responds to requests punctually and provides information by the given deadline.	Responds to requests for student metrics/information by the deadline twice/year	Yes	No	
		Submits deliverables by deadlines (e.g., SOWs, spend plans)	Yes	No	
Leveraging resources	Universities will spend funds according to contractual obligations and within the agreed-upon timeframes; leverages SCALE to seek additional funding.	Spends funds accordingly and within requested timeframes	Yes	No	
		Obtains or seeks additional funding to augment SCALE work	Yes	No	
Program goals	Universities will follow the SCALE model and adhere to the overall goals of the SCALE program.	Achieves goals (on a quarterly basis) as stated in the approved SOW	Yes	No	
		Develops/delivers microelectronics content into courses or classrooms	Yes	No	
		Publishes at least one new curriculum unit or tool on nanoHUB	Yes	No	
		Provides mentoring for SCALE students or graduate student mentors	Yes	No	
		Helps to recruit students into SCALE by giving presentations, holding events, or other outreach activities.	Yes	No	
		Provides microelectronics research opportunities for students at both the undergraduate and graduate level.	Yes	No	
Synergistic activities	Collaboration across institutions and/or content areas (e.g., RH, HIAP) on project activities (e.g., research).	Collaborates with other partners to create and share content, support student mentoring, and other program activities.	Yes	No	
Statement of work (SOW)	Each funding cycle, the university will provide a SOW. The SOW must include key information as recommended by the funding organization.	SOW includes a recruitment and retention plan	Yes	No	
		SOW includes a plan for knowledge share	Yes	No	
		SOW includes information about internship/full-time hiring	Yes	No	
		SOW includes plans for contributions to the PPAP consortium	Yes	No	
		SOW includes information on collaboration in curriculum and teaching	Yes	No	
		If followed, SOW will meet contractual requirements	Yes	No	
		SOW includes spend plans	Yes	No	

SCALE
SCalable Asymmetric Lifecycle Engagement

2. Student Experience

2.1. Goals

The SCALE student experience aims to integrate microelectronics exposure and training from the K-12, undergraduate, graduate, and professional levels. The goal of the undergraduate/Bachelor-level SCALE student experience is to expose, motivate, and prepare students from diverse backgrounds in engineering and engineering technology with the skillset and mindset for careers in defense-related microelectronics (ME). By taking introductory courses that include microelectronics contexts and content integration, students will gain exposure to microelectronics topics and a greater awareness of microelectronics. Students taking SCALE coursework will be immersed in technical-area content to develop their knowledge, skills, and abilities (KSAs) in microelectronics. SCALE students will also participate in a variety of experiences such as seminars, research experiences, co-ops, and internships where they will additionally gain an understanding of the need and societal benefit of defense-related microelectronics careers to further motivate them to pursue further study or careers in this field.

At the graduate level, the goal of the SCALE student experience is to prepare Master's and Ph.D.-level students with KSAs for careers in defense-related microelectronics. Graduate students will develop deep expertise in specialized aspects of ME relevant to SCALE while developing a professional network to launch a career in defense ME research.

The student experience includes the following technical objectives in order to train and motivate students to pursue defense-related microelectronics careers or further training: recruitment, security, curricular innovation, and projects, research, and internships (Figure 1).

1 - Figure 1. Scope and technical objectives of the SCALE student experience

2.2. Features

The Student Experience component of the SCALE model consists of several types of student experiences:

1. SCALE undergraduate and graduate students paired with one or more mentors
2. Undergraduate courses focused on microelectronics
3. Undergraduates in introductory engineering courses (e.g., First-year engineering courses/ENG131)
4. Seminars and special events focused on microelectronics topics
5. Research experiences for undergraduate and graduate students
6. Internships and co-ops with partner institutes/companies for SCALE students
7. Microelectronics course modules integrated into introductory engineering courses (targeted for non-SCALE students)

SCALE also includes other types of related programs that have related, but distinct goals. These SCALE programs include the Center for Secure Microelectronics Ecosystem, the Micro-Electronics Security Training Center, and SCALE K-12. These programs are described briefly below.

2.2.1. Center for Secure Microelectronics Ecosystem (CSME)

The Center for Secure Microelectronics Ecosystem (CSME) is an industry-supported program that engages graduate students to conduct research and training in DoD areas of need. The Center for a Secure Microelectronics Ecosystem (CSME) is a public-private-academic partnership that aims to address key challenges in securing the microelectronics supply chain. graduate students will be trained to work on scientific questions of relevance to a secure microelectronics supply chain assuming a zero-trust model, contributing to the development of a future workforce that is ready to address the challenges of designing secure microelectronics. On the other hand, critical research that can typically not be addressed in industry or government-only settings will be part of the CSME research endeavor. To ensure that the center leverages leading academic talent to achieve impact, CSME brings together multiple academic institutions across the U.S. to collaboratively pursue common research goals.

2.2.2. Micro-Electronics Security Training Center (MEST)

One of SCALE's goals is to provide opportunities to current DoD and DoD-adjacent employees to broaden their skills and gain exposure to new technical content. The Micro-Electronics Security Training Center (MEST) has partnered with SCALE in order to help fulfill this goal. MEST's primary aim is to establish and implement a distinctive educational and training program on an asynchronous online platform. This program is designed to equip a highly skilled cybersecurity workforce across various government agencies, national laboratories, and industry sectors. Many of MEST's resources are accessible through the online platform through a partnership with nanoHUB. The overarching goal is to expand the reach of this program to a broader audience, encompassing undergraduate and graduate students, as well as professionals.

2.2.3. SCALE K-12

The goal of SCALE K-12 is to develop educational materials in partnership with teachers and schools that address SCALE KSAs for incorporation into K-12 schools and summer programs in a scalable way to educate and excite students about ME and increase interest in joining the BS+SCALE program. The SCALE K-12 program does this by co-developing curricular units (including teachers, education researchers, and microelectronics experts) that feature microelectronics contexts and topics with related teacher professional development. The curriculum is vertically integrated so that students will learn about microelectronics topics with STEM content aligned to their grade-level standards.

Although the K-12, MEST, and CSME are important components of the vertically integrated SCALE program, only the original SCALE undergraduate and graduate level programs will be discussed in detail throughout this model guide. Contact the directors of each of those programs if you have any questions.

2.2.4. Features of the Graduate-Level SCALE Program

Approximately 22% of active students in SCALE participate at the graduate level. For this group of students, the focus is on research and training related to specialized microelectronics topics. For graduate-level students, the SCALE program provides:

1. new **elective courses** in specialized areas of ME
2. **fellowships and traineeships** supporting graduate students to work on SCALE-specific research topics
3. organization of **research review meetings**
4. opportunities for **networking** with professionals in defense ME

2.2.5. Features of the Undergraduate-Level SCALE Program

Most students participating in SCALE are undergraduate-level students. For this reason, the model guide will focus primarily on the SCALE program for undergraduate/Bachelor-level students. For this group of students, the SCALE program provides the following:

1. **modular curricular units** implemented in introductory-level courses across SCALE universities. These units integrate microelectronics contexts with the course content to expose students to microelectronics and the importance of microelectronics in defense while providing rigorous instruction in course content.
2. new **elective courses** in specialized areas of ME across relevant engineering disciplines
3. a **certificate** in microelectronics affiliated with SCALE
4. informal curricula that can be integrated into outreach activities in partnership with professional societies
5. SCALE-focused **research symposia**

6. additional opportunities for students to **develop professional skills** needed for effective careers in microelectronics

2.3. SCALE Student Classifications

At the undergraduate level, SCALE students can have one of three classifications to designate the level and type of involvement in SCALE. These include a Trainee, Affiliate Plus, and Near-Peer Mentor. Students can change classification during their time in SCALE depending on the circumstances. For example, a student could participate in mentored research one semester and the following semester they could take SCALE classes without having regular communication with a SCALE mentor.

The **SCALE Trainee** is an accepted SCALE undergraduate student who is assigned a faculty or graduate student mentor and is involved in mentoring circles with industry/government partners. The Trainee receives SCALE funding to perform microelectronics research along with access to SCALE program benefits (e.g., nanoHUB, SCALE events, internship assistance).

A **SCALE Affiliate Plus** designates an accepted SCALE undergraduate student who is assigned a faculty advisor and who is involved in mentoring circles with industry/government partners. Affiliate Plus students receive funding external to SCALE to perform research or engage in internships/co-ops. The students still have access to SCALE program benefits.

A **SCALE Near-Peer Mentor** is an accepted SCALE undergraduate student who has volunteered to help guide and informally mentor their peers. These students generally have experience in SCALE or are upper-level undergraduates who have the knowledge and/or experience to guide and mentor newer SCALE students.

Finally, a **SCALE Graduate Student** is a graduate student who is working on a SCALE-related project under a SCALE faculty member. SCALE graduate students can also serve as mentors and can also have mentors from industry and government.

2.4. SCALE Program Offerings

SCALE provides a variety of options for involvement in the program. At a minimum, SCALE students are required to participate in at least one of the following activities each semester:

- Take special topics courses important to the student's preferred technical area
- Participate in microelectronics-focused senior design projects
- Present their work in a student research conference
- Help with on-campus/virtual recruiting via fairs, clubs, and other student activities
- Participate in multi-disciplinary research projects within SCALE or with SCALE partners
- Pursue internship, co-op, or research experiences with SCALE-affiliated government agencies or private industry partners

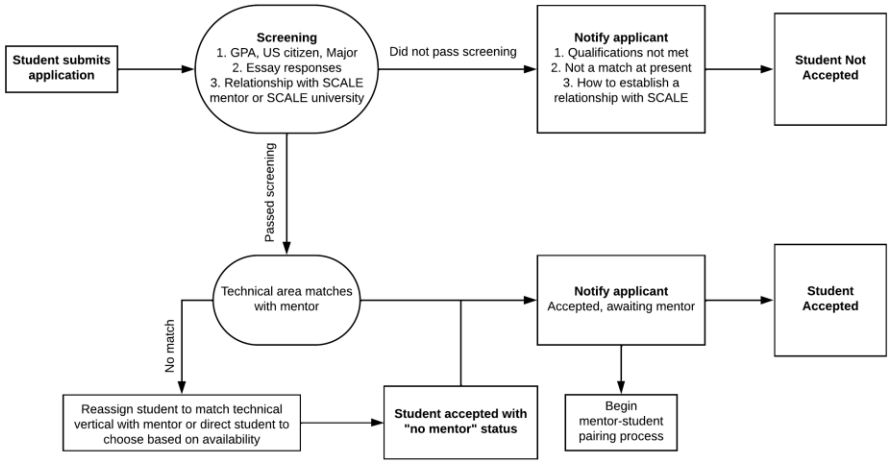
SCALE students and potential SCALE students typically participate in a mix of SCALE offerings depending on their year of study. The activities that students typically participate in by year of study are outlined in Figure 3. These activities may vary slightly by university.

2 - Figure 3. SCALE student and potential student activities by year of study

2.5. The Student Application Process

Students who join SCALE are required to fill out the SCALE application. The application is accessible via a link on the Purdue SCALE website and connects to a Qualtrics survey that asks students their demographic information, education background and status, interest in SCALE, and requires them to upload a resume and transcripts. Students can apply to SCALE and can be accepted on a rolling basis.

Every week, SCALE personnel check the new applications and screen the application for three key criteria: GPA, US citizen, and major. If any of the three qualifications are not met (e.g., GPA is under the minimum) then the applicant is notified and the student is not accepted into SCALE. The second step is to screen the applicant for their responses to the essay questions in the application. The essay responses are screened by the managing director and the student experiences lead. If responses are acceptable, the student is screened for whether they have a relationship with a SCALE mentor or whether they are from a SCALE partner university. If students meet either of these criteria, the next step is to ensure that the student's technical vertical matches with the technical vertical of the mentor that they selected (if they are admitted based on listing a SCALE mentor that they will work with). At this point, students can be reassigned to another technical vertical, accepted to SCALE without a mentor, or accepted with a mentor. The applicant is notified of acceptance and next steps; if students do not have a mentor at this point, the student experience lead will fill this role until a suitable mentor is found. The entire process takes two weeks or less from the time that the student submits their application (Figure 4).



After a student is accepted into SCALE, emails are sent to faculty for the purpose of pairing students with a mentor. Box 1 displays a sample email sent to a faculty mentor if a student named them in the application.

Students can apply to SCALE and can be accepted on a rolling basis.

Box 1. Example email templates sent to potential faculty mentors

Template Email for Faculty Named in Student's Application

Hi [Faculty Member Name],

[Student Name], a SCALE applicant, has requested you as their mentor. This student's information can be found in the Excel spreadsheet [here] with you listed under the "Faculty Mentor" heading. The student's resume and transcript can be found [here]. Please review the application and determine whether the student is a good fit to be your mentee, whether they should work with a different colleague, or whether they are not suited to be in the SCALE program at your university. Please update the Excel spreadsheet category "Accept/Reject" accordingly.

2.6. Onboarding

Onboarding is the process of supporting a student or employee through their first year to introduce and foster their understanding of the organization or program's culture, impart foundational knowledge about the program/organization, and provide social connections that enable the student/employee to see how they fit into the team and why their work is important. SCALE uses the DoD Onboarding Guide[1] as a framework to guide new SCALE students through the onboarding process.

One of the benefits of having an onboarding process in place is to increase retention and productivity. The DoD Onboarding Guide provides a list of best practices for onboarding, which can be used to onboard students in a workforce development program (see Box 2).

Box 2. Best practice themes of onboarding (DoD Onboarding Guide).

- Provide information incrementally.
- Provide information and social connection incrementally; make sure to clearly communicate to the new hire that their colleagues care about them.
- Onboarding must include three dimensions: workplace culture, knowledge, and social connection.
- Involve multiple levels (e.g., peers, manager, leadership) to improve connection to the organization as a whole.
- Provide opportunities for two-way communication (i.e., share information/provide feedback and ask what the new hire may need).
- Onboarding information can begin with standard content that progresses to individualized content over the last 6-12 months.

Worksheets and/or checklists can be used to ensure consistent and quality onboarding.

Worksheets and/or checklists can be used to ensure consistent and quality onboarding. These checklists are aligned to the following chronological periods: pre-boarding, first day (welcome), first week (building familiarity), first 90 days (acculturation), and first 6-12 months (continual development). Examples of what SCALE does at each of the onboarding stages are provided in Figure 5.

3 - Figure 5. Onboarding periods

2.6.1. Onboarding for SCALE students

When a student is accepted to the SCALE program, a welcome email is sent out (see Box 3 for a template). Students are asked to reply to that email stating their agreement with the expectations. Additionally, students are sent a SCALE Onboarding packet. This packet provides information about the SCALE program and technical areas, expectations for SCALE students, how to maximize benefits, contact information for various key personnel (e.g., student experience lead), and how to sign up for and/or navigate the nanoHUB group, SCALE Web App, and the SCALE Job Board. Finally, the packet provides students with information about attending orientation meetings. These meetings are held monthly via Zoom and students are encouraged to attend one of these meetings, which are led by the SCALE student experiences lead.

Box 3. SCALE new student welcome email template

Dear <<first name>>,

Congratulations and welcome to SCALE! You have been accepted into the SCALE student program. We are excited to have you as part of our SCALE community, working with your mentor(s), <<mentor>>. Participants who have already performed research with a faculty advisor and/or graduate student mentors have already experienced one of the primary benefits that SCALE offers. Below are other benefits you can expect from being part of SCALE as well as the expectations for students accepted into the SCALE program. To fully reap the benefits, we will work with you to identify ways to get involved in these opportunities. Your commitment to participate is expected and required. Please review and indicate your agreement to these expectations by replying to this e-mail.

To access private material available only to SCALE students, please register for a nanoHUB account using the InCommon login with your institutional credentials here: [link here]. Next, request membership to the nanoHUB SCALE group page here: [link here].

