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An Adaptive, Improvement-Oriented Evaluation Suite for Undergraduate Research Experiences: A Reflective Case Study from an Engineering Research Center

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Introduction

This **methods research brief** explores how an adaptive, improvement-oriented evaluation suite for undergraduate research experience programs can act as a lever for center-wide organizational learning and improvement when employed within an ecosystemic evaluation strategy informed by research and practice. From this perspective, the program and the program evaluation are iterative: evaluation provides feedback to inform program adjustments, and evaluation methods adapt to assess the impact of those changes. This positions evaluation as a tool for continuous learning and improvement. Here we outline our approach and examples of its application in an Engineering Research Center (ERC) context. ERCs are cross-disciplinary hubs funded by the National Science Foundation (NSF) to integrate convergent research, technology translation, engineering workforce development, and broadening participation [1]. Within this landscape, Research Experiences for Undergraduates (REU) and Research Experiences and Mentoring (REM) (referenced together in this paper as “REX” programs) are programs that share a mission to prepare the next generation engineering workforce for careers within the U.S. innovation ecosystem by offering experiences that boost identity alignment and scientific, technical, and professional development skills [2].

ERC evaluators have collaborated within communities of practice to develop evaluation tools for ERCs. Reflecting on eight years of engineering engagement program evaluation, this research brief details the adaptation and extension of a standardized evaluation suite (MERCII) for REX programs within an ERC [3, 4]. Using a reflective case study approach [5], we report on our experience incorporating standardized methods with a feedback-responsive evaluation strategy to support continuous organizational learning to drive improved program impact. We provide specific examples of how we applied and adapted a range of mixed-method, multi-stakeholder tools within our evaluation suite, including participant pre-and post-surveys, semi-structured interviews, focus groups, rubric-based skills assessment, and mentoring reflections from 92 REX participants. We aimed to answer the following question: *how can adaptive program evaluation methods be leveraged to help support program impact within the ERC and serve a broader function across the engineering ecosystem*? This paper addresses how we developed, integrated, and adapted our evaluation suite by: (1) refining evaluation approaches specifically for this situated, complex ERC context; (2) demonstrating community of practice-engaged approaches to evaluation across multiple sites, participant types, and program activities; and (3) illustrating how standardized tools and instruments can be adapted and extended to drive multilevel learning and improvement. This information is intended to guide program evaluators and leaders in adapting standardized evaluation tools for undergraduate research programs within cooperative research contexts.

Background

Since the launch of the ERC program in 1984, NSF has leveraged policy-mixing programs, such as undergraduate research experience supplements, to support workforce development [6], [7]. When planning engineering engagement programs, ERCs must manage various research priorities, changes in funding allocations, variable faculty mentoring practices, multi-site coordination, and an ever-changing landscape of undergraduate student interests and needs [8], [9], [10]. The existing literature on ERCs identifies several methodological challenges specific to REX-type programs. Evaluations are commonly conducted within a single ERC, resulting in small sample sizes that make it difficult to test the validity of evaluation instruments effectively [11]. This "siloed" approach also limits cross-center comparison [3]. Often, ERC evaluations are further atomized, focusing on a single group within the center, preventing multi-stakeholder insights [3], [8], [12]. In response to these challenges and opportunities, researchers are shifting toward a more unified approach. Beginning in 2019, the NSF funded the ERC Educational Consortium (TEEC) to develop a suite of measures for evaluating education and workforce development programs across ERCs [3]. Concurrently, ERC evaluators formed a community of practice to share instruments, identify best practices, workshop evaluation challenges, and pilot test instruments designed for cross-ERC evaluation. These efforts culminated in the Multi-ERC Instrument Inventory (MERCII), to streamline evaluation and enable large-scale evaluations across all ERCs. Rather than functioning as a rigid evaluation framework, MERCII was intentionally designed to balance the need for consistent metrics and replicable tools with center-specific and formative evaluation goals, enabling centers to adapt instruments to their respective local contexts [8], [11], [13].

