Collaboration across the Continuum: Systemic Partnerships for Reform in Pre-Service Science and Mathematics Teacher Education

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Abstract

Preparing highly qualified math and science teachers in todays' increasingly diverse students requires innovation and collaboration. Multi-institutional partnerships among university colleges of education and arts & sciences, community colleges, and school districts are powerful mechanisms for systemic improvement of teaching and learning across the education continuum. In this longitudinal case study, we investigate the functions and impacts of a multi-institutional partnership established among one university, three Hispanic Serving Institution (HSI) community colleges, and five school districts designed to enhance teacher preparation while concurrently cultivating K-16 teaching and learning among partners in a mid-Western state. This case study revealed three project outcomes 1) improved critical perspectives and practices with multilingual, English learner students K-16, 2) development and/or enhancement of programs and opportunities at each institution, and 3) an increase of K-12 assessment scores across the five years of the partnership project.

Key Words: professional development, partnerships, math and science teachers, multilingual learners

1. Introduction

High-quality teaching continues to be one of the greatest factors impacting student engagement and student outcomes (Center for Education Statistics and Evaluation, 2013; Darling Hammond, & Bransford, 2005). According to Shaw and Newton (2014), "If the most precious product developed in education is the student, then our most prized commodity should be the classroom teacher" (p. 101). Furthermore, the National Council for Teacher Quality (2016) report reveals that when teachers are well-trained in content with evidence-based knowledge, their prospects for future professional success and effectiveness as educators improve substantially.

So what makes a quality teacher able to support the learning of all children effectively? In addition to a deep understanding of content and pedagogy, *Author* (2014) indicates that educators must develop an understanding of their own cultural values, beliefs, and habits to engage in effective and culturally affirming practices. It is well documented that educators who know their own history and identity as well as who understand the cultural and linguistic backgrounds of the students and families, they serve are more effective (Author, 2018; Nieto, 2016; Sensoy, &DiAngelo, 2017). Therefore, many would argue that we cannot wait for teachers to gain this contextual knowledge once they are in the schools (Castagno, 2015). This vital work must begin at the pre-service level.

Producing future teachers who possess the skills and dispositions to effectively foster content understanding with a wide range of diverse learners requires a great deal of effort, expertise, and commitment. This is especially true, given that the historically White and predominantly monolingual teaching force often has limited experiences with cultural and linguistic communities that differ from their own (Achinstein, Ogawa, Seton, & Freitas, 2010; *Author*, 2009; Gorski, 2012; Milner, 2010).For example in a study of the NCES School and Staffing Survey data, Besterman, Williams, and Ernst (2018) found that STEM teachers indicate they "do not feel prepared and often lack professional development opportunities to develop the necessary skills"(p. 33) to meet the needs of multilingual learners in particular. It is therefore essential for preparation programs to provide both thoughtful and ongoing instruction of current and historical issues related to social justice (e.g. race, class, religion, gender, sexual orientation, language) as well as opportunities to acquire and practice strategies for supporting the content and language learning of cultural and linguistically diverse (CLD) students (Gay, 2010; Howard,& Aleman, 2004; *Author*, 2018; Sleeter, 2015).

Unfortunately, what is often absent from these conversations related to K-12 student outcomes and teacher effectiveness is the relative quality of instruction at the post-secondary level. Yet, if we know that teachers tend to "teach the way [they] were taught" (Fettke, 2016, p. 9), why then is the pedagogical practices modeled, the dispositions held, and content knowledge utilized in the preparation and professional development of teachers not the focus of more thoughtful study? More specifically, why are those of us responsible for preparing teachers rarely engaged int the development and reflective study of our own practices?

Researchers such as John Goodlad (1994) have argued that in order to make systemic improvement in teaching and learning, educational institutions must engage in individual and collective critical study of programmatic and pedagogical practices across the K-16 continuum.

Callahan (2016) further supports this dispute:

> The fulcrum for making major educational change is dedication to the success of the classroom teacher. Success comes down to a firm foundation in every single classroom. The best idea for transforming public education in America is to develop and retain highly qualified teachers. To build the capacity for transformation, schools must build the capacity of teachers. (p. 7)

This requires teacher educators to move beyond mere evaluation and reporting for accreditation's sake, and to engage in the real work of systemically improving our practice (*Author*, *in press*). We must ask ourselves, how effective are we as teaching faculty at negotiating across racial and linguistic difference? How often do we model content instruction that is both highly engaging and culturally responsive to the diverse needs of our college students? How inclusive are our curricula? How often do we as faculty rigorously take up issues of equity and access in our respective fields? These are important questions.

As this line of inquiry implies, proponents of educational reform challenge universities to view teacher preparation as a campus-wide responsibility, one that faculty and administrators across colleges and departments take ownership of (Bellamy & Goodlad, 2008; Cochran-Smith, 2006; Iasevoli, 2017). Furthermore, many advocate for sustained collaborative partnerships across disciplines where content faculty work closely with education faculty at all levels, from program design to instruction and assessment (Ake-Little, 2018; *Author*, 1996, 2009; *Author*, *in press*; Darling-Hammond, &Baratz-Snowden, 2005).

Within such a model, faculty across levels (K-16) are engaged in *reciprocal relationships*- both sharing and gaining new knowledge and skills with each other. In some examples from the literature, content faculty actively participate in not only course development for the various content areas but also support the supervision and mentorship of the pre-service teachers as they develop their knowledge and skills during field experiences (Loucks-Horsley, Hewson, Love, & Stiles, 1998; Magiera, & Geraci, 2014; Stotsky, 2006).

