Investigating how ongoing professional learning with modest supports impacts elementary teachers' science and engineering practice

Ryan Summers[1], Cathy Ringstaff[2], Ashley Iveland[2], Rebekah Hammack[3], Martha Inouye[4], Julie Robinson[1], Meghan Macias[2], Tugba Boz[1], & Min Jung Lee[1]

[1]University of North Dakota, [2]WestEd, [3]Purdue University, & [4]University of Wyoming

INTRODUCTION

State and national reports over many years indicate that elementary teachers continue to feel less prepared to teach science when compared to mathematics and language arts. Nationally, only 17% of elementary teachers report feeling fairly well prepared to teach engineering (Banilower et al., 2018). Realizing the *Framework's* ambitious vision of learning and the integration of engineering design, which is embodied by the NGSS (NRC, 2012; NGSS Lead States, 2013), necessitates high-quality professional learning (PL) to shift teachers' instructional practices (Britton et al., 2020; Nilsen et al., 2020).

We are investigating factors that influence elementary teachers' professional learning (PL) in science and engineering. Teachers across four states were were recruited to participate in a year-long intervention. It started with an intense, online PL institute. Then, ongoing modest supports, including professional learning community (PLC) sessions, were offered during the following school year while participants were teaching grades 3-5 in rural school districts. Our overarching research objectives include examining: (1) the impacts of online science and engineering PL; (2) the effectiveness of modest supports on the sustainability of PL outcomes; and (3) the changes to teachers' engineering instructional practices.

Background

Roughly 7.3 M students are enrolled in rural school districts, plus another 2 M students attend rural schools located within districts that are not designated rural by the US Census Bureau (Showalter et al., 2023). Rural teachers have historically faced challenges accessing professional learning (Goodpaster et al., 2012); barriers include geographic isolation, limited resources (e.g., funding), and lack of access to subject-specific experts (Barrett, 2015; Cadero-Smith, 2020). These are known to hinder effective teaching of engineering and impact student engagement (Douglas et al., 2016; Ellerbrock et al., 2018). Still, educators in these settings see the benefits as well as the challenges associated with rural spaces (Inouye et al., 2024). Therefore, to help rural teachers overcome barriers, and leverage existing assets, STEM STRONG was designed to provide online PL and foster collaboration.

Kings Canyon Unified School District (CA) A larger district of 10,000 students spanning ~100 miles through Central Valley agricultural communities and the Sierra Nevada mountains in both Sequoia and Kings Canyon National Parks.	**Park County Schools** (MT) A 12-school district serving mountain communities near Yellowstone, where tourism, logging, mining, and agriculture are the primary industries. Some residents have no cell phone service within 50 miles and must drive more than an hour to reach any stores.
Fremont County School District #2 (WY) A one-campus district of 150 students near Wind River Reservation, serving an area covering 14,094 $miles^2$ with 1 teacher for each grade K-6 and 1 science teacher for all of grades 7-12.	**McKenzie County School District #1** (ND) A community near the Bakken field where the oil boom has led to student enrollment more than tripling in 10 years and infrastructure can't meet the demand. This hub for the oil industry is actively working to attract more teachers and other essential workers.

Figure 1. Select Examples of Rural Schools/Districts Within Participating States

Theoretical Framework

Teachers can be introduced to key aspects of the *NGSS*, including three-dimensional, phenomena-based learning along with engineering design, student agency, and coherence (Iveland et al., 2019). However, teachers need structured opportunities to learn about the *NGSS* to achieve these instructional shifts (Bartels et al., 2019). Studies have found that PL boosts teachers' self-efficacy (Lakshmanan et al., 2011) and leads to improvements in science and engineering instruction (Fischer et al., 2018).

Prior research has concluded that one-time workshops are unlikely to change teachers' practice (Darling Hammond, 2017). Teacher outcomes have been shown to decline following PL. Interventions accompanied by modest supports have been shown to reverse downward trends (Sandholtz & Ringstaff, 2020). These supports may include a variety of resources, which can be characterized as *accessible, inexpensive, timely, adaptable,* and *ongoing*. Importantly, shifting teachers' practice can also be supported by a peer community and time for teachers to implement changes in their classrooms (Zinger et al., 2020).

