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POSITIVE SUSTAINABILITY FACTORS OF NOYCE SCHOLARSHIP PROJECTS IN THE CALIFORNIA STATE UNIVERSITY SYSTEM

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By

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ABSTRACT

POSITIVE SUSTAINABILITY FACTORS OF NOYCE SCHOLARSHIP PROJECTS IN THE CALIFORNIA STATE UNIVERSITY SYSTEM

By

Joshua N. Einhorn

Doctor of Education Degree

In Educational Leadership

The National Science Foundation (NSF) Robert Noyce Scholarship Program (Noyce) is designed to encourage science, technology, engineering, and mathematics (STEM) university students and professionals to teach science, engineering, or mathematics in elementary and secondary schools (National Science Foundation, n.d.a).

I chose to study the factors that sustain Noyce projects in the California State University (CSU) system after expiration of funding. The following questions guided this study: *Are the same factors that have been found in prior research to promote sustainability of project activities and broader impacts in general higher-education settings applicable specifically to Noyce projects in the CSU today, and, if so, what is the relative importance of these factors in terms of influence on sustainability in the CSU?*

My study employed a mixed-methods design. Specifically, I chose an Explanatory Sequential Design, a two-phase model in which quantitative data were first collected and analyzed, followed by collection and analysis of qualitative data. Data included surveys from 30 Noyce Principal Investigators (PIs) and co-PIs and interviews with 6 CSU Noyce PIs. The findings suggest that the same factors that have been found in prior research to

promote sustainability of project activities and broader impacts in general higher-education settings are indeed applicable to Noyce projects in the CSU today. In triangulating the data collected from the mixed-methods analysis, I found that there was correlation between sustainability and the following factors: centrality (i.e., project partners possessing shared goals); connected networks of support; support of campus administration; efficacy (i.e., training of project personnel); and formative assessment and continuing evaluation. Based on the quantitative analysis, the relative importance of the identified factors in terms of perceived influence on sustainability in the CSU was determined to be (in order of relative importance) (a) centrality, (b) connected networks of support, and (c) support of campus administration; efficacy, and formative assessment and continuing evaluation both showed essentially zero correlation. The results of this study create implications for the planning of future Noyce projects at the CSU. Knowing the relative importance of the positive sustainability factors allows PIs to prioritize their efforts accordingly. The planning should begin with choosing a project that aligns with the campus at all levels. Next, in building connected networks of support, Noyce PIs should target partners with shared missions and who are willing to commit deeply to their project through sharing of their time and their resources. Training and evaluation are also pivotal to sustainability.

Recommendations are extended beyond CSU Noyce projects to externally funded projects at institutions of higher education in general. I posit that to foster sustainability PIs should prioritize their efforts in accordance with the relative importance of positive sustainability factors as established in this study. I also recommend setting sustainability benchmarks throughout the term of the grant and monitoring to see if these are being met, seeking continuation funding beginning early in the term of the grant, linking one's

project to other campus initiatives and other externally funded projects on campus, and enacting structural changes to campus and partner policies, procedures and practices that will last beyond the term of the grant.

It is my hope that my recommendations might lead to an increase in the sustainability of Noyce and other (non-Noyce) project activities and broader impacts among CSU campuses and beyond.

CHAPTER ONE: STATEMENT OF THE PROBLEM

The Need for Highly Qualified Science Technology Engineering Mathematics (STEM) Teachers in High-Needs School Districts

A shortfall of qualified science classroom teachers has been a "chronic challenge in the K-12 system" (Thomasian, 2011, p. 21). A report from the Business-Higher Education Forum (BHEF) stated that 280,000 new science and mathematics teachers will be needed nationally from 2007-2015 (Business-Higher Education Forum, 2007). Since math and science majors have attractive career options in private industry, teacher attrition rates are highest in mathematics and science (Business-Higher Education Forum, 2007). Almost half of all teachers depart the profession within five years (Business-Higher Education Forum, 2007). The rate of attrition is 50% higher in high-needs school districts (i.e., districts with a low socioeconomic status [SES] and high minority student population). Teachers in high-needs school districts tend to be less qualified:

> In 2002, 72% of high-minority middle school mathematics classes were taught by teachers who had not majored or minored in mathematics, compared with 55% of low-minority classes. A similar pattern was observed in high schools, where there was a 33% to 23% differential between high- and low-minority mathematics classes (Business-Higher Education Forum, 2007, p.9).

In 2011, ten percent (about $315 million) of federal funding for STEM education was dedicated to pre-service and in-service STEM teachers; an additional $925 million was funneled through federal agencies to improve STEM teacher education, through National Science Foundation (NSF) programs such as the *Mathematics and Science*

Partnership and the *Robert Noyce Teacher Scholarship Program*, hereafter referred to as "Noyce" (Committee on STEM Education National Science and Technology Council, 2013*).* Total funding available in FY2013 for Noyce was $50.6 million (personal communication, Joan Prival, 8/23/13).

The goal of Noyce is to encourage STEM university students and professionals to teach science, engineering, or mathematics in high-needs elementary and secondary schools (National Science Foundation, n.d.a). First authorized in 2002, Noyce was later expanded through the America COMPETES (Creating Opportunities to Meaningfully Promote Excellence in Technology, Education and Science) Act in 2007 and the America COMPETES Reauthorization Act of 2010. Congress enacted America COMPETES in response to a report from the National Academies entitled "Rising Above the Gathering Storm," which forecast that America was at risk of losing its scientific preeminence along with the economic benefits of being the "world's high-tech leader" (California Council on Science and Technology, 2007, p. 1). The purpose of America COMPETES was to invest in innovation through research and development to improve the competitiveness of the U.S. in part through investments in STEM teacher education projects and programs housed within institutions of higher education (National Science Foundation, n.d.b).

My study centers on maximizing this federal investment by exploring the factors that foster the sustainability of externally funded projects after the term of the grant expires, specifically Noyce projects in the California State University (CSU) system.

Historical Overview of Sustainability of Externally Funded Projects in Institutions of Higher Education

Shediac-Rizkallah and Bone (1998) defined sustainability as the long-term viability of a new program within an organization. Sustainability as it pertains to grant-funded projects refers to the maintaining of project activities after the term of the grant has ended (RAND, 1975a). Funders want to see that their significant investments have a sustained impact.

Policy-makers at the federal and state levels, university leaders, and faculty members alike have traditionally been concerned about the tendency of federally funded programs to cease their activities when the funding term ends. In 1967, Senator Peter H. Dominick of Colorado, member of the Congress Education Committee, expressed concern about Title III aid, which supports educational innovation in elementary and secondary education:

> As a legislator, I am vitally concerned whether [Title III projects] are in fact accomplishing the objectives envisioned by Congress and whether the money appropriated is being properly spent. I am specifically concerned about whether the program conducted will have a lasting effect on the school--or if, when the money for a project is exhausted and the initial program is terminated, the tent will be folded with little imprint on the educational processes of the school (as cited in Hearn, 1969a).

Senator Dominick's concern was that such a significant investment of federal dollars would be for naught if project activities and broader impacts were not to continue.

In 1969, Norman Hearn, then Chief of Program Analysis and Dissemination for

the United States Department of Education, described the frustration federal agencies experience when the contributions of a project they sponsored evaporate upon cessation of federal funds. His article's title embodied the agencies' cynicism: "When Sugar Daddy's Gone, Does Baby Starve?" (Hearn, 1969b). More recently, private sector funders coined another derogatory term for evanescent projects: "drive-by philanthropy" (Annie E. Casey Foundation, 2002, p. 8).

In 1975, California State University Chancellor Glenn Dumke wrote that it was imperative for educational reform efforts funded by the State of California, the CSU, and the U.S. Department of Education *Fund to Improve Postsecondary Education* (FIPSE) to continue past their period of funding (Office of the Chancellor, 1975). In the report, which studied 137 major projects, Dumke wrote that noncontinuation of project activities and broader impacts would not only represent a waste of taxpayer dollars, but also be a detriment to students and faculty if the educational reforms and innovations were to evaporate (Office of the CSU Chancellor, 1975).

Rabitoy (1988), a faculty member at California State University, Long Beach, qualitatively analyzed 70 pilot projects across the CSU to examine the long-term impact that the state-funded Academic Program Improvement grants made from 1980 to 1986. He assessed the factors that fostered or hindered permanent adoption of successful innovations. He found that after the end of the grant period only 28% of project activities continued fully as implemented (Rabitoy, 1988). Rabitoy (1988) concluded that "the use of…funds to demonstrate that an idea is sound has little importance to a campus or the CSU…unless the idea is implemented and persists" (p. 13).

The sentiments of these funders, policy makers, and researchers indicate a

historical concern about the waste of state and federal dollars, and the loss of the pedagogical advances and student learning outcomes that the project activities were meant to engender.

Definition of Noyce Sustainability

To comply with the Government Performance and Results Act of 1993 (Tsuchitani, 2008, p.4), the NSF performs continuing evaluation to "compare different types of programmatic investments and identify the most effective means for continuous improvement across the NSF portfolio" (National Science Foundation, 2010, p.1). Noyce has near-term (1-2 year), mid-term (2-5 year), and long-term (5-10 year) goals. The near-term goal is a stipend or scholarship recipient obtaining a teaching credential. The mid-term goal is fulfilling the required teaching commitment in a high-needs school district. Long-term goals include (a) Noyce alumni continuing to teach beyond their required commitment, constituting a pool of highly qualified teachers in high-needs school districts (many of whom take leadership roles earlier in their careers than their non-Noyce trained peers); and (b) middle and high school student proficiency in and passion for STEM subject matter. Throughout, the NSF expects a culture of excellence to be maintained (National Science Foundation, 2011).

The NSF has an expectation that all Noyce activities will be sustained, although sustaining scholarships may be prohibitively expensive without external funding (Joan Prival, personal communication, March 22, 2013).

Noyce project activities include

- student scholarships for STEM majors and professionals to become STEM teachers;

- recruitment of math and science majors on the home campus of the Noyce Principal Investigator (PI) into the teaching profession;
- recruitment of math and science career professionals into the STEM teaching profession;
- online and in-person seminars attended by mentor teachers, current and former Noyce Scholars, university faculty, and district personnel;
- early teaching field experiences for freshman, sophomore, and juniors who are math and science majors and considering a teaching career;
- promotional events at community colleges to attract math and science majors to teaching;
- research experiences at a campus lab or local federal laboratory for teacher candidates; and
- curriculum changes in teaching-credential courses.

Other Noyce activities include support for new teachers (induction programs), and the development of mentor teachers. I did not analyze these two activities in my study because they are not part of most Noyce programs. These two activities are normally performed by other entities. For instance, in California teacher induction is conducted by the Beginning Teacher Support and Assessment (BTSA) program. BTSA is a state-funded program sponsored by the California Department of Education and the Commission on Teacher Credentialing. Also within the CSUs the colleges of education train mentor teachers.

In addition to project activities also broader impacts can be sustained. Noyce broader impacts include changes in pedagogy among faculty members, deeper connections

among partners, increased math and science achievement in local K-12 schools, increased access to STEM education and careers among historically underrepresented populations in high-need school districts, improved teacher preparation, increased involvement of subject-matter faculty in teacher preparation, and change in disposition of faculty towards high-need schools and K-12 teaching.

Purpose and Significance

Through a literature review on the sustainability of externally funded grant projects in higher education, I found that certain factors have tended to have a positive effect on the continuation of project activities after expiration of grant funds. These factors included centrality, connected networks of support, support of campus administration, efficacy, and formative assessment and continuing evaluation. I explored whether these sustainability factors found to be effective in other four-year higher education settings were applicable to Noyce projects at CSU campuses today, and if so, what the relative importance of these factors in terms of influence was.

Historically, studies of the sustainability of federally funded projects at institutions of higher education have been mostly qualitative and hence have only been able to generate lists of positive sustainability factors (Lechuga, 2010; Rabitoy, 1988). Since I included a quantitative survey (rather than just using interviews), I was able to establish the relative importance of the positive sustainability factors with CSU campuses as the unit of analysis. Also the only sustainability study conducted with the CSU as the unit of analysis is 26 years old (Rabitoy, 1988). It is quite possible that changed educational and political conditions since then have altered the factors that promote project sustainability. Future CSU PIs applying for Noyce can benefit from knowing the

relative importance of positive sustainability factors. I posit that with this knowledge Noyce PIs can plan their project and implementation to maximize the chances for project sustainability.

The national STEM education and STEM teacher education effort is vast, and is comprised of an annual allotment of over $3 billion from federal and state governments, private industry and private and corporate foundations (Committee on STEM Education National Science and Technology Council, 2013*)*. An important part of this effort is the NSF Noyce program, which addresses the chronic shortfall of highly qualified science and math teachers in high-needs school districts. Gaining a nuanced view of the sustainability of Noyce project activities and broader impacts will maximize the potential for the long-term impact of Noyce projects.

In order to establish a rigorous, scientific research design, I chose to study just one federal program. Studying one program meant that each of the sites studied would be beholden to the same external goals from the funder, thereby reducing confounding elements. Specifically I chose to study the Noyce program. Noyce was an ideal choice for a number of reasons. Firstly, almost every CSU campus has received Noyce funding and the CSU was my unit of analysis. Secondly, STEM teacher education is prominent in the national dialogue so its relevance in the present and into the future is assured (Association of Public and Land-Grant Universities Science & Math Teacher Imperative, n.d.; California State University, 2012). Thirdly, the CSU has an ethical responsibility to the NSF to ensure the long-term return on its investment (Joan Bissell, personal communication, March 18, 2014). The California State University system wants to see CSU campuses' Noyce recruitment and support strategies institutionalized even as

scholarships have been awarded, and would like to examine the opportunities and the culture of community among students that the Noyce scholarships instilled (Joan Bissell, personal communication, March 13, 2013). Joan Prival, Program Officer at the National Science Foundation, reported that a study on the sustainability of Noyce programs would be of great interest to the Noyce program and NSF (Joan Prival, personal communication, March 14, 2013). NSF is interested in the *long-term impact* of their Noyce investment. The NSF 2011-2016 Strategic Plan defines long-term impact as "the sustainability of specific activities beyond the funding period and other, less-tangible impacts that result from those activities" (National Science Foundation, 2011). Lastly, the CSU has a strong interest in its campuses receiving Noyce funds, and sustaining the project activities and broader impacts after funding has expired, as Noyce and CSU goals dovetail: both share the goals of producing an increased numbers of teachers in severe shortage fields and placing well-qualified new math and science teachers in high need schools (California State University, 2012; National Science Foundation, n.d.a). Success of implementation and sustainability is imperative as the projected need for new mathematics and science teachers in California in the next ten years exceeds 33,000 (California State University, 2012). The CSU, as "the largest producer of mathematics and science teachers in California, preparing close to one-half of the new teachers in these fields," is prepared to help the state meet this need (California State University, 2012).

Research Questions

The following questions guided this study:

Are the same factors that have been found in prior research to promote sustainability of project activities and broader impacts in general higher-education

settings applicable specifically to Noyce projects in the CSU today, and, if so, what is the relative importance of these factors in terms of influence on sustainability in the CSU?

Positive Sustainability Factors Identified in the Literature

My review of sustainability literature found that there was consensus on factors that foster sustainability. Specifically, the literature on sustainability of externally funded projects in institutions of higher education supports the notion that if a project exhibits (a) *centrality* (i.e., project's goals dovetail with partner goals) (Lueddeke, 1999); (b) *support of campus administration* (Licklider, 2012); (c) *connected networks of support* (Coburn, 2012; Licklider & Nossaman, 2012; Perez, 1976; Slavin & Madden, 2012); (d) *efficacy* (Northouse, 2010; Sugerik & Carter, 2011); and (e) *formative assessment and continuing evaluation* (Burdman, 2009, Nguyen & Weges, 2011; Popham, 2010; Tucker & Fischman, 2011) the chances for sustainability after expiration of funding is fostered.

Gaps in the Literature to be Addressed

A review of the literature on sustainability research from the last 45 years has exposed the following gaps:

1. The preponderance of the literature on sustainability in educational projects has been in K-12 settings (Anderson & Helms, 2001; Clarke, Ellett, Bateman, & Rugutt, 1997; RAND 1975a; RAND 1978a; RAND 1978b), or community health education settings (Mancini, Marek, & Brock, 2009; Marek & Mancini, 2002; Marek, Mancini, Brock, & Donna-Jena, 2003; Miller & Tonigan, 1996; Pluye, Potvin, & Denis, 2004; Rogers, 2003; Rollnick, Heather, Gold & Hall, 1992; Shediac-Rizkallah & Bone, 1998; Shrader et al., 2008; Shumaker, Ockene & Riekert, 2009). Only a small number of sustainability studies (Clarke, Ellett, Bateman, & Rugutt, 1997; Hearn, 1969a; Hearn,

1969b; Lechuga, 2010; Rabitoy, 1988) have been conducted in the higher education setting. While my literature review spanned sustainability in various contexts (community health education, K-12, and higher education), my study focused solely on the context of higher education.

2. The few sustainability studies conducted in the higher education setting have been qualitative (Clarke, Ellett, Bateman, & Rugutt, 1997; Lechuga, 2010; Rabitoy, 1988). Qualitative studies of educational innovations are able to describe factors that promote sustainability, but are unable to establish the relative importance of these factors – key information for PIs as they strategize where to place their finite time and resources in planning and implementing their project. Lechuga (2010) conceded that in a qualitative study "it is difficult to conceptualize which factors may be more influential than others in the sustainability process" (p. 38).

3. With only one study regarding sustainability of policies and practices from externally funded grant competitions (Rabitoy, 1988) conducted to date with the CSU as the organizational setting, an update (specific to the CSU) was needed.

4. Hearn (1969a) asked in his sustainability survey for PIs to speculate as to whether or not their project would be sustained in the future. These data have a possibility of bias. RAND warned of this bias, stating that, given the chance to speculate, PIs project rosy, future outcomes (1975a). I improved on Hearn's research design because some CSU Noyce PIs and co-PIs I surveyed and interviewed have concluded the term of their grant and can thus report on the actual sustainability of their activities.

The purpose of my study was to conduct a mixed-methods analysis of sustainability factors in the context of higher education in order to establish the relative

importance of these factors as to their effect on sustainability, and suggest how some of these factors can best be used in practice to effect the sustainability of Noyce projects in the CSU.

Overview of Methodology

As indicated above, I chose a mixed-methods design. Specifically, I employed an Explanatory Sequential Design, a two-phase model in which quantitative data were first collected and analyzed, followed by collection and analysis of qualitative data (Creswell, 2012). Quantitative data and results provided a generalized picture of the research problem, with qualitative data refining, extending, and explaining the generalized picture (Creswell, 2012). This two-phase design also had the advantage of allowing me to use the results of the quantitative analysis in formulating questions for the interviews.

I collected quantitative data from 30 CSU Noyce-funded Phase I and Phase II PIs and co-PIs in May-September, 2013, using a 44-question survey I developed that also included open-ended questions (see Appendix A for the full survey). In November, 2013, I conducted follow-up interviews with 6 CSU Noyce-funded Phase II PIs.