Benefits:
The SCALE Community of Practice with students and faculty at SCALE partner universities includes the following benefits:

1. Career mentoring, including identifying courses and other opportunities in microelectronics
2. Special activities to expand your network of professional contacts
3. Documentation of your job-relevant knowledge, skills, and abilities in microelectronics that helps you communicate effectively with companies and others about future jobs
4. Paid academic year and summer research opportunities
5. Opportunities to initiate multi-disciplinary research projects across universities and with company and government partners

The SCALE Community of Practice with government agencies and private industry partners includes the following additional benefits:

1. Paid internship placement at SCALE government and industry partners
2. Sponsored research and design projects, including Senior Design and VIP
3. Mentoring and open interactions (virtual or in-person) year round
4. Entering multiple, exciting career pathways in microelectronics with future growth
5. Developing technologies that benefit society
6. Collaborating with engineers around the US and the world
7. Fostering national security and global competitiveness

Expectations from students:

1. Maintain academic standing with a GPA at or above 2.80
2. Meet with your SCALE advisor regularly, at least twice per semester
3. Respond to all requests for information like feedback surveys, end of the semester reviews, and other opportunities asking for student experience feedback.
4. Participate in the SCALE Community of Practice by monitoring the schedule of SCALE activities and engaging in ***at least one*** of the activities listed below each semester:
    a. Take special topics courses important to your preferred technical area
    b. Participate in microelectronics-focused senior design projects
    c. Present your work in a student research conference
    d. Help with on-campus / virtual recruiting via fairs, clubs, and other student activities
    e. Participate in multi-disciplinary research projects within SCALE or with SCALE partners
    f. Pursue internship, co-op, or research experiences with SCALE affiliated government agencies or private industry partners

If you have any questions, please reach out to us via SCALE@purdue.edu. Thank you!

Best Regards,
SCALE Leadership

In the first month of beginning SCALE, students are expected to complete the following tasks:

1. Create a nanoHUB account and join the SCALE group
2. Review the rest of the SCALE Welcome Packet
3. Sign into the SCALE Web App through the nanoHUB and update their profile
4. Follow SCALE's Social Media accounts

5. Join the SCALE Discord

Within the first semester of joining SCALE, students are expected to complete the following tasks:

1. Review the list of SCALE Opportunities and begin thinking about their first SCALE goals
2. Identify the types of mentoring relationships they would like to form within SCALE
3. Access the SCALE Job Board and familiarize themselves with the site
4. Plan to attend a SCALE Orientation Meeting with the Student Experiences Lead by the end of their first semester.

[1] DoD Onboarding Guide", US Department of Defense, Defense Civilian Personnel Advisory Service, internal document.

2.7. Mentoring

SCALE students are paired with a mentor following acceptance to the SCALE program (see Section 2.5. for the application process). Many students who apply already know a faculty member whom they already work with or who has encouraged the student to apply. In these cases, the application contains a field that allows students to select whether or not they already have a mentor and write in their mentor's name. SCALE staff follow up with the mentor and the faculty member will have the opportunity to confirm that the student will be mentored by them or suggest another mentor. Students who do not have a mentor when they apply to the SCALE program are assigned to be mentored by the student experience lead until a more permanent mentor can be established In rare circumstances (e.g., in the first few years that the SCALE program was established), students will not have a mentor; however, SCALE makes every opportunity to pair the student with a mentor because of the greater benefits to students.

The mentors of SCALE students are expected to meet regularly with the students and help guide them throughout the SCALE program so that they can reap the most benefits. The mentors should also encourage students to follow all of SCALE's expectations (e.g., completing surveys). At a minimum, a SCALE mentor is expected to do the following:

- Provide career counseling
- Assist in development plans for Knowledge, Skills, and Abilities (KSA's)
- Connect students to DoD/DiB via seminars, research, and internships
- Help students obtain internships
- Meet with students at least twice per semester in a SCALE advisor capacity

The SCALE team has adopted several research-based guiding principles to achieve the highest mentoring quality and capacity (see Box 4). These principles are used to guide leadership in making decisions about student mentoring. For example, all students who apply to SCALE will be paired with a mentor. If a faculty mentor is not available then a graduate student or a near-peer mentor (undergraduate) can serve

in a mentor role. Expectations for mentoring are shared with mentors to help them understand the importance of mentoring for the student as well as for themselves.

Box 4. Mentoring philosophies and guiding principles for SCALE

- Having a mentor can be beneficial in both professional and personal aspects of our lives.
- Throughout one's professional journey, mentoring needs may change and evolve.
- Without training, individuals tend to adopt the same mentoring approach that was used on them.
- Training as a mentor enhances professional skills and improves mentoring effectiveness.
- The need for multiple mentors is crucial, allowing us to avoid being limited by a single mentor or overburdening them.
- To meet the workforce needs for defense, SCALE cannot be limited by the capacity of individual faculty members.
- Mentoring should benefit both the mentor and the mentee.
- A hierarchy of mentorship can support professional development through various mentoring types such as peer-to-peer, near-peer, and expert-to-novice mentoring.
- While individuals are responsible for their own development, mentors can serve as guides.
- Mentees need to feel comfortable with and trust that their mentors are committed to helping the mentee develop.
- Mentoring takes place in various settings, including both formal programs and informal situations.

2.8. Recruitment

SCALE uses a variety of methods to recruit students to the SCALE program. These include word-of-mouth (e.g., a faculty member talking to a class or a student), social media (e.g., LinkedIn, Twitter), an undergraduate Discord channel, programs that provide undergraduate research experiences, and implementing modules into introductory courses that include microelectronics contexts and topics. The SCALE undergraduate curriculum group is responsible for designing curricula that can be implemented into introductory engineering courses across universities to introduce students to microelectronics and increase their exposure and awareness of this field.

2.8.1. SCALE Undergraduate Curriculum Group

The undergraduate curriculum group is tasked with developing curricula, technologies, and pedagogies to recruit and retain talented engineering students in microelectronics. The objectives are to:

- Train faculty in research-based pedagogies.
- Develop curriculum grounded in microelectronic contexts.
- Develop modules to communicate grand engineering challenges associated with workforce development needs.
- Design and build digital learning technologies needed to effectively implement and teach microelectronics curriculum.

The aim of developing and implementing microelectronics-related curriculum is to recruit and retain students in microelectronics. The curriculum is developed for both first-year courses (with the aim of recruitment) and second-year courses (with the aim of retaining students). To do this, instruction is

centered around research-based and culturally relevant pedagogy. SCALE has partnered with an expert in culturally relevant pedagogy to bring this area of expertise to curriculum development. The curriculum is also developed around course learning objectives. Thus, students are not doing anything extra – the course objectives are still being taught and nothing extraneous is added to the coursework. The curriculum includes hands-on design contexts to engage and motivate students. Additionally, professional development is offered for course instructors via workshops or curriculum guides to train faculty in research-based instructional methods. See Box 5 for an example of a SCALE workshop for instructors to learn to incorporate microelectronics into their introductory courses.

The SCALE curriculum group also works with instructors to identify microelectronics contexts that are difficult to teach. Working with nanoHUB and other groups, the curriculum group can leverage technologies to aid in teaching these difficult concepts (e.g., AR, VR, AI). The curriculum group conducts workshops and trains faculty in research-based instructional methods using these advanced learning technologies.

Box 5. Example of a SCALE workshop to train instructors on integrating microelectronics into introductory courses

Microelectronic Integration Workshop

May 22-24 at Purdue University

13 faculty and staff from four SCALE universities confirmed

Topics Include:

- Top Issues in Microelectronics
- Integrating Microelectronics in First-Year
- Culturally Relevant Teaching
- Teaching for Interest, Motivation, and Learning
- Assessing Interest, Motivation, and Learning

Benefits:

- Stipend for workshop attendance
- Microelectronic equipment for use in first- and second-year courses
- Stipend for curriculum implementation
- Creation of community of practice for year-long support

2.8.2. Undergraduate Research Programs

Undergraduate research programs vary across universities. Generally, the larger universities have at least one of these types of programs that allow undergraduates to sign up to join a project for a summer, semester, or year to work with a faculty or graduate student mentor on a research project. At the end of the research experience, the student usually has the opportunity to present the research orally or in a poster at their university. Students can increase their interest in microelectronics or the SCALE program if they sign up for research with a faculty or graduate student mentor who has a microelectronics-related project. These students can then be paid on SCALE funding and sign up as a SCALE student. The First-Time Researcher program is an example of a Purdue undergraduate research project. The process for accepting a student into this project is detailed in Box 6. Please note that students do not have to be part of an undergraduate research program to conduct SCALE-related research with a SCALE faculty mentor.

Box 6. Example process for accepting a student into the First-Time Researcher Program (FTR) for a SCALE research project

1. Oct. 1- Nov. 15: Students apply through OURConnect website.
2. Oct. 15-Nov. 30: Student Selection Window opens.
3. Oct. 15: SCALE Student Experience Lead(s) send out a reminder of the student selection window opening. Ensure that faculty can log on to OURConnect and view projects, or access student applications through Box.
4. Oct. 15-Nov. 15: Faculty review students' information, choose their top candidates.
5. By Nov. 15: Faculty notify [SCALE student experience leads] of the students they would like to work with (Do not use website to accept any students)
6. Nov. 15-30: [SCALE student experience leads] verify eligibility for SCALE, send FTR offer letter to students using the website
    a) Students accept FTR
    b) FTR Application Downloaded, Sent to SCALE Admissions Team
    c) Students are directly admitted and sent SCALE acceptance letter
    d) Second or third drafts of students/offer letters as needed
7. Dec. 15: Student Deadline to Decide

2.9. Knowledge, Skills, and Abilities

Students are expected to gain and enhance their microelectronics knowledge, skills, and abilities (KSAs) during their time in SCALE. Knowledge is the information that the student gains during their time in SCALE. For example, students take microelectronics-related courses to gain subject area knowledge. Skills are the application of students' knowledge and experiences that they practice as a SCALE student. For example, students have opportunities for experiential, hands-on learning and practice in their research and internship experiences.

Abilities are students' inherent potential for mastering the knowledge and skills needed to be successful in SCALE. For example, students with the ability to think analytically have the potential to achieve in SCALE courses and experiences. Students gain KSAs through SCALE from their participation in SCALE offerings, such as courses, seminars, research experiences, or internships.

2.9.1. Career Pathways Working Group

The purpose of the Career Pathways Working Group (CPWG) is to translate workforce needs from the DoD, federal government, and DIB into alignment with the SCALE workforce development model (i.e., curriculum, research, and internships) and ensure proper recognition for employers through professional and technical certification. The CPWG consists of subject matter experts from defense-related employers. The CPWG meets virtually four times a year; typically, August, December, March, and July. Meetings are scheduled based on group availability.

2.9.2. Certification and Professional Development

SCALE's partners (e.g., government, DIB) have specific KSA's – including general and specialty KSAs - that they desire for future employees. Students have many opportunities in SCALE to gain and strengthen KSAs (e.g., formal academic curriculum, research experiences, engagement with stakeholders). One goal of SCALE certification is to document students' KSAs in a portfolio that they can provide as a supplement to their resume. Additionally, students' SCALE mentors can use this information to help students identify gaps in their professional skill development and to aid the student in implementing strategies to fix these gaps (e.g., training modules, SCALE course offerings).

The SCALE Certification team has defined and categorized all of the KSAs for Professional Skills (Oral communication, Written communion, Teamwork, Professional and ethical responsibility, Diversity, equity, and inclusion, Understanding solutions, impacts, and issues, Lifelong learning, Engineering habits of mind, Leadership, Multidisciplinary problem solving). Based on research on best practices in the assessment of these skills, SCALE uses a system that relies on students' reflections on SCALE activities (curriculum, internships, etc.) and a portfolio of artifacts. The Certification team is building a prototype of these assessment systems and is working with SCALE faculty at select partner institutions to pilot the prototype.

The SCALE team is working on developing an Individual Development Plan (IDP) for SCALE students to use when students meet with their SCALE faculty advisors. The IDP is SCALE-specific and focuses on SCALE topics such as Certification, SCALE events, internships, research, and the student's long-term career plans. Students will be able to fill it out before meeting with their faculty advisor where it can be used for discussion during those meetings.

2.9.3. Courses

The SCALE courses include specially designed SCALE content based on DoD KSAs. These include courses meant to expose non-SCALE students to microelectronics (see section 2.8.1. for more information) as well as specialty courses focused on key topics in microelectronics.

Table 1. SCALE course offerings

Course name	Course type	First offering
ENGR 131 -Transforming Ideas to Innovation I	Exposure	Fall 2020
ENGR 132 -Transforming Ideas to Innovation II	Exposure	Spring 2021
MSE 23000 -Structure and Property of Materials	Exposure	Fall 2021
ECE 20001 -Electrical Engineering Fundamentals I	Exposure	Fall 2021
NUCL 20500 -Nuclear Engineering Undergraduate Laboratory I	Exposure	Fall 2021
ECE 29600 -Electrical and Computer Engineering Projects	Specialization	Fall 2020
ECE 49600 -Electrical and Computer Engineering Projects	Specialization	Fall 2020
Vertically-Integrated Projects (Purdue, GaTech)	Specialization	Fall 2020
CSCI-B 551 -Elements of Artificial Intelligence (IU)	Specialization	Fall 2021
CSE 40171 -Artificial Intelligence (ND)	Specialization	Fall 2021
ME 597 -Electronics Packaging (Purdue, GaTech, SUNY-B, ASU)	Specialization	Spring 2021
Introduction to Radiation Effects Engineering (all RH universities)	Specialization	Spring 2021
Design for Security (Purdue Online)	Specialization	Spring 2022
Secure Operations (Purdue Online)	Specialization	Spring 2022

2.9.4. Internships

The SCALE program provides a list of internships to SCALE students annually. A SCALE Positions Website was developed to enable SCALE employers to post information about internships and full-time positions that SCALE students can view and apply for.

One objective of the student experience is to help students prepare for internship opportunities. To facilitate this, SCALE personnel cataloged and summarized institutional career development resources and SCALE's best practices that students can use when applying and interviewing for internships. Students can use links posted on nanoHUB to access information available at their institution regarding career development. Furthermore, the SCALE team has identified particularly high-quality resources in several areas (e.g., interviewing, resume development), which have been posted under a Recommended Resources section on nanoHUB.

2.9.5. Student Events

SCALE holds regular events for SCALE students throughout the year. Faculty PIs from each university are responsible for hosting in-person events at their university if they choose. Otherwise, SCALE holds a variety of virtual events that all SCALE students are invited to attend. An example of a SCALE virtual event is the Virtual Professional Development Seminar. Students have the opportunity to meet with Government and Defense Industrial Base experts via Zoom to discuss resume development, interviewing, networking at career fairs, internships, job searches, and more. The event included an industry and government panel moderated by the SCALE Internship Coordinator. Another virtual event that is offered by Vanderbilt University is a weekly SCALE student seminar series, SCALE Tech Talks, which provide students from any SCALE university to meet other SCALE students, learn about internships, and meet microelectronics industry leaders. An example of an event that is offered on-site at Purdue is a SCALE welcome event that helps students better understand SCALE and network with other students and faculty (see Box 7 for an email template invitation).

Box 7. Email template inviting SCALE students and mentors to welcome event

Dear student,

We hope that your summer research project has gotten off to a good start this week. Since you are working on a SCALE project, we are inviting you and your mentors to a welcome meeting for all of the SURF 2023 SCALE projects. SCALE (nanohub.org/groups/scale/) is the preeminent U.S. program for semiconductor workforce development in the defense sector, and is led by Purdue University.

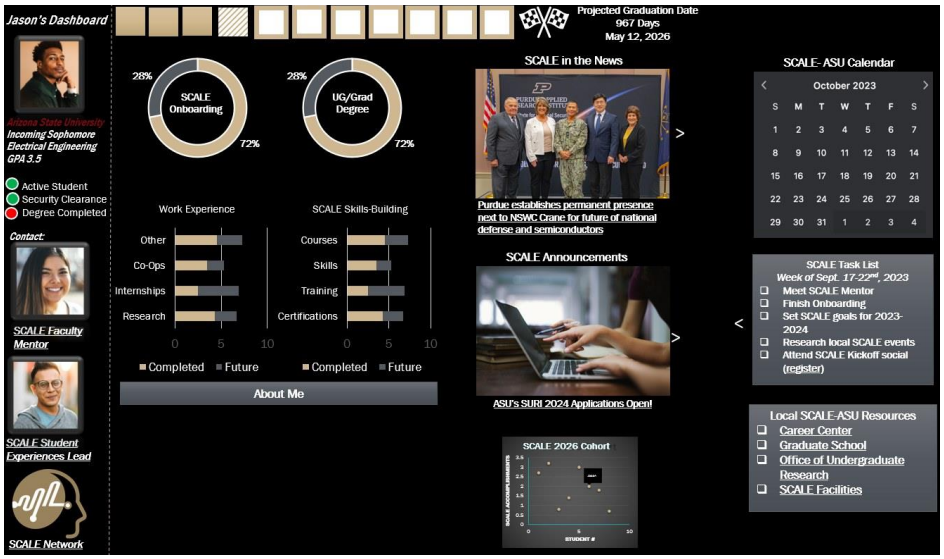
The SCALE Director, [name], will tell you about the goals of the SCALE program and the opportunities that are available to you as a member, including access to internships and future research. You will meet other students and faculty working on SCALE projects, learn about the different SCALE "technical verticals" at Purdue, get a preview of upcoming SCALE events this summer, and have the opportunity to ask questions about what is expected of your participation in SCALE.