METHODS

This poster presents data collected in 2023-2024 following an intervention with one cohort of rural elementary teachers to address the following:

RQ1) To what extent did an intense 5-day science and engineering professional learning (PL) have immediate impact on teachers' understanding of the NGSS and their self-efficacy?

RQ2) To what extent were teachers' understanding of the NGSS and their self-efficacy in science and engineering sustained during the school year after participating in the PL?

Sample

Participants for 2023-2025 included 150 teachers; 39 in CA (26%), 35 in MT (23%), 36 in ND (24%) and 40 in WY (27%). All of them taught grades 3 through 5; 42 in 3rd (28%), 34 in 4th (23%), and 29 in 5th (19%) along with 45 teaching in multi-grade classrooms (30%). Survey data were collected pre-PL (n=150), immediate post-PL (n=124), and delayed post-PL (n=100). Reduced datasets were used for pairwise comparisons; 87 teachers completed surveys at all timepoints.

STEM STRONG

Supporting Teachers in Rural Communities for the Next Generation

Intervention

Online PL institute. The intervention began with an intense, online PL experience for teachers in each of four states: CA, MT, ND, and WY. This PL was designed and developed for elementary teachers using online platforms (Desimone, 2009), which was delivered by WestEd's K-12 Alliance team. For 2023-2024, the online PL took place over 5 days with synchronous and asynchronous activities (see Table 1).

Table 1. Goals set for STEM STRONG 5-day PL Institute in Summer 2023

Summer 2023 Goals	Examples of PL Content	
Participating teachers will understand…	Asynchronous activities	Synchronous activities
Instructional shifts called for by NGSS	Before Day 1: Reading *A Framework for K-12 Science Education* (NRC, 2012, Chapter 2)	Day 1: Phenomenon-driven learning using local weather data
Three dimensions support students' sensemaking of phenomena and solving problems	Before Day 2: Reading "Making the Shift in Practice" (Bang et al., 2017, pp. 36-38)	Day 3: Mapping the 3 dimensions of NGSS-aligned lessons
Authentic, relevant, and meaningful science and engineering instruction supports all students	Before Day 3: Review of grade-specific NGSS-aligned units and lessons	Day 4: Engineering design and NGSS
NGSS-aligned instruction builds on students prior knowledge and leverages students' resources and skills to positions them as knowers	Before Day 4: Reflecting on excerpts from "How People Learn" (National Academies, 2000, 2018)	Day 2: Phenomenon-driven learning and equitable instruction
NGSS-aligned instruction that approximates the work of scientists and engineers positions students as knowers and doers	Before Day 4: Reflecting on the integration of science and engineering in NGSS-aligned lessons and student positioning	Day 3: Scientists' notebooks and using notebooks in classrooms
Formative assessment opportunities provide potential to support teacher facilitation of students engaging as knowers and doers	Before Day 5: Reflecting on current assessments used as part of science teaching	Day 5: Assessment practices in the NGSS facilitated by SCALE Science at WestEd

Modest supports. Throughout the 2023-2024 academic year, STEM STRONG offered teachers a menu of supports, shown in Figure 2, including online professional learning community (PLC) sessions and dedicated electronic supports (e.g., Google Site, shared resources, etc.).