While ERCs provide a broad framework for innovation, REX programs are a vehicle for next-generation preparation, necessitating evaluation strategies that bridge high-level center goals with more granular programs and experiences. This work grows out of an epistemological perspective that intentionally designed evaluation can be more than an accountability tool [8]. Instead, we describe the evaluation suite as both a reflective *and* strategic practice. REX evaluation findings have informed organizational learning across a variety of domains, including mentor training, team training design, and research communication practices within this ERC.

About the Research Center

The Center for Cellular Metamaterials (CELL-MET), like other NSF ERCs, is designed to stimulate convergent, translational research by bringing a multi-institutional, multidisciplinary team together with innovation ecosystem (industry, clinical, and government) partners to transform cardiovascular care by engineering personalized heart tissue that could be used for both clinical and research applications [14]. At the same time, CELL-MET engages with P-12 and informal education (e.g., museums, community) partners to prepare the next generation workforce and broaden participation. CELL-MET has created synergy between their research and education goals by creating a comprehensive set of P-20 programs to attract, engage, and train young learners for careers in engineering. Because of this integrated approach, CELL-MET and all ERCs constitute unique ecosystems that share common goals while also being highly unique to their own local contexts. Therefore, the evaluation of ERCs needs to strike a balance between methods that allow comparison across centers and methods that are adaptive to the specifics of each ERC [13].

Methods

Across CELL-MET's lifecycle, the evaluation team has employed an adaptive, improvement-oriented evaluation perspective. Using the Center's logic model as a basis, we balanced fidelity to established benchmarks and published tools with adaptation to an evolving and evaluation-responsive program environment. Changes in student-facing programming reflect intentional organizational learning and continuous improvement [4]. We assert, consistent with education research, that improvement-oriented evaluation must be responsive and iterative, with customization as a critical piece of effective educational programming [15].

Reflective Case Study Design

In this paper, we frame our work using a reflective case study design [5, 16] to explore how a systematic, theory-informed, and improvement-oriented evaluation approach can provide evidence of impact for individual participants while also generating insights to inform broader program management and improvement. Reflective case studies can be particularly instructive when evaluating complex programs in applied contexts where causal inference is complicated by real-world limitations. By looking backward through a retrospective lens within the situated context of this ERC, we were able to reflect on how evaluation evolved to uncover patterns in participant needs and inform organizational change over time.

Programs and Participants

While CELL-MET has hosted a wide range of engineering engagement programs for P-20 learners and educators, this paper centers the undergraduate research experience. CELL-MET offered REU and REM summer programs annually at each of its three institutions. Over the last eight years, 92 undergraduate students have participated in CELL-MET REX programs that provide an immersive 6-8 week in-person experience centered around high-impact lab research experiences directly related to the Center's convergent research goals, including opportunities for professional and network development. The experience was anchored within a tiered mentoring structure where REX participants were mentored by CELL-MET graduate students and postdocs, who served as near-peer mentors under the guidance of faculty [17].

To maximize the impact of the Center's multi-institutional strengths and areas of expertise from various stakeholders, the program leaders adopted a hybrid model of coordinated and site-specific programming. As such, the evaluation method was adapted to use both shared and differentiated measures for each institution to reflect the interdependencies between participant types and sites. This ensured common metrics provided information about center-wide goals, but more targeted items (e.g., site-specific activities, role-specific activities, or skills) were applied using survey logic or targeted instruments. In the section below, we provide examples of how our evaluation approach balanced standardized methods with an improvement-oriented approach that was responsive to programmatic context and evolution.