The event will be from [date/time] in the [location]. Light snacks will be served.
RSVP here: [RSVP Link]

2.10. SCALE Web App

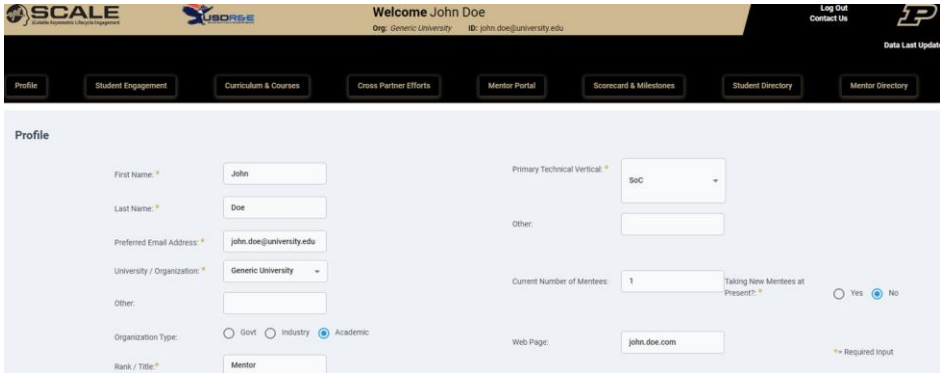
The SCALE Web App was developed to provide SCALE students with a convenient method for storing and updating their personal information related to SCALE. Students can access the web app at any time to update their information and to share relevant information with their mentors or potential employers.

The student's mentor(s) can access non-restricted information about the students (e.g., technical area, year in SCALE) and use that information in meetings to discuss progress and goals. SCALE staff can also access the student information to provide metric data for the funding agency, ensure that all students have been paired with a mentor, view student progress, for example. The dashboard provides value to each stakeholder that uses the dashboard. From the students' perspective (Figure 6), the web app can be shared with potential employers who can easily see the students' experience and security clearance and with mentors to serve as a point of discussion related to progress and goals.



4 - Figure 6. Mock-up of information included on the student dashboard

Mentors can also log into the dashboard and create their own profile of information that can be updated regularly (see Figure 7). This information can be used to fulfill quarterly reporting requirements.



5 - Figure 7. Mock-up of information included on the mentor dashboard

2.11. Withdrawal Process

Students have three options if they wish to withdraw from the SCALE program. They can select from a revised membership, a paused membership, or terminated membership.

1. Revised Membership: This option is for students who would like to remain in SCALE but may need adjustments to their mentor or other areas of the program.
2. Paused Membership: This option is for students who may need to take some time off from SCALE but plan to come back eventually. Students can opt to pause their membership for two consecutive semesters.
3. Terminated Membership: This option is for students who do not want to be part of the SCALE program any longer. To rejoin SCALE, students would be required to submit a new application.

When SCALE staff receive information about a student wishing to withdraw from the program (e.g., from the student or from the student's mentor), SCALE will send a withdrawal email (Box 8). Students are asked to complete a withdrawal survey. This survey asks about students' reasons for withdrawal, their overall experience in SCALE, whether they will continue with the microelectronics workforce, and their contact information.

Box 8. Email template for students who are withdrawing from SCALE

SUBJECT: SCALE Membership Change

Dear {Student Name},

Please read the attached letter for a complete set of instructions regarding the SCALE revision or withdrawal process. The first step is to determine whether you want to change something about your membership, pause your membership, or completely withdraw (losing access to internship information, professional development opportunities, research opportunities, and mentorship opportunities). If you choose the last option, the full process must be completed before you are considered withdrawn from the SCALE program.

1. **Revised Membership:** If you want to remain in SCALE but adjust your Individual Development Plan, project, goals, or assigned mentor, please contact the Student Experiences Team at [email].
2. **Paused Membership:** In this status, we will remove you from access to SCALE online resources and remove the participation requirements (taking courses, attending SCALE events, etc.) for 2 consecutive terms.
3. **Terminated Membership:** In this status, you will be completely removed from the SCALE program, including access to online resources, participating in SCALE events, and fulfilling SCALE requirements. A new application would need to be submitted to rejoin SCALE.

To continue this process, please take the following steps:

1. Fill out the attached letter.
2. Reply to this email. State which membership option you'd like to pursue, and attach the completed letter.
3. If you are pausing or terminating membership, please complete the additional steps listed in the letter. You will need to complete the **SCALE exit survey** for both options as well as conclude any research activities.

We are here to support you as you continue your academic and professional journey. Please do not hesitate to reply to this email with any additional questions about the revision or withdrawal process.

2.12. Graduation from SCALE

Students are considered to be a graduate of the SCALE program when they graduate from their degree program (undergraduate or graduate) while enrolled in the SCALE. A few months before students graduate, the SCALE student experience lead or the student's mentor sends an email to the student with a link to a graduation recognition survey. This survey asks students to select between a SCALE plaque and a graduation stole. Students who respond will also receive a gift card in addition to their selection of a graduation recognition item.

The email to students also contains information about joining the SCALE Alumni Network LinkedIn group. This private group allows former SCALE students to network with each other, post job openings, post job searches, and return for future SCALE events. Potential members must be verified by SCALE staff to be SCALE students or current government/industry partners before they are accepted into the group.

Finally, the list of graduating students is sent to the external evaluators who administer a graduation survey. The external evaluators also invite a small sample of graduating survey respondents to participate in an exit interview to obtain more detailed information about the student's experiences in SCALE. The survey asks for students' non-university contact information so that SCALE personnel can follow up with students after graduation to ask for updates on students' career paths.

2.13. Key Successes

- Development of a web-based job board for employers to post full-time positions or internships at any time along with deadlines for students to apply.
- Development of the SCALE web app/student dashboard to facilitate the access and reporting of information for students, mentors, SCALE staff, and employers.
- Clear processes for student communications, application processing, and other aspects of the student experience, which makes it more streamlined and with greater fidelity of implementation across the academic partners.

2.14. Key Challenges

- Missing/incomplete student data can hinder reporting metrics to the funder, determining correct student classification for sending messages to particular groups of students, and program evaluation.
- Keeping track of a large number of students at different institutions is challenging.
- Coordination of undergraduate programming at different institutions varies substantially according to technical area, faculty bandwidth, and the size and resources available to the institution.
- Keeping students engaged in the program can be a challenge; for example, survey fatigue, quiet quitting, or non-involvement in SCALE activities. Furthermore, it can be a challenge to communicate effectively with students as some students may not be aware whether or not they are in SCALE, are unaware of how to find SCALE events, or how to take advantage of SCALE networks.
- Because the student experience consists of many components, funding a particular event or activity can be a challenge. For example, understanding which events are tied to which accounts, what types of purchases are approved, and who has the authority to make transactions.
- Creating social media content and communications releases can be a challenge without staff who have adequate/dedicated time to work on collecting and publishing this information.

- Verification of student citizenship can be challenging as students must be US Citizens to be accepted in the SCALE program. To address this challenge, SCALE is piloting a process that will address this issue following admittance.

2.15. Recommendations

- Develop processes at the beginning of the project and revise as needed. Having processes in place at the beginning will help ensure that multiple personnel and institutions can follow the processes and they can be adjusted as needed. Additionally, a detailed SCALE organizational chart can be helpful for SCALE personnel to understand their role and others' roles in the broader SCALE program.

- Hire a student experience coordinator to facilitate the student experience across all academic units. This is particularly important with a large project to ensure greater fidelity and ensure that students are not falling through the cracks. Ideally, having a student experience coordinator at each academic partner institution can ensure there is a staff member dedicated to following students through the trajectory.

- Develop a database management system that can handle secure storage and retrieval of student data and information, particularly with large numbers of students and if multiple staff members need to edit the data.

- The SCALE web app can be a useful tool for collecting student information rather than relying solely on faculty input to fill in the gaps.

- Due to a shortage of faculty mentors, rather than assigning a student a faculty mentor when they apply to SCALE, another option could be to provide students with a near-peer, government/industry, or graduate student mentor. A faculty member could be assigned at a later time as needed.

- Hire a Communications staff member, which can be useful not only for keeping students aware of SCALE events but to foster awareness in the public and foster interest in the program.

- Hire a Work Experiences lead who can work with government and industry partners to identify internship and post-graduation employment opportunities and share them across the SCALE network. This role would be vital in building networks and relationships with government/industry partners and employment matching for students.

- Consider exploring organizations within your institution and with whom you can potentially collaborate. For example, the office of Undergraduate Research at Purdue has joined with SCALE to provide research opportunities to students on SCALE projects (e.g., Summer Undergraduate Research Fellowships).

Links to Model Documentation

Partner Relations

The main goal of the Partner Relations component of the SCALE model is to leverage the expertise and capabilities of microelectronics partners from all sectors, including public, private, and academic institutions, to contribute to the scalability and replicability of the microelectronics workforce.

https://sway.cloud.microsoft/q7u8JKL8NEEvKEHn?ref=Link

Student Experience

The SCALE student experience aims to integrate microelectronics exposure and training from the K-12, undergraduate, graduate, and professional levels. The goal of the undergraduate and graduate-level SCALE student experience is to expose, motivate, and prepare students from diverse backgrounds in engineering and engineering technology with the skillset and mindset for careers in defense-related microelectronics.

https://sway.cloud.microsoft/i1KZVKzVAgbPDAid?ref=Link

Knowledge Share

The purpose of the SCALE knowledge share component is to disseminate the knowledge generated by the SCALE program both internally and externally, which includes technology transfer to industry to serve defense and security needs. This includes sharing technical knowledge, creating collaborative partnerships between the SCALE consortium members, and sharing the SCALE model with other external programs.

https://sway.cloud.microsoft/foGVkck25Mo9umkU?ref=Link

Finance and Administration

The primary goal of SCALE's finance and administration component is to enable smooth and efficient program operations both internally at the prime institution and with the academic partners external to Purdue. Finance and administration are key components of the SCALE program as they permit the efficient management of SCALE's resources.

https://sway.cloud.microsoft/BM1bxFRXq6LheG6d?ref=Link

Evidence-Based Improvement

The goal of SCALE's evaluation is to provide a holistic evaluation leading to evidence-based improvement. The SCALE evaluation uses a holistic approach to evaluation, including outcome-based metrics, process evaluation, external evaluation, site-specific evaluation, and financial return on investment to provide a comprehensive understanding of the program.

https://sway.cloud.microsoft/nYz3HSHBN0YDFuIc?ref=Link

3. Knowledge Share

3.1. Goals

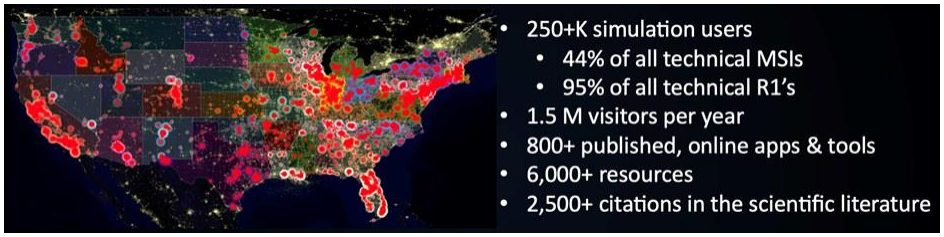
The purpose of the SCALE knowledge share component is to disseminate the knowledge generated by the SCALE program internally and externally to maximize its impact. This includes technology transfer to industry to serve defense and security needs, sharing technical knowledge and educational material, creating collaborative partnerships between the SCALE consortium members, and sharing the SCALE model with other external programs. Internal sharing includes cross-university collaboration and student exchanges as well as multi-university research projects. Methods for internal collaboration and sharing include restricted SCALE groups on the nanoHUB platform, a SCALE newsletter, and SCALE internal working groups (see Section 1.10.3. for more information on working groups). The goal of external sharing is to make the SCALE model available to other programs for replication as well as to disseminate the results of research endeavors. In addition, sharing with students and educators outside the program is an important recruiting tool. Venues for external sharing include publications and presentations at academic conferences and journals, social media groups for SCALE, and open-access components related to SCALE on the nanoHUB platform.

3.2. nanoHUB

The primary method for sharing external and internal information for SCALE is through nanoHUB. Founded in 2002, nanoHUB is a platform for online simulations, data, and collaboration. It facilitates the sharing and dissemination of scientific research, simulation tools, data, and resources. Worldwide, over 1.6 million researchers, students, and educators access nanoHUB content annually. Currently, nanoHUB hosts over 7,500 online resources that include approximately 800 simulation tools that are used in research and education. nanoHUB provides an open-access platform to share simulation tools and materials as well as collaboration tools and platforms for dissemination. Within groups and projects, research teams can upload and share data privately and also prepare that data to be published as a nanoHUB data set. Published nanoHUB tools, code, and data sets are assigned a digital object identifier (DOI), providing a persistent identifier for the online content. nanoHUB tools, compact model codes, and data sets are indexed in the Web of Science's Data Citation Index (DCI).

Operating on the HUBzero platform, nanoHUB is supported by a team of experienced web developers and software engineers, a web security expert, and database, visualization, and analytics

specialists. HUBzero powers dozens of HUBs across a broad range of science and engineering disciplines and nanoHUB is able to leverage development efforts from other HUBs to continually improve functionality.



3.2.1. Platform for SCALE

The purpose of the nanoHUB platform within SCALE is to facilitate knowledge share among the SCALE consortium and other stakeholders. Groups in nanoHUB can be set up as private or public with inward or outward-facing content. Content posted on nanoHUB such as recorded lectures can be shared fully publicly or privately within certain groups. For example, SCALE students have access to selected content on SCALE such as talks, courses, simulation tools, and resources that are accessible to students when they log in and access the SCALE student group page. Reports submitted by SCALE leadership to the Department of Defense (DoD) can be posted to a private section of nanoHUB so that only the DoD has access. A public group showing information about the SCALE program is accessible to the public.

Another feature of nanoHUB is for sharing content, such as simulation tools.

A unique feature of nanoHUB is the ability to publish and share online simulation tools. There are several tools already available on nanoHUB that are related to semiconductors, while other tools continue to be added regularly. The goal is to make these tools and related content available to SCALE partners and to enable them to integrate the tools into their curriculum. The integration of simulation tools with course materials available on nanoHUB can help achieve this goal. nanoHUB is also working on compiling training materials for each of the simulation tools so that they are more user-friendly. Notably, nanoHUB is also working on creating these training materials for commercially available semiconductor tools that are used in industry, which can aid in workforce development.

nanoHUB also has a learning management system where course materials can be bundled together so that students can work through an asynchronous, online course. Course content can be provided by faculty and nanoHUB can assist with organizing the material and adding quizzes and questions to course modules. This feedback can be collected and submitted to the course instructors. For example, SCALE K-12 is using nanoHUB's learning management system for teacher professional development. Live sessions are recorded and submitted to nanoHUB for publication along with assessment questions and related course materials. The SCALE K-12 course content is housed in a SCALE group accessible only to authorized SCALE K-12 group users.

3.2.2. nanoHUB Team

nanoHUB has a team of people who work on various projects within the platform. There is a production and development team responsible for cleaning and processing course content (e.g., lecture recordings),

and transforming it into a course available on nanoHUB. This team works on content for both the SCALE K-12 and the SCALE university partners.

There is a communications team that formats text-based content using InDesign software. For example, this team works on turning large documents of training materials into accessible, user-friendly content that is available on nanoHUB.

A video development and production team works on videos submitted by SCALE faculty to nanoHUB to edit as needed for various audiences and purposes. For example, nanoHUB video editors might edit a seminar to include only the parts where the lecturer is actively talking or answering questions.

There is an outreach and student support nanoHUB staff member who works with the Student Experience Lead for SCALE. Both of these staff members collaborate with SCALE faculty to curate content that will be housed on nanoHUB as well as to develop processes to make it replicable. This team also interacts with students to help promote nanoHUB content.

Two staff members on the nanoHUB analytics team process SCALE applications as they are received and direct those results to appropriate SCALE faculty or leadership. These staff members also coordinate the manual process of ensuring that mentor requests are approved promptly and that the application data are added to the SCALE database. This team also assists with the preparation of a monthly scorecard of analytic data for the SCALE leadership team.