Limitations

1. Responses to my survey were self-reported. I gathered PIs' and co-PIs' perceptions of sustainability and the factors that fostered or hindered sustainability. Self-reporting has an inherent weakness because it is difficult and often times unreliable for people to accurately rate their own efforts (RAND, 1975a).
2. Each CSU Noyce project has a PI and sometimes multiple co-PIs. Therefore I may have received multiple survey responses from one campus. I chose to include

co-PIs as well because I thought the perceptions of sustainability could vary even on the same project.

3. Strangely, there is no standard for rates of sustainability. Rabitoy (1988) remarked that "since there is no commonly accepted standard by which to measure project sustainability, it is not possible to conclude with certainty whether the rate of persistence for … projects is in any way exceptional" (p. 27). This is a limiting factor for all sustainability studies. A review of the literature found that studies can only give the rates of sustainability for specific activities for specific projects, but cannot lead to judgments about whether these rates are "good" or to comparisons of rates across projects.
4. This study relied on an assumption that tendencies and patterns that exist now will exist in the future.

Delimitations

1. The implications of the research are limited to public comprehensive universities and, more specifically, to CSU campuses, which are distinct in being part of the nation's largest comprehensive university system. The findings may pertain to Noyce projects at comprehensive universities, but may not be generalizable to research universities (e.g., University of California campuses, etc.).
2. My unit of analysis was all Noyce projects at CSU campuses. Conclusions were ascribed to the CSU system as a whole and not the individual campuses because there were not sufficient data gathered to individually describe each campus. This holistic analysis of the system is valid and meaningful because each campus is overseen by the CSU Chancellor's Office, which dictates enrollment, budgets,

and policies for all campuses. Conducting 23 separate studies was not feasible given that I was an individual researcher with a time frame of two years.

3. Only Noyce PIs and co-PIs from CSU campuses that were funded by Noyce during the time frame of 2002-2013 were used as subjects.

Operational Definitions

Administration refers to department chairs, deans, and the provost at the home campus of the PI or co-PI.

Capacity building is the building of strengths, resources, and problem-solving abilities in individuals and communities (Shediac-Rizkallah & Bone, 1998).

Centrality occurs when a project's goals dovetail with on-campus and/or off-campus partner goals.

Continuing evaluation is assessment of a project after the expiration of external funds.

Efficacy is having the essential abilities and skills needed to accomplish the objectives of a project (Northouse, 2010).

Formative assessment is collecting, analyzing, and using data to make programmatic changes.

Habits of practice are internalized behaviors, in the case of this study behaviors relating to excellence in teaching.

High-needs school districts are districts with a low socioeconomic status (SES) and high minority student population.

Internal funding is funding provided by the home campus of the PI or co-PI.

Long-term impact is the sustainability of activities beyond the term of the grant and other, less tangible impacts resulting from those activities (National Science Foundation, 2011).

Noyce Scholars/Noyce Fellows: Students and STEM professionals or postbaccalaureate students receiving Noyce scholarships for enrolling in a program that leads to a teacher credential are referred to as "Noyce Scholars." STEM professionals or postbaccalaureate students receiving a stipend to attend a Master's degree level teacher credential program plus salary supplements while teaching are referred to as "NSF Teaching Fellows." In practice, PIs sometimes refer to STEM professionals receiving a scholarship as a Noyce Fellow.

Organizational setting is the home campus of the PI or co-PI.

Phase I and II: Noyce has two phases: Phase I (initial funding of up to five years) and Phase II (continuation funds of up to five years).

Planning is "precisely identify(ing) the problem, the project goals, and the means to attain them" (Rabitoy, 1988, p. 9).

Principal Investigators (PIs) are project directors leading the implementation of Noyce programs. Since PIs and co-PIs responded to the survey anonymously I do not know which open-ended responses are from a PI and which are from a co-PI. Therefore for my study I chose to refer to all open-ended respondents as a PI.

Resources are the space, equipment and materials needed to enact a project.

STEM Center: Some CSU campuses have established centers or institutes dedicated to promoting and advancing STEM education and STEM teacher education. Each campus has given their center or institute a unique name. Since this study is anonymized I will refer to any STEM center or institute on any CSU campus as a STEM Center.

Successful is a quality of a project that reflects that it has met its original goals.

Sustainability as it pertains to grant-funded projects is the maintaining of project

activities and broader impacts after the term of the grant has ended.

System refers to the home campus of the PI or co-PI, the CSU, a school district, or relationships among them.

Systemic change is defined as changes that impact multiple elements of a PI's network of intracampus and extracampus partners.

Systems building is building of interpersonal networks through connections, dialogues and interactions (Campbell, 2012).

Organization of the Dissertation

Chapter Two shows how the literature supports that the factors I have chosen are generally agreed upon to improve the chances of sustainability of project activities and broader impacts of externally funded projects at institutions of higher education. Chapter Three describes the methodology used in this study, detailing (a) the survey instrument, (b) the interviews conducted, and (c) the mixed-methods research design chosen. Chapter Four describes the findings of the research that address the Research Questions. Chapter Five presents recommendations and conclusions based on the findings.

CHAPTER TWO: REVIEW OF THE LITERATURE

In this chapter, I begin with a description of the problem statement. Next I provide an analysis of the importance of sustainability on the organizational setting (i.e., the California State University system of campuses). Lastly, I describe the positive sustainability factors identified in the literature.

Problem Statement

Funders, policy makers, and researchers report concern about the waste of state and federal dollars, and the loss of the pedagogical advances and student learning outcomes that the project activities were meant to engender, if externally funded projects at institutions of higher education are not sustained.

My study focused on the factors that foster the sustainability of the National Science Foundation Robert Noyce Teacher Scholarship Program among California State University campuses.

Noyce fulfills the national goals of STEM teacher production in two ways. Firstly, the NSF estimates that Noyce projects (awarded from 2002 - 2013), as an aggregate, will prepare approximately 12,000 new teachers over the duration of the projects (Note: This is not an annual number; it is over the life of the grants) (Joan Prival, personal communication, February 20, 2014). Secondly, Noyce serves as a platform for best practices in clinical placements that can be modeled by teacher credential programs nationwide. For the latter reason it is important that Noyce project activities are sustained so that a) individual campuses can continue to benefit from the Noyce interventions, and that b) longitudinal studies can be conducted as to the efficacy of the Noyce interventions (e.g., early field experiences, curricular changes, etc.).

Through my literature review, I found that certain factors have a positive effect on the continuation of project activities after expiration of grant funds. These factors included centrality, connected networks of support, support of campus administration, efficacy, and formative assessment and continuing evaluation.

My mixed-methods analysis explored the following research questions: *Are the same factors that have been found in prior research to promote sustainability of project activities and broader impacts in general higher-education settings applicable specifically to Noyce projects in the CSU today, and, if so, what is the relative importance of these factors in terms of influence on sustainability in the CSU?*

The 23-Campus California State University System as Organizational Setting

The unit of analysis for this study was the set of all NSF-funded Noyce projects at CSU campuses. Conclusions were ascribed to the CSU system as a whole and not the individual campuses since there were not sufficient data gathered to individually describe each campus. This holistic analysis of the system was valid and meaningful because each campus is overseen by the CSU Chancellor's Office, which dictates enrollment, budgets and policies for all campuses.

On all externally funded projects, PIs at the CSU have two levels of support. The first is their campus Office of Research and Sponsored Projects and development offices. These offices provide support in grant writing and budget preparation. The second is the CSU-wide Office of Research and Sponsored Projects (in the Chancellor's Office), which (a) provides advice to faculty on the best methods of developing their ideas, (b) coordinates projects and encourages inter-campus exchange and project development, (c) provides research infrastructure and assistance with research compliance issues, and (d)

helps PIs disseminate their findings by hosting workshops and posting dissemination reports (California State University, n.d.c). Also the Chancellor's Office has developed close working relationships with potential funders and partners such as Apple, Hewlett-Packard, and Google on initiatives related to economic and workforce development. Industry partners in Silicon Valley are eager to partner with the CSU, especially on STEM-related issues, as both are located in California. Also the CSU offers the opportunity of an immediate scale up of innovations in educational technology and teacher preparation because up to 23 campuses can be involved in the roll-out of a project at once. For instance, CSU has partnered with Google to form the *CSU Digital Learning Ambassador Program* with the goal of transforming teaching and learning frameworks through online technologies, with special attention to teacher preparation. One project within this program is *Pedagogy Enhanced With Technology for Educational Reform* (PEWTER). PEWTER "aims to equip pre-service teachers with a better command of the free, technology tools available for educators, and strengthen the exchange of best practices among CSU faculty educators in the disciplines of Math, Science, and Education" (California State University, Northridge, n.d.). CSU Digital Ambassador sites include the campuses of Bakersfield, Channel Islands, Fresno, Monterey Bay, Northridge, Sacramento, and Sonoma. Lastly, the CSU has two lobbyists in Washington D.C. advocating for the needs of the CSU. This advocacy can be helpful in generating funding allocated to the CSU, and also in advocating for federal earmarks. These support conditions offer some warrant for considering the 23 campuses together as a unit of analysis**.**

Noyce Projects as a Unit

Just as it makes sense to consider the 23 CSU campuses as a unit it makes sense to consider all Noyce projects as a unit. All Noyce projects must follow the parameters of the Noyce program as specified in the request for proposal. All Noyce projects must follow the reporting guidelines of the NSF. All projects can seek guidance and support from the NSF Program Officer overseeing the Noyce program.

Factors that have a Positive Influence on Sustainability

A review of the literature on sustainability found that there are factors common across different contexts (community health education, K-12 education, higher education) that foster the sustainability of project activities: centrality, connected networks of support, support of campus administration, efficacy, and formative assessment and continuing evaluation.

Centrality

The literature on sustainability supported the notion that if a project's goals dovetail with campus goals, the likelihood of success and sustainability greatly increased. RAND (1975b) reported that federally sponsored projects with the purpose of designing, introducing, and disseminating innovative practices in public schools were more likely to be sustained if the projects' goals were central to the educational goals of administration. Lueddeke (1999) shared that "building a permanent resource capacity … can be facilitated if the innovation demonstrates its compatibility with institutional strategic plans" (p. 10). Identifying opportunities that fit with an organization's strategic directions is a major concern of department chairs, deans, and provosts (Glassman et al., 2003). Decisions by campus administrators regarding grant projects are made based on the

matching of the project's mission with the potential benefits to the institution (Glassman et al., 2003).

As STEM teacher education has been deemed a national priority (Business-Higher Education Forum, 2013; Committee on STEM Education National Science and Technology Council, 2013; Thomasian, 2011) it is no surprise that there are a number of entities across the private and public sector that share Noyce's goal of training an adequate number of highly qualified math and science teachers. A comparison of the mission statements of some of the entities that are part of the national STEM teacher education effort evinces a natural alignment and a shared commonality of purpose (i.e., centrality) (see Table 1).

Table 1

The National STEM Teacher Education Effort

Organization/Entity	Goal
CSU systemwide	Prepare 1,500 math/science teachers annually*
Association of Public and Land-grant Universities Science and Mathematics Teacher Imperative	Train 10,000 highly qualified middle and high school STEM education teachers annually**
100K in10	Train 10,000 new, highly qualified STEM teachers annually***
Business-Higher Education Forum	Work across the public and private sector to meet the nationwide goal of training over 30,000 new science and mathematics teachers annually****

Noyce	Recruit, prepare, and offer induction support to 12,000 new STEM middle and high school teachers over the duration of Noyce projects 2002-2013*****

Note. *(California State University, 2012). **(Association of Public and Land-Grant Universities Science & Math Teacher Imperative, n.d.). ***(100Kin10 Answering the Nation's Call, n.d.). ****(Business-Higher Education Forum, 2007). *****(Joan Prival, personal communication, February 20, 2014).

Since the CSU is the largest producer of science and mathematics teachers in California (California State University, 2012, p. 2), it is natural that the CSU has partnered with "100Kin10," a national initiative comprised of a consortium of foundations whose goals is to prepare 100,000 well qualified STEM teachers by 2021. As a member of this consortium, the CSU has committed to training 1,500 well-qualified new math and science teachers annually (California State University, 2012, p. 1).

A CSU initiative whose goals are consonant with Noyce is California Math and Science Teacher Initiative (MSTI). Many CSUs have maximized both Noyce and MSTI funding by linking the activities of the two programs because their goals are so similar. The goals of MSTI include comprehensive recruitment, "approaches that connect future teachers with communities of practice that include scientists and mathematicians as well as other dedicated teachers in their disciplines," and "broad ranging collaboration and partnerships with other educational agencies and with federal science agencies" (California State University, 2012, p. 5). MSTI was created in response to the findings of a 2007 report "Critical Path Analysis of California's Science and Mathematics Teacher Preparation System." The report highlighted the large percentage of new science teachers with emergency permits or intern certificates. MSTI was created by the California legislature to increase the pipeline of math and science teachers (California Council on

Science and Technology and The Center for the Future of Teaching and Learning, 2007). The California legislature budgeted $2.7 million in 2010-2011 for MSTI with allocations ranging from $65,000-$165,000 per CSU campus (California State University, 2012). Each campus has the latitude to develop its own action plan and set numerical goals for increased credential production (California State University, 2012).

CSUs have creatively maximized the MSTI funds. CSU Bakersfield and CSU East Bay funded scholarships and leveraged matching funds from Chevron Corporation (California State University, 2012). CSU Dominguez Hills and CSU San Bernadino used funding to create new credential pathways; these two campuses also leveraged MSTI funds to obtain federal scholarships that required matching funds. CSU Long Beach and CSU San Marcos used funds to establish partnerships with community colleges that have as a priority preparation of transfer students.

Support of Campus Administration

Campus administrators have the ability to "smooth the way" for resource allocation during and after a project (U.S. Department of Education, 2004, p. 28). Administrators can show support for Noyce projects by (a) serving on the advisory board of the project or the campus STEM Center, (b) providing ongoing consultation and sharing of expertise with PIs, (c) providing the political leverage necessary to secure internal funding to supplement the external funding either during implementation or after expiration of grant funding, (d) providing room space, office space, and/or lab space either during implementation or after expiration of grant funding, and (e) (as part of the curriculum committee) enacting changes in course listings. PIs must receive approval from campus administration to apply for (and implement) Noyce projects. If a PI is

budgeted release time through a Noyce grant this release time must be approved by a department chair.

Garnering the support of campus administration for a Noyce project should not prove difficult given the prominence of STEM teacher education in the national dialogue. However, budgetary realities impinge on a supportive administrator's ability to foster sustainability. In this age of ever-shrinking financial support of public universities, administrators must choose judiciously among proposed educational reform efforts, all of which may be worthy (Barr, 2002; Goldstein, 2005; McBride, 2010). Licklider (2012) lists "strategic discussions with institutional leadership" as a best practice in garnering support from university administration (pp. 35-36). Specifically she reports that conversations during the planning stages of a proposal with department chairs, deans, or provost can be advantageous later on when internal funds or advocacy may be needed, thereby fostering sustainability (Licklider, 2012).

Connected Networks of Support

External partners can be a bulwark against project discontinuation. Coburn (2012) shared that building capacity of "the system" (i.e., project partners) increases the ability of the project to sustain itself over time. She argued that building an infrastructure is a hedge against instability of personnel or policies. Coburn recommended linking a project to other initiatives since this buffets the project activities and broader impacts against new approaches that are not congruent with the intervention. Perez (1976) referred to this strategy as functional linkage support. He described how the Educational Opportunity Program (EOP) at the University of Southern California (USC) improved its long-term stability by developing compatible functional linkages with the various ethnic studies

departments on campus. This led to the acquiring of additional personnel and equipment for the EOP. These linkages were clearly a positive sustainability factor because the EOP at USC is still thriving 38 years later.

Close collaborations with external partners provide multiple perspectives and a broader range of solutions to complex problems (Licklider & Nossaman, 2012). Also, there can be resource sharing, including equipment, personnel, and funds (Licklider & Nossaman, 2012). However, there are also challenges to working with multiple partners, including negotiating the balance of power (who will be granted PI status? which entity will act as fiscal agent?), logistical issues of data sharing and information sharing, and differing approaches (Licklider & Nossaman, 2012).

Slavin and Madden (2012) also found that partnerships foster project sustainability. Their project, Success for All (SFA), is an innovative curricular reform model for P-12 classrooms that was first piloted in Baltimore in the 1987-1988 school year. To date, SFA has been adopted in 1,100 school sites across the nation. Slavin and Madden (2012) found that schools that adopted their curriculum, but were not part of an ongoing supportive network of other SFA schools, at best could only "hang on for a few years" (p. 11).

Carol Campbell, in a presentation at the American Educational Research Association national conference on building capacities for educational change, stressed that systems building is needed for project sustainability (Campbell, 2012). She defined systems building as the building of interpersonal networks through connections, dialogues, and interactions.

Remarks by Noyce PIs from outside the CSU suggested that connected networks of support were perceived to be an important sustainability factor. In a presentation from the 2013 national Noyce conference (posted online at the American Association for the Advancement of Science website), Noyce PI Kevin Carr from Pacific University in Oregon described how he perceived that participation from project partners (faculty, community members, teachers, and Noyce Scholars) will lead to sustained monthly "STEMinars" held at a community site (Carr, 2013). At the same conference, Joseph Meyinsse, Noyce PI from Southern University at Baton Rouge, described the advantages of partnerships: (a) more students are recruited because all partners partake in recruiting efforts, and (b) revenue is increased because engaged project partners from private industry support project activities (in this case, Chevron and Texaco sponsored workshops and conferences) (Meyinsse, 2013).

In a presentation from the 2012 national Noyce conference (also posted online at the American Association for the Advancement of Science website), Noyce project personnel from Kennesaw State University, Gregory Rushton and Nancy Overley, described how connected networks of support are crucial for the recruiting of Noyce Scholars during the term of the grant and beyond, concluding "it's all about relationships" (Rushton & Overley, 2012, p. 1). A report on sustainability in which 24 program officers from private foundations were interviewed reached the same conclusion: relationships built or strengthened are the most valuable lasting impact of a project after expiration of funds (Annie E. Casey Foundation, 2002). However, Weiss, Coffman, and Bohan-Baker (2002) warned against shallow relationships with project

partners: “All …stakeholders with a vested interest should be invited and *expected* to participate” (p. 11) (italics theirs).

Presidents Clinton and Obama have both spoken publicly about the vastness of the national STEM education and STEM teacher education undertaking and the importance of collaboration at all levels. At the 2013 Clinton Global Initiative America, President Clinton announced the successful conclusion of the most recent round of funding for 100Kin10. Final pledges from Google, the Bill & Melinda Gates Foundation, and the William and Flora Hewlett Foundation brought the tally of funds pledged to the second phase of 100K in10 to over $52 million, with over 150 foundations contributing. President Clinton announced that the goal of 100,000 STEM teachers in ten years was almost right on schedule, because five years into the initiative 100Kin10 partners had committed to recruiting and training over 40,000 teachers. During the closing session, President Clinton commended the collaborative approach of 100Kin10:

> We do have the power to rebuild and reinvent these pathways to the American dream.... [We] started with two dozen partners committed to making 20,000 STEM teachers. And...before you know it, we got over 100 partners and 40,000 STEM teachers....Never think, “Well, I can't do this because I haven't solved the whole problem.” The whole premise of what we do is that none of us can solve the whole problem, but together, we can move the world (Carnegie Corporation of New York, n.d.).