K-12 teachers also play a vital role within this partnership models as active participants in the instruction, supervision, and mentorship of pre-service teachers (Darling-Hammond, 2006; Smith, Kindall, Carter, &Beachner,2016).Once the pre-service teachers become in-service, they join the cadres of existing teachers within the partnership. This recursive relationship between universities and K-12 schools has been known to strengthen induction programs by providing access to professional development (in content and pedagogy) and collaborative mentorship experiences throughout the K-12 school system (*Author*, 2005).

In an important foundational study done by Darling-Hammond and Friedlaender (2008) the authors support this concept as they challenged national policymakers to shift their focus toward *developing human capital* across the educational continuum (p.19). They call for targeted support in improving capacity for teacher education programs, funding for extensive ongoing professional development for practicing teachers, increasing the access to high-quality professional development in critical areas, building in time for teachers to collaborate with each other on a consistent basis, and grooming teacher leaders for administrative roles (p.19-20).

Furthermore, the Committee on Strengthening Science Education through a Teacher Learning Continuum, Board on Science Education (2016), found that institutions need to consider the "rich and complex contexts of teachers' work – the diversity of students and communities, the pressures of resource limitations, and the array of state and district policies." (p. 2) and that unfortunately, "teachers work is not organized to provide the time or opportunities for collaboration with other teachers needed to best support their learning" (p. 2).

In regard to science and math instruction there is a need to focus on STEM teachers' learning in three areas, 1) "knowledge, capacity, and skill to teach and support a diverse range of students", 2) content knowledge in core areas, as well as "crosscutting concepts" and STEM practices, and 3) "pedagogical content knowledge" for teaching STEM that leads to "rigorous and consequential learning" (p. 2-3).

Similarly, Domina and Ruzek (2010) employed a longitudinal study considering the effect of K-12 and university partnership programs. Their investigation revealed that comprehensive partnership programs increased high school achievement rates and college admission for minoritized students. In his seminal piece on simultaneous renewal, Goodlad (1994) describes this type of systemic approach to reform in this way, "There must be a continuous process of educational renewal in which colleges and universities, the traditional producers of teachers, join schools, the recipients of the products, as equal partners in the simultaneous renewal of schooling and the education of educators" (p.1-2).

The construct of sustained, simultaneous renewal across the education continuum outlined and supported within this body of research served as the guiding framework for a large multi-institutional collaborative grant project funded by the U.S. Department of Education. The main goal of this multi-institutional partnership, referred to here as the *Equity & Access Partnership,* was to enhance teacher preparation, while simultaneously improving K-16 teaching and learning among partners from the college of arts &sciences and the college of education at one university, three Hispanic Serving Institution (HSI) community colleges, and five school districts. In addition to strengthening teacher preparation, partnership efforts included cultivation of teacher leadership, increased recruitment, and retention for culturally and linguistically diverse (CLD)candidates, and ongoing specialized professional development in content and pedagogy for all project participants, K-16. Though part of a larger, longitudinal study, the purpose of this specific study was to consider the impact of such an integrated, broad-based reform model (see Figure 1) on the science and mathematics teaching and learning at the individual and organizational level.

Therefore in this paper, we 1) briefly outline the context and process of the multi-institutional systemic reform effort in pre-service science and mathematics teacher education, 2) describe and interpret the data according to our theoretical framework, focusing particularly on the individual and organizational outcomes and the critical reform initiatives that supported these outcomes, and 3) highlight the conclusions and implications of this study for future systemic reform in science and mathematics teacher education.

2. The Context and Process of Systemic Reform

While the current study considers the impact of the *Equity & Access Partnership*, it is important to note that initial collaborations upon which this grant was established began with a previous professional development school partnership grant funded by the Department of Education through the early 2000s. It is through this first grant project that the partnerships across the various departments within the college of education and the college of arts &sciences as well as across targeted school districts were defined and developed (*Author*, 2012). The initial partnership project focused on increasing participant awareness and understanding of state and national standards for K-12 schools as well as standards for teacher education at the postsecondary level. During the life of this initial grant, participants worked not only to improve alignment of their programs and courses to these state and national standards but also to improve professional practice across all content areas and grade levels, K-16.

The second grant continued the systemic work of the initial partnership but added in three additional school districts and three HSI community colleges from the southwest part of the state. This grant project as implied by its name, the *Equity & Access Partnership*, focused on pre-service teacher education and simultaneous improvement across the K-16 continuum, but specifically as it relates to meeting the needs of CLD learners within the state (Authors, 2013; Author, *in press*). Given the exponential growth of the Latinx population in the region over the past twenty-fiveyears, an emphasis on improved teaching and learning for multilingual learners (ELs) continues to be of critical importance for the future well-being of the state.

Throughout both grant initiatives, project leadership maintained a similar structure for the facilitation of grant objectives and a similar process for soliciting sustained participation from faculty across grade levels, content areas, and institutions. Over the twelve years of the reform effort, there were approximately 100 university/college faculty and 60 to 70 teachers and administrators from partner school districts in the state who participated annually. In both projects, individuals selected to participate were paid a month's salary for their work on the project to be conducted over the course of the year.

In June of each year participants (K-16) attended a concentrated, two-week Summer Institute, which served as the primary mechanism for improving pre-service teacher education and K-16 teaching and learning as well as the ideal context for forging partnerships and galvanizing relationships across levels and institutions. At the Summer Institute, participants experienced a wide range of professional development in an array of formats. They engaged in workshops and content specific mini-courses in addition to sessions, lectures, and roundtables on inquiry-based learning, cognitive development, effective pedagogy, differentiated instruction, assessment, and strategies for working with multilingual learners.