This team also interacts with students to help promote nanoHUB content.

nanoHUB's leadership team meets regularly with core SCALE leadership team members. The nanoHUB PI for SCALE collaborates with SCALE leadership and provides a visionary perspective on how SCALE can best use nanoHUB's resources or what else should be developed within nanoHUB for SCALE. The nanoHUB project manager is responsible for implementing the project's vision and guiding staff members in their work. The project manager serves as the main point of contact between SCALE and the nanoHUB team, facilitating communication between staff members.

nanoHUB team members have been working with SCALE's director of operations and the consulting firm hired to develop the SCALE Web App (see the Student Experience section for more information about the SCALE Web App). The SCALE Web App will be accessible via nanoHUB and automatically pull demographic data from nanoHUB. When faculty or students register for the SCALE groups, they add their email and other demographic data. This will allow the SCALE Web App to auto-populate some fields using that information with the benefit of not burdening students or faculty for requests to fill in that information separately. Some of nanoHUB's developers are also working with the SCALE Web App development firm to ensure proper integration into nanoHUB. The goal is to have a single sign-in for nanoHUB and the Web App. Thus, nanoHUB serves as the platform where all these data can reside.

There is a large administrative need regarding the budget for nanoHUB's work with the SCALE project. Not only is staff time needed, but there must also be a budget allocated for the platform. These operations costs include keeping the platform up and running, troubleshooting and fixing issues as needed, and costs for the external development team at HUBzero.

There is a large administrative need regarding the budget for nanoHUB's work with the SCALE project.

3.2.3. SCALE nanoHUB Use

nanoHUB is utilized in different ways by SCALE leadership, faculty, and students.

The internal nanoHUB leadership team meets weekly to discuss a weekly scorecard and analytics data such as the number of resources produced during a given period. It is also possible to track the number of people who have accessed content, such as videos or courses. In terms of SCALE analytics, nanoHUB leadership primarily asks the following questions to drive continuous improvement: How much are the SCALE faculty and students viewing or accessing SCALE content? How many of the SCALE faculty and staff are accessing or using nanoHUB content that is not specific to SCALE? What percentage of SCALE-related open-access content viewers are not SCALE faculty or students?

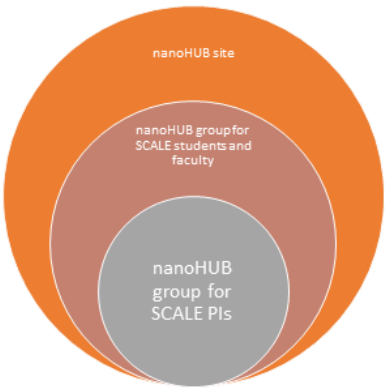
There are two main ways that SCALE faculty use nanoHUB. The first is by posting content that they produce, such as lecture materials. Several SCALE faculty are very active in submitting their content. For example, seminar series content for one SCALE faculty member is recorded and posted weekly for all SCALE faculty and students to access. Another way that faculty can use nanoHUB is by accessing content that others have produced. Currently, not as many SCALE faculty members are utilizing the nanoHUB content posted by other SCALE faculty. However, cross-usage of the content could prevent SCALE faculty from reinventing the wheel. nanoHUB is working on a tagging system so that SCALE faculty can more easily search and find relevant content.

Before a student joins SCALE, they can access publicly available information on nanoHUB about the SCALE program. After creating an account on nanoHUB, SCALE students can access the SCALE student group page. nanoHUB serves as their main portal to learn about SCALE activities, such as summer research experiences, internships, or other relevant programs. Students can also log in to nanoHUB to access the SCALE Web App and engage with their mentor via the app. Students might also access nanoHUB based on a recommendation or requirement from their instructor(s) or mentor; for example, to use simulation tools or to view videos. nanoHUB also serves as a repository for SCALE-branded templates. These include poster templates for student presentations or SCALE-branded letterhead.

3.2.4. SCALE nanoHUB Groups and Content

nanoHUB allows restricted access to SCALE content. There are two groups created to restrict access: one is a group solely for SCALE PIs and leadership and the second group was created for all SCALE students and faculty.

The SCALE PI Group is a private group for SCALE PIs to access information important to the project. The group contains institutional reports for the partner academic institutions, relevant publications, SCALE templates and logos, and symposium materials, including recordings and presentation documents. The student group provides access to courses, lecture series, research opportunities, internships at industry and national labs, simulation tools, information about SCALE, and other relevant materials. Group content can be added and removed as needed. There are group administrators who can help add or remove content by request.



1 - Figure 2. nanoHUB access overall and for subgroups of SCALE

SCALE hosts courses on nanoHUB that cover several technical vertical areas as well as cross-cutting concepts. For example, there are approximately 30 course videos published on the nanoHUB group website that cover RH topics.

2 - Figure 3. Example of a course video published on nanoHUB

In addition to videos, nanoHUB also includes SCALE-specific lecture series content. For example, Vanderbilt's Weekly Seminar Series is published on nanoHUB so that students from all SCALE universities can view the content.

The SCALE student group on nanoHUB offers a variety of resources for students. Students have access to simulation and specialized CAD tools. Currently, there are seven tools available to SCALE students. Current and archived research and internship opportunities are posted in the group. For example, application details and project descriptions of the First-Time Researcher program are posted, which can allow students to learn about and apply to work on a SCALE research project. The SCALE student group also includes a list of recommended resources categorized by partner universities. The SCALE team has reviewed resources from each partner university regarding career development resources and best practices.

3.3. Social Media

SCALE uses social media platforms to inform the public and students about SCALE activities and pertinent information related to SCALE. These platforms help bring a greater awareness about SCALE to stakeholders and students who are not part of SCALE as well as provide information to SCALE students

about SCALE events or noteworthy happenings. SCALE has a presence on LinkedIn, Facebook, and Twitter (X). Posts are customized for the audience that is most likely to access the different sites.

Internally, SCALE publishes a quarterly newsletter sent out to SCALE partners and students that highlights the major events and news related to SCALE.


Volume 1, Issue 1

SCALE

Scalable Asymmetric Lifecycle Engagement

SCALE QUARTERLY

Funded by the Office of the Under Secretary of Defense for Research and Engineering (OUSD R&E)
Trusted & Assured Microelectronics Program

In this edition:

SCALE PI Symposium- pg. 1

SCALE Student Spotlight- pg. 1

MEST & nanoHUB Collaboration- pg. 2

SCALE Social Media Campaign pg. 2

Event Calendar- pg. 2

OUSD WFD Leadership

SCALE provides academic opportunities for working in defense microelectronics for learners at all stages of one's education and career through:

- K-12 curriculum and hands-on learning experiences;
- undergraduate and graduate curriculum;
- research, internships, and career opportunities in preferred technical areas of strong national need; and
- technical content accessibility through nanoHUB

SCALE PI Symposium– Purdue University

The 2nd Annual Scale PI Symposium was held at Purdue from May 22-24, 2023, with nearly 50 attendees representing the Department of Defense (DoD), Defense Industrial Base (DIB), and SCALE consortium academic partners.

On Day 1, SCALE leadership presented updates on the consortium, including funding, the workforce development model, metrics, student career pathways, partnering strategies and outcomes with SCALE Director, Dr. Peter Bermel. At the same time, the academic partners held a working session focused on planning for the next year, including brainstorming within the technical verticals on recruitment and retention, incorporating SCALE into the classroom, research, mentoring, professional development practices, and collaboration across the verticals and academic

tical, measures of success, and new opportunities and barriers. Results from this session are currently being used to help identify ways to strengthen the consortium.

Concurrent to the Symposium, Dr. Jason Morphew facilitated a workshop on Integrating Microelectronics into Introductory Engineering led by multiple Purdue faculty and graduate students, as well as training on culturally-relevant pedagogy, led by Dr. Kelly Cross, Georgia Tech.

3 - Figure 4. SCALE's quarterly newsletter

3.4. Publication and Presentations

The primary method of dissemination for SCALE's technical research is through academic publications and conference presentations. SCALE students have opportunities to present their research via student programs, such as the First Time Researcher (FTR) program at Purdue. Another example is The Radiation Hardened Microelectronics (RHM) team, led by Vanderbilt University, which gave 35 SCALE students and mentors the opportunity to attend a technical conference on radiation effects in microelectronics.

SCALE faculty and graduate students in engineering education also disseminate research related to SCALE. The American Society of Engineering Education (ASEE) annual conference is a venue where these researchers commonly share their work.

3.5. Key Successes

- nanoHUB is accessible to the DoD despite restrictions limiting access to many other sites on government computers.
- The SCALE Web App and nanoHUB have a single sign-on interface, providing students with a convenient one-stop-shop for accessing SCALE content.
- nanoHUB enables tagging of users based on their role within the SCALE group (e.g., student or mentor). Although used primarily for messaging, SCALE is driving the development of providing certain access privileges to people with particular tags.
- nanoHUB provides a platform specifically for housing SCALE material and resources that is not branded with a particular university.

- There has been success in gaining greater visibility for the nanoHUB SCALE groups with a steady stream of students creating a nanoHUB account. Part of this comes from SCALE asking students to register for a nanoHUB account when they join SCALE. This has led to greater awareness of what is offered on nanoHUB.
- The nanoHUB analytics team and the SCALE team have continued to refine the process of student application processing and applicant data. They also put into place more stringent controls for data protection and access.
- Collaboration between the nanoHUB outreach and student support staff and the SCALE Student Experience lead has enabled more cohesion between the student experience on nanoHUB and the broader SCALE program as well as better uptake of student-centered processes to benefit SCALE.

3.6. Key Challenges

- It can be challenging to disseminate outcomes of SCALE when research and publishing are not prioritized.
- At the beginning of SCALE it was difficult to understand the workforce needs when beginning the project and how to communicate this to nanoHUB to get the right tools for SCALE.
- Some of the simulation tools may not be user-friendly for integration into courses.
- It has been difficult to encourage SCALE faculty to utilize content created by other SCALE faculty members.
- When nanoHUB got involved with SCALE, only personnel were budgeted. However, the platform needed a development budget to keep things running smoothly.

3.7. Recommendations

- It's important to find the right platform for dissemination based on the needs of your project. The platform should be accessible yet can lock down content as needed.
- A recommendation is to add training materials to accompany each simulation tool following what one SCALE faculty member has done successfully using nanoHUB's commercial simulation tools. This can increase integration and use of the tools in SCALE courses.
- nanoHUB is working on a tagging system so that SCALE faculty can more easily search and find relevant content.
- It's recommended to have a single platform where students can access all important content. This can increase student use and provide a more user-friendly experience.
- It's beneficial to build the data collection and storage interface (e.g., the SCALE Web App) as a tool within nanoHUB that can pull data from the nanoHUB profile information and interface with

an external database. This can enable data to populate the database without additional requests or surveys to faculty and students.

- It would be helpful at the beginning of a project to have a well-defined end-product and an understanding of how all of the pieces fit together for a project. Then nanoHUB can step in and be the platform to serve as the pipeline for those needs (e.g., internship opportunities or progression through participation levels). Before working with nanoHUB, it is recommended to define the workforce and their needs upfront. This will help nanoHUB better provide what is needed.
- Keep in mind that not only do time and administration have costs but platforms have costs. It is essential to build both of those costs into plans and budgets.
- The SCALE model is adaptable for others looking to use nanoHUB as a platform. nanoHUB has expanded over the years to include anything STEM and could include other types of projects in other areas. Projects can have their own identity and private space, yet take advantage of the capabilities that nanoHUB provides.

For more information about nanoHUB or working with the platform, contact Dr. Lynn Zentner (lzentner@purdue.edu).

Links to Model Documentation

Partner Relations

The main goal of the Partner Relations component of the SCALE model is to leverage the expertise and capabilities of microelectronics partners from all sectors, including public, private, and academic institutions, to contribute to the scalability and replicability of the microelectronics workforce.

https://sway.cloud.microsoft/q7u8JKL8NEEvKEHn?ref=Link

Student Experience

The SCALE student experience aims to integrate microelectronics exposure and training from the K-12, undergraduate, graduate, and professional levels. The goal of the undergraduate and graduate-level SCALE student experience is to expose, motivate, and prepare students from diverse backgrounds in engineering and engineering technology with the skillset and mindset for careers in defense-related microelectronics.

https://sway.cloud.microsoft/i1KZVKzVAgbPDAid?ref=Link

Knowledge Share

The purpose of the SCALE knowledge share component is to disseminate the knowledge generated by the SCALE program both internally and externally, which includes technology transfer to industry to serve defense and security needs. This includes sharing technical knowledge, creating collaborative

partnerships between the SCALE consortium members, and sharing the SCALE model with other external programs.

https://sway.cloud.microsoft/foGVkck25Mo9umkU?ref=Link

Finance and Administration

The primary goal of SCALE's finance and administration component is to enable smooth and efficient program operations both internally at the prime institution and with the academic partners external to Purdue. Finance and administration are key components of the SCALE program as they permit the efficient management of SCALE's resources.

https://sway.cloud.microsoft/BM1bxFRXq6LheG6d?ref=Link

Evidence-Based Improvement

The goal of SCALE's evaluation is to provide a holistic evaluation leading to evidence-based improvement. The SCALE evaluation uses a holistic approach to evaluation, including outcome-based metrics, process evaluation, external evaluation, site-specific evaluation, and financial return on investment to provide a comprehensive understanding of the program.

https://sway.cloud.microsoft/nYz3HSHBN0YDFuIc?ref=Link

4. Finance and Administration

4.1. Goals

The primary goal of SCALE's finance and administration component is to enable smooth and efficient program operations both internally at the prime institution and with the academic partners external to Purdue. Finance and administration are key components of the SCALE program as they permit the efficient management of SCALE's resources, including budgeting and financial forecasting, confirming regulatory compliance, informing program decision-making, ensuring timely and accurate financial reporting, budgeting and planning, developing processes for financial and administration program components, and strategic planning. SCALE faces the added challenge of coordinating finance and administration between partner academic institutions.

There are several faculty and staff members who are integral to the financial and administration components of SCALE.

There are several faculty and staff members who are integral to the financial and administration components of SCALE. A **full-time managing director** is responsible for overseeing this aspect of the program, which includes (1) proactive management of the consortium, which includes building relationships with SCALE's partners, clearly communicating expectations, and developing and implementing efficient data collection methods, (2) management of SCALE partnerships and business affairs, which includes monitoring how funding is spent, how deliverables are achieved, what data is collected, and intervening as necessary to ensure things are on track, and (3) coordination and submission of on-time written quarterly and annual reports to the funding agency. A dedicated **full-time staff member at Purdue's sponsored research services** assists with the coordination of financial management and spending across the partners. SCALE also hired a **part-time technical writer** to primarily assist with writing the quarterly reports for each technical vertical. SCALE also hired a **contractor** who aids in process creation and improvement. SCALE also has a **full-time Work Experiences lead**, who is responsible for coordinating and managing relationships with government and industry partners.

4.2. Finances

The primary financial task is financials support, which includes collecting and compiling spending information from each of the academic partners and providing them with information about the annual process for funding.

Information provided to the partners regarding the annual funding process includes the information that should be included in statements of work (SOW), expectations for spending plans, and contracting requirements. Providing this information and following up on the progress of each partner helps the annual funding process go smoothly at the start of each fiscal year.

4.2.1. Statement of Work (SOW)

At the beginning of each fiscal year, the technical leads/PIs provide a statement of work (SOW) to Purdue. The managing director leads the collection of this information from each responsible partner. A SOW template is shared to ensure that the technical leads/PIs provide the information that is needed (Box 1). For example, PI SOWs should include information about participating in working groups, attending important events, recruitment and onboarding of SCALE students, knowledge share, mentorship, and participation in data collection efforts.

Box 1: SOW Template

Technical Lead

1) Perform increased leadership activities for [technical vertical]:
    a. reviewing team members' plans and providing feedback to the team members and Purdue,
    b. advise on allocation of resources.
2) Continue to lead/participate in the weekly seminar series [(for example: research working group for radiation-hardened technology)], including expansion to engage other technical thrust areas as appropriate.

Principal Investigator

1) Continue participation in student recruitment & retention and career pathways working groups, and the educational standards working group, led by Purdue.
2) Support overall SCALE program development and planning. Attend annual PI symposium and participate in Vision Day and subsequent activities.
3) Recruit and onboard at least [5] new undergraduate students into SCALE; engage them in summer and/or academic year research projects with designated mentors.
4) Recruit and onboard at least [2] new graduate students into SCALE; engage them in summer and/or academic year research projects with designated mentors.
5) Work with Purdue nanoHUB personnel on the transfer of recorded materials to nanoHUB for access by the SCALE program.
6) Integrate microelectronic and [technical vertical] materials into existing courses (esp. Freshman and Sophomore level).
7) [Teach a for-credit (technical vertical) grad-level course at (your institution) if applicable].
8) Provide mentorship to SCALE students at [your institution].
9) Support data collection efforts of Purdue for program assessment.