At the 2013 White House Science Fair, President Barack Obama similarly declared:

> One of the things that I’ve been focused on as President is how we create an all-hands-on-deck approach to science, technology, engineering, and math. We need

> to make this a priority to train an army of new teachers in these subject areas, and to make sure that all of us as a country are lifting up these subjects for the respect that they deserve (Committee on STEM Education National Science and Technology Council, 2013).

These two presidential speeches elucidate the importance of connected networks of support at a national level. The training of hundreds of thousands of highly qualified STEM teachers will require the interfacing of local, regional, and national connected networks of support.

Efficacy

To implement and sustain a project, training is required of project personnel in the use of new materials or methods. Project personnel must develop efficacy, defined as having the essential abilities and skills needed to accomplish the objectives of a project (Northouse, 2010). While the newness of a project means that there is always some degree of uncertainty involved, providing information (i.e., training) reduces uncertainty (Rogers, 2003).

Noyce projects involve training of university faculty. Faculty affiliated with the Noyce project may need to learn recruitment techniques, the special considerations of working with high-needs districts, and the nuances of the teacher credentialing process (for non-Education faculty). Other faculty, not affiliated with the project (i.e., not receiving release time) may be asked to change their policies, practices, pedagogy, or curriculum. They may be asked to teach a new course (e.g., one Noyce project developed a new course on teaching in high-needs school districts that is now available for all teacher candidates on that campus). They may be asked to organize early field

experiences for freshman, sophomore and junior math and science majors considering teaching as a profession (something heretofore these faculty may not have done). They may be asked to organize research experiences for students on campus or off-campus at federal labs. All of these require training of project personnel, especially if these activities are to be sustained after expiration of funding.

Mentor teachers may also require training in areas such as best practices for mentoring, Common Core State Standards, Next Generation Science Standards, and the use of educational technology in the classroom.

Efficacy as a positive sustainability factor is elucidated in the example of another NSF-funded program: *Math Science Partnership* (MSP). The goal of MSP is to "support innovative partnerships to improve K-12 student achievement in mathematics and science" (National Science Foundation, n.d.d, p. 2). A review of MSP projects found that 30% of project personnel (i.e., faculty and administrators) from institutions of higher education reported "no prior experience in K-12 reform" so required training to enact project activities (National Science Foundation, 2008, p. 3). This training led directly to sustainability: "As (project personnel) gained experience in working productively on K-12 issues through their MSP work, they became a valuable human resource for K-12 in the future" (National Science Foundation, 2008, p. 3).

Formative Assessment and Continuing Evaluation

Formative assessment provides "feedback loops to inform decisions through research and data" (Burdman, 2009, p. 37). Popham (2010) described formative assessment as a magic bullet that is underused by PIs. The NSF 2011-2016 strategic plan reported as a best practice for its projects the use of performance assessment to "inform

the ongoing management and evaluation of programs and drive continuous improvement" (National Science Foundation, 2011, p. 18).

Continuing evaluation is assessment after the end of the term of the grant. Beery et al. (2005) recommended that "long-term monitoring and evaluation mechanisms" be established and maintained (p. 153). Positive results from continuing evaluation, when presented to campus administrators, can maintain their excitement and support of a project.

In a presentation from the 2011 national Noyce conference (posted online at the American Association for the Advancement of Science website), Tucker and Fischman (2011) reported that the purpose of evaluation has evolved from "proving" to "improving." *Proving* is an analysis of whether project goals were met (number of teachers trained, number of students impacted, number of partner schools involved, etc.). *Improving* seeks to analyze data with the purpose of informing decisions about future programming and emphasizes continual project improvement and usefulness of evaluation to project stakeholders.

Noyce Phase II funding can be seen as continuing evaluation for Noyce Phase I. Phase II allows PIs to "gather data" and "improve upon Phase I" (Joan Prival, personal communication, March 22, 2013). In a presentation from the 2011 national Noyce conference, Nguyen and Wegesin (2011) described how being awarded a Noyce Phase II funding has advantages for a campus in terms of their evaluation efforts. Not only did Phase II funding allow for an increased number of scholarships and two years of mentoring for two years after program completion (thereby increasing the retention of novice teachers who were Noyce Scholars), Phase II funding also allowed for a

longitudinal evaluation of the effectiveness of the Noyce program and the impact on student learning (Nguyen & Wegesin, 2011).

Summary

Through a literature review on the sustainability of externally funded grant projects in higher education, I found that certain factors have a positive effect on the continuation of project activities after expiration of grant funds. These factors included centrality, connected networks of support, support of campus administration, efficacy, and formative assessment and continuing evaluation. I explored whether these sustainability factors found to be effective in other four-year higher education settings were applicable to Noyce projects at the CSU today, and if so, what the relative importance of these factors in terms of influence was.

CHAPTER THREE: METHODOLOGY

Introduction

This chapter begins by stating the purpose of the research. Next I provide a description of the research setting and the research design. I then describe my research sample and data sources for quantitative data collection followed by my procedure for qualitative data collection. I conclude by describing my role as researcher.

Description of the Research Project

To ensure highly qualified teachers are teaching K-12 STEM classes, the federal government sponsors the NSF Robert Noyce Teacher Scholarship Program (hereafter sometimes abbreviated as "Noyce") to encourage STEM majors and professionals to teach science, engineering, or mathematics in elementary and secondary schools (National Science Foundation, n.d.a).). First authorized in 2002, Noyce was later expanded through the America COMPETES (Creating Opportunities to Meaningfully Promote Excellence in Technology, Education and Science) Act in 2007 and the America COMPETES Reauthorization Act of 2010. The purpose of this funding was to invest in innovation through research and development to "to improve the competitiveness of the United States" (National Science Foundation, n.d.b, p. 1).

My study focused on positive sustainability factors of Noyce projects housed within California State University campuses. Selecting Noyce is highly relevant because California has a shortage of skilled science and math teachers—a shortage that undermines the chances of students to compete for jobs in technology and the sciences (California Council on Science and Technology, 2007).

Objectives

I posited that to help CSU Principal Investigators (PIs) in applying for future Noyce funding an analysis of internal factors of the CSU campuses that affect sustainability would be useful in that PIs might alter their time, energy and resources regarding the various factors. In creating a project design informed by the positive sustainability factors, PIs can plan future projects to be better sustained with longer-term, broader impacts.

Problem Statement

Funders, policy makers, and researchers reported concern about the waste of state and federal dollars, and the loss of the pedagogical advances and student learning outcomes that the project activities were meant to engender, if externally funded projects at institutions of higher education were not sustained.

My study focused on the factors that foster the long-term impact of the Robert Noyce Teacher Scholarship Program among California State University campuses. A knowledge of the relative importance of the positive sustainability factors can assist Noyce PIs devise a program design that fosters sustainability, and thereby maximizes the NSF's investment.

Research Questions

My mixed-methods analysis explored the following research questions:

Are the same factors that have been found in prior research to promote sustainability of project activities and broader impacts in general higher-education settings applicable specifically to Noyce projects in the CSU today, and, if so, what is the relative importance of these factors in terms of influence on sustainability in the CSU?

Hypothesis/Expected Results

I hypothesized that all of the sustainability factors identified in prior research would apply to Noyce projects in the CSU, just to varying degrees. One expected result was a new clarity about which of these factors were most salient in the CSU today (at least to Noyce projects) and perceived as most important for fostering sustainability. A second expected result was how some of these factors could best be used in practice to effect the sustainability of Noyce projects in the CSU.

Purpose of Research

The CSU has a strong interest in its campuses receiving Noyce funds, and sustaining the project activities and broader impacts after funding has expired since the NSF and CSU goals dovetail. Both share the goals of producing an increased numbers of teachers in severe shortage fields and placing well-qualified new math and science teachers in high-need schools (California State University, 2012; National Science Foundation, n.d.a). Success of implementation and sustainability is imperative because the projected need for new mathematics and science teachers in California in the next ten years exceeds 33,000 (California State University, 2012). The CSU, as "the largest producer of mathematics and science teachers in California, preparing close to one-half of the new teachers in these fields," is prepared to help the state meet this need (California State University, 2012). The purpose of this study is to explore whether sustainability factors found to be effective in other four-year higher education settings were applicable to Noyce projects in the CSU today, and if so, what the relative importance of these factors in terms of influence was.

Research Setting/Context

Comprised of 23 campuses, the California State University system serves almost 427,000 students, and employs 44,000 faculty and staff. The CSU is "the largest" and "the most diverse" university system in the country (California State University, n.d.a). As of Fall 2011, the student ethnic breakdown across the CSU was 5% African-American, .4% American Indian, 14% Asian-American, .4% Pacific Islander, 2% Filipino, 22% Mexican-American, 8% Other Latino, 32% White, 4% two or more races, 8% unknown, and 4% non-resident alien.

Twenty percent of CSU math and science teacher candidates have annual Noyce awards of $10,000, lasting from three to five years (California State University, 2012).

As of Spring 2013, 20 of the 23 CSU campuses have received Noyce funding (see Table 2).

Table 2

Noyce Funding Awarded by the NSF, Ordered by Award Date

Institution	End Date	Noyce Funding
California State University Fresno	31-Dec-07	$2,588,399
California State University-Long Beach Foundation	30-Sep-09	$ 460,000
Cal Poly Pomona Foundation, Inc.	31-Aug-10	$ 592,917
San Diego State University Foundation	31-Aug-11	$ 611,476
California State University Los Angeles	31-Dec-09	$ 478,689.
California State University -San Marcos	31-Dec-10	$ 499,960

California State University-San Bernardino Foundation	9/30/12	$ 516,179
California Polytechnic San Luis Obispo	6/30/12	$ 483,772
California State University-Fullerton Foundation	8/31/11	$ 470,588
California State University Northridge	12/31/11	$ 499,940
California State University, Chico Research Foundation	31-Aug-12	$ 917,067
California State University-Fresno Foundation	31-Aug-12	$2,700,000
California State University-Long Beach Foundation	31-Aug-12	$1,500,000
California State University-Dominguez Hills	31-Aug-14	$ 900,000
California State University, East Bay Foundation, Inc.	31-Aug-13	$1,500,000
California Polytechnic State University Foundation	30-Sep-13	$ 800,000
Cal Poly Pomona Foundation, Inc.	30-Jun-13	$ 484,000
California State L.A. University Auxiliary Services Inc.	30-Jun-14	$ 900,000
California State University, East Bay Foundation, Inc.	31-Aug-15	$1,500,000
California State University-Bakersfield	30-Jun-14	$ 900,000
California State University-Fresno Foundation	31-May-15	$ 624,000
California State University-Fullerton Foundation	31-May-14	$1,500,000
California State University-San Bernardino Foundation	31-Jul-15	$ 896,000
California State University-Stanislaus	31-Aug-14	$895,946
Humboldt State University Foundation	31-Aug-14	$ 900,000
Sonoma State University	31-Jul-14	$ 900,000

Research Design

I chose a mixed-methods design. Specifically, I employed an Explanatory Sequential Design, a two-phase model: quantitative data were first collected and analyzed, followed by a collection and analysis of qualitative data (Creswell, 2012). The rationale is that the quantitative data and results provided a generalized picture of the research problem, with qualitative data serving to refine, extend, and explain the generalized picture (Creswell, 2012). This two-phase design also had the advantage of allowing me to use the results of the quantitative analysis to make minor adjustments to questions for the interviews.

For the interviews, I used an ethnographic design, specifically a "collective case study," because describing and comparing multiple cases allowed me to illustrate alternative approaches to best practices for sustainability among policies and practices of Noyce projects at CSU campuses (Creswell, 2012, p. 465). Case studies are intensive descriptions of a bounded system (Merriam, 1998). The bounded system that I studied is the California State University system, which comprises 23 campuses.

The data gathered from the interviews added depth to the data garnered from my quantitative analysis. The interviews provided specific examples of each factor in the context of a Noyce-funded project implementation in the CSU.

Research Sample and Data Sources for Quantitative Data Collection

In summer, 2013, I surveyed PIs and co-PIs who were CSU faculty and who implemented a Noyce project. The CSU Chancellor's Office provided me a list of the emails of all CSU Noyce PIs and co-PIs from the funded campuses. Survey data were

collected electronically through Lime Survey and included open-ended questions. To improve the response rate, the survey was designed to be fairly brief.

The survey was sent out on June 17, 2013 and reminders were sent on June 24 and on July 1 for those who had not yet responded. The original cut-off date for submission was July 10, 2013. An electronic token was ascribed to each link sent out so that respondents could not answer the survey more than once nor forward the survey to another person. The initial response rate was low (22 out of 81) so my dissertation committee asked that I resend the survey. I waited until the 2013/2014 academic year resumed and faculty returned from their summer vacations. On September 3, 2013, I resent the survey to all PIs and co-PIs who had not responded. The new cut-off date was September 15, 2013. Additional responses were received, bringing the tally to 32 of 81, a 40% response rate. This 40% response rate represents the number of responses as compared to the number of surveys sent and not the percentage of CSU campuses responding. This latter percentage is not obtainable because I programmed Lime Survey to anonymize the responses. Therefore I may have received multiple responses from some Noyce-funded CSUs and no responses from other Noyce-funded CSUs. Lastly, the effective response rate might be characterized as higher than 40% in spite of the potential amount of overlap of project respondents: There are only 23 campuses, and about 40 Noyce-funded projects (i.e., not 81 independent projects). If there were only one respondent per project the response rate would be 80%. Since the survey was anonymous, I cannot determine how many responses were received per project. Therefore I conclude that the response rate was somewhere in the range of 40-80%.

Recruitment of Subjects

All 81 PIs and co-PIs of CSU Noyce projects were eligible for and were invited to participate in the survey. Each project has a PI and sometimes multiple co-PIs. I chose to include co-PIs as well because I thought the perceptions of sustainability could vary even on the same project.

Subjects were eligible to participate in the interviews if they were a Noyce-funded CSU PI. For the interview, ten Phase II Noyce recipients were chosen from the wider pool. Dr. Joan Bissell (Director of Teacher Education and Public School Programs at California State University) recommended the ten Noyce PIs to contact. Since only 10-15% of Phase I recipients have received Phase II funding (Joan Prival, personal communication, April 2, 2013), this group of ten interviewees represented projects that exemplified best practices related to sustainability as evidenced in annual Noyce reports to the National Science Foundation. (Note: Phase 1 projects must be near completion to be eligible to apply for Phase 2 funding, which is why this percent is low.) Since my study is focused on positive sustainability factors I wanted projects deemed successful by the NSF in meeting their project goals. Also, the perceptions of PIs with Phase II funding are informed by up to five more years of experience viewing the factors I identified as having a positive effect on sustainability.

Six of the ten PIs contacted agreed to be interviewed (See Table 3).

Table 3

List of Interviewees

PI #	Description of Home Campus
PI #1	A CSU in an urban area and with a large student population of over 30,000 students.
PI #2	A CSU in a suburban area and with a mid-sized student population of over 20,000 students.
PI #3	A CSU in an urban area and with a smaller-sized student population of over 13,000 students.
PI #4	A CSU in a suburban area and with a mid-sized student population of over 18,000 students.
PI #5	A CSU in an agricultural area and with a mid-sized student population of over 22,000 students.
PI #6	A CSU in a suburban area and with a large-sized student population of over 37,000 students.

Development of Survey Instrument

I chose to develop my own instrument using survey questions based on surveys conducted by past researchers studying sustainability qualitatively (Lechuga, 2010; Lueddeke, 1999; Rabitoy, 1988) and quantitatively (Hearn, 1969a; RAND 1975a; RAND 1978a; RAND 1978b).

A member of my dissertation committee, Dr. Joan Bissell, arranged conference calls in March, 2013 between herself, four Noyce PIs from different CSU campuses who were selected by Dr. Bissell for their particularly successful Noyce projects, and myself. (Some of these four PIs were part of the group of PIs interviewed for this study, and all were invited to respond to the survey.) From notes from these calls I developed a list of common Noyce activities offered at CSU campuses. The list included

- student scholarships for STEM majors and stipends for STEM professionals to become STEM teachers;
- the recruiting of math and science majors on a CSU campus into the teaching profession;
- the recruiting of math and science career professionals into the STEM teaching profession;
- in-person and online seminars with mentor teachers, current and former Noyce Scholars, university faculty, and district support personnel;
- early field teaching field experiences for freshman, sophomore, and junior math and science majors;
- promotional events at community colleges to attract math and science majors to teaching; and
- research experiences at a campus lab or local federal laboratory for teacher candidates.

Each of these activities was formulated into a statement with a corresponding Likert scale. CSU faculty with completed Noyce projects reported whether the activity had sustained. Faculty with current Noyce projects were asked to offer their perceptions

of whether activities would sustain after the funding expired. The tabulated responses comprised the dependent variable.

Similarly, I measured centrality quantitatively in my survey through the following statements, each with a corresponding Likert scale, the tabulation of responses comprising the independent variable "centrality."

1. *Our Noyce project was aligned with explicitly stated DEPARTMENTAL priorities.*
2. *Our Noyce project was aligned with explicitly stated COLLEGE priorities.*
3. *Our Noyce project was aligned with explicitly stated UNIVERSITY priorities.*
4. *Our Noyce project was aligned with explicitly stated CSU SYSTEMWIDE priorities.*

I quantitatively measured efforts to garner support of campus administration in my survey through the following statement, with a corresponding Likert scale:

In planning for and preparing our initial proposal, we had a sufficient number of meetings with university administration (Department Chair, Dean, Provost) to garner support for our Noyce project.

I measured connected networks of support quantitatively in my survey through a combination of questions and statements, all with a corresponding Likert scale:

1. *In designing and implementing our Noyce project, we built upon existing initiatives (such as relationships with federal research labs in California, the CSU STAR Program, MSTI, other campus programs, and other grants) to leverage resources and opportunities.*

2. *How many colleges within your university were involved in your Noyce project design?*
3. *How many departments across those colleges were involved in your Noyce project?*
4. *How many project partners (e.g., community colleges, secondary-level schools, not-for-profits, other CSU campuses, etc.) were external to campus?*
5. *In preparing our initial Noyce project, we had a sufficient number of meetings with the external partners on the project.*
6. *During implementation of our Noyce project, we had a sufficient number of meetings with the external partners on the project.*

I measured efficacy quantitatively in my survey through the following questions, both with a corresponding Likert scale:

1. *We provided sufficient training or professional development to university faculty (e.g., workshops on best practices for recruitment, diversity training, etc.) to implement the Noyce project.*
2. *Our Noyce project provided sufficient formal training or professional development to the secondary-level teachers who mentored Noyce Scholars.*

I measured formative assessment and continuing evaluation quantitatively in my survey through the following statements, both with a corresponding Likert scale:

1. *During the implementation phase of the Noyce project, we made changes to the project design based on formative assessment.*
2. *My Noyce project built in provisions for assessing or evaluating any of the project activities or broader impacts that continue beyond the end of Noyce funding.*

(For full survey see Appendix A).