Moreover, during these two weeks, the participants were divided into eight *cross-institutional planning teams* (educational foundations, humanities, language arts, math, recruitment and retention, science, social studies, and teacher leadership) to address the needs of the project and the goals of the grant related to reform in pre-service teacher education and K-16 teaching and learning. Each of these planning teams had representation from the two colleges within the university and K-12 partners (and in the second grant, from the HSI community college partners as well). In the two weeks following the Summer Institute, the project leadership offered additional professional development opportunities, such as the *Content, Curriculum, & Children (C^3) Academies*, which were open to the teacher leadership team as well as all K-12 teachers within the partner districts.

The C^3 Academies focused primarily on improving middle-school mathematics in partner districts. They were designed as concentrated, two-week, mini courses that provided teachers the opportunity to increase their content knowledge and improve their pedagogy related to mathematics. Throughout the year the teacher leadership team, with financial and staff support from the *Equity & Access Partnership* grant, also organized, and offered a variety of additional professional development opportunities in other topic areas for educators within their districts, based on needs identified during the Summer Institute.

While there is a great deal of continuity across both grants, based on lessons learned with the first project, the leadership team decided to include several unique features in the design of the *Equity & Access Partnership* grant. In addition to placing diverse learners at the center of all project goals and activities, project implementers established measures for ensuring accountability and sustainability that did not exist in the first grant. By creating a system of *pressure and support*, participants were held accountable to continue their personal efforts related to the goals of the grant throughout the year.

For example, each planning team was responsible for completing a set of team tasks each year and each planning team member developed their own *action plan* that identified their role in addressing those tasks individually and collaboratively. Participants engaged in collaborative peer mentoring to provide support for individual and organizational improvement efforts identified in these action plans. Team members reported their individual progress quarterly to their team facilitator who provided feedback and support throughout the year. Team facilitators, who were partially funded by the grant, were responsible for notifying project leadership when needs or issues arose within their teams for resources to be allocated to participants in a timely manner. Participants also were required to maintain a *documentation log* of their professional activities related to the goals of the grant within the project database and to update their log with corresponding evidence once they completed their individual action plans. Peer collaborative mentoring feedback reports and sharing sessions were implemented to provide additional evidence of individual and team progress and impact.

Furthermore, as an extension of the Summer Institute experience, project leadership worked with key community college participants to a conduct a yearly, one-day Winter Summit in the southwest part of the state where participants could report out their progress and continue discussions related to team tasks outlined during the Summer Institute. The three partner community colleges took turns hosting the Winter Summit each year. This event provided opportunities to integrate faculty from the newly added community colleges and districts in that region into the project. The Winter Summit provided an ideal context for additional networking, problem solving, and information sharing with faculty and teachers who were not able to attend the Summer Institutes yet played a role in accomplishing project related tasks at their given institutions.

Given the breadth and depth of experiences provided by this reform initiative and the variety of associated data collected over the life of both projects, for the purposes of this study the researchers focused primarily on the impact of such an integrated, broad-based reform model on K-16 science and mathematics teaching and learning, with major themes triangulated with additional sources of data involving partnership participants outside the fields of science and mathematics.

3. Methods

Design and Data Collection

In conjunction with the Office of Educational Innovation and Evaluation, the project leadership team developed a comprehensive research agenda and evaluation plan for the project, which utilized evaluation personnel in the research and data collection process. For the overall reform initiative, the research team initiated a longitudinal study to include a wide variety of quantitative and qualitative data using an evaluative case study design (Guba, & Lincoln, 1981; Saldaña, 2013). Qualitative data sources included: a) participant documentation logs, b) individual semi-structured interviews with 14 representative members of the project (four college faculty on the math and science teams, five K-12 teachers, six clinical instructors, four district administrators, and three community college administrators), and c) peer collaborative mentoring feedback reports.

Quantitative data sources included: a) state assessment data from partner districts, b) college of education program data (pre-service teacher licensure exam pass rates), and c) annual post-Summer Institute surveys administered to all participants. Additionally, numerous institutional and project documents from planning teams and staff observations and experiences were reviewed to provide context and to substantiate participant involvement and project impact.

Analysis

The research team utilized both quantitative (descriptive and inferential statistics) and qualitative (content analysis, pattern analysis, and constant comparison) techniques to analyze all data. They organized the data both by participant group (university faculty - education and arts &sciences, community college faculty, K-12 teachers, and K-12 students) and by content planning team (education foundations, humanities, language arts, math, recruitment and retention, science, social studies, and teacher leadership) to define the areas of impact relative to the context.

Using national frameworks produced by the National Science Teachers Association

(NSTA, 2012), the National Academy of Sciences (2015), the National Council for Teachers of Mathematics (NCTM) (2000), and Goodlad's foundational 1994 model for simultaneous renewal as the guiding frameworks for the study, the researchers read and considered the data, making initial notes on the various texts. The researchers then reread each piece of data coding for themes and commonalities across them (Miles, & Huberman, 1994; Creswell, 2007).

Long-term observations, peer debriefing (with at least two researchers coding each piece of data), triangulation, and audit trails were used to establish credibility and trustworthiness of the analysis (Miles, & Huberman, 1994).

4. Results

Overall, analysis of data from K-12 teachers, clinical instructors and administrators, arts & sciences faculty, education faculty and community college faculty and administrators, revealed the following three **project outcomes** as the most significant across all groups: 1) Improved Teaching Practices & Perspectives, 2) Enhanced Programs & Opportunities, and 3) Increased Learning & Student Achievement. Findings indicate that these three project outcomes were most significantly supported by four key **reform initiatives** of the Equity & Access Partnership: 1) Professional Development, 2) Collaboration & Networking, 3) Leadership Opportunities, and 4) Ownership and Accountability.