Special Projects

[(Project objectives) and develop an education plan for use by SCALE personnel]

4.2.2. Financial dashboard

SCALE's partners report to Purdue regarding their expenditures and budgets. SCALE uses a financial dashboard as a means of tracking each partner's spending. Throughout the fiscal year, the main financial responsibility is to create or update a financial dashboard every month to reflect actual spending versus spending plans. This dashboard is used to determine how well the program is meeting spending targets and to pinpoint areas where follow-up is needed. The SCALE managing director works in conjunction with a dedicated staff member in Purdue's sponsored program services (SPS) to create and/or update the monthly financial dashboards. The SPS staff member is also the main point of contact for all of the subcontractors who are external to Purdue. The managing director gathers the financial information from the Purdue internal accounts; however, the business office at Purdue is beginning to perform this

task. The managing director reviews the dashboard at least once per month to ensure that any gaps in spending are identified as areas for follow-up.

4.2.3. Billing process

SCALE's process for billing includes 19 steps (see Box 2) that are documented in a Gannt chart, by month. The chart specifies the task, the person responsible, the duration in days, the start date, and the end date. The process steps include the month-end close for subcontractors, when the subcontractors should email monthly actuals to Purdue and in what format, the preparation and invoicing for approvals at Purdue and the funding agency, receipt and approval of invoices by fiscal agent and Purdue, and Purdue's payment and documentation of subcontractors.

Box 2. SCALE's billing process

1. Compare the prior month's Excel actuals versus the prior month's invoice
2. Send reminder email to subcontractors (business office contact + PI's) of need to email Excel template with prior month's actuals and plan updates by the 10th
3. Send a reminder email to Purdue business office contact + PI's of need to email Excel template with any plan updates by the 10th
4. Submit Excel template with prior month actuals and plan updates as appropriate for subcontractors and Purdue
5. Collect and tabulate Excel templates received from subcontractors, identify those with no responses
6. Send follow-up email to subcontractors (business office contact + PI's) indicating input past due and still needed
7. Send follow-up email to Purdue business office contact + PI's indicating input is past due and still needed
8. Collect and tabulate Excel templates received from Purdue, identify those with no responses
9. Aggregate Excel template input + data provided by Purdue's business office + reconciliations to determine DoD invoice total and any supporting information
10. Prepare DoD facing invoice and record A/R journal entry
11. Review and approve DoD facing invoice (following internal review)
12. Issue monthly invoice to DoD
13. Send reminder email to subcontractors (business office contact + PI's) indicating monthly invoicing is needed by end-of-month
14. Collect and tabulate sub-invoices received, identify those with no responses
15. Send follow-up email to subcontractors (business office contact + PI's) indicating invoicing is past due and still needed
16. Aggregate invoices + data provided by Purdue's business office and compare versus Excel template actuals and identify variances by subcontractors/account
17. Identify variance of Excel template actuals versus plan and change in plans from the prior month - follow up with subcontractors and Purdue (e.g., are you on plan?)
18. Review variance and identify those needing follow-up (subcontractors + Purdue), check on the status of quarterly reporting and follow up on late ones
19. Review variance between actuals reported in Excel template versus subcontractors invoice and identify those needing follow-up

To clarify and define roles and responsibilities for implementing the billing process, a RACI matrix is used. RACI stands for the following: Responsible (Does It), Accountable (Makes Sure It's Done), Consulted (Provides Input), and Informed (Notified of Completion / Outcome). Example tasks included in the RACI matrix for SCALE are: Collect and tabulate Excel templates received from subcontractors, identify those with no responses; Review variance between actuals reported in Excel template vs sub invoice and identify those needing follow-up.

These tasks are listed in one column, while several other columns list the employee's name and include one of the following letters to designate the responsibility (R, A, C, or I). The RACI matrix also specifies the day of the month the task is due.

RACI stands for the following: Responsible (Does It), Accountable (Makes Sure It's Done), Consulted (Provides Input), and Informed (Notified of Completion / Outcome).

1 - Figure 1. SCALE uses a RACI matrix to designate financial roles and responsibilities

4.2.4. Contracting Requirements

Because Purdue is the prime institution that subcontracts with many academic partners, the subcontracting process needs to be as efficient as possible. The process for subcontracting has been reduced to approximately one month from over three months cycle time. This modification process focused on three main areas: expectations document, SOW improvements, and contracting improvements. The subcontractors are provided with the anticipated timeline at the beginning of the fiscal year. The timeline for the contracting cycle is shown in Table 1.

Table 1. Timeline for contracting cycle

Task	Expected completion and timing
Letter of intent (LOI) issued	
Statement of work (SOW) draft due from subcontractor	2 weeks from LOI
SOW approved by Purdue and technical lead	1 week after draft received
Export control terms and conditions reviewed	2 weeks from LOI
Export control terms and conditions approved and final	1 month after LOI
Foreign government talent review completed	1 week after export control terms and conditions complete
Spending plan due from subcontractor	3 weeks from LOI
Knowledge, Skills, Abilities (KSA) identified for new technical vertical	4 weeks after statement of intent

To complete financial tasks successfully, several people are needed. The managing director leads and oversees the financial aspects while supporting roles include the Purdue business office and administrative support. Other key roles will be discussed in the Administration section.

4.3. Administration

The managing director leads the administration of SCALE, which includes quarterly report preparation and submission, supervising and supporting SCALE personnel, planning and facilitating SCALE meetings and events, metrics collection, and process improvement.

4.3.1. Quarterly Reports

Quarterly reporting is one of the main responsibilities of SCALE's administration team. Every quarter, SCALE gathers data from partner institutions (currently via the SCALE Web App; historically via emailed spreadsheets) to use in the quarterly reports that are submitted to the DoD. These reports provide evidence that SCALE has accomplished and spent money towards the objectives in the contract, which is based on both milestone and contract line item numbers. The reports also provide a financial summary

of how SCALE is performing as compared to spending plans including any issues as well as anything that SCALE needs help with. The reports include highlights from the last quarter as a bullet list. These reports are prepared by the managing director and then reviewed by the SCALE Co-Directors before sharing with the DoD.

Currently, the report prepared is a single report for SCALE but the plan is to transition to individual quarterly reports by technical vertical. This should enable a more fine-grained analysis of performance as well as increased buy-in from the technical leads to hold them accountable in their respective areas. One-page summaries will accompany the reports and can be used to highlight key program achievements. Each technical vertical will submit a report at different times throughout the year. A part-time technical writer has been hired to assist the technical leads in preparing the quarterly reports.

4.3.2. Supervising and supporting SCALE personnel

One administrative function of SCALE is the managerial responsibility of staff members, which includes making sure staff members are engaged, supported, and contributing to the project. The managing director supervises staff that are leading various components of the project (e.g., student experience lead, work experience lead), a technical writer, contractors, and some of the administrative staff.

Because SCALE is a large, complex program, it requires significant resources in terms of staffing to enable the program to run efficiently. Currently, approximately 15% of SCALE's budget is allocated just for management.

4.3.3. SCALE program meetings

The annual SCALE Symposium is held each year at Purdue to ensure there are annual plans in place. Attendees include Purdue leadership and staff, technical leads, PIs, the external evaluation team, and government representatives. Due to the increasing size of the Symposium, efficient administrative planning and support is necessary. The SCALE managing director assists the SCALE Co-Directors in preparing for the Symposium. SCALE's administrative assistant handles logistical details of securing rooms, ordering food, and contacting the participants to provide travel information.

The SCALE quarterly planning meetings are organized and led by SCALE's managing director. The purpose of these meetings is to make sure SCALE's annual and quarterly plans are moving in the right direction. These meetings include in-person and virtual participation from the leadership team and from the technical leads. Topics for each quarterly meeting vary but generally include SCALE updates, time for group planning, assessing progress on challenges that were previously identified, and development of goals for the upcoming quarter.

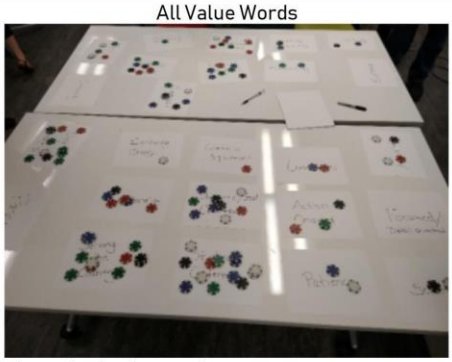
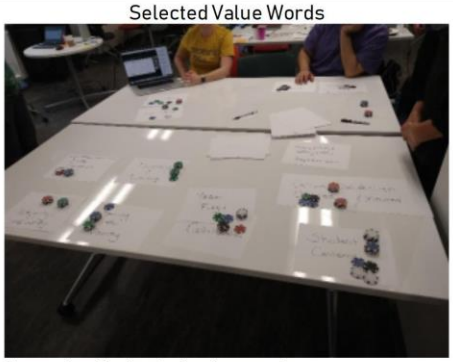
The SCALE managing director assists the SCALE Co-Directors in preparing for the Symposium.

SCALE Vision Day was a full-day, in-person meeting that took place at Purdue University and included less than 20 individuals from the Purdue leadership team as well as selected PIs from partner intuitions. Each person was selected to attend based on their potential for providing input, insight, and firsthand experience to aid in shaping the three- to five-year vision for SCALE. The goal of the meeting was to select a list of core values for SCALE, prioritize a list of challenges that SCALE is facing with strategies to

overcome the challenges, and create a shared team calendar, and select a list of core values for SCALE. Before the event, participants and stakeholders were asked to develop a list of challenge themes. During the meeting teams worked to convert these lists into FROM -> TO statements describing shifts that SCALE needs to make over the next 5 years with ideas of steps to take to connect the FROM/TO statements.

Before the event, members of the leadership team were asked to vote on a list of value words proposed by leadership. After narrowing the list, the poker chip method was used to further narrow down the choices, which included time for discussion and negotiation (Table 2).

Table 2. Selection of key SCALE values

All Value Words	Selected Value Words
	
Example of value words: • Commitment • Initiative • Learning	Example of selected value words: • Serving the country • Student-centered • Integrity & trustworthiness

The primary outcome was a prioritized list of ten challenge statements defining the three to five year vision for SCALE.

4.3.4. Metrics

The managing director oversees metric data collection and the development of the SCALE Web App to collect data from faculty and students. The SCALE Web App is described in more detail in section 2: Student Experiences. Another component of metrics work is proposing the metrics that are collected for an internal SCALE scorecard.

The Department of Defense (DoD) requested the creation of a metric to measure the return on investment (ROI). The managing director led the development of the ROI metric that will measure and improve SCALE value delivery, enable comparisons between SCALE and other workforce development programs or approaches, and diagnose the performance of SCALE across universities, technical areas, and degree levels.

Administratively, collecting these data promptly and with fidelity is crucial to track SCALE's progress and recommend actions.

4.4. Process Improvement

Process improvement is important for efficient and effective program administration. The managing director leads process improvements for SCALE. A contractor with a background in Six Sigma and process

methodologies was hired to assist with this task. The main role of the contractor is to develop cycle time improvements for contract modifications and establish an onboarding process for new technology verticals and academic partners. Process improvement for SCALE has involved helping others develop processes (e.g., the process of onboarding students), developing processes within the financial and administration components of SCALE, helping others to utilize their own processes, and assisting in developing a list of improvement projects and priorities. The list is prioritized so that when a new improvement project is started it is one of the most valuable projects for SCALE.

4.4.1. Billing Cycle Process

The billing cycle process uses an updated process for simple and more robust results. Expense reporting to Purdue uses an Excel template and occurs on the 10th of each month. This process takes 19 steps laid out in a Gantt chart (see Box 2). The previous method relied on invoices and was vulnerable to invoicing issues and unnecessary complexity. Using a simplified Excel form for expense reporting from SCALE subcontractors to Purdue cut the cycle time to 25 to 55 days with no disruption in other processes. Dedicated resources at Purdue manage this new approach with all subcontractors.

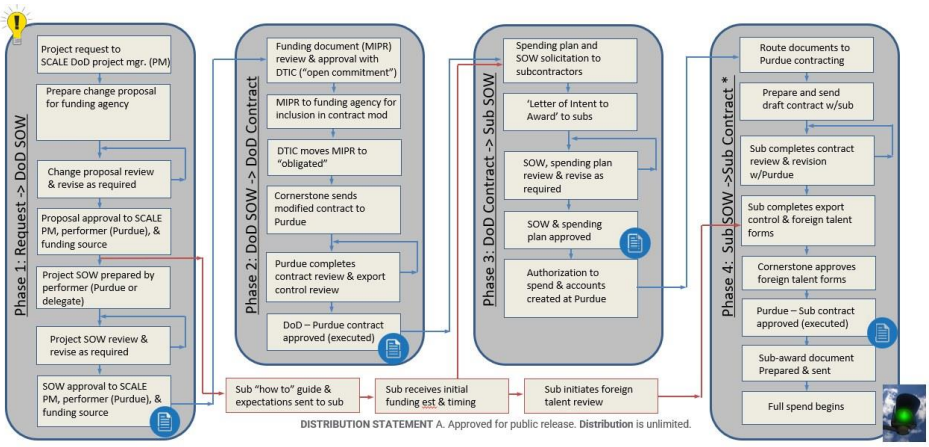
4.4.2. Contract Modification Process

The contract modification process was updated with improvements to a current cycle time of approximately one month from a cycle time of around three months. Three changes were made to improve the cycle time, including an expectations document, SOW improvements, and contracting improvements. The changes that have been implemented are shown in Table 3.

Table 3. Improvements to the contract modification process

Expectations Document	SOW Improvements	Contracting Improvements
• Create a one-page document that describes the process flow, steps, and expected cycle times • For each step, track the actual cycle times by subcontractor and compare them to expectations. • Communicate that late execution of the process may affect the amount of funding received • Share expectations across all affected functions within subcontractor (e.g. PI, business office, contracting, export control) at start of SOW and contracting efforts	• Provide SOW document template • Set clear expectations on content • Share example SOWs and/or begin with the subcontractor's prior SOW • Initiate SOW development earlier in the cycle • Assign SOW submission and approval deadlines • Have technical leads conduct SOW review and approval to increase capacity and ensure consistency and communication within tech verticals.	• Initiate discussions on terms and conditions and US citizenship requirements earlier in the process • Highlight any changes from the prior contract • Initiate non-citizen approval forms earlier in the cycle. • Assign contract approval deadlines.

The current/updated contract modification process takes place in four stages. The tasks occurring within each stage are outlined in Figure 2.

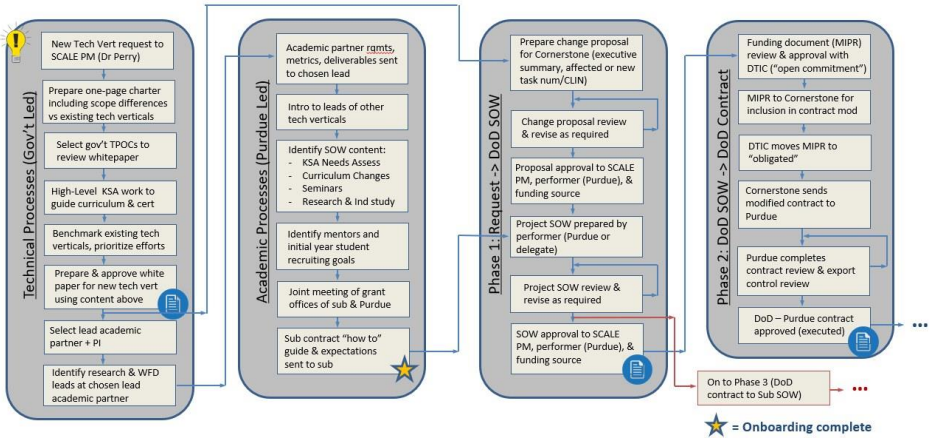


2 - Figure 2. New contract modification process.

4.4.3. Technical Vertical Onboarding Process

Structured onboarding of technical verticals was needed to speed the transition from contract to reporting and to prevent duplication of effort. Standardization of the process (see Figure 3) was needed to ensure fairness and awareness of requirements for communications with potential partners. The benefits of this process for SCALE include increasing the breadth and depth of SCALE's network, connection to a greater variety of DoD/DoD-adjacent employers, greater benefit and reach to students, opportunities to generate knowledge, and greater responsiveness to changing technical and workforce needs.

A quick start guide was developed for this process that can be used by Purdue faculty and staff.