Development of Interview Questions

In October, 2013, I created a list of questions to fill in existing gaps in the information gained from the surveys. For instance, the surveys had yielded a great deal of information about the lists of activities that were sustained, but not the processes by which they were sustained. My interviewing strategy was to ask open-ended questions to allow the PIs free license to postulate as to what they actually did to foster sustainability (as opposed to sustainability just spontaneously arising).

After I gathered my survey data, I conducted a statistical analysis that revealed that only three of the five factors (centrality, connected networks of support, and support of campus administration) that had been found in prior research to promote sustainability of project activities and broader impacts in general higher-education settings appeared applicable to Noyce projects in the CSU today. Two of the factors (efficacy; and formative assessment and continuing evaluation) showed no influence on sustainability in the CSU. Therefore, I added the following interview questions in hopes that my interviewees could help explain this surprising finding:

1. *Three months ago I surveyed all CSU Noyce PIs and had two surprising findings. PIs in that survey didn't see any connection between training for faculty and mentor teachers and the ultimate sustainability of Noyce activities after the funding period. This contradicted the literature. Do you have any ideas about why I might have seen this discrepancy?*
2. *In your project do you expect that the training of faculty and mentor teachers you are conducting will have an impact on activities sustaining post-funding?*

3. *PIs in my survey didn't see any connection between formative assessment/continuing evaluation and the ultimate sustainability of Noyce activities after the funding period. This contradicted the literature. Do you have any ideas about why I might have seen this discrepancy?*

(See Appendix B for a full list of interview questions).

Procedures for Consent

PIs and co-PIs responded to the survey via Lime Survey. Accessing this website brought respondents first to a paragraph at the top of the survey explaining the conditions of confidentiality. They could choose not to participate once they read this form. Lime Survey gathered and tabulated the responses while keeping the anonymity of the respondent.

A consent form and Experimental Subjects Bill of Rights were mailed to potential interviewees. The consent form explained the nature of the study, how confidentiality was to be maintained, and how risks were minimized.

Data Analysis of Survey

Using Minitab statistical software, I conducted a quantitative analysis of the survey data using both univariate and multivariate regression of factors that foster the sustainability of externally funded projects. Univariate regression looks at how the dependent variable is influenced by only one factor. Multivariate regression analyzes how the dependent variable is influenced by multiple factors.

In each case the percentage of variation in the response variable (perceptions of factors that foster sustainability) that is explained by the predictors (independent variables – i.e., the positive sustainability factors: centrality, connected networks of support, support of campus administration, efficacy, and formative assessment and

continuing evaluation) was determined. For the case of multiple regression, the outcomes of my statistical inference included tests of statistical significance and the calculation of standardized beta coefficients. A standardized beta coefficient showed the relative importance of my independent variables. Prior to the statistical analysis, my hypothesis was that all of the independent variables would be correlated with sustainability, just to varying degrees.

Data Analysis of Interviews

I had the recorded interviews transcribed. Then I described the cases and compared them in order to provide insight into site-specific, positive sustainability factors. I then conducted an iterative process, reading through the data to obtain a general sense of the material, establishing themes that ran through the data. Codes included the five positive sustainability factors. Themes included (a) factors internal to the campus that hindered or fostered sustainability, (b) factors external to the campus that hindered or fostered sustainability, (c) how best to use the positive sustainability factors in practice, (d) reasons to account for the lack of correlation between sustainability and efficacy, and (e) reasons to account for the lack of correlation among sustainability and formative assessment and continuing evaluation. I also analyzed the interview data by counting the number of mentions in interview transcripts by theme (with the assumption that the greater the number of times PIs mentioned a theme the more prevalent that phenomenon was in the field). I conducted this analysis manually (i.e., I chose not to use coding software such as ATLAS.ti) because I created my own method of coding using italicization of text. (See Appendix C: Excerpts of Coded Transcripts from Four Interviewees).

Anticipated Risks and Minimization of Risks

Those responding to the survey read an introductory paragraph that stated that the survey was confidential and anonymous, and that participation was voluntary. The introductory paragraph also described the purpose of the study, the potential risks and discomforts to subjects, and the rights of research subjects. Potential risks to the respondents included discomfort about answering questions about their place of work. Respondents were allowed to skip questions or stop completing the survey if discomfort was too great. While the open-ended questions on the survey requested some naming of partners or activities that might identify the respondent's campus, these details were not used in this dissertation and will not be used in any further reports of this study; only aggregated, general information will be reported (e.g., "Ten of the campuses surveyed report partnering with local technology companies.").

The risks to interviewees were mitigated by the fact that I only interviewed Phase II recipients. Noyce Phase II projects represent the standouts in the phenomenon under study—sustaining the project beyond funding. Those interviewed were exemplars sharing their best practices. Even so I chose to disguise their identity in my study so as to minimize the risk that might be associated with their sharing any critical comments about other parties (e.g., colleagues and community partners). In December, 2013 I sent to each of the interviewees quotes from the transcribed interviews that I planned to use in my dissertation. I redacted portions of quotes from three of the six interviewed upon their request.

Storage and Disposition of Data

Survey responses and transcripts of interviews will be maintained on my office computer, which is password protected. I will keep all data collected (audio files of interviews, transcripts of interviews, and survey responses) for ten years in case I choose to publish aspects of my findings after completion of my dissertation in 2014. After ten years from the completion of my dissertation in 2014, I will delete all data collected related to this study from my computer.

The Time Duration of Each Part of the Research

June-September, 2013	Survey data collection
September-October, 2013	Analysis of survey data
November, 2013 - January, 2014	Interview data collection and analysis

Potential Benefits

I will encourage Research Directors at the 23 CSU Offices of Research and Sponsored Projects to post an Executive Summary of this study on their website so that future CSU Noyce PIs can benefit from the recommendations in Chapter Five. I will also share this information with the Noyce Program Officer. I posit that this knowledge will lead to a more targeted strategy of implementing and sustaining Noyce funds among CSU campuses and beyond, and that some of my findings and recommendations apply to other federally funded projects in the CSU, and externally funded projects in higher education in general.

Limitations

I equally weighted the eight responses that comprised my dependent variable data collection in my survey. Similarly I equally weighted all questions relating to each of my

independent variables in my survey: I equally weighted four centrality questions, six connected networks of support questions, two efficacy questions, and four questions relating to formative assessment and continuing evaluation. This equal weighting assumed that all were of equal value, something that was not determined.

PIs interviewed were also sent a survey so their perceptions may be overrepresented in the data analysis.

Role of the Researcher

As Grant Writer of the Michael D. Eisner College of Education at California State University, Northridge, I want to see the federal dollars that I and others have worked hard to raise have a lasting impact. My perceptions of sustainability have been influenced by a 2002 report from the Annie E. Casey Foundation, *End Games: The Challenge of Sustainability*. The report, which was the result of interviews with 24 officers from private foundations, found nearly universal concern about lack of sustainability of funded projects. Funders described the lack of sustainability as chronic and the addressing of the issue as critical. The report even coined a damning term for projects whose impact ended upon expiration of funds: "drive-by philanthropy" (Annie E. Casey Foundation, 2002, p. 8). It is my hope that my recommendations might lead to an increase in the sustainability of Noyce (and other externally funded projects) project activities and broader impacts among CSU campuses and beyond.

My expertise as a grant writer is a benefit to the study because I have a deep understanding of project design, having worked with dozens of faculty members on hundreds of submissions. I do not have a bias towards the results because my job description does not include the implementation of grants. My role ends when funds are

awarded.

Summary

Through a literature review on the sustainability of externally funded grant projects in higher education, I found that certain factors have a positive effect on the continuation of project activities after expiration of grant funds. These factors included centrality, connected networks of support, support of campus administration, efficacy, and formative assessment and continuing evaluation. In this study, I explored whether these sustainability factors found to be effective in other four-year higher education settings were applicable to Noyce projects at the CSU today, and if so, what the relative importance of these factors was in terms of influence. This study was conducted with a mixed-methods design. Specifically, I employed an Explanatory Sequential Design, a two-phase model in that quantitative data were first collected and analyzed, followed by collection and analysis of qualitative data. A mixed-methods analysis of surveys and interviews allowed a comprehensive data set concerning the positive sustainability factors. I will share a summation of this data set in Chapter Four.

CHAPTER FOUR: FINDINGS

Introduction

This chapter presents the analysis of data collected to address the study's research questions. The findings are comprised of results from a survey sent to all Noyce-funded CSU PIs and co-PIs, and six interviews with CSU Noyce PIs. The interview data illustrate specific trends that the surveys show. The overall prevalence or strength of each of the factors is discussed as pertains to their link to sustainability. A summary of the results appears at the end of the chapter.

Research Questions

Are the same factors that have been found in prior research to promote sustainability of project activities and broader impacts in general higher-education settings applicable specifically to Noyce projects in the CSU today, and, if so, what is the relative importance of these factors in terms of influence on sustainability in the CSU?

Quantitative Findings

Statistical Analysis of Survey

Data structure and adjustments.

The response rate to my survey yielded a sample size with somewhat limited statistical power. Eighty-one surveys were sent out and 32 surveys were returned. Thirty of the 32 were deemed sufficiently completed to be acceptable for use in data analysis. Two surveys were not used because one respondent answered only 10 of the 26 Likert-style questions and another 8. The remaining 30 respondents had answered at least 29 of the 32 Likert-style questions.

Data analysis and Results.

Initially univariate analyses were conducted, using each independent variable (i.e., positive sustainability factor) by itself to predict the dependent variable (i.e., perception of sustainability in CSU Noyce projects by PIs). Based on the quantitative analysis, the relative importance of the identified factors in terms of perceived influence on sustainability in the CSU was determined to be (in order of relative importance) (a) centrality, (b) connected networks of support, and (c) support of campus administration; efficacy, and formative assessment and continuing evaluation both showed essentially zero correlation (see Table 4).

Table 4

Univariate Associations (in order of strength of correlation)

Independent Variable	Pearson's *r*	R^2 Value	Correlation (Direction and Degree)
1. Centrality	.519	26.9%	Moderate positive
2. Connected networks of support	.486	23.7%	Moderate positive
3. Support of campus administration	.306	9.4%	Weak positive
4. Efficacy	.047	0.2%	No correlation
5. Formative assessment and continuing evaluation	-.049	0.2%	No correlation

Pearson's correlation coefficient (*r*) was determined for each of the variables. The linear correlation coefficient measures the strength of the linear relationship between *x*

and *y*.

Although essentially no relationship was found between each of the non-significant factors (efficacy, and formative assessment and continuing evaluation) and sustainability, it is possible that these factors do have *some* influence on sustainability, as reported in other studies (Beery et al., 2005; Northouse, 2010; Popham, 2010; Rogers, 2003), but I was not able to establish this with the relatively small sample size involved in this quantitative study.

R^2 is the percentage of variance in sustainability that is explained by regression on the explanatory variable, and describes the strength of the association between the two variables. The greater the R^2 is the greater the association; if R^2 were 100% then all of the variation in sustainability would be explained by the explanatory variable, and the points would fall exactly on a line. As an example from Table 4, an R^2 of 26.9% means that 26.9% of the variability in sustainability values can be accounted for by the centrality factor.

Another way of viewing the data to reach conclusions about the direction and degree of correlation between sustainability and the independent variables (i.e., the positive sustainability factors) is through a scatterplot. A scatterplot has been called a "visual picture of a correlation" (Salkind, 2000, p. 91). As seen in Figures 1-3, the correlation is positive if there is a positive slope (i.e., the data points cluster from the lower left-hand corner of the graphs to the upper right-hand corner). As seen in Figures 4-5, if the slope is near zero, there is essentially no correlation. In Figure 2, three cases dominate and may be driving the results. These outliers may have an over-exaggerated influence and thereby be responsible for the trend exhibited. Deleting these observations

from the data set might noticeably change the outcome of the calculation, a phenomenon referred to as influential observations (Fox, 1997).

The following figures show scatterplots of sustainability vs. each of the five independent variables. In each case the regression line that best predicts sustainability from the given independent variable is also shown (see Figures 1-5):