1. Virtual Professional Learning Community (PLC)	**1. Virtual PLC Meetings** • 3 Whole group sessions with all teachers • 4 State cohort sessions
2. Resource Library	**2. STEM STRONG PL Landing Page and Google Folder** • Teachers will keep access to all PL materials from K-12 Alliance
3. Dedicated Project Share Space	**3. STEM STRONG Google Classroom** • Research Team will compile resources recommended during the PL • We will also share free (or low-cost) high quality resources to support S&E instruction
4. Project Newsletter	**4. STEM STRONG will have a column in a monthly newsletter** • Research Team will contribute a column to an existing newsletter(s) and STEM STRONG teachers will get articles • Our focus will be on S&E education in connection with place and rural issues
5. NGSS Lesson Support	**5. Guided support implementing NGSS lessons** • Guided walkthrough of engineering design lesson (Fall 2023). • Guided walkthrough of science lesson with formative assessment (Spring 2024).
6. Other project-specific electronic supports	**6. Optional supports to support your needs** • Staying connected through social media groups • Sharing materials on affinity platforms (e.g., Pinterest) • Additional (optional) virtual S&E PL opportunities (e.g., webinars) • Virtual opportunities to interact with other teachers (e.g., NGSS Chat)

Figure 2. Modest Supports Offered to Participating Teachers, 2023-2024

PLC sessions. Seven 1.5 hour PLC sessions were offered during the school year. These sessions were delivered using an online platform, Zoom, along with features to enable collaboration (e.g., breakout rooms). Fall 2023 sessions were designed to support NGSS-aligned engineering lesson implementation. Spring 2024 sessions focused on implementing science and NGSS-aligned performance assessment tasks in their classrooms.

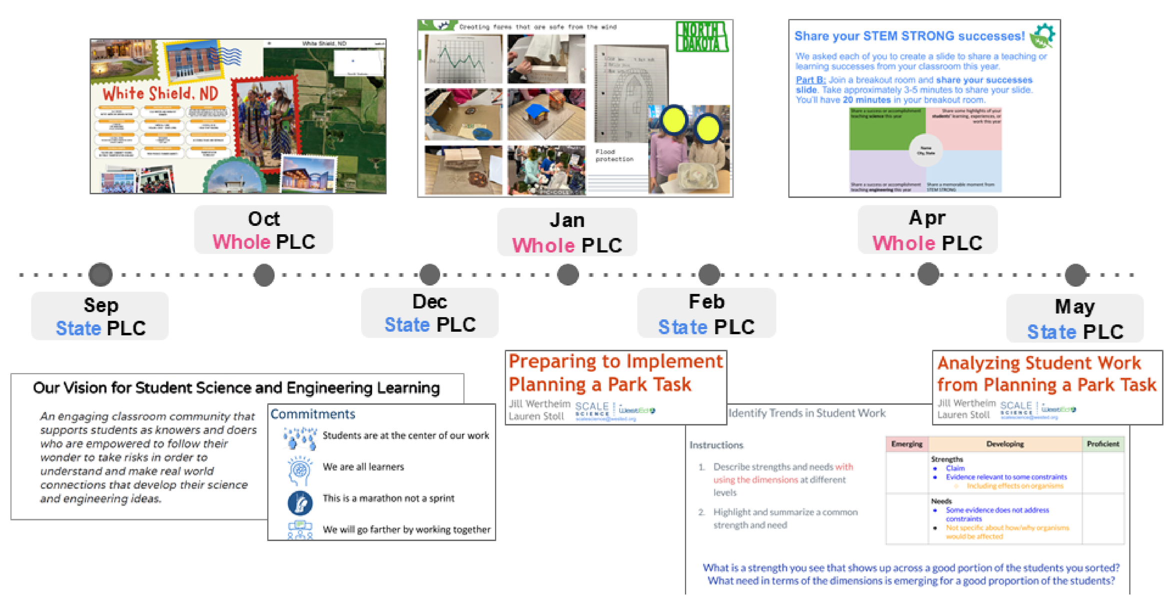

Figure 3. Snapshot of Online PLC Sessions, 2023-2024

Measures & Analyses

Surveys. Items used to capture teachers' backgrounds, like prior PL participation and instructional time for science and engineering, were adapted from the *National Survey of Science and Mathematics Education* (NSSME+) developed by Horizon (Banilower et al., 2018). Six items were developed by the research team about target NGSS understandings consistent with the intervention goals. Self-efficacy beliefs were assessed using the following scales of Teacher Efficacy and Attitudes toward STEM (T-STEM; Friday Institute for Educational Innovation, 2012): Science teaching efficacy and beliefs scales (11 items); Engineering teaching efficacy and beliefs (11 items); Science teaching outcome expectancies (9 items); and Engineering teaching outcome expectancies (9 items).