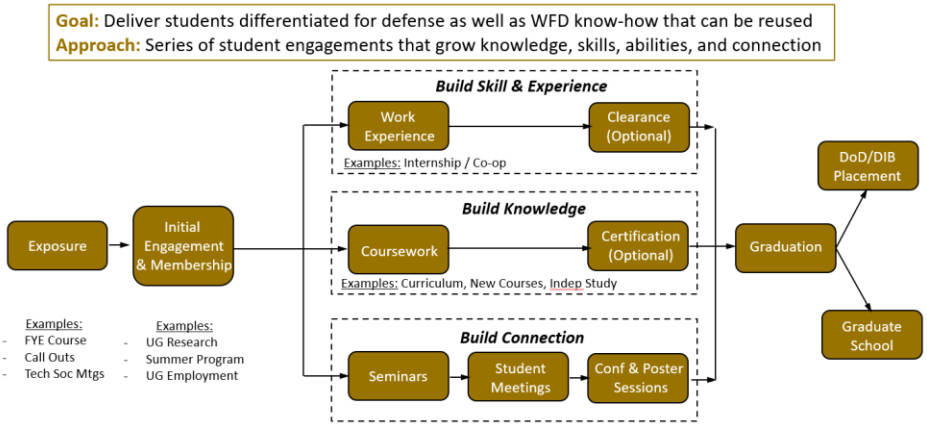
3 - Figure 3. Proposed new approach for technical vertical onboarding process

4.4.4. Value Stream Mapping

Value stream mapping is a strategy used to improve components of the SCALE program. Pioneered by Toyota[1] , value stream mapping captures: the flow of materials (e.g., students and their supporting resources), information/data flow (e.g., student metrics), the passage of time (e.g., cycle and wait times such as when a student applies to SCALE and when they are accepted into the program), performance metrics (e.g., students accepting a defense-related position in microelectronics), and resources consumed (e.g., budget).

A value stream map shows the major process steps and connections, efficiency/effectiveness metrics, information and data flow, cycle time and event triggers, customer requirements for the end product, and supplier inputs. In SCALE, the customer is the DoD, while the product is the students who graduate from SCALE. Resources include DoD and industry funding, mentors and advisors, internship and research opportunities, and laboratory facilities and equipment. Key customer metrics include the number of certified/graduated students, the number of students not placed with DoD/defense-related industry, and certifications and levels achieved by students.

A value stream map of SCALE was created with those inputs in mind. The SCALE value stream map is used to show how and to what extent the process is working. Examining the process steps in detail enables SCALE leadership to develop a portfolio of improvement projects as well as redesign the process for increased performance and improvement.



4 - Figure 4. Example of a SCALE value stream map

[1] Lander, E., and J. K. Liker. 2007. "The Toyota Production System and Art: Making Highly Customized and Creative Products the Toyota Way." International Journal of Production Research 45 (16): 3681–3698.

4.5. Key Successes

- There is recognition within the DoD that it takes 15% to 20% of SCALE's budget at a minimum allocated for management to run the program effectively. As management needs grow this allocation ensures that the program will scale appropriately. DoD has increased this budget allocated to SCALE's finance and administration aspects, which are key in running a successful program.
- Purdue's sponsored program services recognized the need for a dedicated finance staff member to work on SCALE. A research specialist was hired full-time to work with all Purdue PIs on the finances of SCALE and alleviate issues related to communication between staff at a large university. For any financial issues for SCALE, the PIs will go to this person instead of their individual account manager.
- Started involving the technical leads in more finance and administration such as spending plans and quarterly reports. The technical leads have the expertise to understand whether the

spending plan makes sense and why it may differ from those at other universities. It also motivates them to find out what's going on at different universities within their technical vertical and not to work only independently.

- Quarterly reports to the DoD are provided by technical vertical rather than a single, high-level report. With the reports broken down by technical vertical, it's clearer how each technical area performs and more information about how SCALE performs on metrics is revealed. Since technical vertical leads are helping to prepare the report, there is more buy-in and accountability. Technical leads also have the domain expertise to better complete these tasks.
    - One-page summaries are requested from each partner university on the project work they are doing (e.g., curriculum, research), which helps the DoD communicate and share the reports.
- Hired a part-time technical writer for editorial content. Because more was being required of technical leads, providing them with appropriate resources to be successful at completing their tasks was an important success, which included providing a technical writer to assist.
- Shifted the process of financial reporting from the subcontractor to the prime (Purdue). An Excel template was rolled out that removes 45 days of delay from the financial reporting as detailed in the project Gantt chart.
- Academic partners must submit monthly spending plans and SCALE administrators provide them with a target percentage of the budget to spend by a certain date. This has helped partners know how well they are or are not doing before the end of the fiscal year. It also allows SCALE administrators to follow up with partners who are behind on spending so that the budget can be reallocated as needed; thus it has enabled SCALE to be more proactive in the use of the funds and understanding when partners are off track.
- Development of a return-on-investment (ROI) metric. This will guide SCALE's approach, as scoring well on the ROI will mean that the program is doing well. This is a unique contribution in the area of DoD-funded workforce development.
- Development and implementation of process improvements that reduce the time from contracting to performing. These processes enable fewer time delays in the billing cycle, reduce contract modification over time, and improve the onboarding of new technical verticals.
    - A new technical vertical onboarding process, which enables a structured approach to onboarding of new technical verticals. This approach will speed the transition from contract to performing as well as prevent duplication of effort.
    - New contract modification process includes fast-tracking and parallel flows where possible. The new process goes from a cycle time of over three months to a cycle time of under one month from DoD contract to subcontract. This modification process focused on three main areas: expectations document, SOW improvements, and contracting improvements.
    - An improved billing cycle process simplifies expense reporting from SCALE subcontractors to Purdue leading to 45 days cut from the typical cycle time with

increased robustness. Furthermore, there was no disruption of existing government processes.

- Administering a work experiences survey to students shortly after the start of the new academic year has been successful in shoring up gaps in students' missing data. This survey will continue to be administered on an annual basis in September.
- Administering a graduation recognition survey was a success with a 70% response rate. The recognition items provided by SCALE following survey completion make students feel accomplished and motivated to fill out the survey. Valuable information on students' paths after graduation is obtained from this survey.
- One key achievement has been reporting transparency. The Purdue team created dashboards (e.g., large Excel files with pre-programmed graphics) that can be quickly updated with the latest monthly totals on project performance. Based on this, the finance team at Purdue and at the DoD has worked on a common Excel template that they can exchange monthly to measure progress.

4.6. Key Challenges

- Because SCALE is a large, complex project, obtaining buy-in for the resources needed for the program and putting the resources in place effectively has been challenging.
    - There was not a managing director employed with SCALE at the time of hiring the current managing director. There were insufficient resources in place at that time to support running a successful program, which required persuading funders of the importance of allocating sufficient resources to finance and administration.
- At large universities, the various personnel needed for finance do not necessarily communicate. This was a key challenge that SCALE faced until a full-time finance person was hired for the project.
    - A related challenge is working with various staff members from different business offices at Purdue.
- Having the right balance between local support and SCALE-wide support is a key challenge due to having academic partners at various institutions while most of the support staff is located at the prime institution.
- Onboarding new academic partners has been challenging in terms of getting to an executed contract. One reason for this is that universities often find unfavorable terms in the contract (e.g., the US citizen requirement) that cannot be negotiated. For example, SCALE cannot guarantee that funding is available and may not allow a partner to spend until obtaining an executed contract.
    - One issue in getting to an executed contract is with export control restriction and involves the restriction of US citizens for SCALE students and special permission for non-US citizens in a staff or faculty role. Because SCALE received those contract terms from

the DoD, Purdue is unable to negotiate these terms, while partners often believe the terms are negotiable.

- Obtaining information about where students go after graduating from SCALE has been challenging. This data quality challenge can impact the ROI calculation and other associated metrics.

4.7. Recommendations

- At large universities, we recommend hiring a person specific to your program who can work just with your project's finances as well as having one person from the business office dedicated to the project.
- The managing director should have a diverse set of skills and be willing to do what it takes to make the program succeed.
- Having an understanding of the academic environment and the different needs of faculty and staff is useful for management and administration.
    - At a university, there tends to be a hierarchical structure among faculty and staff so being aware of this can help one to successfully navigate the challenges that emerge within this structure.
    - The availability of faculty versus staff may vary due to the academic calendar and fiscal year calendars.
    - Academic calendars will differ between universities.
- It is important to keep in mind that staff should support all of SCALE across universities, rather than just at the prime university where most of the staff are located. It may be a good idea for staff to support or test a process locally first, before expanding to the other partner institutions.
- Hiring a full-time staff member in the business office can alleviate the challenges of working within the constraints of staff who are part-time or who are juggling multiple other funded projects.
- Have an expected timeline of when the spending plan, SOW, and an executed contract should be completed. For example, SCALE expects partners to get an executed contract within a month of when we first begin the conversation.
    - To avoid delays in getting to an executed contract with academic partners (with the goal being one month to an executed contract), it's recommended to use a template SOW and timeline.
    - Another recommendation for achieving an executed contract is that when the funding agency selects partners, the funding agency can have the partners agree beforehand to the terms. It should be communicated to the institution up front that if they cannot resolve any terms within a month, that it can lead to a reduction in the funds.

- Performance tends to improve when individuals are aware of how well they are performing; thus, for SCALE it's important to have transparency among the partners for spending plans, data quality, and time to get to an executed contract. This information should be communicated to technical leads for comparison purposes while not providing information that could potentially create conflicts. For example, the percentage of funds spent by each partner can be compared, without revealing the amount allocated per partner.
- We recommend using a site such as SharePoint for collecting information on finances with appropriate privacy controls so that spending plans and partner reporting are centralized and easily accessible when needed.
- To gather the information needed for the ROI metric that is specific to students (e.g., where a student goes after graduation), we recommend asking students directly rather than relying on secondary reports from faculty. However, we also recommend incentivizing students or reinforcing to them the importance of gathering that data. For example, a work experiences survey administered to students after they returned from the summer was useful for SCALE to gather information on students' previous internship and research experiences.

Links to Model Documentation

Partner Relations

The main goal of the Partner Relations component of the SCALE model is to leverage the expertise and capabilities of microelectronics partners from all sectors, including public, private, and academic institutions, to contribute to the scalability and replicability of the microelectronics workforce.

https://sway.cloud.microsoft/q7u8JKL8NEEvKEHn?ref=Link

Student Experience

The SCALE student experience aims to integrate microelectronics exposure and training from the K-12, undergraduate, graduate, and professional levels. The goal of the undergraduate and graduate-level SCALE student experience is to expose, motivate, and prepare students from diverse backgrounds in engineering and engineering technology with the skillset and mindset for careers in defense-related microelectronics.

https://sway.cloud.microsoft/i1KZVKzVAgbPDAid?ref=Link

Knowledge Share

The purpose of the SCALE knowledge share component is to disseminate the knowledge generated by the SCALE program both internally and externally, which includes technology transfer to industry to serve defense and security needs. This includes sharing technical knowledge, creating collaborative partnerships between the SCALE consortium members, and sharing the SCALE model with other external programs.

https://sway.cloud.microsoft/foGVkck25Mo9umkU?ref=Link

Finance and Administration

The primary goal of SCALE's finance and administration component is to enable smooth and efficient program operations both internally at the prime institution and with the academic partners external to Purdue. Finance and administration are key components of the SCALE program as they permit the efficient management of SCALE's resources.

https://sway.cloud.microsoft/BM1bxFRXq6LheG6d?ref=Link

Evidence-Based Improvement

The goal of SCALE's evaluation is to provide a holistic evaluation leading to evidence-based improvement. The SCALE evaluation uses a holistic approach to evaluation, including outcome-based metrics, process evaluation, external evaluation, site-specific evaluation, and financial return on investment to provide a comprehensive understanding of the program.

https://sway.cloud.microsoft/nYz3HSHBN0YDFuIc?ref=Link

5. Evidence-Based Improvement

5.1. Goal

The goal of SCALE's evaluation is to provide a holistic evaluation leading to evidence-based improvement. The SCALE evaluation utilizes various methods, including outcome-based metrics, process evaluation, external evaluation, site-specific evaluation, and financial return on investment to provide a comprehensive understanding of the program. The established theory of social cognitive career theory (SCCT) provides a framework for selecting metrics and assessments that can inform program stakeholders.

5.2. Evaluators

SCALE has both internal and external evaluation (see section 5.6. for more information about the external evaluation). SCALE's internal evaluation is led by a Director of Evaluation and Assessment with support from other SCALE staff (e.g., postdoctoral researchers, undergraduate research assistants). The internal evaluation of SCALE includes collecting data and interpreting those findings to make evidence-based recommendations for stakeholders. The internal evaluation involves disseminating outcome-based metrics, conducting a process evaluation of the program, engaging in site-specific evaluation, and examining the financial return on investment. Related tasks for the internal evaluation team are tracking the progress of the program, adjusting indicators as needed, developing and revising assessments, developing and refining logic models for various components of the program, assisting with metrics collection and interpretation, administering surveys, analyzing quantitative and qualitative survey data, conducting interviews or focus groups as needed, leading the Assessment Working Group, and preparing reports and presentations on evaluation findings.

SCALE has both internal and external evaluation.

The external evaluation team (e.g., not based at the lead university) is subcontracted to provide an unbiased evaluation of the program. This team provides: a) feedback that can be used to aid in decision-making, and b) information that can be used by program leadership to understand the connections

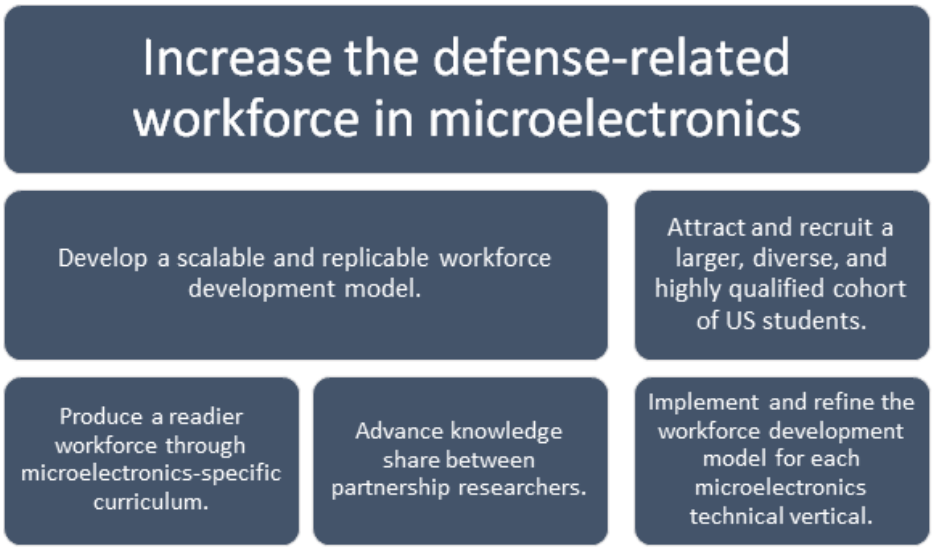
between the project rationale, activity implementation, effectiveness, and outcomes, with a specific focus on issues related to the strategic and sustainability plans of SCALE. The external evaluators prepare a formative evaluation report for program leadership on a biannual basis, conduct exit surveys and interviews with SCALE students, conduct in-depth case studies of academic partners, and provide specific assessment and evaluation as needed.

5.3. Holistic Evaluation

SCALE employs a holistic evaluation for evidence-based improvement. This evaluation consists of reporting on outcome-based metrics, process-level evaluation, external evaluation, site-specific evaluation, and financial return on investment. The holistic evaluation will be explained in more detail in the following sections.

5.4. Outcome-Based Metrics

One component of SCALE's evaluation is to select and examine outcome-based metrics. The key evaluation question asks: To what extent is SCALE meeting stated goals? The primary aim of the SCALE program is to increase the defense-related workforce in microelectronics. The SCALE goals that support this aim are shown in Figure 1.



1 - Figure 1. SCALE goals

To assess progress toward meeting these goals, SCALE uses an outcomes-based, metrics-driven approach. That is, SCALE is evaluated on an ongoing basis based on key indicators. The leadership team and program funders have identified the most important metrics that can capture whether or not SCALE is accomplishing its goals and objectives most efficiently and effectively.

5.4.1. SCALE Metrics

SCALE uses several key metrics to report on the progress of the program. Many of these metrics are reported on a cumulative basis. These metrics consist of student enrollment metrics, student experience metrics, graduated student metrics, course and mentor metrics, and partner metrics. The specific metrics and descriptions for each are listed below.

SCALE is increasingly focused on including more demographic information such as race/ethnicity and gender into each of the above metrics data. There have been some challenges in collecting this information due to low student reporting of these fields on surveys or application data. In the future, SCALE aims to incorporate diversity, equity, and inclusion (DEI) metrics. SCALE leadership is working with the external evaluators to develop DEI-focused metrics that can be used for targeted student recruitment and retention.