Project Outcomes

The first project outcome of *Improved Teaching Practices & Perspectives* surfaced continuously in documentation logs, peer collaborative mentoring reports, and interviews from the science and math planning team participants. This outcome was supported by survey responses involving all project participants. Through the documentation logs and peer collaborative mentoring feedback reports, science and math team members reported their progress related to personal and team plans for enhancing their own teaching and providing more equitable teaching opportunities for diverse students in their classrooms. An analysis of these documents revealed that all science and math team members implemented approximately one to three new effective and equitable teaching strategies each year during the four years these strategies were documented. The documentation logs and peer collaborative mentoring feedback reports also include data indicating the impact these strategies had on student learning.

Two- and four-year college faculty reported the use of strategies such as "ticket-in, ticket-out", partner/ group discussions, cooperative learning, project-based learning, peer assessments, individual review sessions, offering additional time, additional office hours, writing prompts, and the use of instructional resources, materials and technology to help students develop deeper understanding of key concepts and to create relevant connections to these concepts. The K-12 teachers reported the use of differentiated instruction, comprehension strategies, essential questions, targeted academic vocabulary, cooperative learning, data driven dialogue, sheltered instruction for ELs, class discussions, hands-on inquiry, manipulatives, graphic organizers, flexible grouping, and exit slips along with instructional resources and technology to deepen conceptual understanding and to meet the unique needs of their students. College faculty and K-12 science and math teachers both reported the use of new formative assessment strategies to enhance their own awareness of their students' prior knowledge and developing conceptual understanding. College faculty typically created cross-institutional, 2-member mentoring teams to plan new teaching strategies, to observe one another's teaching, and to provide feedback and support. The K-12 teachers more typically formed 3-5 member Japanese lesson study groups as a mechanism to plan, observe, provide feedback, and support each other in using new teaching strategies.

Individual interview data from four college faculty on the math and science teams, five K-12 teachers, six clinical instructors, four district administrators, and three community college administrators supported the outcome of *Improved Teaching Practices & Perspectives*. Interview questions specifically focused on the impact of the Equity &Access Partnership on teaching and learning at the individual and organizational level. College faculty and community college administrators related that faculty were “more compassionate”, “more interactive” in the classroom, and “more accommodating and flexible with students” after their participation in the project. College faculty stated that they had gained a greater awareness and understanding of diversity by better “knowing their audience” and that they received greater satisfaction from teaching because of these changes in practice and perception. School-based clinical instructors focused on the changing culture of their schools revealed through "changes in the ways teachers talk", renewed emphasis on helping all students learn, and teachers "taking more risks" to help all students learn. District administrators also noted a greater use of “data-based decision making” in their practice.

Survey results from all project participants also supported the theme of *Improved Teaching Practices & Perspectives*. At the end of the final Summer Institute, 104 surveys were completed by K-12 teachers (42), College of Education faculty (20), College of Arts & Sciences faculty (18), and faculty from the three partnering community colleges (17). Although differences were revealed between groups, mean scores for all participants indicated at least an "average" level of competence to apply the 18 different instructional strategies that had been focused on during the four years of Summer Institute professional development sessions.

The survey used a 4-point scale that ranged from: (1)"I do not feel competent to apply this strategy in my teaching", (2) “My level of competence to apply this strategy in my teaching is minimal", (3)

"My level of competence to apply this strategy in my teaching is average", to (4) "My level of competence to apply this strategy is high". These 18 surveyed instructional strategies were clustered under the sub-scales of Curriculum Renewal (3.48 mean), Effective Teaching (3.41 mean), Diversity (3.09 mean), and Standards-Based Teaching (3.03 mean). Although statistically significant differences were found based on level of teaching (K-12, community college, arts & sciences, or college of education), all groups scored at least a 3, or at the average level of competence, on each sub-scale.

The second outcome of *Enhanced Programs & Opportunities* was revealed through program documents, documentation logs, and individual interviews with the science and math team members. Program documents and documentation logs provided evidence that programs and opportunities were created and/or enhanced at all educational levels. New formal articulation agreements were created and institutionalized between the 2- and 4-year colleges and the 2- and 4-year college content and methods courses were aligned with state and national teaching standards.

More specifically, at the university, college algebra was completely re-designed to enhance the use of technology and include the use of algebra studios to meet the needs of all students more effectively. Mathematics for elementary teachers, an upper-level mathematics course, was co-taught twice by 2- and 4-year mathematics faculty as a combination distance-based and face-to-face alternative to expand opportunities for students in the southwestern region of the state. The elementary teacher education program also was redesigned to include five new classes and a new field experience block. The original and more traditional "Multicultural Education" course in the College of Education was expanded and revised to become "Teaching Culturally and Linguistically Diverse Students" to more specifically prepare future teachers to meet the linguistic demands of their increasingly multilingual classrooms.

Community college partners also established new roles in teacher education. They re-designed existing courses and offered new courses to meet the needs of future teachers. They provided tutoring and established resource centers for CLD students in their programs and designed support opportunities for students preparing to take the ETS entrance exams. In addition, they collaboratively created Grow-Your-Own-Teacher programs, future teacher clubs, and student National Education Associations.

At the K-12 level, teachers across all five districts implemented new teacher mentoring programs, the sheltered instruction for ELs, and differentiated instruction. Leadership Academies also were offered at three of the partner districts in collaboration with faculty from the university.

In addition, two cohorts of predominately non-traditional, Latinx, multilingual learners graduated from a collaboratively designed and implemented distance-delivered, 2+2, teacher education program. Both cohorts successfully completed a hybrid, distance-delivered version of the science and math methods courses (followed by language arts and social studies methods) and completed their internships in partner districts in the highly diverse southwestern region of the state. Findings indicate that to date, over 70% of graduates are still teaching, providing strong, relevant educational experiences for diverse students whose needs have not always been met.

