Establishing a Shared Vision of Effective Pedagogy to Sustain Networked Reform

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In this preliminary report, we share results from an ongoing project related to the professional development of K-12 math and science teachers in Washington state. The goal of this work is to establish and sustain a network of STEM teacher leaders who can support teachers statewide in using effective STEM pedagogy. In the project's first phase, we surveyed 290 stakeholders, including administrators, support specialists, teachers, and other community/industry partners, in order to identify attributes valued in a STEM teacher leader. Initial findings from this mixed-methods study indicated that STEM stakeholders prioritize teacher leaders' abilities to foster the incorporation of integrated, community-based STEM projects and culturally responsive pedagogy in theirs and their peers' teaching. We seek input from the RUME community on the project's second phase, in which we will study the efficacy of a particular change model in facilitating cross-institutional systemic change toward the adoption of STEM best practices.

Keywords: STEM teacher leaders, network, professional development of K-12 teachers

Networks are an established vehicle for effecting pedagogical change (Lewis, 2015). Networked communities exist in a variety of STEM education contexts; such diversity merits the investigation of a variety of network models that may contribute to large-scale pedagogical reform in STEM. For example, the Academy of Inquiry Based Learning provides a network for individual instructors seeking to adopt inquiry-based pedagogical practices in their classrooms (Yoshinobu et al., 2022), while the SEMINAL project established a network of university mathematics departments pursuing the implementation of active learning strategies in Precalculus through Calculus courses (Smith & Funk, 2021). The overarching goal of our WA-STELLAR project (NSF DUE #1950332, #2150054) is to grow and support a sustainable network of K-12 STEM instructional change agents (teacher leaders) across Washington state. Through this project, we will support the development of teacher leaders to mentor other STEM teachers in using effective STEM pedagogy (Objective 1); we will then support the systemic change efforts of the teacher leaders via network activities that promote collaboration among a range of STEM stakeholders (Objective 2).

Education networks vary in their motivations and goals, their participation and leadership structure, and their processes for catalyzing organizational change. Regardless of localized complexities, effective network collaboration is predicated on the following eight features: (1) focusing on ambitious student learning outcomes linked to effective pedagogy; (2) developing strong relationships of trust and internal accountability; (3) continuously improving practice and systems through cycles of collaborative inquiry; (4) using deliberate leadership and skilled facilitation within flat power structures; (5) frequently interacting and learning inwards; (6) connecting outwards to learn from others; (7) forming new partnership among students, teachers, families, and communities; and (8) securing adequate resources to sustain the work (Rincón-Gallardo & Fullan, 2016). In this report, we share preliminary results identifying a *stakeholder-informed* vision of "ambitious student learning outcomes linked to effective STEM pedagogy"

(Feature 1; Project Objective 1). In particular, we recognize that professional development associated with this project's second phase will only be effective if the aforementioned vision is truly *shared* amongst the network's constituents. Subsequently, we discuss implications for achieving project Objective 2 and conducting further research during this second project phase.

Theoretical Framing

This project is grounded in communities of practice theory (Wenger, 1998). Schools or districts form individual communities of practice. Through the WA-STELLAR network, we (the project leadership team) and teacher leaders act as *brokers* (Wenger, 1998) between these communities by translating, aligning, and facilitating coordination of perspectives, creating the possibility for collective meaning-making. Teachers' instructional strategies are simultaneously influenced by obligations to the discipline, themselves, others, and the institution or school (Herbst & Chazan, 2012). As such, changing practice is operationalized as "both building on existing instructional situations and breaching with some of their norms" (p. 611). With teachers from schools and districts across Washington state, the WA-STELLAR network can serve as a tool to breach existing norms while accounting for existing conditions. The network can unify strategies for supporting student success by leveraging the strengths of all members.