Student enrollment metrics

- Number of students withdrawn from SCALE
- Number of current SCALE students
- Number of students by year in school and by university

Student experience metrics

- Number of students participating in research by technical area and university
- Number of students holding an internship (Industry, Government, Academic, and/or Defense-related) by technical area and university
- Number and type of student experiences by institute name (e.g., Sandia, Intel).
- Number of students who received security clearance
- Number of students who completed individual mentor plan

Graduated student metrics

- Number of students who graduate from SCALE
- Number of SCALE undergrads who enroll as SCALE graduate students
- Number of full-time job offers of SCALE students (by technical area and university) in DoD
- Number of full-time job offers of SCALE students (by technical area and university) in government
- Number of full-time job offers of SCALE students (by technical area and university) in industry
- Declination rate (% declines to offers)
- Acceptance rate (% acceptance to offer)
- Number of interns hired full-time by the same organization (by DoD, industry, and government)
- Number of participants hired by cross-organization exchange

Course and mentor metrics

- Number of regular meetings with students
- Number of curriculum units developed
- Number of new courses
- Number of courses implementing SCALE-developed curriculum
- Number of courses implementing microelectronics curriculum
- Number of participating universities in delivering curriculum
- Number of students reached through coursework
- Number of students exposed if SCALE was mentioned in any course
- Number of elective technical courses developed related to SCALE
- Number of senior capstone courses that mentors advised on during the semester
- Number of students who took existing courses in which SCALE curriculum was implemented
- Number of students who took new SCALE-related courses
- Whether and from what sources the mentor had subsidized funding for students in SCALE
- Number of students the mentor is funding through SCALE
- Whether or not the mentor has any multi-institutional research projects with other SCALE partners (number of multi-university projects)
- Whether or not the mentor has hosted students as research assistants from other SCALE schools (number of cross-student exchanges)
- Number of total students (paid or not) who are engaged in the mentor's research
- Number of publications and presentations related to SCALE

Partner metrics

- Number of DoD partners
- Number of government partners
- Number of university partners
- Number of industry partners
- Number and type of technical area
- Number of organizations offering internships by type of institution (DoD, government, industries)

SCALE also includes several metrics on weekly and monthly scorecards that are shared internally with leadership. Some of these metrics are used to calculate the ROI metric while others are used to track the

progress of the program and identify any issues (e.g., # students withdrawn). These metrics are listed below; many are also listed in the SCALE metrics list.

- Return on Investment (ROI): uses several metrics for this calculation
- Number of graduating students placed: full-time placements in research or internship positions
- Account-based selling (percentage of graduating students placed with advanced degrees minus target)
- Average cost per graduated student placed
- Average increased value per graduated student placed
- Percent of returned value due to practice reuse by other DoD workforce development efforts and within SCALE
- Number of students with graduation dates in the upcoming semester
- Number of accepted offers of employment or graduate school
- Number of acceptances in defense or graduate school
- Cumulative value of acceptances [$]
- Percentage of students with graduation dates before the upcoming semester in graduate programs
- Percentage of all students in graduate programs
- Cumulative total graduates + Undergraduate and Graduate SCALE budget expended
- Percentage of budget expended
- Number of students with internships during the prior year
- List of companies hiring graduates by technical area
- Number of internships by industry or DoD/DoD-adjacent by technical area
- Number of full-time placements by industry, research/grad school, or DoD/DoD-adjacent by technical area
- Number of student research experiences by technical area
- Number of students who graduated from SCALE by technical area
- Number of current students by technical area
- Number of withdrawn students by technical area and year of study

The primary methods that SCALE personnel use to obtain metric data are the SCALE student application, SCALE faculty quarterly data collection reports, and the web app.

SCALE application. The SCALE application is hosted on the Purdue Qualtrics platform and publicly available via the web for students to apply on a rolling basis. The application includes questions to determine if the student is qualified for SCALE (e.g., G.P.A.), questions about their experience and interest in microelectronics, and demographic questions (e.g., gender, year of study).

SCALE Faculty Quarterly Data Collection. Faculty are asked to provide quarterly updates, which are reported to the DoD regularly. A key component of quarterly reporting is to collect progress toward contractual milestones. Faculty/mentors are also asked to provide information about their courses (e.g., new courses developed/implemented) and number of students enrolled. Currently, this information is collected from faculty via Excel templates and email.

SCALE Web App. The SCALE Web App was developed to assist with collecting student data (e.g., internship/research experiences, demographic information) that can be used in metric data collection. Students' mentors go through the shareable pieces of student information in meetings as part of professional development, which leads to higher completion rates of student information that can be used for metrics reporting.

2 - SCALE Web App Mock-Up

5.4.2. Targets for Metric Numbers

Identifying targets to include in the evaluation can ensure the project is moving toward an agreed-upon goal, which is useful for reporting to the funding agency as well as tracking internally. When identifying targets, it is important to determine how success will be demonstrated or achieved. This will provide clarity and direction towards achieving the desired outcome.

SCALE has found success with setting achievable but challenging targets that can motivate team members to exceed expectations while still meeting objectives. Surveying team members can aid in setting achievable targets that are not too easy to reach. Typically, if the team is 80% certain that they can attain the target, it provides the right level of challenge without being overly ambitious. SCALE's Project Director is instrumental in guiding the process of selecting and implementing suitable targets.

5.5. Process-Level Evaluation

A critical component of SCALE's evaluation is to conduct a process-level evaluation of the program. The key evaluation question asks: What is the quality of services provided? The process-level evaluation aims to provide actionable information to improve the program. This component of the evaluation examines how the program is implemented to ensure that the program produces the expected results or to better understand why the results are not as anticipated. To determine the most appropriate measures for the process-level evaluation, SCALE is informed by the empirically-supported social cognitive career theory (SCCT) upon which SCALE is based.

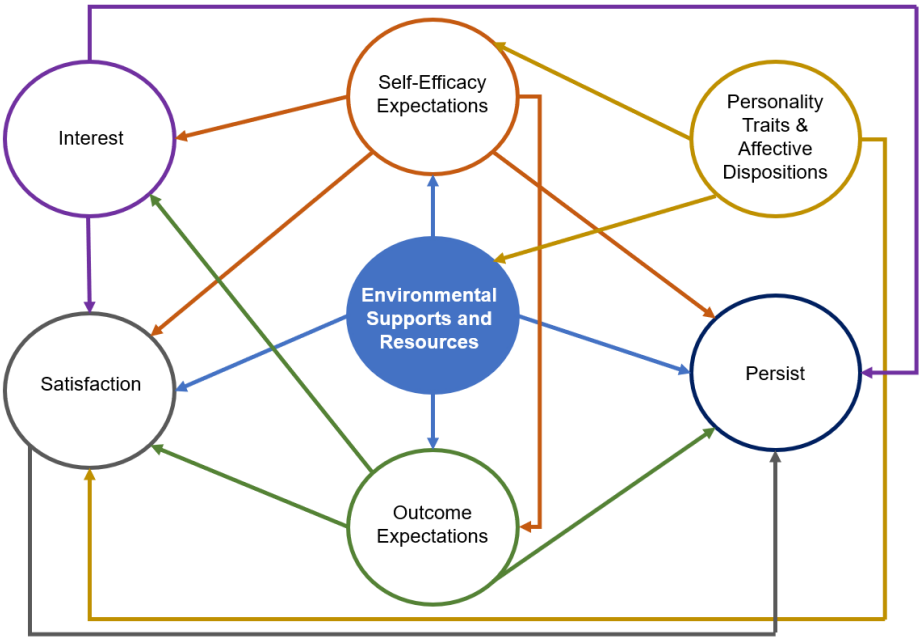
5.5.1. SCALE Program Theory

SCALE bases the evaluation on program theory to determine which key metrics and measures to use to answer key evaluation questions. The empirically supported Social Cognitive Career Theory (SCCT) is used to guide the evaluation of the SCALE program. This theoretical framework has been extensively studied across various fields using validated instruments. SCALE uses the SCCT survey, adapted from Lent et al.[1] , to measure seven aspects of students' career interest development, which have been operationalized for the SCALE program (Table 1). These factors include self-efficacy, outcome expectations, interests, satisfaction, persistence, and environmental support and resources. SCCT links career interest with positive self-efficacy and career outcome expectations, which can be developed through support and resources[2] .

Factor	SCALE Definition
Self-efficacy	Students' confidence in their ability to complete their engineering/major coursework.
Career outcome expectations	Beliefs about the impact of their career on themselves and society.
Interest	Students' interest in a career in microelectronics/Trusted AI.
Satisfaction	Students' satisfaction with the SCALE program and their opportunities within the field of microelectronics/Trusted AI.
Persistence	Students desire to persist in the SCALE program and in the field of microelectronics/trusted AI.
Environmental supports and resources	The career and academic supports available to SCALE students.

Each factor in the SCCT model exerts an influence on students' career-related decisions. For example, students who are confident in their ability to perform a task (self-efficacy) are more interested in pursuing the task or topic as a hobby or career. The model also includes career outcome expectations, which means that if a student perceives that the career will have positive impacts on themselves or society, they will be more interested in taking steps to pursue that career. The directional arrows in the model indicate feedback loops; for example, students who are more interested in microelectronics and derive satisfaction from engaging in the topic will be more likely to persist in the field.

SCALE is focused on creating the environmental supports and resources that can increase students' self-efficacy, outcome expectations, and influence the other components of the model, which can ultimately lead them to pursue a defense-related microelectronics career. For example, SCALE can provide internship or research experience that allows students to put into practice what they learned and apply their knowledge, which could lead to higher satisfaction, self-efficacy, and persistence.



3 - Figure 2. SCCT framework[3] and SCALE's role

The social cognitive predictors of career choice can help evaluators determine the most important factors to measure, which are the key outcomes of the program. Measuring these outcomes is part of the process evaluation, which helps us determine what processes led to the resulting metrics, or quantitative outputs. These outcomes provide an indicator of magnitudes of change. For example, students' interest in microelectronics is a key construct that can be measured when evaluating the program. Examples of process-level evaluation questions to examine the supports that SCALE provides are: To what extent to students feel like they belong in the SCALE program? Are students satisfied with the support they are receiving from their mentors? Which resources are they accessing and how frequently? For the most part, these outcomes are measured through data collected via surveys.

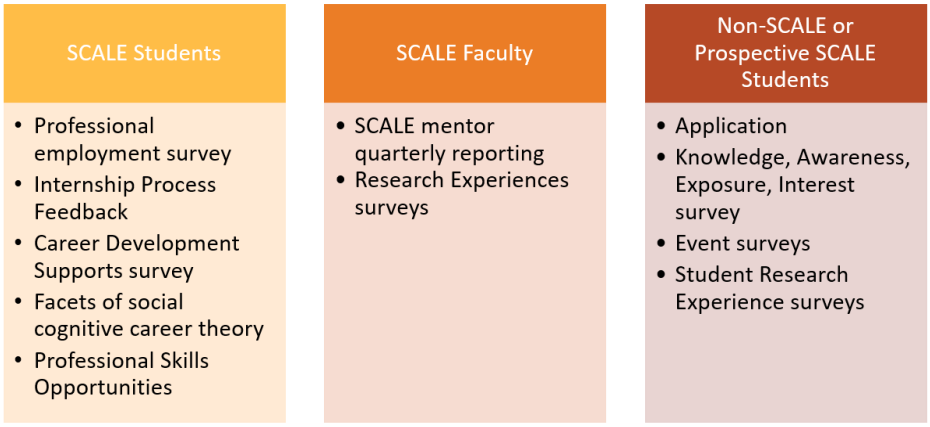
[1] Lent, R.W., Miller, M.J., Smith, P., Watford, B.A., Lim, R.H., & Hui, K. (2016). Social cognitive predictors of academic persistence and performance in engineering: Applicability across gender and race/ethnicity. Journal of Vocational Behavior, 94, 79-88.

[2] Lent, R. W., & Brown, S. D. (2002). Social cognitive career theory and adult career development. In S. G. Niles (Ed.), Adult career development: Concepts, issues and practices (pp. 76–97). National Career Development Association.

[3] Lent, R. W., et al. (2013). Social cognitive predictors of adjustment to engineering majors across gender and race/ethnicity. Journal of Vocational Behavior, 83(1), 22-30.

5.5.2. Data Collection

SCALE administers several student surveys throughout the year to measure SCALE's outcomes as part of the process-level evaluation. Each survey and data collection method is described in this section. Figure 3 provides an overview of each measure grouped by the type of participants.



4 - Figure 3. SCALE assessments

Social Cognitive Career Theory (SCCT) survey. The SCCT measures students' career interests and development in microelectronics. The survey includes factors of self-efficacy, outcome expectations, interests, satisfaction, persistence, and perceived environmental support and resources, as they relate to microelectronics/trusted AI. The survey takes approximately 10 minutes to complete. The SCALE team uses the results of the survey to determine how well SCALE is supporting students in their microelectronics career interests and what areas can be improved.

Career Development Supports (CDS) survey. The purpose of the CDS survey is to evaluate engineering students' career support, sense of belonging, and satisfaction with SCALE. There are two sections in the CDS: Perceived Cohesion and Career Social Capital. Perceived Cohesion refers to a student's feelings of being a part of a particular group, in this case, a part of the SCALE program. Perceived Cohesion can be broken down into two subsections of sense of belonging and satisfaction with SCALE. In the Career Social Capital section, students' social capital is evaluated through a social capital name generator that asks students to list up to five influential individuals in their careers and specify the career support received from these mentors. They reported how their mentors contributed to their career self-efficacy, positive career outcome expectations, and career interests and goals. The survey takes approximately 10-15 minutes to complete. SCALE staff use the survey to gauge the extent to which students have adequate career support as well as to examine their sense of belonging in the SCALE program.

Professional Skills Opportunities (PSO) survey. PSO measures engineering students' opportunities to practice professional skills including shared leadership, communication, problem-solving, business and management principles, and ethics and professional responsibilities. The survey is used by SCALE staff to identify what professional development opportunities SCALE needs to provide to SCALE students. The survey contains mainly closed-response items and takes approximately 5 minutes to complete.

Internship Process Feedback (IPF) survey. The IPF Survey asks students about their experience looking for internships and/or research experiences. The survey asks students about the location of their summer placement, job search feedback from microelectronics organizations, their satisfaction with SCALE's role in internship/research search, how SCALE impacted their search, and their feedback on improving the process. The survey is used by SCALE staff to examine the extent to which students participate in summer internships and research experiences and how to improve this process for students. The survey takes approximately five to ten minutes to complete.

Professional Employment survey. The Professional Employment (Prof. Work Exp.) survey asks students about their professional work experiences during their time in SCALE. The survey includes questions about students' prior professional work experiences as well as information about their anticipated graduation date and if they desire assistance in seeking employment. The survey is used as part of metric data collection (e.g., number of students holding internships) and as a means of assisting students who need help with finding employment. The survey takes 10 to 15 minutes to complete.

SCALE Event surveys. A SCALE event survey is used to obtain feedback and suggestions on SCALE-related events from SCALE and non-SCALE students who attend the event. These brief (approximately 5-minute) surveys also collect exposure and interest data from students who respond that they are not a member of SCALE. The survey is used to assess the usefulness of the event for students and gather suggestions for future events. The survey is also used to collect information about exposure to microelectronics as well as interest in microelectronics from students who are not part of SCALE.

Student/Mentor Research Experience surveys. The Student Research Experience survey and the Mentor Research Experience survey were developed to capture students' and their mentors' experiences following participation in a SCALE research experience. The Student Research Experience survey assesses students' satisfaction with various components of the program, their experiences with their mentors, and their perceptions of how useful the program is for their career pathways. The SCALE Mentor Experience survey assesses mentors' satisfaction with the program, their perceptions of the skills that students were practicing in the program, satisfaction with the performance of students that they mentored, and suggestions for feedback and improvements. SCALE staff use the results of the survey to improve the quality of students' research experiences. Each survey takes approximately 10 to 15 minutes to complete.

Awareness, Exposure, and Interest survey. The purpose of this survey is to assess students' awareness of the field of microelectronics/trusted AI, their exposure to the field, and their interest in learning or pursuing this topic. The survey was developed for students who do not have prior formal exposure and is used either as a pre/post assessment to capture changes following an intervention or as a retrospective post-survey. SCALE staff use this survey (e.g., in a first-year engineering course) to capture changes in students' awareness, exposure, and interest following some type of intervention (e.g., microelectronics curriculum, course module). The survey typically takes about 10 to 15 minutes to complete.

See Figure 4 for the overall data collection timeline for each of the main SCALE surveys.