The importance of these *Enhanced Programs & Opportunities* was supported through the interviews with K-12 teachers, clinical instructors, district administrators, and community college administrators. All four groups mentioned the impact that new programs had on the educational system. New teacher mentoring programs, grow-your-own-teacher programs, teacher leadership training and sheltered instruction programs were identified as having a "significant impact" at the K-12 level. K-12 participants also shared the impact that the collaborative partnership had on recruiting new, high-quality teachers to their districts who were "prepared to meet unique needs" of the southwestern region.

Community college participants also targeted their new role in teacher preparation as an area of impact. Participants shared an increase in understanding of and priority for teacher education on their campuses. Community college administrators referred to the improvement of the "pipeline" between 2-year and 4-year institutions due to the strong articulation agreements developed through the collaboration. Additionally, the community college participants highlighted key developments on their campuses because of the partnership that had an impact on students within this "pipeline." ETS entrance exam workshops, service-learning opportunities, additional course offerings, increased tutoring options, future teacher student organizations, and a comprehensive orientation program are just a few of the components identified as increasing access and opportunities, particularly for CLD and non-traditional students on their campuses.

A third outcome identified as *Increased Learning & Student Achievement* was demonstrated through an analysis of statewide K-12 science and mathematics achievement data and college of education student data.

Documentation logs, peer collaborative mentoring feedback reports, K-12 *teacher share fairs*, and interviews supported these findings. In terms of K-12 student achievement, combined district means on state assessments indicated increased test scores across the five years of the Equity & Access partnership grant in both science and mathematics for all grades tested. An analysis of individual district data indicated four of the five districts demonstrated achievement gains on the fourth-grade state science assessment from years 1-5 while three of the five districts demonstrated gains on the 7th and 11th grade state science assessments from years 1-5.

Student achievement gains in mathematics, where professional development initiatives were targeted, were more striking. Three districts showed student gains on the state math assessments across the five years of the project at grades 3 and 11, while all five districts showed 5-year achievement gains (ranging from 15.8% to 29%) on the state assessments at grades 4, 5, 6, 7, 8, and 10. Documentation logs and annual *teacher share fairs* also demonstrated continuous increases in K-12 student learning based on teacher-generated tests and performance items as well as state assessments. These assessment tools were utilized as part of annual teacher action plans, action research studies, and the Japanese lesson studies.

Data from the teacher education program indicated continuous improvement of scores on the ETS Principles of Learning and Teaching (PLT) and the PRAXIS Academic Content Area exams across the five years of the project. Institutional summary reports from ETS indicated that both elementary and secondary education students performed higher than state and national averages on all 7 test categories of the Praxis II-Principles of Learning and Teaching (PLT). The average pass rate on the PLT K-6 was 99% (statewide pass rate was 97%) while the pass rate for the PLT 7-12 was typically 100% (average statewide pass rate was 96%). Furthermore, teacher education students performed at or above the state and national levels on Academic Content Area exams, both at the elementary and secondary level.

Documentation logs, peer collaborative mentoring feedback reports, and interviews from arts &sciences and education faculty also indicated improved student learning based on instructor-generated tests and performance items created and assessed as part of yearly action plans. Impressive learning was documented for students in the elementary science methods course and the principles of biology course taught in the college of arts & sciences, while the coordinator of mathematics for elementary teachers (also in arts &sciences) provided evidence of enhanced appreciation of mathematics and application of learning.

Reform Initiatives Supporting Project Outcomes

According to interview data, documentation logs, and the observations of project staff, one of the most important initiatives supporting the outcomes of this project was *Professional Development*. The effective and equitable teaching practices and program improvements outlined in participant action plans each summer and reported in documentation logs each year were always related to teaching strategies, teaching, and learning topics, and programmatic concerns and issues presented during the summer institutes. The significant impact of this professional development surfaced during the interviews primarily in relation to sessions on student learning offered during the summer institutes. Participants shared that they learned about "students and their needs" not only through the sessions and book studies offered but also through the resources and materials provided by the project to their institutions. One K-12 teacher related that the professional development was "in-depth and focused" and allowed her "to move knowledge to application and impact".

School-based clinical instructors highlighted the quality content knowledge being shared with K-12 teachers, particularly in the field of mathematics. Clinical instructors also shared examples of the changing culture in their school that they believed was a result of their school's involvement in the Equity & Access Partnership. They described greater awareness and knowledge, more proactive behaviors, and increased efficacy and professionalism exhibited by teachers who participated in the summer institutes. Teachers, clinical instructors, and district administrators commented on the wide number of book studies, guest speakers, topics for discussion and action, and resources that were shared school-wide and even district-wide by the teachers who attended the Summer Institutes. The K-12 participants also commented during interviews on the importance of the follow-up implementation support they received from the project staff and leadership team. The most frequently mentioned K-12 follow-up support was related to the Japanese lesson study process.

According to program documents, documentation logs, peer collaborative mentoring feedback reports, and particularly individual interview data, the second most important reform initiative to support project outcomes was *Collaboration & Networking*. As previously mentioned, all participants were placed within planning teams (such as science, mathematics, or district leadership).

These teams were then responsible for studying reform documents, effective and equitable teaching strategies, and state and national teaching standards and finding ways to implement recommendations from these sources across the teacher education program and their own classrooms. In this way, teams were responsible for collaboratively identifying and addressing individual and programmatic issues and concerns across the K-16 continuum.

Additionally, participants were asked to create smaller *peer collaborative mentoring teams* to plan, observe, provide feedback, and support one another as they implemented effective and equitable teaching strategies in their own classrooms. Consequently, faculty from 2- and 4-year colleges - arts &sciences as well as education - interacted with one another and with K-12 teachers on a variety of improvement initiatives across all five years of the project.