Development and Evolution of the REX Evaluation Suite, Over Time

This section summarizes the evaluation strategy, including engagement with the ERC evaluation community, adoption and adaptation of shared ERC instruments, and development of Center-specific tools. Below, we provide examples based on emergent program needs, including mentoring, direct assessment of student learning, and formative feedback for evolving programs. Collectively, these adaptive efforts positioned evaluation as an integrated component of program operations, generating actionable feedback loops to support organizational learning, inform ongoing program refinement, and enable both longitudinal and cross-ERC learning. The REX evaluation suite over time is shown in Table 1.

Table 1. REX Evaluation Suite Over Time

Instrument	Description	Year(s) of Implementation*						
		’18	‘19	‘21	‘22	‘23	‘24	‘25
URSSA Post-Survey	Validated tool for assessing undergraduate research programs. 56 questions (253 items), likert, multiple choice, and open-ended, on skills, knowledge, identity, and career preparation.	X	X					
REX Post-Survey	32 questions (132 items), likert, multiple choice, and open-ended , on knowledge and skills, identity, culture, training experiences, mentoring, career preparation, and summative feedback. Items adopted/ adapted from URSSA and MERCII, as well as unique items.			X	X	X	X	X
REX Pre-Survey	21 questions, (85 items), likert, multiple choice, and open-ended, on motivation, prior experiences, skills, identity, and career goals. Developed for pre-post comparison, program mgmt., and cross-site consistency.				X	X	X	X
REX Poster/ Presentation Rubric	3 questions (11 items), likert and open-ended, on science communication, research elements, and mentor comments. Adapted from MERCII rubrics.				X	X	X	X
REX Mentor Pre-Survey	3 open-ended questions on prior mentoring experience, motivation, and support needs. Adapted and expanded lead-site onboarding data collection to support cross-site consistency.					X		
REX Mentor Post-Survey	6 questions (11 items), likert and open-ended, on mentoring skills, benefits, challenges, suggestions to improve, and satisfaction.						X	X
REX Week 1 Check-in Interview	6 open-ended questions on early program experiences, logistics, participant goals, mentor interactions, and questions or concerns						X	X
REM Focus Group	Conducted at program end, via Zoom. 3 open-ended questions (with follow-up probes) on program strengths, challenges, and suggestions to improve.							X

**No REX programs were offered in 2020 due to the COVID-19 pandemic.*

Evolving an Evaluation Suite for Center Needs. A central feature of our evaluation strategy was sustained engagement with the broader ERC evaluation community. During the Center’s early years, the Undergraduate Research Student Self-Assessment (URSSA) was adopted to assess REX participant outcomes and served as a launchpad for the development of a customized REX post-program survey more closely aligned with the Center’s activities and targeted outcomes [18], [19], [20]. Following the first two years of REX implementation, the evaluation team conducted a strategic review to better align the evaluation approach with evolving program needs. This review was informed by participation in ERC-wide evaluation networks, including the 2019 ERC biennial, where the team connected with other ERC evaluators and learned about an NSF-funded TEEC [19, 3]. Building on these connections, the evaluation team began convening an ERC evaluator community of practice, engaged with the TEEC, and helped to organize the 2020 All ERC Workshop, where we both presented some of our evaluation and learned about approaches used at other ERCs [21].

Through these engagement activities, we were able to share and receive access to evaluation instruments used and being developed by other ERC evaluators, including the evaluation suite developed by the TEEC team. These shared resources informed our strategic review and refinement of our REX evaluation approach. Because we were already in year 3 of the Center, we selected items that would enable cross-ERC evaluation, while preserving the ability to collect longitudinal data as the Center evolved its annual REX summer programs. Working closely with the REX program leaders, the evaluation team compiled items to ensure consistency with program goals, activities, and scope, and to reduce response burden. Items that were not closely aligned with the program goals and scope were eliminated. Retained items were adjusted to increase alignment. New items were added to align with cross-ERC evaluation efforts.