Figure 1: Scatterplot of Sustainability vs. Centrality

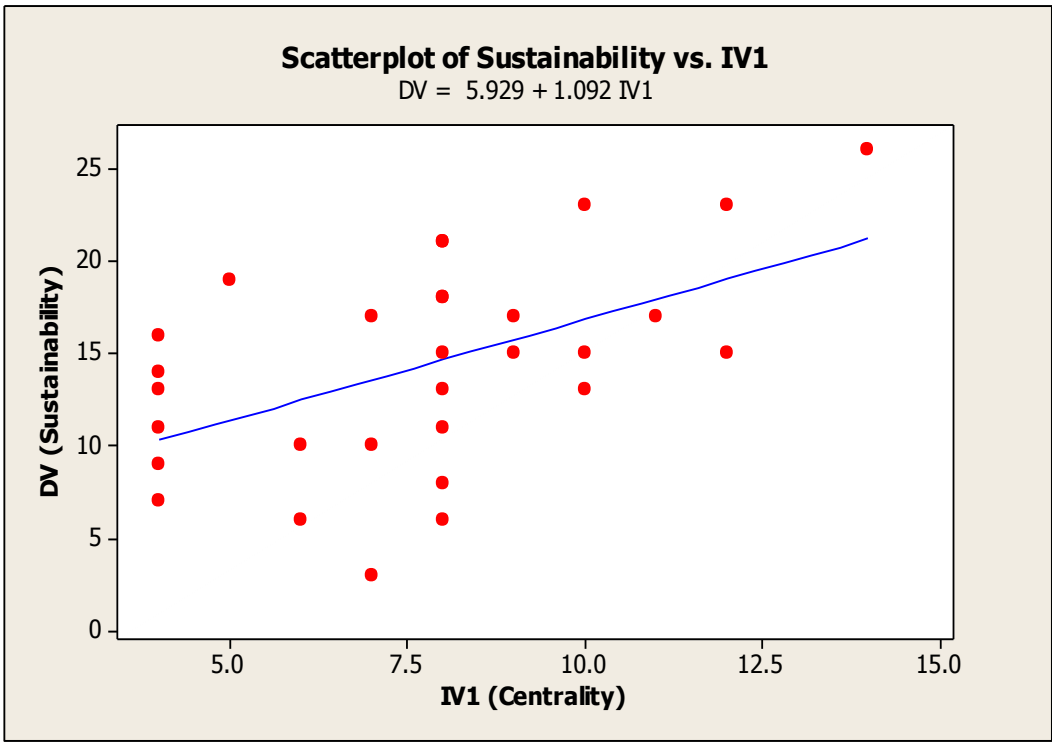


Figure 2: Scatterplot of Sustainability vs. Connected Networks of Support

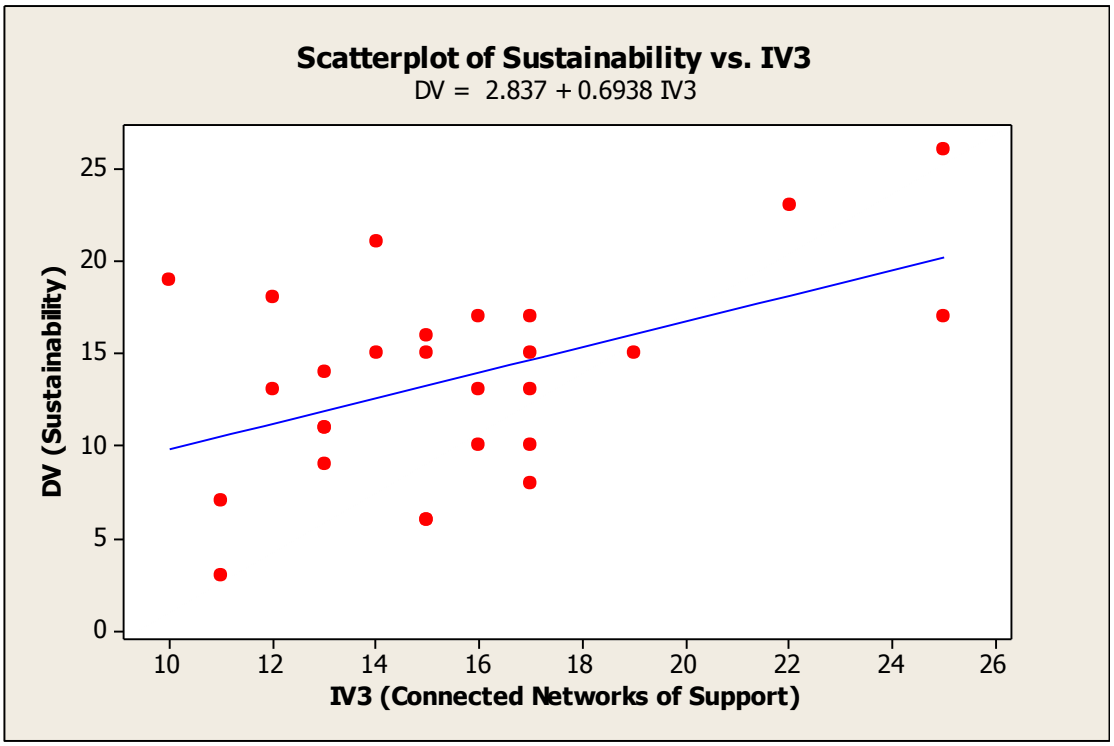


Figure 3: Scatterplot of Sustainability vs. Support of Campus Administration

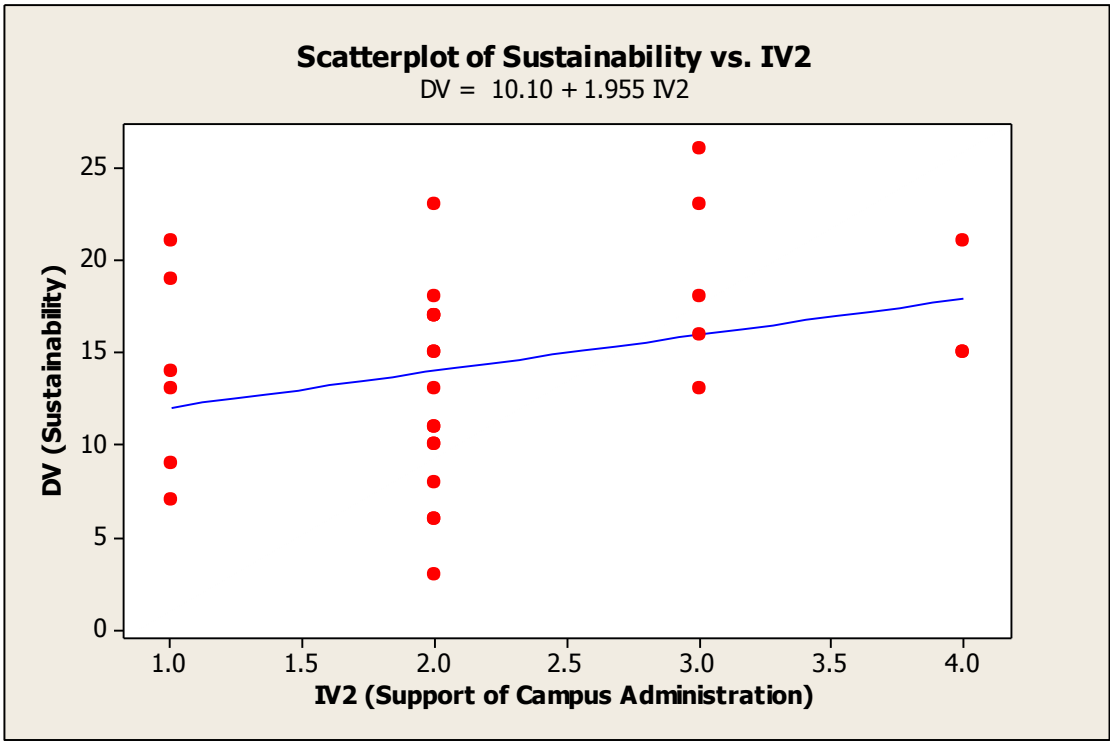


Figure 4: Scatterplot of Sustainability vs. Efficacy

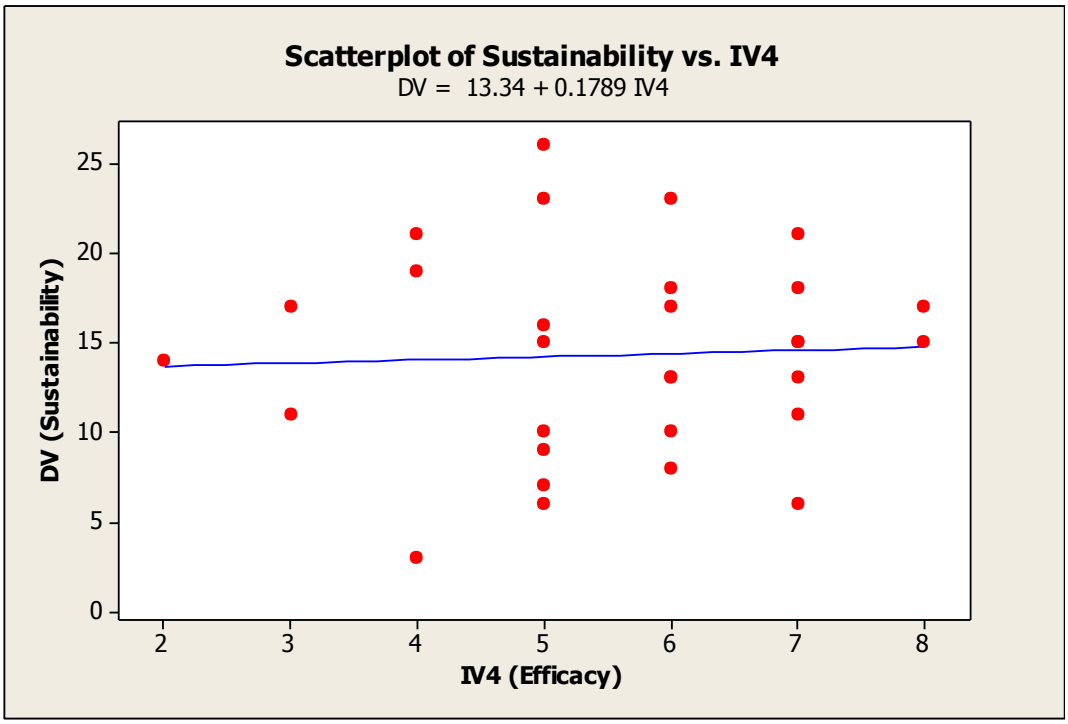
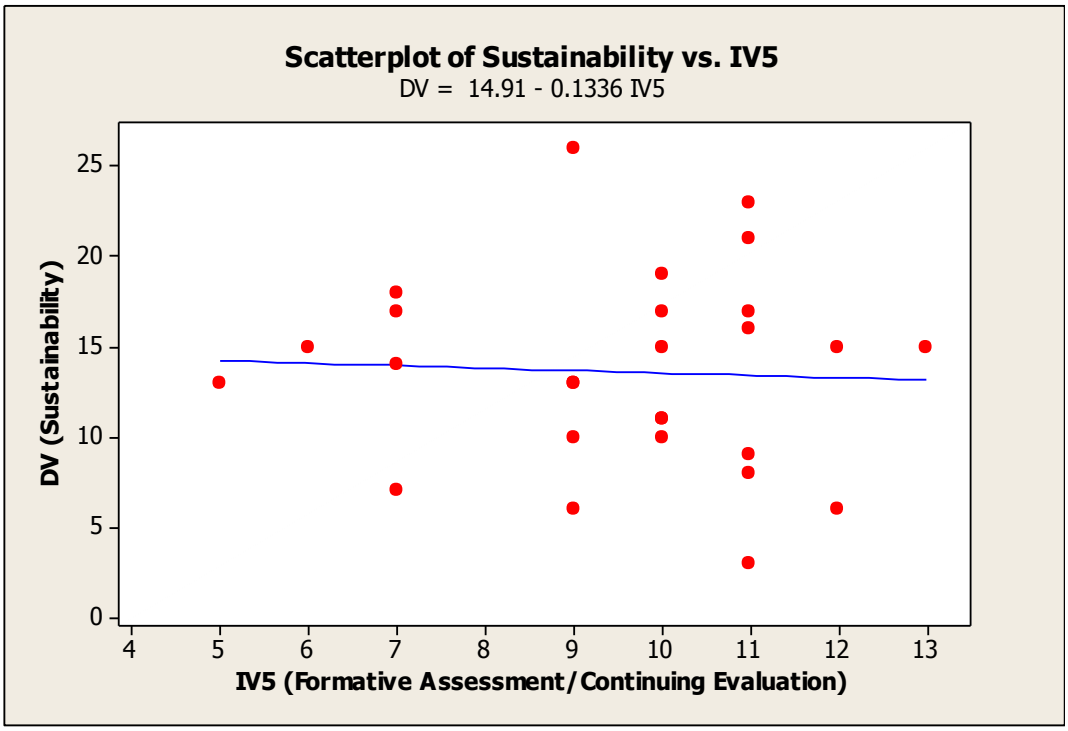


Figure 5: Scatterplot of Sustainability vs. Formative Assessment/Continuing Evaluation



Following the univariate analyses, multivariate regression analysis was conducted using all of the independent variables as predictors. This yielded the results shown in Table 5.

Table 5

Results of Multivariate Regression Analysis (listed in order of significance)

Predictor	Coefficient	SE Coefficient *	*t*	P-value
Constant	9.228	6.493	1.420	0.170
1.Centrality	1.097	0.600	1.830	0.082
2.Connected Networks of Support	0.419	0.327	1.280	0.214
3.Support of Campus Administration	-1.367	1.519	-0.900	0.379
4.Efficacy	-0.764	0.726	-1.050	0.305
5.Formative Assessment and Continuing Evaluation	-0.347	0.486	-0.710	0.484

Note. *SE coefficient is the standard error of the regression coefficient. The sample standard deviation = 4.81. R^2= 35.8%. R^2 (adjusted) = 20.5%.

Data from Table 5 established the relative importance of the five independent variables (i.e., positive sustainability factors) -- ranked based on the largest *t*-statistic/smallest P-value. With the exception of support of campus administration, the multiple regression analysis was generally consistent with what the univariate regressions found as far as centrality and connected networks of support being the factors with the most relative importance with little evidence for the other three factors being relevant. Multiple regression allowed me to determine how much of a role in sustainability each

independent variable played when the remaining variables were held constant. The data were found to be well behaved with few outliers.

Overall the value of R^2 was 35.8%. This is a fairly typical percentage in an experiment that occurs in a non-controlled environment and whose data depends on human responses to surveys, and indicated a moderate association between the dependent variable and the collection of all five independent variables.

This should be considered a preliminary study. The data was suggestive, but not entirely conclusive (given the small sample size) of an association between the dependent variable and the independent variables. The overall P-value for the multiple regression was .077, indicating that it was relatively unlikely to have found such a strong degree of association between the dependent variable and the independent variables simply by chance.

Collinearity.

Collinearity measures the degree to which two independent variables measure the same thing. Significant collinearity was found between the following pairs of independent variables:

- Centrality and support of campus administration (r = .602; moderately strong correlation).
- Centrality and connected networks of support (r = .634; moderately strong correlation).
- Centrality and efficacy (r =.493; moderate correlation).

This collinearity helps to explain why the univariate analysis does not align perfectly with the multivariate analysis. There was no significant correlation between any other pairs of independent variables.

Heretofore I described the positive sustainability factors as having discrete influences when in fact there are interrelationships (i.e., in part they measure the same thing). For instance, centrality was measured quantitatively by summing the Likert-style responses to the following questions:

- *Our Noyce project was aligned with explicitly stated DEPARTMENTAL priorities.*
- *Our Noyce project was aligned with explicitly stated COLLEGE priorities.*
- *Our Noyce project was aligned with explicitly stated UNIVERSITY priorities.*
- *Our Noyce project was aligned with explicitly stated CSU SYSTEMWIDE priorities.*

Since I defined campus administration as department chair, dean, and provost, one can easily see the overlap between the two independent variables: centrality and support of campus administration. It seems logical that if the mission of the project dovetails with the mission of the department, college, and university, the campus administration will be supportive (and hence sustainability will be fostered). Similarly, it is logical that there is overlap of centrality and connected networks of support if there is a consonance of mission between intracampus and extracampus partners. Lastly, the relationship between the training of faculty and master teachers (i.e., efficacy) and the centrality of the mission is more tangential than the last two correlations described. Hence there was only a moderate correlation between centrality and efficacy.

Next I will describe the qualitative findings regarding the five positive sustainability factors.

Qualitative Findings

In this section, I refer to the six PIs interviewed by number (1-6). PIs that are mentioned or quoted, yet not identified by a number, are PIs that wrote in responses to open-ended questions in the survey. Also, I chose to refer to all open-ended respondents as a PI since PIs and co-PIs responded to the survey anonymously so I do not know which open-ended responses are from a PI and which are from a co-PI.

Responses to Open-ended Survey Questions Regarding Systemic Change and Broader Impacts

In the survey I asked PIs and co-PIs open-ended questions regarding systemic change and broader impacts on their campus in regards to Noyce project activities in order to establish what sustainability means in the Noyce context. I will share responses below followed by a description of all the ways that sustained impact can be facilitated through the positive sustainability factors I identified in the literature.

Systemic change.

Systemic changes were defined as changes that impacted multiple elements of a PI's network of intracampus and extracampus Noyce partners. In the survey, PIs reported the following systemic changes due to Noyce: (a) Eight PIs described that Noyce led to an increased and sustained level of collaboration between the colleges of sciences and education, both at the administration level and at the faculty level. (b) One PI stated there was "change in culture for content faculty." (c) Many PIs described new and strengthened partnerships: eight PIs described stronger ties between project personnel and local school

districts; one PI described Noyce as “creating and solidifying” partnerships with the local office of education, the STAR program and federal research lab; and one PI shared that the local school district is now much more amenable to future partnerships. (d) One PI described the creation of a master’s of science degree in science education sponsored by Noyce. (e) One PI described that “our project contributed to our University's change from Teacher Performance Assessment to Performance Assessment for California Teachers. This improvement has changed our network of internal and external partners in assessing our credential candidates.” (f) One PI described that “as a result of the successful early field experience program developed in Noyce programs…, the entire Single Subject program is going to use this model.”

Broader impacts.

An open-ended question in the survey asked PIs to reflect on perceptions of broader impacts of the Noyce program. Two PIs shared that the community benefited because Noyce training and professional development provided the foundation of a lifelong career for “quality teachers in math and science.” A PI reported that Noyce Scholars were highly regarded and had taken on leadership roles early on in their teaching careers. One PI reported that Noyce-trained teachers “would heavily influence future STEM recruitment” because they were a key feature of Noyce recruitment fairs at colleges and universities. Another PI stated that Noyce Master Teaching Fellows would “continue to support new colleagues and engage in the larger professional community as a result of their experiences in this program.” Another PI stated that “the cadre of Noyce Scholars in the local area would have a lasting impact because they interacted with our students and faculty over time.” Another PI stated that the Noyce alumnus of today

would be the Noyce mentor teacher of tomorrow. One PI shared perceived broader impacts of the Noyce project: (a) Noyce had been branded in the community as representing excellence. A benchmark for quality teacher training had been set ("a STEM Noyce Scholar is resourceful, knowledgeable, etc."). (b) Noyce alumni seeking jobs would benefit ("Local school districts now know we have a cadre of prospective STEM teachers and want to hire our alumni."). (c) Recruiting would be helped because undergraduate students would aspire to be a Noyce Scholar. (d) Teacher quality had improved in "a critically under-served area" (i.e., a high-needs school district).

Responses to Interview Questions Regarding the Five Positive Sustainability Factors

In the surveys and interviews I asked PIs open-ended questions regarding the five positive sustainability factors. I will share responses below.

Centrality.

Previously reviewed literature supported the notion that if a project's goals dovetailed with campus goals, the likelihood of success and sustainability greatly increased (Glassman et al., 2003; Lueddeke, 1999; RAND, 1975a). The survey data and interviews for this study confirmed that notion. PIs shared their perceptions of centrality as having significant influence over whether project activities would continue beyond the end of the Noyce grant.

PI #1 shared that "there is much more emphasis on campus for math and science teaching than there was a dozen years ago," and PI #2 that "the political climate now is actually better than it was four years ago or five years ago for doing the work that we are doing." PI #4 described centrality as finding commonalities among project partners, not just creating the relationship, but:

finding the common ground – what is it that you both believe in that can form the core of this program. A program has to be a coherent entity. It can't be just a jumble of components put together. Then it's not sustainable and it falls apart. But if you have this core of beliefs and of values that really sees the program and supports everything so it feeds into everything – then you have a chance of it being sustained.

In general, the interview findings strongly supported the idea that shared, deeply held beliefs fostered project sustainability. Next I describe in greater detail how PIs perceive that the sustainability of Noyce projects can be fostered by linking Noyce activities to projects with missions related to Noyce, but whose funding is independent of Noyce.

Linking Noyce to MSTI.

A good example of centrality between two, on-campus programs is Noyce and MSTI, because both share similar goals. While MSTI is a systemwide initiative, its benefit to CSU Noyce sustainability is derived at a campus level because each campus decides how best to use their allotted MSTI funds, the result being that MSTI project designs vary widely from campus to campus.

According to the survey results, most of the PIs built upon MSTI in their Noyce project design. Nineteen of 26 survey respondents listed MSTI as an initiative upon which they built their Noyce project. As described in open-ended responses to the survey, PIs who linked their Noyce project to MSTI found that (a) MSTI support for early experiences in teaching helped to identify and encourage talented individuals to pursue mathematics education and apply for Noyce scholarship funding; (b) MSTI tapped into

support staff and faculty already involved, making it easy for everyone to understand the importance of the Noyce project; and (c) MSTI is a strong recruitment pool for their Noyce project.

PI #1 described blending MSTI and Noyce funds to sponsor events with a shared mission. For instance, "MSTI money supported some of our future science teacher events and the Noyce people were at that as well." PI #1 concluded that "at a certain point you have your future science (teacher events) -- you have your MSTI -- you have your Noyce – since they all have the same purpose it's all one thing."

PI #2 shared that MSTI is "a focus point for recruiting candidates into the seminar…and into the credential program and hopefully into the scholarships that we hope to maintain beyond NSF funding and support."

Some PIs did not have as favorable success linking Noyce to MSTI. One PI described MSTI as totally separate from Noyce due to local politics. Another PI stated, "MSTI had similar program goals, but seemed opaque on our campus." Strangely, one survey respondent said he or she did not know of the existence of the MSTI program.

Linking Noyce activities to other, relevant, on-campus, externally funded projects.

PIs shared that they perceived that linking Noyce activities to other, relevant, on-campus, externally funded projects fostered sustainability. Two such projects were the NSF *Collaboratives for Excellence in Teacher Preparation* (CETP) and *Science, Technology, Engineering, and Mathematics Teacher Preparation* (STEMTP) programs. The purpose of the CETP program is to produce and retain increasing numbers of well-qualified math and science teachers. CETP "promotes the development of preK-12

teachers who are competent in their subject matter; able to teach effectively in these disciplines; …and able to implement the national mathematics and science standards" (NSF Collaboratives for Excellence in Teacher Preparation, n.d.). The purpose of the STEMTP program is to support the development and dissemination of exemplary math and science preK-12 teacher education models. The goals of the program include significantly increasing the number of preK-12 teachers who are certified and well-qualified to teach math and science, and improving the quality of pre-service teacher education (National Science Foundation, n.d.c). Two surveyed PIs stated that they built their Noyce project on the pre-existing foundation of CETP and STEMTP programs on their campus because both programs had strong field and summer research components. PI #1 shared that CETP funded the establishment of a STEM Center on her campus in 1999, and she perceived that the STEM Center was the internal campus factor that most fosters Noyce project sustainability because its mission included recruiting and retaining undergraduate science and mathematics majors into teaching through academic counseling and early field experiences, and providing professional development for in-service teachers.

Another PI linked Noyce to *Edvention Partners*, a U.S. Department of Education-funded project connecting several universities and school districts with the goal of improving teacher education programs. The PI reported that Edvention Partners project personnel provided "in-kind support, and administrative assistance," and had promised to share data from the evaluation of the teaching of former Noyce Fellows, once they were in full-time positions.

Another PI stated that he built his Noyce project on the pre-existing foundation of the *Association of Public and Land-grant Universities Science & Math Teacher Imperative* (APLU SMTI). The Association of Public and Land-grant Universities launched an initiative, the Science and Mathematics Teacher Imperative, in response to addressing the need for new math and science teachers. APLU SMTI has grown to include over 132 universities including California State University, Fresno; California Polytechnic State University, San Luis Obispo; and California State University, Fullerton. Since this PI answered anonymously through the survey I was not able to ask why she perceived linking Noyce with APLU SMTI would foster Noyce sustainability. After closely reading the APLU SMTI website, I concluded that APLU SMTI could help sustain Noyce goals after expiration of funds through (a) grants "to enhance the preparation of secondary mathematics teachers to meet the instructional shifts called for by the Common Core State Standards for Mathematics," (b) research on the need and value of STEM Centers, and (c) use of the "Analytic Framework," a taxonomy of attributes developed by APLU SMTI to assess science and math teacher preparation programs, allowing faculty and administrators "to analyze policies, processes and practices that are, could or should be in place at institutions desiring more predictable and positive outcomes in the preparation of science and mathematics teachers" (Association of Public and Land-Grant Universities Science & Math Teacher Imperative, n.d., p. 1).

Conclusion: Centrality of the Noyce project to a broader campus mission significantly contributes to sustainability of the Noyce project.

Connected networks of support.