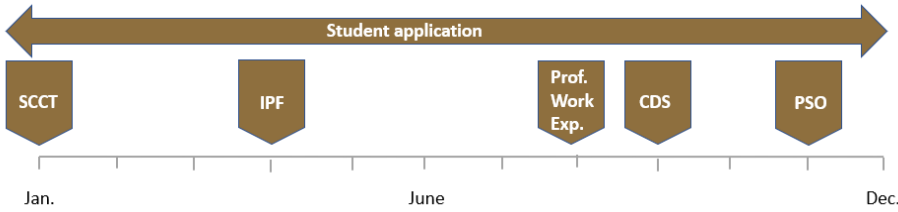


Figure 4. Data collection timeline

The period that a survey is open is typically one month. This includes an initial email to the student distribution list asking students to complete the survey. Students are offered a $15 gift card incentive for completing the survey, which has improved the response rates from approximately 30% to 50%.

Students are also told that the surveys are a requirement of the funding agency. Approximately 7 to 10 days after the initial email to students, a reminder email is sent to all students who did not complete the survey. Following another approximately 7 to 10 days, SCALE staff send an email to the student's mentor and/or the technical vertical lead at the student's university asking the faculty member to remind their students to complete the assessments (see Box 1 for a template email to faculty).

Box 1. Email template survey reminder for faculty mentors or technical vertical leads

Dear [student name],

On [date], we launched a survey for all SCALE students to collect required data for DoD reporting purposes on students' [main purpose of the survey] during their time in SCALE. The name of the survey is the [survey name] survey. Students will receive a $15 gift card for completing this brief (approximately 5-minute) survey.

The survey link is: [link here]

We ask that you please remind your students to complete this survey. An obligation of SCALE students is that they complete SCALE surveys to fulfill the program requirements. If you believe that a student on the list has graduated or withdrawn, please let us know so that we can update our information. The list of students who have not completed the survey are:

Student first name	Student last name	Student email
Student first name	Student last name	Student email

Please let me know if you have any questions or concerns about this or other surveys.

5.5.3. Dissemination of Survey Results

Timely dissemination of the survey results is important to provide actionable insights for program improvement, share relevant information with funders and leadership, and receive feedback from stakeholders. The program results are shared in several ways.

After each survey is distributed and analyzed, the results are reported at the monthly Assessment Working Group (AWG) meeting. During this meeting, results are shared with PIs and technical leads. The PIs and technical leads have the opportunity to discuss results, provide insight into why certain results were achieved, and suggest any next steps or actions. For more information about the AWG, see Section 1.10.3. in the Partner Relations section.

Results are also distributed internally via informal PowerPoint presentations and reports on an ongoing basis. The information is used for program evaluation and improvement.

Survey findings are also shared informally with the external evaluation team during biweekly meetings. The raw data and summary reports are shared with the external evaluation team for inclusion in the biannual reports. The biannual reports are provided to the DoD.

After the overall results of each survey are presented, the evaluation team reports the information at the institution level. An individual report for each academic institution is created, which also includes overall findings in each technical area as a basis for comparison. These reports are shared with PIs on nanoHUB.

Finally, the SCALE evaluation team publishes and presents some of the findings in journals at conferences. These publications and proceedings are shared with the SCALE PIs on the nanoHUB site.

5.6. External Evaluation

The purpose of the external evaluation is to provide an independent source that can assess the effectiveness of SCALE in fulfilling its contractual obligations, functioning as a consortium, achieving outcomes, and promoting equity and diversity. The external evaluation uses various data sources such as internal data review, interviews, end-of-symposium surveys, focus groups, and exit surveys.

Each year, the external evaluators submit a statement of work (SOW) to SCALE leadership that details their plans for the upcoming year. Examples included in the statement of work are annual data collection efforts (e.g., exit interviews), providing biannual reports, regular meetings with the SCALE team, providing suggestions from an outside perspective on evaluation activities and findings, travel to interact with program personnel and participants, and any additional work that has been arranged with SCALE leadership (e.g., case studies of SCALE academic partners). The main evaluation questions are also included in the SOW, which focuses on four areas: implementation of the program, program outcomes, the effectiveness of SCALE's program activities, and equity and diversity (e.g., opportunities and barriers).

5.6.1. Independent data check

A key component of the external evaluation is to provide an independent, unbiased evaluation of the program. To that end, the external evaluators perform an independent check of the surveys and metric data. Biannually, the raw data and summary reports of all surveys and data collection are shared with the external evaluators who provide a biannual report that is submitted to the DoD.

5.6.2. Attend annual symposium

The external evaluators attend the annual SCALE symposium where they conduct interviews or focus groups, survey faculty on their perceptions of SCALE overall and the symposium, and interact with program PIs and participants.

5.6.3. Collect additional data

As needed and requested, the external evaluators collect additional data that is not collected by SCALE's internal evaluation team. For example, the external evaluators have conducted exit surveys and interviews with graduating SCALE students, performed site visits to SCALE universities as part of case studies, and administered and analyzed a post-symposium feedback survey. In most cases, SCALE leadership requests this data collection to outsource some of the evaluation needs so that the internal evaluation can focus on other key evaluation activities. For example, the case studies of SCALE universities are time-consuming and require additional staff effort for site visits, interviews, archival analysis, qualitative analysis, and reporting.

5.6.4. Monitor progress on an ongoing basis

The external evaluators are regularly in touch with the internal evaluators and other program staff. The external evaluators meet with relevant SCALE personnel every two weeks to exchange project updates, discuss upcoming work, and gather information as needed.

5.7. Site-Specific Evaluation

Part of the SCALE evaluation includes site-specific evaluation. Because the SCALE program is made up of many different academic partners, it is essential to include information about how the program is functioning at each institution. The key evaluation question asks: How engaged are partners at each partner academic institution?

Methods of collecting site-specific evaluation data are through case studies and a partnership rubric. Case studies are conducted by the external evaluators through site visits, examination of archival data (e.g., an institution's SOW), interviews, observations, and survey data. The evaluators present their findings in a report to SCALE leadership, which can be used to better understand how different academic institutions implement the SCALE program as well as the challenges and affordances unique to each institution.

The academic institutions are evaluated via a partnership rubric (the partnership rubric can be found in the Appendix for Section 1, Partnerships). The rubric includes attributes selected by leadership and the funding organization that are thought to contribute the most to effective program implementation. The attributes include participation in program meetings and events, communication with the prime organization, leveraging resources, adherence to program goals, collaboration across technical areas/institutions, and the inclusiveness of key information in the statement of work.

One way in which the site-specific data is used is as a method of identifying reasons for student outcomes such as attrition or student satisfaction with the program. The information is also used to provide feedback to the academic partners regarding contractual obligations.

5.8. Financial Return on Investment

SCALE is also in the process of developing a Return-On-Investment (ROI) metric. The metric follows the standard business practice of comparing the value of returns to the investors versus the investment that enabled those returns. The ROI metric will be shared once it's finalized at a later date.

5.9. Selection of Measures

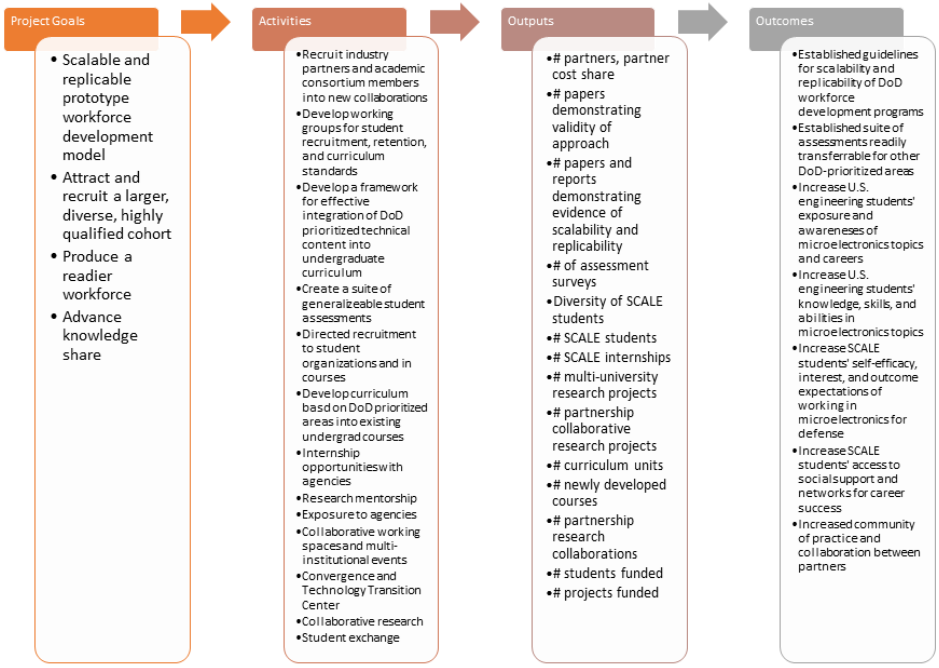
The project's success is measured in part by the outcome-based metrics, most of which were identified at the beginning of the program. The program implementation is evaluated through the process evaluation to determine whether the program was implemented as intended.

To determine if the metrics that SCALE had been using were appropriate, SCALE used guidelines from several sources including the literature and personal experience. The key takeaways from these guidelines are to focus on the outcomes and performance rather than the activity, limit the number of metrics used, ensure that metrics are tied directly to the creation of value, and continue evaluating and revising the metrics over time. Because programs might shift in focus or direction, continuously evaluating metrics and ensuring their usefulness is important throughout the life of the project. A logic model can be used to guide the overall evaluation and alignment of the goals to the program activities, indicators, and outcomes.

5.9.1. SCALE Logic Model

SCALE uses a logic model as a framework to align the activities of each goal to the program outputs and outcomes. See Appendix A for more information about logic models. The graph below shows a version of SCALE's logic model that has been used by SCALE's evaluation to track progress, align goals to activities and metrics, and select appropriate assessments to measure key outcomes.

The logic model is used for internal and external evaluation purposes. The logic model guides the biannual external evaluation reports as the external evaluators examine the logic model to determine whether SCALE is making progress toward meeting the goals. The internal evaluation tracks progress formatively. The formative evaluation seeks to uncover how and why any changes might be taking place and provide relevant information to project leadership on how the project is progressing. This enables the project to function more efficiently and successfully.



5 - SCALE Logic Model (high-level)

5.10. Key Successes

- Providing a gift card incentive for completing each survey has brought up the response rates from approximately 30% to around 50%.
- The development of a logic model at the beginning of the program enabled the evaluation to be more focused and efficient.
- Hiring a full-time staff member devoted to internal evaluation was needed due to the time-consuming nature of internal evaluation of such a large, complex project.
- Improved processes in data collection and management via the development of the SCALE Web App. The Web App enables students to update their SCALE-relevant information at any time and

facilitates quarterly reporting of SCALE leads and mentors. The Web App employs secure data storage practices and is less subject to data corruption and loss.

5.11. Key Challenges

- Response rates for surveys tend to be low (<50% response rates) even though the surveys are a requirement of participating in SCALE.
- Demographic reporting (e.g., gender, race/ethnicity) tends to be low among students, making it more difficult to obtain information on how diverse students are faring the program.

5.12. Recommendations

- The SCALE team had greater success with survey response rates by providing incentives for students to complete surveys. Sending a reminder to both students and their faculty/mentors also helped increase response rates.
- The external evaluators can assist with some assessment tasks that may be too time consuming for the internal team, such as case studies/site visits.
- At least one full-time staff member is needed for internal evaluation tasks.
- The SCALE app may increase the reporting of student and faculty information. It will also make data collection more efficient for internal evaluation in terms of collating and downloading information needed for students and faculty.
- A return on investment metric could enable comparisons between other workforce development programs.

Links to Model Documentation

Partner Relations

The main goal of the Partner Relations component of the SCALE model is to leverage the expertise and capabilities of microelectronics partners from all sectors, including public, private, and academic institutions, to contribute to the scalability and replicability of the microelectronics workforce.

https://sway.cloud.microsoft/q7u8JKL8NEEvKEHn?ref=Link

Student Experience

The SCALE student experience aims to integrate microelectronics exposure and training from the K-12, undergraduate, graduate, and professional levels. The goal of the undergraduate and graduate-level SCALE student experience is to expose, motivate, and prepare students from diverse backgrounds in

engineering and engineering technology with the skillset and mindset for careers in defense-related microelectronics.

https://sway.cloud.microsoft/i1KZVKzVAgbPDAid?ref=Link

Knowledge Share

The purpose of the SCALE knowledge share component is to disseminate the knowledge generated by the SCALE program both internally and externally, which includes technology transfer to industry to serve defense and security needs. This includes sharing technical knowledge, creating collaborative partnerships between the SCALE consortium members, and sharing the SCALE model with other external programs.

https://sway.cloud.microsoft/foGVkck25Mo9umkU?ref=Link

Finance and Administration

The primary goal of SCALE's finance and administration component is to enable smooth and efficient program operations both internally at the prime institution and with the academic partners external to Purdue. Finance and administration are key components of the SCALE program as they permit the efficient management of SCALE's resources.

https://sway.cloud.microsoft/BM1bxFRXq6LheG6d?ref=Link

Evidence-Based Improvement

The goal of SCALE's evaluation is to provide a holistic evaluation leading to evidence-based improvement. The SCALE evaluation uses a holistic approach to evaluation, including outcome-based metrics, process evaluation, external evaluation, site-specific evaluation, and financial return on investment to provide a comprehensive understanding of the program.

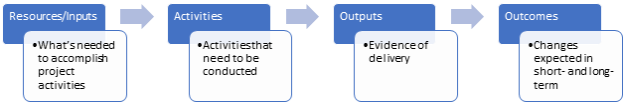
https://sway.cloud.microsoft/nYz3HSHBN0YDFuIc?ref=Link

Appendix

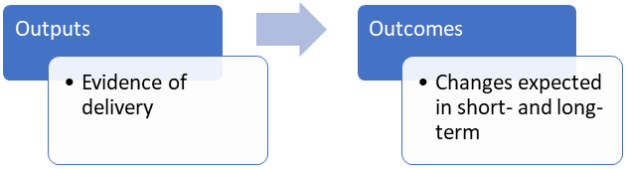
Logic models

A logic model is a graphical representation of a program's theory of change that is used to align the activities of each program component with numerical outputs and the magnitude of change (i.e., outcomes). Read holistically, logic models portray the intended relationships among program components. The logic model is divided into resources/inputs, activities, outputs, and outcomes. This division enables the research team to identify measures, generate success targets, test model

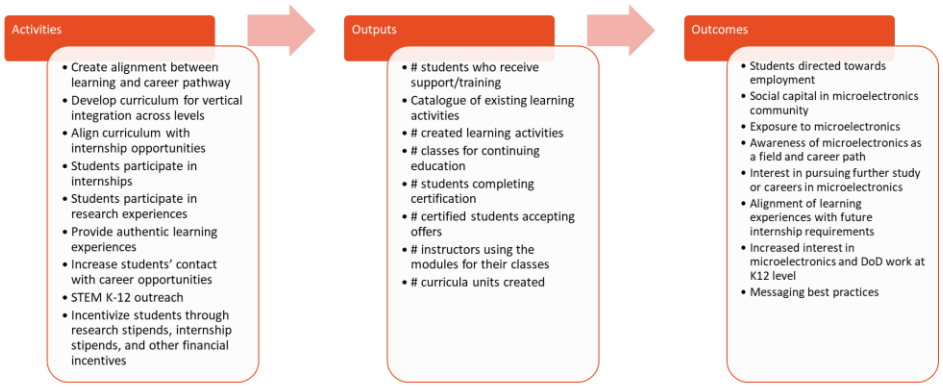
assumptions, and investigate outcomes. For example, if the program includes a knowledgeable microelectronics instructor as a resource/input, and the instructor implements the curriculum (activity), then the number of students who participate in the class is an output and the increased awareness of microelectronics among students is a short-term outcome.



Outputs and outcomes are metrics associated with program delivery. Outputs refer to evidence of delivery and are quantitative, while outcomes are process-based and refer to anticipated changes.



An example of a logic model is shown in the next figure. It shows examples of some of the main activities that take place for the student experience component of the SCALE program. Following the activities are the outputs, which are the deliverables and quantitative indicators that result from the activities. The outcomes can be short to long-term and indicate the results and magnitude of change that is expected to take place following the activities.



Logic models represent a program's theory of change and should be developed at the beginning of the program to aid in program planning. Logic models should be revisited throughout the program for evaluation purposes and adjusted as needed.

Two resources used by the SCALE team to develop logic models are the following:

1. Paul, Christopher, Assessing and Evaluating Department of Defense Efforts to Inform, Influence, and Persuade: Worked Example. Santa Monica, CA: RAND Corporation, 2017. https://www.rand.org/pubs/research_reports/RR809z4.html.

2. W. K. Kellogg Foundation, Logic Model Development Guide: Using Logic Models to Bring Together Planning, Evaluation, and Action, Battle Creek, Mich., January 2004.