Targeting Center Goals. As mentoring became a greater focus of the ERC, the evaluation strategy adapted to explicitly capture mentoring experiences and outcomes for both REX participants and the graduate students and postdocs serving as their mentors. An annual mentor post-survey, and a one-time mentor pre-survey were added to better understand mentoring practices and support needs. By including multi-stakeholder data collection, we were able to provide a more holistic view of the REX program, enabling program leaders to incorporate multiple perspectives in their program refinements. Feedback from both REX participants and their graduate student and postdoc REX mentors indicated that those relationships were critical to the participant experience. This insight led the Center to offer mentor training and to develop a REX notebook to structure and support that interaction, and the REX experience overall.

Targeting Direct Assessment. In response to NSF site visit feedback calling for direct assessment of student learning outcomes, beyond self-assessment, the evaluation team adopted and adapted the REX Poster/Presentation Rubric from similar-purpose MERCII rubrics [13]. Final research presentations and posters provided a natural opportunity for direct assessment. In addition to assessing program impacts on science communication and engineering research competencies, the rubric introduced a standardized mechanism for formative mentor feedback, which participants identified as a valuable component of the program.

Targeting Formative Feedback for New Program Components. Finally, formative, qualitative evaluation tools such as the Week 1 Check-In and a post-program REM focus group were incorporated to provide timely and reflective participant feedback. The Week 1 Check-In enabled program leaders to identify and address issues early; signaling organizational responsiveness and ensuring student voices were centered. When the Center implemented a novel REM Includes program for early-stage undergraduates that integrated the summer research component with year-round mentoring and professional development activities, the evaluation team added a focus group at the end of the program to better understand their experiences and insights [22]. The post-program REM focus group complemented the early week 1 feedback by creating space for participants to reflect on the full arc of their experience. Together, these formative approaches elevated participant voices, supported real-time and retrospective learning, and reinforced Center values that prioritize participant input across the full program lifecycle.

Feedback Loops for Organizational Learning. Each year, following data analysis on the above instruments, we have facilitated a collaborative feedback loop with REX program leaders to translate the insights into actionable program improvements. We took the dataset further than a simple analysis and presentation of student outcomes. Through data collection across different methods, roles, and years, we were able to leverage institutional knowledge to crystallize broader patterns of change, expectations, and experiences of REX participants in a three-dimensional understanding of the program(s) [23], [24]. This approach has allowed us to provide iterative feedback to create an environment where the programs and our assessment methods evolve in tandem to meet the shifting needs of summer program participants. We view our methodological choices and actions as a generative procedure that triggers reflexivity among stakeholders, supports practical shifts in programming, and offers understanding into participant experiences that might otherwise be hidden.

Discussion

This paper demonstrates an adaptive, improvement-oriented evaluation approach for undergraduate research programs in an ERC. Central to this approach is balancing the use of cross-ERC metrics with customized evaluation tools that evolve alongside program goals, structures, and participant needs. Rather than treating evaluation as a fixed or compliance-driven activity, the approach described here positions evaluation as a dynamic system that supports learning, decision-making, and continuous program refinement. By integrating mixed method, multi-stakeholder, longitudinal feedback, the evaluation captured the complexity of team-based, convergent research training environments. This integration provided more actionable program-level insights that enabled program leaders to translate findings into concrete changes to drive impact and improve participant outcomes. From the outset, evaluation design was informed by engagement with the broader ERC evaluation community and the selective adoption of shared instruments such as URSSA and MERCII. These tools provided a common measurement foundation that supports cross-center learning. At the same time, instruments were intentionally adapted and augmented to reflect local program priorities, reduce response burden, and preserve longitudinal tracking as the program evolved. This balance between standardization and flexibility was critical to maintaining both rigor and relevance. This approach also supports organizational learning for funders seeking to compare across grantees or to demonstrate ecosystemic impact.