In the survey data, PIs shared their perceptions of connected networks of support

as having significant influence over whether project activities would continue beyond the end of the Noyce grant. All survey respondents and interviewees were unanimous in their assessment of connected networks of support as a positive sustainability factor. On the survey, eight PIs described how Noyce led to an increased and sustained level of collaboration between the colleges of sciences and of education, both at the administration level and at the faculty level. This increased and sustained level of collaboration led directly to faculty of the College of Science becoming "more involved and interested in serving teachers and in the recruiting of future teachers," as one PI put it. Another PI described the cultural change as manifesting in a stronger institutional commitment to growing STEM teachers. Five PIs reported the perception that these cross-campus cultural changes would sustain Noyce activities after expiration of funds. One PI shared that some faculty even reported changes in their teaching, with more of a focus on active learning and the adapting of course content to the ends of the teacher candidates.

Other perceived advantages of connected networks of support in terms of sustainability as including strengthened relationships among CSUs. One PI described that due to the strengthened partnerships between three CSUs "additional funding proposals are forthcoming out of this collaboration." If funded, these submissions will sustain activities. Another PI similarly described how Noyce led to "a strong relationship with our sister campus which will lead to future work together." One of the PIs described Noyce as the catalyst for an increased number of "connections and collaborations within the network (of community partners)," and that in turn this increased number of connections will promote a lasting project.

PIs were unanimous in reporting that networks of support (and hence sustainability) could be fostered by connections with and through the CSU Chancellor's Office. In the survey, one PI wrote that the CSU Chancellor's Office had been "excellent in encouraging Noyce project activities" and that this encouragement "tended to remove possible barriers from forming at higher administrative levels." Survey respondents and interviewees stated that they perceived that the following projects sponsored by the Chancellor's Office fostered the sustainability of Noyce CSU programs: (a) *Math and Science Teacher Initiative* (MSTI); (b) *MERLOT Voices* (Voices is MERLOTs' community networking site. MERLOT is the Multimedia Educational Resource for Learning and Online Teaching created by California State University. CSU Noyce PIs reported using Voices to maintain professional learning communities among faculty, mentor teachers, Noyce Scholars, Noyce Fellows, and Noyce alumni.); (c) *STEM Teacher and Research Program* (STAR) in which students, including Noyce Scholars, conduct summer research in federal laboratories. Survey results of participants of the STAR program (half of whom were also Noyce Scholars) found that 95% reported that the summer research internship at a federal lab made them "feel like they were part of a broader community of teacher-researchers" and that mentors, master teachers, and university faculty members developed strong relationships that lasted beyond their time in STAR (Keller, 2012); and (d) *Virtual Courseware Project* (funded by the NSF and CSU) which provided interactive, web-based simulation activities that emphasized the methods of science for both life and earth science topics. These activities are available to Noyce Scholars (and all teacher candidates) throughout their teaching career.

PIs perceived that recruitment of STEM majors into the teaching profession could be sustained post-Noyce funding through another connected network of support: student clubs such as the Biology Club and the Chemistry Club. PI #6 described centering recruiting efforts around clubs since STEM undergraduates identify most with their major, with few considering teaching as a career:

> So if I link teaching and teacher science education – science education research through the organizations in which they identify as majors to the biology club, the chemistry club – you know, each department's major club – and maybe even the graduate students - that's more likely to be sustained - because we've had that where we tried to do like a NSTA [National Science Teachers Association] student affiliate or a CSTA [California Science Teachers Association] student affiliate – for students in NSM [College of Natural Science & Mathematics] and once the initial small group that was interested dies that club dies. But these clubs won't because the majors are still always going to be there.

In summation, linking recruitment efforts to student affiliates of professional organization was tenuous because these student groups proved to be evanescent. Networks cannot remain connected if some of the partners cease to exist. Therefore PI #6 declared linking recruitment efforts to clubs within a major a best practice since these clubs were sustained through the departments and thus were ensured a continuing status.

Another, on-campus network of support, the STEM Center, also was perceived by PIs to foster sustainability. One PI reported that her campus STEM Center "fostered collaboration between the teacher educators in mathematics and the biological sciences" and that "this support provided a structure that allowed sustained collaboration." Another

PI reported the perception that his campus STEM Center was the key internal factor that would "support the recruitment and development of a highly qualified and diverse pool of future STEM teachers before and after Noyce funding."

PI #2 reported the perception that the STEM Center on his campus would help not just with CSU Noyce sustainability, but sustainability of Noyce at campuses nationwide. All of the Noyce Scholars funded through Phase II on his campus participated in research through the STAR program. His campus STEM Center not only managed their own STAR program, but also organized the STAR program for many Noyce-funded campuses across the country. He predicted that this national impact would be viewed favorably by funders and lead to "sustained funding for STAR" and a "continued role" for his campus STEM Center "within the entire Noyce community."

Surveyed PIs whose campus had a STEM Center reported that the Center Director and affiliated faculty could directly help sustainability efforts through (a) the writing of future proposals requesting external funding, (b) gathering evidence for these proposals by conducting evaluation during Noyce project implementation, and (c) conducting continuing evaluation on Noyce activities, the results of which would be of interest to campus administration and external funders in their deciding whether or not to provide future funding to the project.

Another connected network of support that was perceived to foster sustainability was professional learning communities (PLCs). One PI perceived as a best practice for sustainability the use of MERLOT Voices, Google Plus, or Facebook to maintain PLCs among faculty, mentor teachers, district personnel, Noyce Scholars, Noyce Fellows, and Noyce alumni. PI #2 described another CSU-wide PLC: *Noyce MERLOT Commons*.

Building on MERLOT, CSU Fresno created the Noyce MERLOT Commons online learning community that spans CSU Noyce-funded campuses. Noyce MERLOT Commons was funded by the NSF and acts a repository for science and mathematics teaching materials and lessons. The Science and Mathematics Education Center (SMEC) at CSU Fresno has been described as:

> a leader in the state for the development of a new online learning community that allows students and teachers at all stages of the teacher preparation and development continuum to be connected digitally to a wealth of teaching and learning resources and to share their contributions to the community (California State University, Fresno, n.d.).

Connected networks of support are not just about the number of project partners, but the depth of the relationship amongst the partners. It is the depth of the collaboration that is of importance for implementation and sustainability (Tenkasi & Chesmore, 2003; Weiss, Coffman, & Bohan-Baker, 2002). PI #4 stated bluntly that "paper-thin" partnerships "just don't work." All six PIs interviewed described the need to develop *deep* relationships with project partners. PI #2 reported that deep relationships among project partners must be based on synergistic benefits. A project must have a benefit to all partners. She stated that "in addition to knowing what you're wanting from the partner you need to know what the partner wants from you." PI #4 shared a list of best practices for forging deep relationships with local school districts: (a) She invited mentor teachers at the outset (i.e., when writing the proposal requesting initial Noyce funding) to take part in creating the design of the Noyce program. (b) She visited the mentor teacher classrooms multiple times each year. (c) She staged professional development seminars at

the school site and not the university. She stated that this signaled that Noyce was a shared effort, and not just a university-led effort. (d) She volunteered at non-Noyce related district events, regularly acting as a resource: "At any time the district asks me to attend a meeting or give a presentation - if it's at all possible I say, 'Yes' – because that increases the number of people I know – the number of people who will see me as a resource – someone that they want to work with." (e) She organized meetings with conference specialists, coordinators, directors, assistant superintendents, deputy superintendents, and superintendents: "I've had meetings with them all. And (lengthy) discussions on how we view things – seeing that we have sort of common values in terms of education. And that tends to strengthen relationships." This last remark harkens back to another positive sustainability factor: centrality.

Proof of the success of PI #4's having developed a deep relationship with the local school district is that the district pays the cost of an external evaluator for her Noyce program. This evaluator was formerly the math specialist of the district. PI #4 stated that this support "really indicates both how much they value [the evaluator's] expertise and how much they value the [Noyce] program." PI #4 perceived that this deep relationship between her campus and the local school district would certainly be sustained past Noyce funding.

PI #5 shared his perception that deeper connections with project partners could be fostered by partner representatives serving on the campus STEM Center advisory board. His STEM Center advisory board was comprised of local school district superintendents, community college presidents, and representatives from local industry. PI #5 also perceived that community connections were deepened because his campus STEM Center

regularly offered professional development to community partners. He reported that his campus STEM Center offered professional development to 30 area school districts and to local community colleges. He perceived these deep relationships as leading to sustained and ongoing relationships and partnerships in the future.

Lastly, one surveyed PI recommended applying to Noyce for a Capacity Building Project (CBP). CBP provides funds to strengthen collaborations between STEM colleges/departments and education colleges/departments; strengthen collaborations between two- and four-year institutions; and creates "new partnerships with school districts, informal science education institutions, and industry" (National Science Foundation, n.d.a).

Conclusion: Connected networks of support significantly contribute to sustainability of the Noyce project. For CSU Noyce projects, survey respondents and interviewees reported that the total list of elements of the connected networks of support were comprised of (a) the NSF, (b) county offices of education, (c) Beginning Teacher Support & Assessment (BTSA) – a two-year induction process required by State of California for new in-service teachers, (d) community colleges, (e) entities on the home campus (e.g., colleges of education and science and mathematics, student clubs, research labs, plus STEM Centers if applicable), (f) other CSU campuses, (g) CSU Chancellor's Office, (h) private foundations, (i) online professional learning communities (PLCs) comprised of faculty, mentor teachers, and current and former Noyce Scholars, (j) federal labs, (k) private industry, and (l) other projects, including MSTI, MERLOT Voices, STAR, Virtual Courseware Project, Noyce MERLOT Commons, NSF CETP, NSF STEMTP, Edvention Partners, and APLU SMTI.

Support of campus administration.

In the survey data, PIs shared their perceptions of support of campus administration as a moderate influence over whether project activities would continue beyond the end of the Noyce grant. Six surveyed PIs mentioned supportive campus administration as a positive sustainability factor, one describing a "very supportive provost…that (will) help us continue our work," and another a "VERY supportive College of Natural Sciences & Mathematics dean and College of Education dean." Surveyed PIs reported that the support of campus administration took the form of (a) use of campus space to conduct professional development and recruiting seminars; (b) release time; (c) funding to purchase equipment used by credential candidates (including Noyce Scholars) to improve their teaching of lab activities; (d) the instituting of a sustainable, longitudinal system to track the teaching careers of Noyce Scholars and non-Noyce Scholars; and (e) (according to one PI) the campus STEM Center, which "supports Noyce related activities" and is staffed by the Dean's granting of one full-time equivalent position taken out of a science professor line to support two the co-directors of the STEM Center. Surveyed PIs predicted that much of this internal support would continue after expiration of Noyce funds.

In the interviews, PIs shared their perceptions of supportive campus administrators fostering sustainability. PI #2 shared that "internally we have support from the President, from the Provost, and from both the Dean of the College of Science and Mathematics and the Dean of the School of Education." PI #2 shared that during the Phase I grant, the Dean of the College of Science and Mathematics provided internal funds to cover half of the release time needed for four faculty to conduct their Noyce

responsibilities. Revised Noyce requirements precluded the Dean from offering release time during Phase II because cost sharing was no longer allowed to be reported. However, the Dean supported Noyce both during and after the term of Phase I and Phase II funding by providing release time for the two co-directors of the campus STEM Center, one of whom was the Noyce PI. PI #2 perceived the STEM Center as fostering sustainability through the following: (a) the "running of the STAR program, which is central to our Noyce Phase II proposal;" (b) the "running of the MSTI program," which is "a focus point for recruiting candidates into the high-needs teaching seminar and into the credential program;" and (c) "providing a focus for …STEM professional development that not every campus has if you are just an individual faculty member running the Noyce program."

PI #5 was Noyce PI as well as Executive Director of his campus STEM Center. His campus administration had been supportive of both Noyce and the STEM Center. The Provost was a member of the STEM Center advisory board. The Dean of the College of Science & Mathematics approved a permanent, state-funded position in the STEM Center for an academic counselor that advised Noyce Scholars during the term of the grant and to counsel STEM majors considering a teaching career. PI #5 predicted this counselor would continue to offer counsel to STEM majors considering a teaching career after expiration of Noyce funds. PI #5 perceived the STEM Center as fostering Noyce sustainability because the Center was "pretty well known throughout our [area] as being involved in teaching professional development in pre-service STEM, pre-service enhancement – primarily single subject level."

PI #1 was department chair concurrent to her tenure as Noyce PI so was able to

singlehandedly approve the allocation of some of her administrative release time to the conducting of Noyce activities. PI #1 envisioned that the type of intense academic counseling she currently provided Noyce Scholars would continue after expiration of Noyce funds because she would continue to allocate part of her administrative release time to continue offering this counseling (which is over and above the counseling offered to most teacher candidates) to STEM majors considering a teaching profession.

There was a consensus among PIs surveyed and interviewed that there were two things outside CSU administrators' control that control their level of support: the state and federal budget. CSUs are state universities so are very affected by the economic health of the state. Similarly, programs such as Noyce are federally funded so the amount of awards and number of awards are directly tied to the health of the national economy. In this age of ever-shrinking financial support of public universities, administrators must choose judiciously among proposed educational reform efforts, all of which may be worthy (Barr, 2002; Goldstein, 2005; McBride, 2010). Even with STEM teacher education being deemed a national priority (Business-Higher Education Forum, 2013; Committee on STEM Education National Science and Technology Council, 2013; Thomasian, 2011), seven PIs relayed that state and federal budget reductions had resulted in a decrease in administrative support and a decrease in release time to support Noyce activities. One PI stated that administration is advocating cutting programs for science teacher training (eliminating the master's of science degree in science education) due to low enrollment, and that this would have the consequence of "eliminating the main pipeline for recruiting qualified teachers for Noyce." In this case, budgetary realities impinged on a supportive administrator's ability to foster sustainability.

Conclusion: Support of campus administration contributes moderately to sustainability of the Noyce project.

Efficacy.

The overall trend in the survey data suggested that efficacy had no influence over whether project activities would continue beyond the end of the Noyce grant. This finding contradicted my literature review, which deemed efficacy a positive sustainability factor (National Science Foundation, 2008). Therefore I added an interview question asking PIs to hypothesize why this discrepant finding occurred.

PI #4 felt that the survey prompt regarding efficacy of mentor teachers (*Our Noyce project provided sufficient formal training or professional development to the secondary-level teachers who mentored Noyce Scholars*) confused survey participants, deeming "sufficient" and "formal" both highly subjective terms. For instance, PI #4 stated that she offered training, but it was not "formal" since it consisted of impromptu visits to the mentor teacher classrooms. She also stated that a PI could offer a set amount of training and characterize the training efforts as sufficient, while another PI could offer the same amount of training and deem the training insufficient.

PI #6 stated that she answered the prompt NA since she was a member of faculty in the College of Natural Sciences & Mathematics so consequently did not train the mentor teachers (i.e., this was accomplished by College of Education faculty). PI #5 described that he responded NA to the prompt because his campus had "been doing mentor teaching training for our science student teachers for decades and so we didn't do anything special for the Noyce (mentor teachers)."

The survey prompt regarding efficacy of university faculty (*We provided sufficient training or professional development to university faculty (e.g., workshops on best practices for recruitment, diversity training, etc.) to implement the Noyce project*) may have been similarly confusing to survey participants because this prompt also contained the subjective word "sufficient," thereby eliciting no correlation between efficacy and sustainability.

In interviews, CSU Noyce PIs' perceptions were decidedly different from survey respondents, with all interviewees describing efficacy of mentor teachers and faculty as important to sustainability. Three PIs interviewed reported that Noyce mentor teachers required training in best practices for mentoring, the use of educational technology, and project-based learning advocated by the Next Generation Science Standards and the Common Core State Standards. These PIs perceived that training master teachers leads to sustainability of the broader impacts of the Noyce activities, specifically to better trained teachers and better student outcomes. These PIs shared that trained mentor teachers can better mentor future teacher candidates (both Noyce and non-Noyce) and can better serve their own students with information they (the mentor teachers) have learned in their Noyce training. PI #2 shared that "you can tap into these (well-trained mentor) teachers in the future." PI #3 described these well trained mentor teachers as "megamentors" who work with the local county office of education to provide training to Noyce Scholars during the grant and can work with the office of education to offer professional development to in-service teachers (including Noyce alumni) after expiration of Noyce funding. PI #5 felt strongly that there should be professional development offered at regional and national conferences to teach PIs grantsmanship (i.e., strategies on

researching funding targets, liaising with foundation and federal agency program officers, and writing winning proposals) because this is "out of the realm of the Noyce PI types" and something they are not "naturally trained [in]." PI# 5 viewed the securing of continuation funding as a path to Noyce sustainability.

Noyce is unlike many federally funded projects in that the majority of the funding is necessarily allocated to students for scholarships. Little is left for the training of project personnel. The majority of the tasks required to implement the project are enacted by the PI. Therefore, efficacy, while still a positive sustainability factor, may have less of an impact on the Noyce project than for other externally funded, non-scholarship programs.

Conclusion: For Noyce, the quantitative analysis did not yield evidence that efficacy contributes to sustainability. However, interviews did suggest that efficacy does foster sustainability.

Formative assessment and continuing evaluation.

Formative assessment.

The overall trend in the survey data indicated that formative assessment had no influence over whether project activities would continue beyond the end of the Noyce grant. This finding also contradicted my literature review, which deemed formative assessment a positive sustainability factor (Nguyen & Wegesin, 2011). Therefore I added an interview question asking PIs to hypothesize why this discrepant finding occurred. PI#4 posited that there might have been confusion as to the definition of "formative assessment" since the concept is defined differently among faculty. For instance, ongoing program tweaks that occurred as the result of faculty visiting mentor classrooms and speaking with the Scholars might not rise to the level of formative assessment in the

minds of some PIs answering the survey. PI #4 also stated that early recipients of Noyce funding received "very, very small" grant awards so, even had they deemed formative assessment to be important for sustainability, they may not have had the resources to conduct the assessment themselves or the resources to hire an evaluator. So while PIs might deem assessment a positive sustainability factor, they might not have conducted assessment due to budgetary constraints.

In interviews, CSU Noyce PIs' perceptions were decidedly different from survey respondents, with all interviewees perceiving formative assessment as important to sustainability. PI #4 stated that making programmatic changes based on formative assessment "absolutely" had an impact on activities sustaining after funding expires. PI #6 budgeted for an external evaluator (3% of her Noyce award) and met with the evaluator via Skype once per month and once per year in-person in part to develop strategies to sustain project activities and broader impacts. PI #5 pointed to other advantages of formative assessment that had a positive effect on sustainability:

> You can see what works and doesn't or could be improved. So you have time to make the improvements and field test those improvements and so when you get to the point when you want to sustain – you've got a product that is proven.

Continuing evaluation.

The overall trend in the survey data showed the perception that continuing evaluation had no influence over whether project activities would continue beyond the end of the Noyce grant. This finding contradicted my literature review, which deemed continuing evaluation a positive sustainability factor (Beery et al., 2005; Tucker and Fischman, 2011). In interviews, CSU Noyce PIs' perceptions were decidedly different

than survey respondents, with all interviewees reporting a perception that continuing evaluation is important for sustainability.

