From Presentation to Practice: Teachers' Professional Growth Through Informal STEM Lesson Pilots

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I. Introduction and Objectives

Contemporary workforce projections consistently indicate that demand for workers with strong backgrounds in science, technology, engineering, and mathematics (STEM) will continue to grow in the coming decades [1], [2]. Prior research demonstrates that early exposure to high-quality STEM instruction is associated with increased interest in STEM fields at the collegiate level [3], [4], directly contributing to the long-term sustainability of the STEM workforce pipeline. Therefore, teachers play a critical role in shaping students' early perceptions of STEM, particularly through instruction that is both conceptually rigorous and authentically connected to real-world issues.

The National Science Foundation (NSF) seeks to address the need for high-quality instruction by funding Research Experience for Teachers (RET) programs that immerse K-12 educators in novel research environments and support the development of research-aligned engineering and STEM lessons broadly. Existing literature suggests that participation in RET programs can enhance teachers' content knowledge, pedagogical skills, and understanding of the engineering design process [5], [6]. Yet, translating research experiences into effective classroom instruction demands more than exposure to research content alone. Teachers must also possess a strong sense of self-efficacy. That is, teachers must have a belief in their ability to successfully design and implement research-aligned lessons with confidence and fidelity.

The Rice University RET site program is unique in that it provides teacher participants with the opportunity to test their lessons in an informal educational setting in the spring, following their summer research experience. These informal presentations allow teachers to test instructional strategies with students, receive peer feedback, and iteratively refine lesson design before classroom implementation. Such experiences play an important role in strengthening teachers' instructional confidence and self-efficacy.

This study contributes to existing literature on RET program design by examining how informal lesson pilots influence teachers' professional practice and self-efficacy. Specifically, the study is guided by the following research questions: *1) How do opportunities to present lessons in informal STEM settings influence teachers' approaches to curriculum design and classroom implementation?* And *2) To what extent do pilot lesson presentations affect teachers' confidence and self-efficacy in delivering STEM instruction?*

Using a qualitative research design, this study draws on nine semi-structured interviews with RET participants to examine how informal lesson pilots shape curriculum design practices and teacher self-efficacy.

II. Literature Review

1. RET Programs and STEM Education

Research Experiences for Teachers (RET) programs were established by the National Science Foundation (NSF) to strengthen K–12 STEM education by immersing teachers in authentic research environments and supporting the development of research-aligned instructional materials. The existing literature has documented a myriad of positive outcomes related to RET participation, including increased content knowledge, improved understanding of STEM practices, and greater familiarity with inquiry-based instructional approaches [6], [7].

RET participation can also influence teachers' pedagogical practices and professional identities. Teachers who complete RET programs often report a greater willingness to implement innovative instructional strategies and stronger alignment between classroom lessons and real-world STEM applications [8], [9], [10]. These outcomes are particularly relevant in engineering education, where translating complex research concepts into developmentally appropriate classroom activities presents persistent challenges [11].

Notwithstanding, less attention has been given to how teachers enact and refine research-based lessons following their summer research experiences. Many RET studies focus on immediate post-program outcomes, such as self-reported gains in knowledge or attitudes [12], [10], rather than examining opportunities for teachers to test and receive feedback on their research-based curriculum materials. This gap in the literature limits understanding of how RET programs can best support the transition from research participation to sustained instructional practice.

Informal STEM learning environments are promising spaces for instructional development [13], [14]. Such settings offer flexible structures, diverse student audiences, and reduced accountability pressures, allowing teachers to pilot instructional strategies and engage in iterative lesson refinement. Understanding how these experiences support curriculum development and teacher self-efficacy can inform the design of RET programs that more effectively translate research experiences into classroom impact.

2. Theoretical Framework

This study is grounded in Bandura's self-efficacy theory, which posits that individuals' beliefs in their ability to perform tasks successfully strongly influence motivation, persistence, and performance [15]. Teacher self-efficacy has been shown to influence instructional practice and student outcomes. Teachers with higher self-efficacy are more likely to implement innovative instructional strategies, persist through challenges, and adapt instruction to meet students' needs [16], [17].

Bandura conceptualized self-efficacy as developing through four primary sources: mastery experiences, vicarious experiences, verbal persuasion, and physiological and affective states [15]. Mastery experiences direct opportunities to successfully perform a task and are considered the most influential source of efficacy beliefs. Vicarious experiences, such as observing peers succeed, provide social models that shape beliefs about one's own capabilities. Verbal persuasion, including feedback and encouragement from others, can further reinforce confidence, while affective states influence how individuals interpret stress, uncertainty, or excitement associated with task performance.

The informal lesson pilot presentations function as critical efficacy-building experiences. Presenting lessons to students allows teachers to test instructional strategies (mastery experiences), learn from peer educators and facilitators (vicarious experiences), and receive feedback from students and colleagues (verbal persuasion). These experiences collectively support the development of teacher self-efficacy by helping teachers refine lesson design, adapt research content for student audiences, and build confidence in their ability to deliver authentic STEM instruction [18]. By applying Bandura's self-efficacy framework, this study examines how informal lesson pilots contribute to teachers' professional growth and instructional confidence following participation in an RET program.