Importantly, this adaptive evaluation approach has been applied beyond ERC REX programs to other Center initiatives, including the NSF-funded Coastal Hazards, Economic Prosperity, and Resilience (CHEER) Hub; demonstrating its transferability across programs with different structures and audiences [25]. For ERCs and similar organizations, these findings underscore the value of embedding evaluation into center operations and organizational culture. For engineering education researchers, they highlight the importance of planning evaluation strategies that are theoretically informed, improvement-focused, and responsive to program evolution.

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References

[1] National Science Foundation. “Engineering Research Centers,” NSF - U.S. National Science Foundation. https://www.nsf.gov/eng/engineering-research-centers.

[2] E.A. Corley, B. Bozeman, X. Zhang, & C.C. Tsai, “The expanded scientific and technical human capital model: The addition of a cultural dimension,” *The Journal of Technology Transfer*, *44*(3), 681–699. Jul. 2017. Available: https://doi.org/10.1007/s10961-017-9611-y

[3] Z. Zhao et al., “Design and Development: NSF Engineering Research Centers Unite: Developing and Testing a Suite of Instruments to Enhance Overall Education Program Evaluation,” in *2021 ASEE Virtual Annual Conference Content Access*, Jul. 2021. Available: https://peer.asee.org/design-and-development-nsf-engineering-research-centers-unite-developing-and-testing-a-suite-of-instruments-to-enhance-overall-education-program-evaluation

[4] C. H. Blakely et al. “The fidelity-adaptation debate: Implications for the implementation of public sector social programs,” *American Journal of Community Psychology*, vol. 15, no. 3, pp. 253–268, Jun. 1987. Available: https://doi.org/10.1007/bf00922697.

[5] S. Tardi, “Case Study: Defining and Differentiating Among Types of Case Studies,” in Case Study Methodology in Higher Education, IGI Global, Jun. 2019. Available: https://www.igi-global.com/book/case-study-methodology-higher-education/221165

[6] D. Gray, L. McGowen, T. L. Michaelis, O. Leonchuk, and D. Rivers, “A policy mix experiment to promote start-up success: exploratory evaluation of the NSF Small Business Innovation Research (SBIR)/Industry University Cooperative Research Center (IUCRC) membership supplement,” *The Journal of Technology Transfer*, vol. 47, no. 1, pp. 176–212, Apr. 2020. Available: https://doi.org/10.1007/s10961-020-09794-6.

[7] “ERC History,” Erc-assoc.org, 2020. Available: https://erc-history.erc-assoc.org/

[8] D. O. Gray, “Making team science better: Applying improvement-oriented evaluation principles to evaluation of cooperative research centers,” *New Directions for Evaluation*, vol. 2008, no. 118, pp. 73–87, May 2008. Available: https://doi.org/10.1002/ev.262.

[9] National Science Foundation, NSF 09-0545: Engineering Research Centers (ERC)-Partnerships in Transforming Research, Education, and Technology (Program Solicitation), Arlington, VA: National Science Foundation, 2009. Available: https://nsf-gov-resources.nsf.gov/solicitations/pubs/2009/nsf09545/nsf09545.pdf?VersionId=iGgyn2yO4o3YEd3y66RKGnXiztoL7hqe

[10] H. Bae and J. Mondisa, “Work-in-progress: Mentoring experiences of students at an Engineering Research Center,” in *2025 ASEE Annual Conference & Exposition*, Jun. 2025. Available: https://peer.asee.org/work-in-progress-mentoring-experiences-of-students-at-an-engineering-research-center.

[11] J. S. Larson, L. Folkestad, and R. Pareek, "BOARD #436: Research in the Formation of Engineers (RFE): Sustaining and Scaling the Multi-Engineering Research Center Instrument Inventory (MERCII)," in *2025 ASEE Annual Conference & Exposition,* Jun. 2025. Available: https://peer.asee.org/board-436-research-in-the-formation-of-engineers-rfe-sustaining-and-scaling-the-multi-engineering-research-center-instrument-inventory-mercii

[12] M. Drummond Oakes, K. Everett, M.T. Harris, M. Sydlik, and A. Godwin, "Expanding summer research programs at an NSF ERC: Innovation, assessment, and adaptation," presented at the *2020 ASEE Virtual Annual Conference*, Jun. 2020. Available: 10.18260/1-2--34626.