These continuous interactions and the resulting program improvements, new student opportunities, and examples of enhanced teaching and student learning are illustrated in numerous program documents and participant documentation logs. It is obvious from reading these documents that individual participants would not have been able to identify the critical issues, solve the many problems, and create the new programs and opportunities as multi-institutional teams were able to do. In addition, the lessons learned from planning together, observing one another's teaching, and providing feedback and support was dramatically illustrated in the participant documentation logs and peer collaborative mentoring reports, during K-12 *teacher share fairs*, and during individual interviews.

Participants repeatedly stated that having opportunities "to interact with others and bring back ideas to the district", "to learn from other campuses across the partnership" and having the opportunity to "work with peers" within one's own institution proved significant. Many participants particularly saw value in "networking" in their content area from other institutions. For example, science and mathematics faculty from 2- and 4-year colleges repeatedly commented on the value of learning from one another, their renewed appreciation for other K-16 teaching environments, and a greater understanding of the need for K-16 articulation.

In addition, the school-based clinical instructors in the southwestern region of the state created a support network of their own to find effective strategies and share resources to help teachers deal with the challenges of their learning environment. This collaboration and networking built greater understanding of each unique educational setting – the differences and similarities between the diverse students they teach, expectations for each educational position, and the trials and tribulations they all face as teachers. It also allowed greater articulation from grades K-16.

Overall, the findings indicate that the collaborative partnership served as the foundation for efficient knowledge transfer and the cross-institutional and cross-content area team approach was highly effective in building strong K-16 relationships among the participants. Out of these relationships, opportunities to institutionalize key programs and policies beyond the life of the partnership have developed. Furthermore, ongoing research collaborations have resulted in multiple journal articles and additional grant funding for other related projects at both the K-12 district and post-secondary level.

District administrators and school-based clinical instructors first identified the importance of the third reform initiative to support project outcomes, *Leadership Opportunities* during their interviews. However, the importance of leadership opportunities for promoting and sustaining reform also was supported by program documents, documentation logs, and during annual *teacher share fairs*. Instructional leadership is essential to K-12 school improvement and yet many principals do not have time to provide such leadership and still tend to school management issues, parental communication, student discipline, and staff needs. The administrators and clinical instructors immediately recognized the benefits of creating teacher leaders through the partnership project to provide instructional leadership within their schools and districts.

Program documents, documentation logs, share fairs, and interviews indicated that these teacher leaders set up Japanese lesson study groups, action research projects, book studies, and discussion groups. They shared resources and new practices learned through the Summer Institutes with other teachers in their buildings. Furthermore, they became advocates for new programs, new curricula, and new teaching strategies within their buildings. Practices such as differentiated instruction, comprehension strategies, and the use of essential questions became part of the school culture at many sites. In several districts, practices such as sheltered instruction for EL's, and comprehensive frameworks for teaching and teacher evaluation became institutionalized across the entire district. As previously noted, new teacher mentoring programs were institutionalized across all five districts.

The final reform initiative that supported project outcomes was *Ownership & Accountability.* The relationship between ownership & accountability and the outcomes realized through this project was demonstrated through staff experiences, program documents, documentation logs, peer collaborative mentoring feedback reports, and individual interviews.

From their previous experience on the initial grant and with participants in the first year of the *Equity & Access*, the project leadership learned that for participants to buy-in and fully participate, they needed to understand the reform mission of the grant on a deeper level and to have an increased sense of ownership and responsibility. Otherwise, it was impossible to accomplish the extensive multi-institutional goals needed for reform. When participants did not understand the need for change and did not see themselves as responsible or accountable for project success, project activities were not taken seriously, team members did not plan or implement team projects, and individual participants did not attempt to examine or enhance their teaching. The initial assumption seemed to be that the project staff would accomplish the goals of the project and the participants would do little beyond attending the Summer Institutes. Each team was assigned a staff member to serve as a team facilitator; but the facilitators experienced great difficulties motivating their teams into action.

Therefore, project leadership and staff met to discuss ways to create ownership and accountability for all participants. Project goals were analyzed, and specific team tasks were developed based on these goals. The majority of the team tasks required inter-institutional cooperation among team members; however, one task, assigned to every participant across all teams each year, was to plan and implement at least one new effective and equitable teaching strategy to enhance teaching and learning in individual classrooms K-16. Project leaders spent a good deal of time helping participants to understand the need for change and to relate needed changes to project goals and team tasks. Student achievement, achievement gaps, the changing demands on teachers, and new visions for a better educational future were shared and extensively discussed. Teams examined project goals and team tasks in relation to this shared sense of need and purpose.

Participants came to realize that only through the team tasks would the goals of the project be accomplished and therefore, they, as participants, were responsible for helping to build a better educational system. Each participant was then asked to complete an action plan detailing what they intended to do *individually* and *collectively* to accomplish their team tasks. Each individual action item had to be related to a project goal and an identified team task. It was the responsibility of the team to make sure all team tasks were addressed. The team facilitator (staff member assigned to each team) monitored the entire process. Action plans were shared within each team and each team then presented their plans to the entire partnership on the last day of the summer institute.

This action planning process improved participation immediately; but, not for all participants. Therefore, the following year the staff added an additional accountability measure, the documentation logs. Each action plan was loaded onto a database with space provided for participants to document, on a regular basis, his or her progress in implementing their individual action plan. The team facilitator monitored the documentation logs on a regular basis and sent reminders to team members to document their activities. Participants were told that they must implement their action plans throughout the following academic year; although they were given the opportunity to modify their plans if the intended plans proved unreasonable or if more meaningful tasks presented themselves. The following summer project leaders implemented share sessions within each team to discuss each participant's progress and to plan future team efforts.