III. Methodology

This study employed a qualitative research design to examine teachers' experiences presenting research-based lesson pilots in an informal STEM learning environment and the perceived impacts of those experiences on instructional confidence and practice. The researchers developed a sixteen-question interview protocol that inquired about participants' experiences piloting their lessons, the feedback they received from peers and program staff, and how the lesson pilot impacted their confidence, lesson design, and classroom implementation. This interview protocol was tailored to the unique components of the Rice University RET program and was created in consultation with program staff.

Nine interviews were conducted with past Rice University RET participants. Two teachers indicated they taught elementary school, two said that they taught middle school, and five were high school teachers. Full participant demographics are presented in Table 1 below. Eligible participants included teachers who had completed both the summer research experience and the spring informal lesson pilot component. Institutional Review Board approval was obtained prior to data collection. All participants provided informed consent before participating in the study, and all interview responses were anonymized to maintain confidentiality.

Table 1. *Participant Demographics*

Participant	Years Teaching	Grade	RET Year
P1	7	Elementary	2021-2022
P2	14	Middle School	2023-2024
P3	X*	High School	2024-2025
P4	20	High School	2023-2024
P5	11	High School	2024-2025
P6	X*	Elementary	2024-2025
P7	2	Middle School	2022-2023
P8	7	High School	2018-2019
P9	15	High School	2022-2023

****Participant did not address the "years teaching" question during the interview***

Two of the researchers conducted the interviews, which were audio-recorded and transcribed using Otter.ai. Transcripts were reviewed for accuracy by the research team prior to analysis and were imported into Dedoose, a qualitative data management software, to support data organization and coding. The coding was then done manually in Dedoose to allow for close engagement with the data and to capture nuanced shifts in teacher perceptions and experiences.

A structured thematic analysis was applied to identify patterns and variations across participants' responses [19]. Interview transcripts were first segmented into key phrases and meaningful units of analysis [20]. Initial coding labels were assigned to reflect emergent ideas related to lesson refinement, confidence, feedback, and instructional practice. Codes were iteratively refined through repeated review of the data to enhance consistency and analytic rigor.

Once code categories were established and refined, a comparative analysis was conducted to identify cross-cutting themes and relationships among participants' experiences. Data saturation was determined when repeated readings of the transcripts yielded no new codes or insights. Ongoing re-coding and review of excerpts within Dedoose confirmed that all salient themes were captured and that the final thematic structure was well aligned with the data.

IV. Results

Data analysis revealed three major themes related to teachers' experiences presenting research-based lesson pilots in informal STEM learning environments: iterative lesson refinement, research into practice, and increased teacher confidence. Together, these themes illustrate how the informal lesson pilots supported both instructional development and teacher self-efficacy.

Theme One: Iterative Lesson Refinement

Participants consistently described their informal lesson presentations as opportunities to refine lesson structure, pacing, and alignment based on direct student interaction and feedback. Teachers noted that presenting lessons outside their own classrooms allowed them to identify gaps in instructions, anticipate student misconceptions, and make practical adjustments before formal classroom implementation.

One participant reflected, *"Part of the reason I've been revamping [the lesson] is that I saw some gaps in my written instructions, and that really aided me"* (Participant 5). Another described how pacing adjustments became immediately apparent during the pilot, noting, *"If I were to go back and redo it, I would have a backup solution with a higher concentration, because it took longer than expected and students were sitting and waiting"* (Participant 3).

Teachers also highlighted the importance of aligning lessons with students' prior knowledge and available resources. An elementary teacher explained, *"As a second-grade teacher, I had to bring that [research content] down. [Program staff] had to help me strip it down to the basic components—what am I learning and how can I apply it to my kids?"* (Participant 6). Leveraging student feedback from the pilots, participants made iterative refinements to their lessons with support from peers and RET program staff. These refinements often resulted in more scaffolded, student-centered lessons that teachers felt were better suited for classroom use.

Theme Two: Research into Practice

A second major theme centered on teachers' efforts to translate complex research concepts into grade-appropriate, inquiry-based lessons. Participants described informal lesson pilots as a space to experiment with how much disciplinary content to include and how to frame research ideas in ways that are accessible to students. Participants did not describe this translation as a purely technical process but rather as one that required shifts in their pedagogical approach to student engagement and understanding, as observed during the lesson pilot.

Teachers discussed the challenge of simplifying advanced research without watering down content. One middle school teacher reflected, *"It really gave me great experience turning a really complicated topic into something more digestible for kids . . . that's a teacher's job"* (Participant 7). Similarly, another participant noted, *"I needed to figure out how much of this research to give my kids and what to focus on, because I wasn't familiar with the topic at first"* (Participant 5).