Methods

Research Questions and Design

The following research questions guided the first phase of this project (Objective 1) in order to determine what attributes WA-STELLAR network stakeholders value in a STEM teacher leader, and what program components the stakeholders view as likely to develop these attributes:

RQ 1: *What are principles and practices that advance STEM education and that a STEM Leadership program can support?*

RQ 2: *Who is the target audience for a STEM Leadership program?*

RQ 3: *What are the skills, certifications, and responsibilities necessary for an effective STEM leader, thus establishing guidelines for program curriculum?*

Utilizing a mixed-methods approach, we first surveyed 290 STEM stakeholders from four key groups: administrators, STEM support specialists, STEM teachers, and other STEM community and industry partners. Follow-up emails and phone interviews were conducted with seven survey participants, with four additional survey participants attending in a focus group. This report focuses on the first and a portion of the third research questions, as these results offer insight into how we might establish shared vision for "effective STEM pedagogy," an *essential feature* (Rincón-Gallardo & Fullan, 2016) needed to sustain the work of the WA-STELLAR network.

Participants and Sampling

To answer the research questions from the perspective of STEM stakeholders in Washington state, we developed and administered a survey online via Qualtrics. Stratified convenience sampling was employed to collect survey data. Members of the Apple STEM network, members of the South Central Washington STEM network, members of the Washington state Science Teachers Association, and graduates of our undergraduate STEM teacher preparation program were contacted until a minimum of 100 responses were received from STEM teachers and at least ten responses were received for each of the three other subgroups of stakeholders. In total, 290 participants consented to be part of the study and completed at least part of the survey. Their positions are summarized in Table 1.

Table 1. Summary of survey participants' educational positions.

Educational Position/Role	Count
Administration (District Superintendents, School Principals)	13
STEM Support Specialists (Curriculum and STEM Specialists, Coaches)	18
STEM Teachers (Math, Science, Technology, Computer Science)	208
STEM Partners (STEM community and industry advisors, Other)	51

Quantitative and Qualitative Data Sources

The skills and responsibilities included in quantitative survey questions were based on the characteristics of effective STEM leaders identified in literature on the topic (The Aspen Institute, 2014; National Council of Supervisors of Mathematics, 2008; Sublette, 2013; Tanenbaum, 2016; Toncheff, 2020). Prior to administering the survey, we incorporated feedback from other STEM educators to establish face validity (Gravetter & Forzano, 2012). In this preliminary report, we focus on results from two questions pertaining to establishing a shared vision of effective STEM pedagogy.

Qualitative data was collected to supplement and triangulate quantitative results from the survey and consisted of the following three data sources. At the end of the survey, participants were given an opportunity to share their thoughts in an open-ended question: *What would you like to tell us about STEM education? You can explain responses, add new ideas, or ask questions*. Follow-up phone and email interviews were conducted with seven survey respondents including representatives from all categories of stakeholders. Finally, we organized one focus group with four survey respondents including three STEM teachers and one STEM coordinator.

Results

Thematic Analysis of Qualitative Sources

In addition to triangulation of three data sources, we used analyst triangulation methods to strengthen the credibility of inquiry (Patton, 2002). Two of the authors independently analyzed qualitative sources, identifying repeated themes within and across participant subgroups. The two researchers then met to compare findings and understand any inconsistencies, generating a final list of four themes; three are related to a shared vision of effective STEM pedagogy:

1. All stakeholder subgroups stated STEM content needs to be integrated across disciplines.
2. All stakeholder subgroups identified the importance of promoting equity and diversity in STEM education. Several responses suggested meaningful community partnerships and project-based learning might help address equity issues.
3. From a curriculum standpoint, we need rich and engaging activities as well as meaningful applications connecting to industry.

Participant responses related to these themes are integrated into the next results section.

Quantitative Survey Results

In question one of the survey, participants were asked to rank a list of statements in order of importance for advancing STEM education. Table 2 provides average rankings of each statement for each stakeholder subgroup of participants. To determine the overall ranking, each stakeholder subgroup was treated as equally weighting the overall ranking. Thus, the ranking provided in each row of the 'Average' column is an unweighted average of the four numbers to its right.