Program records and documentation logs indicated significant improvement in individual and team participation after the implementation of the increased accountability measures (action plans, documentation logs, and Share Fair sessions). Overall, team members demonstrated greater commitment to project goals and activities and therefore team tasks and project goals were accomplished. Community college and university faculty became more involved in the distance-delivered, 2+2, teacher education program and designed new programs to help these future teachers succeed.

Documentation logs and peer collaborative mentoring feedback reports indicated that effective and equitable strategies were implemented in all participants' classrooms. Furthermore, participants who worked on joint projects or collaborated on "mentoring" each other through new instructional practices demonstrated greater accountability to one another. Interview data supported this finding, providing evidence for the importance of these ownership and accountability measures. School-based clinical instructors noted the impact of the action planning process in particular. They indicated that it enhanced "ownership" and made participation more "meaningful and relevant" for teachers. Clinical instructors, teachers, and college faculty also noted the motivation provided by the annual share fair sessions and winter summits.

5. Conclusions and Implications

This case study of systemic reform in pre-service science and mathematics teacher education contributes to our understanding of how collaborative, multi-institutional reform in pre-service teacher education can influence science and mathematics teaching and learning across the K-16 continuum.

The researchers have documented the experiences and resulting outcomes of such a broad-based, collaborative partnership and the evidence suggests that ongoing professional development, collaboration, leadership opportunities, as well as ownership and accountability provide an ideal blend of *pressure and support* needed to sustain systemic reform in pre-service teacher education and to enhance K-16 teaching and learning. Program documents provide evidence that significant improvements were made in the on-site teacher education program, a distance-delivered, 2+2, teacher education program was designed and implemented, and 31 CLD pre-service teachers completed the program and began teaching in one of the most diverse and high needs regions of the state. In addition, 2- and 4-year college faculty and K-12 teachers and administrators gained a greater understanding of the needs of CLD learners and assumed new roles and responsibilities in the teacher education process.

The support provided by professional development sessions deepened participants' understanding of current trends in public education and the need for innovation and change at both the community college and university levels. The partnership provided opportunities for collaboration and networking, which led to cross-institutional problem solving. The pressure applied through accountability measures such as team tasks and action plan helped participants realize that reform in teacher education is a shared responsibility.

Although the focus of reform in this project was pre-service teacher education, by involving all the individuals who touch the lives of future teachers, science and mathematics teaching was improved across the partnership - at the university, the three community colleges, and all five school districts. Action plans, documentation logs, and peer collaborative mentoring feedback reports indicated that participants at all levels implemented new effective and equitable teaching strategies when provided with pressure and support to do so.

According to the participants, the most powerful forms of support in this project were continuous in-depth professional development, collaboration and networking, and leadership opportunities. Participants learned about new strategies and then had the opportunity to discuss them with colleagues at all educational levels, to practice them with the support of a mentoring team, to observe them in practice in one another's classrooms, and to share results with other educators. Pressure was applied through a variety of accountability measures such as action plans, documentation logs, peer collaborative mentoring feedback reports, and share sessions. These accountability measure helped participants develop ownership and a sense of responsibility to the project, to one another, and to the educational system.

Student data at the K-12 level provided additional evidence for the power of pressure and support. The greatest and most consistent gains in student achievement were in mathematics, the area most frequently targeted for professional development. A two-week *Content Curriculum and Children (C^3)* Academy was conducted each summer all five project years. Teachers left some of the content sessions in tears due to the rigorous demands of learning mathematics. They were held accountable for their learning through exams, the creation of action plans, documentation logs, the Japanese lesson studies, end-of-the-year teacher share fair sessions, and district pressure to make gains in test scores. Teachers also received continuous support to implement new learning in mathematics through the Japanese lesson study process, on-going staff and teacher leader assistance, and follow-up sessions during the academic year.

Project staff attempted to provide regular professional development in science, but these sessions did not generate the teacher interest or administrative demand needed to offer more than one- or two-day sessions each summer. Due to the lack of emphasis on science over the past 25years (as a result of NCLB and Common Core's focus on math and literacy), science was rarely identified as an area of need by teachers or administrators. This lack of focused pressure and support may be partially responsible for smaller gains on K-12 science achievement tests.

The major implication of these findings is that systemic reform is achievable, and the outcomes can be exceptionally rewarding; but such initiatives require time, continuous effort, resources, broad-based participation of all stakeholders, and a sense of need for change. As paralleled in the study done by Darling-Hammond and Friedlaender (2008), without time, effort, resources, and extensive participation, the Equity & Access Partnership would not have been able to a) provide the support needed to accomplish systemic improvement in the areas of math and science teaching and learning or b) to engage educators (K-16) in critical study of their pedagogical practices and cultural competencies in supporting CLD students. When participants did not sense of need for change or feel a sense of responsibility, they were less willing to invest. Yet, when given pressure and support to achieve individual and collective goals, they assumed more ownership or felt more accountable for the reform initiatives.

These findings further support previous studies on the impact of K-16 systemic reform and should be of interest to teacher educators, scientists and mathematicians, K-12 teachers, school administrators, and policy analysts as we look for effective ways to enhance teacher education and improve teaching and student learning in STEM for CLD students at all levels.

6. References

Achinstein, B., Ogawa, R. T., Sexton, D., & Freitas, C. (2010). Retaining teachers of color: A pressing problem and a potential strategy for "hard-to-staff" schools. *Review of Educational Research, 80*, 71-107.