PI #6 viewed continuing evaluation as a form of clinical supervision. She described that she "had a vision of what I wanted in terms of the teachers that I would produce and I had a certain idea of the experiences I wanted them to have as they were preparing to become teachers and I was hoping to see if that was instantiated in how they perform as teachers." She had the luxury of having Phase II funds to send project personnel to observe Noyce alumni teaching in their classrooms. She wanted to see "if they were exhibiting what I was hoping they would be based on… their [research lab] experience." This PI had insisted on the Noyce Scholars participating in a research experience so hoped to see the influence of laboratory and data analysis:

> In a lesson plan, are they thinking of ways in which they can engage the students in using a real experience or real data that they somehow collect and interpreting that to make sense within the context of whatever the lesson is teaching? I wanted them to understand that science has an awful lot to do with uncertainty and how to tolerate it and it's working at something persistently over time and then getting your reward at the end.

PI #2 also described the advantages of continued observation of Noyce Scholars after expiration of funding:

> I would think about activities that active Noyce Scholars could be involved in during the five years of the grant that becomes a habit of practice – that the Scholars continue after the grant funding is over. So what are the types of activities – whether that's supporting each other's activities so whether that's

going to a professional conference activities or doing things that we think are good for better teaching that you are doing with your Noyce Scholars so they become used to doing it that way and then that whenever your funding is done those Noyce scholars will continue to do it?

Many PIs interviewed interpreted my question about continuing evaluation to be about the Noyce-program requirement to track Noyce Scholars to report to the NSF whether the Scholars were fulfilling their years-long commitment to teach in high-needs district. Many PIs viewed this requirement as a burden as tracking can go on for many years and no release time is provided for this task. However, some PIs viewed this requirement as an opportunity. PI #4 described seeing as a broader impact of Noyce "a community of teachers in our area that view us at the university as a resource." To foster this she hosted (and will continue to host post-funding) a monthly gathering at which Noyce alumni, current Noyce Scholars, mentor teachers, Noyce Fellows, and other teachers not affiliated with Noyce all gather, without financial incentives, to "do some math problems and talk about how they may pertain to the classroom." In this way, PI #4 reported that she "is automatically in touch with (Noyce Scholars) after the grant is over and I just know where they teach – I know them. I know who they are – I know where they teach." She further added that "(I view the required tracking) as an opportunity to review (Noyce Scholars' teaching) and look at it from a different perspective and take the bird's eye view and do all kinds of things like that. I view the tracking of Noyce graduates as part of creating this unity and so it actually is not a burden." PI #4 concluded that having high standards and continuous evaluation of a

project was key because “you don’t want to sustain something that’s not really good anyway.”

PI #4 recommended delineating classroom observation post-funding as a best practice, but acknowledged that with limited resources this might not be possible for most PIs. Another PI acknowledged the challenges for PIs in observing Noyce alumni in their classrooms after expiration of funds: (a) Firstly there are a large amount of Noyce alumni (for example, one campus has 400 Noyce alumni). (b) Faculty have finite time and resources and this observation would be unpaid.

Fortunately, Phase II provides funds to “expand and extend the evaluation and research efforts” of Phase I (National Science Foundation, n.d.a, p. 2). Phase II also provides funding to monitor whether scholarship and stipend recipients have completed their teaching requirement and “to measure project outcomes and impact through longitudinal evaluation studies” (National Science Foundation, n.d.a, p. 2). Proposals must include “plans for evaluating the impact of the program on recruitment and retention of teachers, the impact on the institution, and the effectiveness of the Noyce recipients as K-12 teachers” (National Science Foundation, n.d.a, p. 2). However, since Phase II funding is competitive, with not all of those applying receiving funds (Joan Prival, personal communication, April 2, 2013), PIs not receiving Phase II funding (and Phase II-funded PIs whose funding is expiring) must look to alternate funding for continuing evaluation. From my findings possible ways to enact continuing evaluation surfaced: (a) One PI recommended using existing structures that evaluate success (e.g., the accreditation process which looks “at things beyond the credential program”). (b) PI #1 described how her department (natural sciences) had a “self-study year” every seventh

year for program review. As part of this, Noyce was evaluated. In this way, continuing evaluation could occur in the absence of Noyce funding. (c) PIs whose campus had a STEM Center reported that the Center Director and affiliated faculty could help sustain projects by providing continuing evaluation.

One PI suggested that as a cost saving measure, Noyce alumni could digitally record samples of their teaching and forward these to Noyce personnel, saving the time and expense of in-person visits.

Conclusion: For Noyce, the quantitative analysis did not yield evidence that formative assessment and continuing evaluation contribute to sustainability. However, interviews did suggest that formative assessment and continuing evaluation do foster sustainability.

Formative assessment can and should lead to programmatic changes, including changes to the curriculum. Next I describe how PIs are making modifications or additions to the curriculum which will have an impact on the teacher credential program on their campus beyond the term of the Noyce grant.

Emergent factor: The institutionalization of structural program changes.

Beyond the original five identified positive sustainability factors a sixth emerged as part of the findings: the institutionalization of structural program changes. In the surveys and interviews, PIs perceived these changes to occur largely through curricular revisions. Noyce led to curricular changes that are indefinitely permanent and not dependent on Noyce funding. Thus, some Noyce-inspired changes will be sustained (and in fact extended to other students) through permanent courses that would require a determined and formal effort to extinguish.

PI #4 described the profound impact Noyce has had on the campus pre-service program courses, in "both math and education courses." Specifically, on her campus Noyce has led to the incorporation of the Common Core State Standards of math practice early on in the methods courses in the college of education:

> In terms of the math courses for the teaching track we have courses that were designed specifically for the teaching track and a lot of our work in the seminars as we evaluate how (Noyce) Scholars and mentors work on the… Common Core kinds of math. We use that learning to influence the curriculum in our teaching track courses. So something that went really well in highlighting a particular aspect in a seminar we sort of tweak that and bring it into one of these courses.

PI #4 shared that on her campus several faculty teach each course co curriculum changes have an even bigger "ripple effect" that is sustained. Another PI concurred, adding that Noyce activities have "bled over" into other activities on campus – for example "some of the topics from the Noyce seminar series are making their way into the science student teaching seminar series."

PI#1 developed a new course on teaching in high-needs school districts, which is now available for all teacher candidates on her campus. The new course is a seminar for juniors or seniors who are exploring the idea of a teaching credential, or for credential candidates. PI #1 also incorporated informational topics developed in Noyce Scholars professional development seminars into the student teaching seminar offered to all credential candidates. Efficacy was accomplished by inviting faculty not involved in Noyce to the seminar and also by providing faculty with curriculum developed in the seminar for possible inclusion in their courses. Curricular additions were developed in

conjunction with district human resources personnel and partner district personnel. Topics included mock interviews, grant writing, Next Generation Science Standards, and the new Common Core State Standards.

PI #5 described that on his campus the Noyce early field experience was so successful that it had been adopted by the entire university single subject program (i.e., not just in science and math, but the entire single subject program). One PI reported that on her campus a master's in science education was created that was sponsored by Noyce. Lastly, a PI relayed that Noyce funds allowed for the creation of a new online, master's level science course offered through the department of teacher education. PIs predicted that the above curricular changes would be sustained.

Other structural changes mentioned by PIs included (a) changing the job description of a co-director of a STEM Center to include continuing evaluation of Noyce, (b) changing the entire single subject program to include the early field experience model, (c) the introduction of a blended program (i.e., a four-year path for undergraduates to obtain a credential), and (d) the opportunity for research experiences on- or off-campus for all teacher candidates.

In summation, the findings suggested another broad sustainability factor that might apply to projects in general: the institutionalization of structural program changes.

Conclusion: Structural program changes contribute to sustainability of the Noyce project.

Summary

Based on the quantitative analysis, the relative importance of the identified factors in terms of perceived influence on sustainability in the CSU was determined to be (in

order of relative importance) (a) centrality, (b) connected networks of support, and (c) support of campus administration. Surprisingly, the quantitative analysis of the survey found that two of the variables (efficacy; and formative assessment and continuing evaluation) had no influence on sustainability in the CSU. However, interview data moderated this finding, suggesting that these two factors do foster sustainability. Also, beyond the original five identified positive sustainability factors a sixth emerged as part of the findings: the institutionalization of structural program changes.

In conclusion, my mixed-methods analysis found that the same factors that have been found in prior research to promote sustainability of project activities and broader impacts in general higher-education settings were perceived by Noyce PIs as applicable to Noyce projects in the CSU today.

In Chapter 5, recommendations and policy implications related to the findings in Chapter 4 will be presented.

CHAPTER FIVE: DISCUSSION AND CONCLUSIONS

Introduction

This chapter synthesizes and interprets the findings presented in Chapter Four. I will start with a summary of the study followed by a summary of major findings. I will then present implications and recommendations for policy and practice, discussion points, generalizability of findings, recommendations for future research, limitations, and concluding remarks. Throughout, a description of how the findings relate to the literature will be included.

Summary of the Study

Sustainability as it pertains to grant-funded projects refers to the maintaining of project activities and broader impacts after the term of the grant has ended (RAND, 1975a). Private foundations and federal agencies alike hope that successful aspects of funded proposals will sustain. My study focused solely on the factors that fostered the sustainability of the activities and broader impacts of the National Science Foundation (NSF) Robert Noyce Teacher Scholarship among California State University campuses. The Noyce program, which is designed to encourage university students in STEM majors and science and mathematics professionals to train to teach STEM classes in K-12 settings, is of importance since California, like the rest of the nation, has a shortage of skilled science and math teachers (California Council on Science and Technology, 2007).

The following research questions guided this study: *Are the same factors that have been found in prior research to promote sustainability of project activities and broader impacts in general higher-education settings applicable specifically to Noyce projects in the CSU today, and, if so, what is the relative importance of these factors in*

terms of influence on sustainability in the CSU?

My study employed a mixed-methods design. Specifically, I chose an Explanatory Sequential Design, a two-phase model in which quantitative data were first collected and analyzed, followed by collection and analysis of qualitative data. I analyzed data from 30 surveys of CSU Noyce PIs and co-PIs and 6 interviews of CSU Noyce PIs.

Summary of Major Findings

The findings suggest that the same factors that had been found in prior research to promote sustainability of project activities and broader impacts in general higher-education settings are applicable to Noyce projects in the CSU today. In triangulating the data collected from the mixed-methods analysis, I found that there was correlation between sustainability and each of the following factors: centrality; connected networks of support; support of campus administration; efficacy; and formative assessment and continuing evaluation. Based on the quantitative analysis, the relative importance of the identified factors in terms of perceived influence on sustainability in the CSU was determined to be (in order of relative importance) (a) centrality, (b) connected networks of support, and (c) support of campus administration; efficacy, and formative assessment and continuing evaluation both showed essentially zero correlation.

The results of this study create implications for the planning of future Noyce projects at the CSU. Knowing the relative importance of the positive sustainability factors allows PIs to prioritize their efforts accordingly. The planning should begin with choosing a project that aligns with the campus at all levels. Next, in building connected networks of support and support of campus administration, Noyce PIs should target partners with shared missions and who are willing to commit deeply to their project

through sharing of their time and their resources. According to the interviews, training and evaluation are also pivotal to sustainability.

Relative Importance of the Positive Sustainability Factors

The quantitative analysis of the survey found that only three of the five factors (centrality with an R^2 of 26.9%, connected networks of support with an R^2 of 23.7%, and support of campus administration with an R^2 of 9.4%) that had been found in prior research to promote sustainability of project activities and broader impacts in general higher-education settings were applicable to Noyce projects in the CSU today. Two of the factors (efficacy with an R^2 of 0.2%), and formative assessment and continuing evaluation with an R^2 of 0.2%) were found to have no influence on sustainability in the CSU. Possible explanations for this unexpected finding were discussed at length in Chapter Four.

Centrality

According to the survey, centrality emerged as the factor with the most relative importance in this study. As STEM education and STEM teacher education have been deemed a national priority (Business-Higher Education Forum, 2013; Committee on STEM Education National Science and Technology Council, 2013; Thomasian, 2011) it is no surprise that there is a multitude of entities across the private and public sector that share the goal of training an adequate number of highly qualified math and science teachers. As one CSU Noyce PI wrote in the survey response, “Every organization is interested in STEM projects so I believe there will be future support for projects similar to Noyce.” While this is comment is hyperbolic, it is based on the truth that STEM initiatives are high priority for the CSU and for many private and corporate foundations

and state and federal funding initiatives (California State University, 2012; Carnegie Corporation of New York, n.d.; Committee on STEM Education National Science and Technology Council, 2013*).* Noyce also readily accomplishes centrality at the campus level since it is a cross-college initiative necessarily involving faculty from colleges of education, science, engineering and mathematics.

PI #4 pointed to the central tenet of centrality – that finding goals that dovetail with the mission of all project partners creates a "common ground," "a core of the program." This core supports and sustains project activities during implementation and after expiration of funding, and is key also to another sustainability factor: connected networks of support.

Connected Networks of Support

According to the survey and interviews, connected networks of support emerged as a major concern for Noyce PIs, one that appears to have significant influence over whether project activities would continue beyond the end of the Noyce grant.

PIs reported that cross-college participation in Noyce changed the campus culture. As a result of working on Noyce with college of education faculty, STEM faculty became more involved and interested in the recruiting of future teachers, especially into high-needs school districts. Some of these faculty even reported changes in their teaching with more of a focus on active learning and the adapting of course content to the ends of the teacher candidates.

PIs reported an additional layer of support available to CSU PIs that fosters deep relationships – the Chancellor's Office. PIs described strong partnerships the Chancellor's Office has developed with research labs (through STAR and Howard

Hughes Medical Institute), area school districts, private foundations, private industry, federal agencies, and community colleges as beneficial to sustainability.

PIs reported another important network of support was the campus STEM Center. Relationships were strengthened because many Noyce project partners served on the STEM Center advisory board. Often these boards were comprised of deans, provosts, department chairs, community college contacts, industry leaders, and district personnel.

PIs described another important connected network of support: professional Learning Communities (PLCs). PLCs are an important means of communication and lesson plan sharing during a new teacher's first years of teaching (Bobronnikov & Price, 2013; Wang, 2013). Participants have the opportunity to form networks with others teaching in the same discipline and who face similar challenges in teaching math and science in high-needs districts. PLCs "help Noyce Scholars identify long-lasting solutions to strenuous problems" and "avoid repeated discoveries of the same solution through an ineffective trial-and-error approach" (Wang, 2013). PLCs foster the sustainability of the broader impacts of Noyce: "80-90% of new teachers who experienced a comprehensive, long-term induction program stay in the field for at least 5 years" (Business-Higher Education Forum, 2007, p. 16).

Support of Campus Administration

According to the surveys and interviews, support of campus administration emerged as an important influence over whether project activities would continue beyond the end of the Noyce grant. For a project like Noyce to be successful and sustained, support is needed at multiple levels of an organization as complex as a university, specifically the department level, the college level, and the university level.

While campus administration could be viewed as just another connected network of support, in fact administrators serve a role different from other project partners: a gatekeeping function. PIs must receive approval from campus administration to apply for (and implement) Noyce projects. Administrators have the ability to grant release time both during and after a Noyce grant to faculty required to implement project activities or conduct continuing evaluation. Administrators must approve the allocation of time for a campus development officer to work with a PI to solicit continuation funding from private foundations. Administrators approve the funding of a STEM Center and the use of campus space for recruitment and training.

PIs reported that Noyce support of campus administration during the term of the grant took the form of use of campus space to conduct professional development and recruiting seminars, release time, and funding to conduct research and to purchase equipment used by credential candidates to improve their teaching of lab activities. PIs predicted that much of this internal support would continue after expiration of Noyce funds. Some PIs I interviewed reported that post-Noyce funding support from administration included release time for the purpose of continuing evaluation. This continuing evaluation was conducted either by the PI or a director or co-director of a STEM Center.

Efficacy

According to the open-ended questions on the survey and responses of interviewees (but not the closed-form survey questions), efficacy emerged as having influence over whether project activities would continue beyond the end of the Noyce grant. PIs reported that Noyce mentor teachers required training in best practices for

mentoring, the use of educational technology, and project-based learning advocated by the Next Generation Science Standards and the Common Core State Standards. These PIs perceived that training master teachers would lead to sustainability of the broader impacts of the Noyce activities, specifically to better trained teachers and better student outcomes. These PIs shared that trained mentor teachers could better mentor future teacher candidates (both Noyce and non-Noyce) and could better serve their own students with information the mentor teachers learned in their Noyce training. PIs advocated for the training of faculty (including themselves) in grantsmanship to improve the chances of their receiving continuation funding from Noyce or some other federal competition or private foundation.

Limiting the impact of efficacy on Noyce sustainability is the fact that often little of the budget is allocated to training. Unlike many federally funded projects, Noyce requires the majority of the funding to be necessarily allocated to students for scholarships. Noyce is also unlike many other externally funded grants due to the lengthiness of the term of the grant. The term of a Noyce grant is either five years (if Phase I only) or ten years (if Phase II funding is granted). Due to this lengthy term, the chances of personnel turnover greatly increases.

Turnover has a deleterious effect on efficacy and hence sustainability (Scheirer, 2005). PIs reported that efficacy was hampered when there was personnel turnover among mentor teachers or district personnel (who have to approve ongoing Noyce activities at their schools). Another hindrance to sustainability occurred when there was turnover among university faculty (e.g., a PI retiring). Although the professors were replaced, PIs reported that the new members of faculty tended to be not as experienced in

grant writing or lacked the history of prior funding that federal agencies prefer. This was perceived as a detriment when applying for Phase II funding or funding from private foundations. Therefore, efficacy, while still a positive sustainability factor, might have less of an impact on the Noyce project than on other externally funded, non-scholarship programs.

Formative Assessment and Continuing Evaluation

According to the open-ended questions on the survey and responses of interviewees (but not the closed-form survey questions), formative assessment and continuing evaluation emerged as having influence over whether project activities would continue beyond the end of the Noyce grant. In the interviews there was unanimity that formative assessment fostered sustainability. Formative assessment led to programmatic improvements (and as PI #4 pithily stated, "You don't want to sustain something that's not really good anyway"). Concrete sustainability strategies emanated from conclusions drawn from evaluation: (a) Student clubs were viewed as an ongoing source of recruitment. (b) One reason online, professional learning communities (which can be joined asynchronously) were established was because Noyce alumni reported that afterschool professional development sessions conflicted with other responsibilities such as coaching of sports. (c) Across entire CSU teacher credential programs field experiences were introduced earlier (i.e., freshman, sophomore and junior years) so students suitability for the profession of teaching was determined earlier.