Table 2. *Statement rankings in order of importance for advancing STEM education (1=most important, 5=least).*

Statement	Rank	Average	Admin	Support Specialists	Teachers	Partners
A. STEM projects should be integrated into all STEM courses.	1	1.89	1.85	1.71	2.14	1.86
B. STEM education principles are best advanced by hiring effective math, science teachers.	2	2.14	2.08	1.93	1.91	2.62
C. STEM education should focus on Career and Technical Education.	4	3.32	3.08	3.50	3.37	3.33
D. STEM education principles are best advanced through programs with industry, community partners.	3	3.15	3.46	3.29	3.13	2.71
E. STEM education principles are best advanced through extracurricular programs.	5	4.51	4.54	4.57	4.46	4.48

For all stakeholders, the two most important principles/practices for advancing STEM education were integrating STEM projects into all STEM courses (Statement A) and hiring effective math and science teachers (Statement B). These findings were further triangulated with qualitative results, in that all stakeholder subgroups mentioned that STEM content needs to be integrated across disciplines. In particular, as one STEM coach/coordinator expressed, “The trend and long-standing practice of trying to do each one of these [disciplines] exclusive of the other is the biggest hurdle we face.” Community partners, CTE support, and extracurricular programs help foster and grow STEM learning experiences; however, effectively implemented, integrated STEM projects must be the foundation of STEM education. Any STEM program must have integrated, project-based learning at its center. Additionally, STEM partners advocated for ‘integrating community projects, participatory science, and industry partners into schools.’

In question four of the survey, participants were asked: *How important are the following responsibilities for a STEM leader?* Table 3 provides a weighted average for each stakeholder subgroup and each responsibility. Each participant’s response was assigned one of the following weights: Extremely Important → 1; Moderately Important → 0.5; Not at all Important → 0. A score close to 0 indicates the subgroup views the feature as less important. A score closer to 1 indicates the subgroup views the feature as more important.

The most highly valued STEM leader responsibility was utilizing culturally responsive teaching practices. This finding was also substantiated in open-ended responses, where participants voiced a need for promoting diversity and equity in STEM education. For instance, one of the STEM coach/coordinator participants expressed “how important it is for students to see professionals they identify with in STEM professions. In order to draw more diversity into the STEM field, we need more STEM leaders with diverse backgrounds. Programs should promote diversity.” One STEM teacher felt that “STEM education that is hands-on problem solving has a better chance of bridging gaps with equity issues and schools that struggle with cultural responsiveness, better than most any other field.”

Table 3. Weighted averages for different stakeholder subgroups addressing question four.

Responsibility	Admin	Support Specialists	Teachers	Partners
Lead Professional Development in Designing and Teaching Problem-based Instruction	0.78	0.76	0.67	0.72
Initiate and Administrate Community-based STEM Projects	0.73	0.71	0.62	0.73
Coach colleagues in effective STEM Teaching	0.84	0.97	0.76	0.82
Coordinate STEM education district curriculum and programs	0.75	0.88	0.72	0.78
Lead professional development in integrating engineering practices for STEM courses	0.80	0.91	0.68	0.70
Utilizing culturally responsive teaching practices	0.90	0.94	0.79	0.87

Additionally, administrators, STEM support specialists, and community and industry partners identified initiating and administrating *community-based* STEM projects as an important responsibility of STEM leaders. However, STEM teachers felt support from their district and other STEM educators is essential to assist STEM leaders in both using STEM projects in their own classrooms and becoming STEM champions of district and community-wide projects.

Discussion and Implications

These results evidenced the need to redesign our (previously) traditional, content-focused master's degree in mathematics to train teacher leaders (Objective 1) in a way that better aligns with the values of the larger collective of STEM stakeholders. In our talk, we plan to provide a brief overview of the novel graduate STEM Leadership program we designed to serve as a *network hub* (Bryk et al., 2015) for the WA-STELLAR network.

As we move toward the next phase of our project (Objective 2), we will implement the Keck/PKAL change model (Elrod & Kezar, 2016) to facilitate the work of the WA-STELLAR network. This model has been used in higher education settings to coordinate multiple stakeholders and has eight stages, the first of which is: *establishing a shared vision for improving STEM student learning outcomes and success*. This next phase of our project will be guided by the research question: *What is the efficacy of the Keck/PKAL model in facilitating cross-institutional systemic change toward the adoption of STEM best practices?*

Our intended questions for the RUME audience concern ways in which we can leverage preliminary results to *maintain* a vision of effective pedagogy throughout implementation of network activities that is shared by all network stakeholders. We are interested in identifying potential opportunities/barriers to implementation that might impact the efficacy of our implementation of the Keck/PKAL model.

Acknowledgments

This work is supported in part by the National Science Foundation under DUE #1950332, #2150054. The findings, conclusions, and opinions herein represent the views of the authors and not necessarily the view of personnel affiliated with the National Science Foundation.

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