Analyses. Data were analyzed descriptively and statistically in R (Bryer & Speerschneider, 2016). Initially, data were explored using using a Wilcoxon signed-rank test (Galisky et al., 2024). Paired t-tests were used to compare the differences between timepoints. Pre- and immediate post-PL comparisons were made to examine PL impacts (RQ1), parsing NGSS understandings (Summers et al., 2024) and self-efficacy (Hammack et al., 2024). Immediate post- and delayed post-PL comparisons were made to examine the sustainability of PL outcomes (RQ2). Repeated measures ANOVA were also computed to compare the means of responses collected using the T-STEM scales across multiple time points (Summers, Hammack, et al., 2025; Summers, Iveland, et al., 2025).

SELECT FINDINGS

RQ1a: Immediate impacts on teachers' NGSS understandings. Survey findings suggest that teachers' understandings, on average, improved following the online PL. Table X shows the change in means was significant (<.005) for each of the following: 1) Three-dimensional instruction that incorporates the SEPs, CCCs, and DCIs, 2) Organizing instruction around science phenomena, 3) Organizing instruction around engineering problems, 4) Assessment of students' work evidence of the three dimensions, 5) Designing instruction to leverage students' unique cultural backgrounds, 6) and Allowing students to take an active role in sensemaking.

Table 2. Comparison of NGSS Understandings Between Pre- and Immediate Post-Professional Learning

		Mean	Std. Deviation	Std. Error	95% Confidence Interval of the Difference		t	*df*	Sig. (2-tailed)
					Lower	Upper			
NGSS 1	PRE	3.573	2.595	0.233					
	POST	6.839	1.321	0.119	-3.759	-2.774	-13.127	123	< .005
NGSS 2	PRE	4.008	2.766	0.248					
	POST	7.129	1.210	0.109	-3.644	-2.599	-11.821	123	< .005
NGSS 3	PRE	3.21	2.608	0.234					
	POST	6.855	1.458	0.131	-4.141	-3.149	-14.557	123	< .005
NGSS 4	PRE	3.492	2.471	0.222					
	POST	6.363	1.358	0.122	-3.349	-2.393	-11.885	123	< .005
NGSS 5	PRE	3.573	2.678	0.240					
	POST	6.839	1.445	0.130	-3.795	-2.737	-12.216	123	< .005
NGSS 6	PRE	4.234	3.069	0.275					
					-4.072	-2.912	-11.920	123	< .005

RQ1b: Immediate impacts on teachers' self-efficacy. Pre-PL to immediate post-PL, survey responses indicate a significant increase in teachers' science self-efficacy, $t(86) = -5.26$, $p = <.001$. The observed change in outcome expectancy during the same period was also significant, $t(86) = -3.51$, $p = <.01$. Based on Cohen's d, the intervention had a moderate-large effect on participants' science self-efficacy (.64) and a small (.27) effect on their outcome expectancy (Cohen, 1988). There was also a significant increase in participants' engineering self-efficacy, $t(86) = -11.14$, $p = <.001$. The observed change in outcome expectancy during the same period was also significant, $t(86) = -3.74$, $p = <.001$. Based on Cohen's d, the intervention had a moderate-large effect on participants' engineering self-efficacy (.73) and a small (.18) effect on their outcome expectancy.