Several teachers emphasized that lesson pilots helped them specifically prioritize inquiry. By presenting lessons in informal settings, teachers observed how students made sense of the content, which prompted shifts away from content-heavy instruction towards inquiry-based learning experiences. One high school teacher explained, *"I'm trying to make them learn reasoning and deeper understanding and critical thinking more often than just giving formulas and applying them"* (Participant 8). These experiences supported teachers in reframing research content into hands-on, inquiry-driven activities that aligned with students' developmental levels and curricular standards.

Theme Three: Increased Teacher Confidence

Participants described increased confidence in their ability to deliver research-based STEM instruction because of presenting lesson pilots and receiving feedback from students, peers, and program staff. Teachers identified these experiences as affirming and motivating, particularly when student engagement exceeded expectations. One participant shared, *"Everything was positive . . . [my peers in the program] wanted me to send them the worksheets I developed. The feedback was really encouraging"* (Participant 7). Another noted that student reactions reinforced their confidence, stating, *"When I present this lesson in my class, it really creates a wave of excitement for learning for my students"* (Participant 9).

Teachers also connected increased confidence to mastery experiences gained through repeated practice. A participant explained the benefits of piloting their lesson, saying, *"I actually taught the lesson before I taught it to my students, and that made a big difference in how confident I felt"* (Participant 2). Others described how feedback helped them anticipate challenges and troubleshoot issues, which reduced anxiety about classroom implementation. As one teacher noted, *"There's a part of the lesson where you troubleshoot—if this goes wrong, then do this—and that really helped me feel prepared"* (Participant 6). Sentiments like these indicate that the opportunity to present lessons in informal spaces outside of the classroom enabled participants to build confidence through constructive feedback from peers and RET program staff. Collectively, these findings suggest that informal lesson-pilot experiences fostered confidence by providing teachers with opportunities to practice instruction, refine curricula, and receive feedback in a supportive environment.

V. Discussion

This study examined how informal lesson pilot presentations within an NSF Research Experiences for Teachers (RET) program influenced teachers' curriculum development and instructional confidence. Guided by Bandura's self-efficacy theory, the findings suggest that informal lesson pilots serve as important efficacy-building experiences that support teachers in translating research participation into classroom practice.

Self-Efficacy Development Through Informal Lesson Pilots

The informal lesson presentations served as meaningful mastery experiences, allowing teachers to enact research-based lessons and observe student engagement prior to classroom implementation. Teachers described using these experiences to refine pacing, clarify instructions, and anticipate implementation challenges, which increased their confidence when teaching the lessons in their own classrooms. These findings extend prior RET research [8], [9], [10] by demonstrating that opportunities to *practice* teaching research-aligned lessons rather than just designing them are critical for supporting instructional confidence [6].

Informal lesson pilots also supported vicarious learning and verbal persuasion through peer observation and feedback from program staff and students. Teachers reported that observing colleagues teach similar content and receiving constructive feedback reinforced their beliefs that research-based instruction was both feasible and effective. Additionally, the low-stakes nature of informal STEM settings appeared to reduce anxiety associated with teaching unfamiliar content, thereby positively shaping teachers' affective states and their willingness to take instructional risks.

Implications for RET Program Design

The findings highlight informal lesson pilots as a promising and underutilized design feature within RET programming. While many RET programs emphasize research immersion and curriculum development [6], few offer structured opportunities for teachers to enact and refine lessons before classroom implementation. Embedding informal lesson presentations within RET programs may help bridge the gap between research experiences and sustained instructional practice.

Informal pilot settings allow teachers to iteratively refine lessons based on authentic student interaction, increasing the likelihood that research-based curricula are classroom-ready. These experiences also create feedback-rich environments in which teachers can engage in reflection, collaboration, and professional learning without the pressures of formal classroom accountability. As a result, teachers may be more likely to implement research-aligned lessons with fidelity and confidence.

For RET programs seeking to promote long-term instructional change, incorporating informal teaching opportunities may strengthen teacher self-efficacy and support the sustainability of program outcomes. Program designers should consider integrating structured lesson pilots, opportunities for peer observation, and facilitated feedback sessions as core components of RET programming rather than optional extensions. Such design features may enhance the translation of research experiences into meaningful classroom practice and ultimately amplify the impact of RET programs on K–12 STEM education.

VI. Conclusion

This study demonstrates that informal STEM lesson pilot presentations can play a meaningful role in supporting teachers' professional growth within RET programs. By providing opportunities to enact, refine, and receive feedback on research-based lessons, informal pilots support curriculum development and strengthen teacher self-efficacy. These findings underscore the value of embedding structured, feedback-rich instructional experiences into RET program design to better support the translation of research experiences into sustained classroom practice

Future research should examine the longer-term impact of informal lesson pilot experiences on teachers' instructional practices and self-efficacy through longitudinal study designs. Additional work is also needed to explore how participation in lesson pilots influences student learning outcomes, engagement, and interest in STEM. Examining these outcomes would provide a more robust understanding of how RET program design features shape both teacher practice and student learning and could further inform the development of RET models that promote lasting instructional change.

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