Ake-Little, E. S. (September, 2018). What K-12 and higher education can learn from each other: Secondary schools and universities need to work together. *Education Week*. Retrieved from https://www.edweek.org/ew/articles/2018/09/19/what-k-12-and-higher-education-can-learn.html?cmp=eml-enl-eu-news1-rm&M=58615790&U=2536339&print=1

Bellamy, G. T., & Goodlad, J. I. (2008). Continuity and change: In the pursuit of a democratic public mission for our schools. *Phi Delta Kappan, April*, 565-571.

Besterman, K., Williams, T., & Ernst, J. (2018). STEM teachers' preparedness for English language learners. *Journal of STEM Education Innovations and Research, 19*(8), 33-39.

Callahan, J. (2016). Encouraging retention of new teachers through mentoring strategies. *The Delta Kappa Gamma Bulletin: International Journal for Professional Educators, 83*(1), 6-11.

Castagno, A. E. (2015). *Educated in Whiteness: Good intentions and diversity in schools*. Minneapolis, MN: University of Minnesota Press.

Center for Education Statistics and Evaluation (2013). *Great teaching, inspired learning. What does the evidence tell us about effective teaching?* Retrieved from http://www.schools.nsw.edu.au/media/downloads/news/greatteaching/gtil_cese_resear ch_report.pdf

Cochran-Smith, M. (2006). *Policy, practice, and politics in teacher education*. Thousand Oaks, CA: Corwin Press.

Creswell, J. (2007). Data analysis and representation. In Creswell, J. (Ed.). Qualitative inquiry and research design: choosing among five approaches (2nd ed.). Thousand Oaks, London: Sage.

Darling-Hammond, L. (2006).*Powerful teacher education: Lessons from exemplary programs*. San Francisco: Jossey-Bass.

Darling-Hammond, L., & Baratz-Snowden, J. (2005a). *A good teacher in every classroom: Preparing the highly qualified teachers our children deserve.* San Francisco: Jossey-Bass.

Darling- Hammond, L., & Bransford, J. (2005b). *Preparing teachers for a changing world: What teachers should learn and be able to do.* San Francisco: Jossey-Bass.

Darling-Hammond, L., & Friedlaender, D. (2008). Creating excellent and equitable schools. *Educational Leadership, 65*(8), 14-21.

Domina, T., & Ruzek, E. (2010). Paving the way: K–12 partnerships for higher education diversity and high school reform. *Educational Policy, 26*(2), 243–267.

Fettke, Steven M. (2016). What Makes and Excellent Teacher? *The Pentecostal Educator 3*(2), 9-17.

Gay, G. (2010.) *Culturally responsive teaching: Theory, research, and practice* (2nd ed.)In J.A. Banks (Ed.), *Multicultural Education Series*. New York: Teachers College Press.

Goodlad, J. I. (1994). *Educational renewal: Better teachers, better schools.* San Francisco: Jossey-Bass.

Gorski, P. C. (2012). Instructional, institutional, and sociopolitical challenges of teaching multicultural teacher education courses. *The Teacher Educator, 47*(3), 216-235.

Guba, E. G., & Lincoln, Y. S. (1981). *Effective evaluation: Improving the usefulness of evaluation results through responsive and naturalistic approaches.* San Francisco, CA: Jossey-Bass.

Howard, T. C., & Aleman, G. R. (2004). Teacher capacity for diverse learners: What do teachers need to know? In M. Cochran-Smith, S. Feiman-Nemser, & D. J. McIntyre (Eds.), *Handbook of research on teacher education: Enduring questions in changing contexts (3rd Ed.)*. New York: Routledge.

Iasevoli, B. (2017). Landscapes in teacher prep: Undergraduate secondary education. *Education Week*, *36*(31), 4.

Loucks-Horsley, S., Hewson, P. W., Love, N., & Stiles, K. E. (1998). *Designing professional development for teachers of science and mathematics.* Thousand Oakes, CA: Corwin Press.

Magiera, K., & Geraci, L. M. (2014). Sustaining a rural school–university partnership: A twenty-two-year retrospective of an after-school tutoring program. *Rural Special Education Quarterly, 33*(1), 12–17.

Miles, M. B.,& Huberman, A.M. (1994). *Qualitative data analysis: An expanded sourcebook*. Thousand Oakes: Sage Publications.

Milner, H. R. (2010). What does teacher education have to do with teaching? Implications for diversity studies. *Journal of Teacher Education, 61*(1-2), 118-131.

National Academy of Sciences, Committee on Strengthening Science Education through a Teacher Learning Continuum. (2015). *Science teachers' learning: Enhancing opportunities, creating supportive contexts.* Washington: DC: National Academies Press.

National Council for Teachers of Mathematics (NCTM). (2000). *NCTM Principles and standards for school mathematics*. Reston, VA: Author.

National Science Teachers Association (NSTA). (2012). *NSTA standards for science teacher preparation.* Arlington, VA: Author.

National Council for Teacher Quality. (2016). *The landscape of teacher preparation: Elementary education.* Retrieved from https://www.nctq.org/dmsView/UE_2016_Landscape_653385_656245

Shaw, J., & Newton, J. (2014). Teacher retention and satisfaction with a servant leader as principal. *Education, 135*(1), 101-106.

Stotsky, S. (2006). Who should be accountable for what beginning teachers need to know? *Journal of Teacher Education, 57*(3), 256-268.

Sleeter, C. (2015). Deepening social justice teaching. *Journal of Language and Literacy Education*, 6. Retrieved from http://jolle.coe.uga.edu/.

Smith, E., Kindall, H., Carter,V., & Beachner, M. (2016). Impact of adopt-a-classroom partnerships between K–12 and university faculty. *School Community Journal*, *26*(1), 163-182.

Terrell, R. D., & Lindsey, R. B. (2009). *Culturally proficient leadership: The personal journey begins within*. Thousand Oaks, CA: Corwin Press.

1. Equity & Access Partnership Project Reform Model