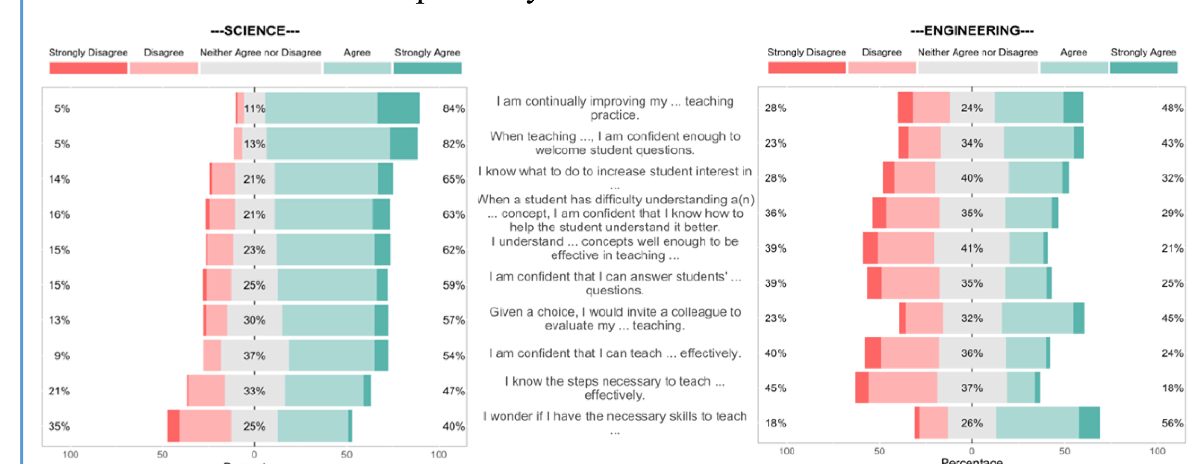

Figure 4. Teachers' Science and Engineering Self-Efficacy Before the PL in July 2023

RQ2a: Extent teachers' NGSS understandings were sustained during the school year. There was no significant difference between teachers' responses between the immediate post- and delayed post-PL for four of the NGSS understandings assessed (NGSS 2, 3, 4 & 6). Teachers' responses about three-dimensional instruction had a mean of 6.40 (SD = 1.764) on the delayed post-PL. Based on the results of the paired t-test, $t(99) = 2.180$, $p = .032$, the means differed between time points, indicating the mean was significantly less at the immediate post-PL time point (6.77; SD = 1.392). Likewise, teachers' responses about designing instruction to leverage students' unique cultural backgrounds at the immediate post-PL (6.72; SD=1.443) had a mean that was significantly higher than the delayed post-PL time point (6.25; 1.844), $t(99) = 2.448$, $p = .016$. Note the means for these two NGSS understandings at the end of the year were higher than the means captured at the beginning of the year.

RQ2b: Extent teachers' self-efficacy was sustained during the school year. Bonferroni adjusted paired t-tests indicate a significant change in participants' science self-efficacy between the immediate post- and the delayed post-PL time points, $t(86) = -0.74$, $p < .001$. Science teaching efficacy increased significantly across the three time points, $F(2, 172) = 24.15$, $p < .05^*$ $\eta g2 = .09$. Outcome expectancy also increased significantly, Huynh-Feldt corrected, $F(2,157) = 5.33$, $p = 0.013$. Engineering teaching efficacy increased significantly across the three time points: Huynh-Feldt corrected, $F(2,157) = 5.33$, $p = 0.013$. Outcome expectancy also significantly increased across these three time points, $F(2, 172) = 6.69$, $p < .05^*$ $\eta g2 = .02$.

NEXT STEPS

Currently, as we near the end of Year 3, two cohorts of elementary teachers have completed the year-long STEM STRONG intervention. The 2024-2025 cohort (n=175) included a mix of new (53%) and returning teachers (47%). These research questions presented in this poster will be further examined using longitudinal data to explore changes in elementary teachers' self-efficacy and instructional practices over time (N_{total}=227). Emergent questions about online PL outcomes and teachers' use of modest supports will also be considered. This research has implications for future PL design, including structure of online PL (e.g., synchronous vs. asynchronous PL) and interaction effects (e.g., number of PLC sessions), plus teachers' engagement with specific supports.

REFERENCES

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