[13] Z. Zhao, M. O'Donnell, M. Jordan, W. Savenye, G. Roehrig, and M. Lyra, "Developing common qualitative tools for cross ERC education program evaluation," in *2022 ASEE Annual Conference & Exposition*, Jun. 2022. Available: https://peer.asee.org/developing-common-qualitative-tools-for-cross-erc-education-program-evaluation

[14] National Science Foundation, "Award Abstract #1647837 - Nanosystems Engineering Research Center for Directed Multiscale Assembly of Cellular Metamaterials with Nanoscale Precision: CELL-MET," *National Science Foundation Award Details*, Oct. 01, 2017. Available: https://www.nsf.gov/awardsearch/show-award/?AWD_ID=1647837

[15] R. E. Stake, *Standards-Based and Responsive Evaluation,* SAGE Publications, Jan. 2011. Available: 10.4135/9781412985932

[16] Yin, R. K. The abridged version of case study research: Design and methods. In *Handbook of applied social research methods*, pp. 229–259, 1998. Sage Publications.

[17] T. McKean, L. S. Bates, G. Bates, J. D. Wiersma-Mosley, and S. R. Wickramasinghe, "A multi-tiered mentoring community approach to research experiences for local students from disadvantaged and underrepresented minority backgrounds," *Frontiers in Education,* vol. 9, Jun. 2024, doi: 10.3389/feduc.2024.1366063.

[18] T. J. Weston and S. L. Laursen, "The Undergraduate Research Student Self-Assessment (URSSA): Validation for Use in Program Evaluation," *CBE—Life Sciences Education,* vol. 14, no. 3, p. ar33, Sep. 2015, doi: https://doi.org/10.1187/cbe.14-11-0206.

[19] Z. Zhao et al., "Creating Common Instruments to Evaluate Education and Diversity Impacts across Three Engineering Research Centers," *2019 IEEE Frontiers in Education Conference (FIE)*, Covington, KY, USA, 2019, pp. 1-4, doi: 10.1109/FIE43999.2019.9028711.

[20] N. Kalkunte, L. McGowen, M. Qasim, and M. Borrego, "Conducting a Diversity, Equity, and Inclusion Climate Survey of Engineering within a Large Texas University," in *2022 ASEE Annual Conference & Exposition,* Jun. 2022. Available: https://peer.asee.org/conducting-a-diversity-equity-and-inclusion-climate-survey-of-engineering-within-a-large-texas-university

[21] L.C. McGowen, C. Wade, S. Schaible, and J. Scott, "Measuring Culture of Inclusion for Engineering Research Centers," Presented at the *NSF ERC Engineering Workforce Development,*

Diversity and Culture of Inclusion, Evaluation, and Student Leadership Workshop, 2020, North Carolina State Univ., Raleigh, NC.

[22] National Science Foundation, “NSF INCLUDES Research Experience and Mentoring (REM) Supplemental Funding Opportunities,” *NSF - U.S. National Science Foundation,* Feb. 2024. Available: https://www.nsf.gov/funding/opportunities/dcl-nsf-includes-research-experience-mentoring-rem-supplemental/nsf24-062

[23] P. Bazeley, *Qualitative Data Analysis: Practical strategies.* London: Sage Publications, 2013.

[24] L. L. Ellingson, *Engaging crystallization in qualitative research: an introduction.* Thousand Oaks: Sage Publications, 2009.

[25] National Science Foundation, “Award Abstract #2209190 - Large-scale CoPe: Coastal Hazards, Economic prosperity, and Resilience,” *National Science Foundation Award Details*, Sep. 01, 2022. Available: https://www.nsf.gov/awardsearch/show-award/?AWD_ID=2209190