Some PIs viewed the required tracking of Noyce Scholars after funding expired to monitor if they were fulfilling their commitment to teach in a high-needs school district as an opportunity to establish whether Scholars had adopted the standards of teaching excellence faculty wished to instill. These PIs conducted continuing evaluation through

classroom observations post-Noyce funding. Noyce goals for STEM teachers are just not quantity (i.e., number of teachers trained), but quality. Noyce is interested in "successful" and "highly effective" teachers, traits listed as goals by the NSF in the Noyce guidelines (National Science Foundation, n.d.a). While the NSF Noyce website does not define "successful" and "highly effective," PIs do. They want to see Noyce alumni (a) taking part in ongoing professional development through attendance in professional learning communities and relevant regional and national conferences, (b) maintaining relationships with research labs on- and off-campus, and (c) instilling a culture of inquiry and experimentation in the classroom. PIs proposed creative ways to fund this longitudinal analysis, including ascribing this responsibility to STEM Center personnel, including classroom observation of Noyce graduates into existing structures such as accreditation review or departmental self-study, or turning to public-private partnerships such as the Business-Higher Education Forum for assistance.

Emergent Factor: The Institutionalization of Structural Program Changes

Beyond the original five identified positive sustainability factors a sixth emerged as part of the findings: the institutionalization of structural program changes. PIs perceived modifications or additions to the curriculum as having an impact on the teacher credential program on their campus beyond the term of the Noyce grant. These changes included the addition of seminars (e.g., teaching in high needs school districts), online courses, and new degrees (e.g., a master's in science education). In summation, these findings suggest another broad sustainability factor (the institutionalization of structural program changes) that might apply to projects in general.

Implications and Recommendations

for Policy and Practice Related to Noyce Projects

The results of this study create implications for the planning of future Noyce projects at the CSU. Knowing the relative importance of the positive sustainability factors allows PIs to prioritize their efforts accordingly. The planning should begin with choosing a project that aligns with the campus at all levels (department, college, and cross-college). Ideally the project will also align with funding priorities at all higher levels (system wide, statewide, and federal). Next, in building connected networks of support, PIs should target partners with a shared mission and who are willing to commit deeply to their project, sharing of their time and their resources. This centrality or consonance of purpose is easily managed since STEM teacher education is currently a priority of campus administration, private foundations, federal agencies, and policy makers. Therefore, a PI, in choosing to apply for Noyce funding, achieves centrality (the factor with the highest ranking of relative importance for sustainability) with no effort at all.

The factor with the second highest ranking of relative importance for sustainability is connected networks of support. Some partners are already in place and will require little effort to develop or maintain an alliance (e.g., professional learning communities, the Western Regional Noyce conference, the national Noyce conference, MSTI, STEM Center, local school districts, etc.). PI #3 described that "certainly sometimes for special projects we don't think we need to develop any deeper of a relationship because we feel like we've been working with this school district for so many years – we think we've got it down." Other partnerships might be recently formed

or nonexistent and thus require more effort on the part of the PI to instill depth and breadth to the partnerships (e.g., STAR, private foundations, private industry sponsors, etc.).

The factor with the third highest ranking of relative importance for sustainability is support of campus administration. Concrete ways in which administrators expressed Noyce support included serving on an advisory board, sharing expertise, providing internal funding (e.g., creation or ongoing support of a STEM Center, release time) and securing of resources (e.g., room space, office space, lab space). Also administrators served on departmental, college, and university curriculum committees. In sum, support of administrators was perceived as critical to sustainability, because they have the ability to "smooth the way" (U.S. Department of Education, 2004, p. 28). Engaging the support of campus administration for Noyce PIs was not difficult given the prominence of STEM teacher education in the national dialogue. However, two PI, in their open-ended responses to the survey, attested to encountering internal campus politics that hindered sustainability. Specifically one reported not being able to link Noyce activities to MSTI activities due to local politics and the other due to the opacity of MSTI on his or her campus. I would recommend that PIs in this situation offer compelling data to campus administrators as to the efficacy of functional linkage support and the successes other campuses have had in linking MSTI and other externally funded projects to Noyce in their efforts to foster sustainability. In terms of the Stages of Change Model (Sharma & Romas, 2012), the offering of compelling data can progress decision makers from *contemplation* (in which an individual is unsure and is weighing pros and cons) to *action* (in which an individual is actively taking steps to implement the change). The compelling

data could be in the form of findings from this dissertation or could come from evidence gathered by CSU Noyce PIs through their formative assessment and continuing evaluation.

According to the interviews, efficacy is important in fostering sustainability. Areas of training for university faculty reported in this study included recruitment techniques, elements of teaching courses online, establishing a professional learning community, and learning the special demands of working with high-needs school districts. Areas of training for mentor teachers included the use of educational technology in the classroom and the requirements of new standards such as Common Core State Standards and Next Generation Science Standards.

That efficacy did not show correlation with sustainability in the quantitative analysis is not surprising for the following reasons: (a) Noyce budgets are required to allocate the majority of funding to student stipends and scholarships. Consequently there is not much funding left for training. Oftentimes project personnel is comprised almost solely of the PI and co-PIs. (b) Project personnel are already highly trained prior to enactment of Noyce. PIs described both university faculty and mentor teachers as highly trained. (c) Some of the training required, such as effective mentoring techniques, is already taught through the colleges of education on CSU campuses so no Noyce funding or input is required.

In the closed-form survey responses, PIs shared their perceptions of formative assessment and continuing evaluation as not having significant influence over whether project activities would continue beyond the end of the Noyce grant. I posit that this perception was not because formative assessment and continuing evaluation are weak

promoters of sustainability, but because of the PIs' experiences in their Phase I grants, which for the most part did not allow for extensive program assessment. So it may not be that formative assessment and continuing evaluation are unimportant to sustainability, but that CSU Noyce Phase I PIs have not had the opportunity to work with extensively these factors.

In summary, based on the interpretation and synthesis of my survey and interview data, my recommendations on how current and future Noyce CSU PIs can best foster sustainability are as follows.

Recommendation #1: Link Noyce activities to other, relevant, on-campus, externally funded projects.

Recommendation #2: Partner with campus STEM Center (if one exists).

Recommendation #3: Develop deep support with project partners.

Recommendation #4: Include relevant student clubs in ongoing STEM teacher recruitment efforts.

Recommendation #5: Approach private foundations and other external funding sources early in the term of the grant.

Recommendation #6: For campuses without a STEM Center, consider advocating to the Dean to consider expanding the campus grant writer job description to include continuing evaluation of Noyce projects. Basic information could be easily gathered and shared with administrators interested in evidence-based decision making. Basic information a grant writer could collect include: *Have new, Noyce-funded courses and programs persisted? Is the early field experience model still succeeding? Do opportunities for research experiences continue to be offered to all teacher candidates?*

Recommendation #7: Enact structural changes in campus and partner organizations.

Discussion

A common perception among PIs surveyed and interviewed was that PIs were so busy implementing a grant they could not focus on sustainability until the end of the term of the grant when expiration of funds was nearing so the topic of sustainability could not be avoided. However, the findings from this study suggest that a savvy PI would be well served to adopt a sustainability strategy at the outset. Some PIs shared that they did just that, working with an external evaluator to include approaches to foster sustainability as part of their yearly report to the NSF. Researchers agree that devising sustainability strategies at the outset is a best practice. Weiss, Coffman, and Bohan-Baker (2002) advocated designating sustainability as a project outcome. Project directors can then "track its progress, and feedback regular information that can be used to ensure sustainability is on course, and if not, to point to opportunities for midcourse corrections" (Weiss, Coffman, & Bohan-Baker, 2002, abstract). In this way evaluation can serve a more vital and deliberate role in project sustainability and PIs can move from a "passive approach to sustainability" to "active attempts to modify conditions to maximize the potential for long-term sustainability" (Shediac-Rizkallah & Bone, 1998, p. 98).

Mancini, Marek, and Brock advise employing more than one sustainability strategy (2009). I posit a two-pronged approach would be efficacious: a PI should begin seeking continuation funding early in the term of the grant, and a PI should seek to enact lasting, structural changes in campus and partner policies, procedures, and practices. This two-pronged approach is advisable as chances for success in obtaining continuation funds are slim. Not all Noyce Phase I recipients receive Phase II funds (Joan Prival, personal

communication, April 2, 2013), and, on average, private foundations fund only 5-10% of submissions and federal agencies just 1% of submissions (Karsh & Fox, 2003).

Approach #1: Seek Continuation Funding Early in the Term of the Grant

A proactive PI can, when initially designing a project, incorporate a sustainability focus by determining at the outset what aspects of the project can and should be sustained. Concurrently this PI should analyze funding trends to assess what other funders are supporting and whether that aligns with the project's focus (Weiss, Coffman, & Bohan-Baker, 2002).

Since dedicating time to write proposals seeking funding can be challenging given their own research agenda or teaching agenda (and their implementing of Noyce), PIs can also look to the campus grant writer who will conduct research into appropriate funding targets or the CSU Chancellor's Office (which has developed close working relationships with potential funders and partners such as Apple, HP, and Google on initiatives related to economic and workforce development).

A PI should work also with the campus development office early in the term of the grant to try to secure alternate (non-Noyce) funding to continue project activities. Results will vary based on existence of a development officer, allocation of the development officer's time to work on the project by campus administration, depth of development officer's relationship with appropriate funders, and commitment of PI in pursuing alternate funding as success usually involves multiple submissions.

PIs should be realistic in their expectations. Continuation funding at Noyce funding levels for scholarships and stipends may not be possible. For instance, some campuses reported continuing scholarships after expiration of Noyce funds using MSTI

funds, but at a funding level much less than the annual Noyce award of $10,000 per student. In conclusion, securing funding to sustain certain Noyce activities (summer research experiences, recruitment and training, etc.) may be feasible, but securing scholarships at the level Noyce provides may not.

Approach #2: Enact Structural Changes in the Campus and Partner Organizations

A method that emerged as a best practice for sustainability is the enacting of structural changes in the campus and partner organization policies, procedures and practices. Structural changes are a lasting legacy that can be built into the teacher credential program. These changes are not dependent on funding so there is no reason to undo them. Once funding expires they are part of the credential program and available to all students.

As mentioned earlier in the chapter, one structural change that can occur on campus is curricular revision. The PIs in this study perceived that structural changes such as curriculum revisions fostered sustainability because these changes are instrumental in holding modifications into place after the grant is over, thereby institutionalizing these new systems. Other structural changes mentioned by PIs included (a) changing the job description of a co-director of a STEM Center to include continuing evaluation of Noyce, (b) changing the entire single subject program to include the early field experience model, (c) the introduction of a blended program (i.e., a four-year path for undergraduates to obtain a credential), and (d) the opportunity for research experiences on- or off-campus for all teacher candidates.

Structural changes can also include changes to the practices on campus. An oft-repeated observation among the PIs in this study was the perception that Noyce changed

the culture of content faculty. Many STEM faculty professed to experience a greater interest in encouraging students to consider teaching as a profession and a greater sensitivity to the needs of high-needs schools. My findings dovetailed with the recent findings of Abt Associates (Bobronnikov & Price, 2013). Hired by the NSF to conduct a national program evaluation of Noyce, Abt found in their preliminary highlights that after receiving a Noyce award "over half of faculty/PI respondents reported increased STEM faculty member engagement in training STEM K–12 teachers" and "about a quarter of STEM faculty respondents reported changes in their teaching due to the Noyce Program (e.g., focus on active learning, adapting course content to needs of [student] teachers)" (Bobronnikov & Price, 2013). These changes to faculty teaching practices will be sustained post-funding.

Next I will extend my recommendations to include practices that can foster sustainability in externally funded projects in institutions of higher education nationwide.

Generalizability of Findings

I posit that some of my findings and recommendations apply to other federally funded projects in the CSU, and externally funded projects in higher education in general. PIs interested in sustaining their projects should certainly seek continuation funding to maintain their projects at their current level or possibly to scale up. Certain federal competitions such as Investing in Innovation (sponsored by U.S. Department of Education) and Innovative Technology Experiences for Students and Teachers (sponsored by the National Science Foundation) provide scale-up funds. These competitions are extremely competitive and require compelling evidence as to the efficacy of a project. Working with internal connected networks of support (the campus

grant writer, development office, and, in the case of CSUs -- the CSU Chancellor's Office) will greatly increase the chances for success.

Noyce PIs benefit from a natural centrality among many funders as STEM teacher education has been deemed a national priority. PIs of other (non-Noyce) projects may struggle to find centrality if their area of interest has not been deemed a national priority or at least an area of interest of a number of large private or corporate foundations. The campus grant writer (or grant writers) and development officers can conduct research to ascertain appropriate funding targets.

PIs of other (non-Noyce) projects can also benefit from the recommendation of seeking to enact structural changes in the policies, procedures, and practices of their campus or their project partners in order to promote sustainability. PIs awarded initial funding are in a good position to advocate for such changes because they can bring resources to the campus and to project partners. A funded researcher can provide tangible benefits in the form of resources (class sets of computers, professional development, etc.) to project partners, as well as the promise of improved teaching and improved student outcomes. For instance, a current California State University, Northridge researcher received state funding ($1 million over three years) to enact professional development for math teachers with the goal of improving algebra pass rates and algebra test scores on standardized tests. The novel approach required daily, collaborative planning among eighth-grade math teachers. A structural change the principal enacted was the shifting of student elective periods so that teachers could have a shared period during which they could collaborate on lesson planning. Once this change was made (and student scores in algebra began dramatically improving) there was no reason to undo it. Without putting

any more money into the system the teachers are still able to meet (even though grant funding has expired). Collaborative lesson planning has become part of their practice, and the structural change of shared planning periods has allowed this to occur. The researcher warned that a future principal might be tempted to undo the change, but could most likely be swayed to keep the shared planning period if presented with strong evidence of the outcomes of the intervention (Dr. Ivan Cheng, personal communication, February 11, 2014)

In conclusion, PIs can (at the outset of a grant when establishing the project design) build in some activities that will make relatively permanent structural changes in the system that are not dependent on continued funding and that will foster sustainability of project activities.

Recommendations for Future Research

This study has contributed to the defining of positive sustainability factors among Noyce-funded projects throughout the CSU. It has also established a relationship between certain of these factors. Future research is needed to establish whether the same factors that have been found to promote project activities and broader impacts of CSU Noyce projects are applicable to Noyce projects nationwide and also to other (non-Noyce) projects.

A future researcher might also conduct a meta-analysis of extant sustainability studies to establish a commonly accepted standard by which to gauge the rates of sustainability for specific activities for specific projects, as this currently does not exist (Rabitoy, 1988). PIs could then have a measure against which to rate the success of their sustainability efforts.

Lastly, a future researcher might avoid the inherent limitations of self-reporting by objectively linking the actual (measurable) sustaining of activities with actual implementation of factors.

Limitations

1. In some cases there are likely to have been more than one response from a campus, particularly since some have as many as two or even three Noyce projects, and that it is not absolutely certain that every campus having a Noyce project was represented.
2. As a result of triangulating the data collected from the mixed-methods analysis, I found that centrality, connected networks of support, support of campus administration, efficacy, and formative assessment and continuing evaluation were all positive sustainability factors. As mentioned, the individual methods found different results -- the statistical analysis of the survey found that there was no correlation between two of the variables (efficacy; and formative assessment and continuing evaluation) and sustainability. However, CSU Noyce PIs interviewed attested to the importance of all five variables, and illuminated possible methodological flaws (such as inadequately phrased questions) that may have led to the finding of a lack correlation of sustainability to two of the independent variables. I gave more credence to the data gathered from the PIs I interviewed. Their perceptions were informed by up to five more years of experience viewing the factors I identified as having a positive effect on sustainability because they are all Phase II awardees (the survey was administered to a combination of Phase I and Phase II awardees). Also the survey was

administered to PIs and co-PIs. I interviewed only PIs. By definition a PI is more intimately responsible and knowledgeable of a project than a co-PI. Therefore I ascribed more relative importance to the perceptions of the PIs than the co-PIs. Lastly, in an interview, I was able to restate and clarify the question for the respondent, thus avoiding the potential misunderstanding of the questions that may have plagued the survey respondents.

3. This should be considered a preliminary study. The data are suggestive, but not entirely conclusive (given the small sample size) of an association between the dependent variable (i.e., perception of sustainability in CSU Noyce projects by PIs) and the independent variables (i.e., the five positive sustainability factors identified in the literature).
4. The study has limited generalizability. Recommendations relate to NSF Noyce projects housed within the CSU. Noyce projects across the country are generally not part of a system of universities like the CSU, which provides the ability to partner with other CSU campuses on Noyce projects, an additional layer of support in the CSU Chancellor's Office, and CSU-specific projects like the Math Science Teacher Initiative (MSTI) to share resources to achieve project goals.
5. CSU Noyce projects of PIs interviewed and surveyed and co-PIs surveyed were in various stages of the term of their Phase I and Phase II five-year grants. As this is a perceptions/self-report study, I have not empirically linked the actual factors in action to actual evidence of sustainability for projects that have not completed the end of their term.

6. Noyce is unlike many federally funded projects in that the majority of the funding is necessarily allocated to students for scholarships. Little is left for the training of project personnel. The majority of the tasks required to implement the project are enacted by the PI. Therefore the PIs in this study could not adequately expound upon efficacy as a sustainability factor as their experience with this factor may be limited.

Concluding Remarks

Funders, policy makers, and researchers report concern about the waste of state and federal dollars, and the loss of the pedagogical advances and student learning outcomes that the project activities were meant to engender, if externally funded projects at institutions of higher education are not sustained. The lack of sustainability is chronic and the addressing of the issue is critical. It is my hope that my recommendations might lead to an increase in the sustainability of Noyce and other (non-Noyce) project activities and broader impacts among CSU campuses and beyond. These recommendations include prioritizing one's efforts in accordance with the relative importance of positive sustainability factors as established in this study, setting sustainability benchmarks throughout the term of the grant and monitoring to see if these are being met, seeking continuation funding early in the term of the grant, linking one's project to other campus initiatives and other externally funded projects on campus, and enacting structural changes to campus and partner policies, procedures, and practices that will last beyond the term of the grant.

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APPENDIX A: SURVEY QUESTIONS

CSU Noyce Sustainability Survey

Please click “yes” below if you agree to participate in this brief survey, or “no” if you choose not to participate.

--Yes I agree to participate in the survey.

--No, I do not wish to participate in the survey.

1 [0]

Please click “yes” below if you agree to participate in this brief survey, or “no” if you choose not to participate.

--Yes I agree to participate in the survey.

--No, I do not wish to participate in the survey.

Please choose only one of the following:

Yes

No

2 [x]

Thank you, goodbye

Only answer this question if the following conditions are met:

° Answer was N 'No' at question '1 [0]' (Please click “yes” below if you agree to participate in this brief survey, or “no” if you choose not to participate.

--Yes I agree to participate in the survey. --No, I do not wish to participate in the survey.)

Please write your answer here:

If you have any comments please leave them here.

Questions regarding the PLANNING phase of your Noyce project

3

In planning for and preparing our initial proposal, we had a sufficient number of meetings with university administration (Department Chair, Dean, Provost) to garner support for our Noyce project.

Please choose only one of the following:

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

4 Our Noyce project was aligned with explicitly stated DEPARTMENTAL priorities.

Please choose only one of the following:

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

5 Our Noyce project was aligned with explicitly stated COLLEGE priorities. *

Please choose only one of the following:

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

6 Our Noyce project was aligned with explicitly stated UNIVERSITY priorities.

Please choose only one of the following:

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

7 Our Noyce project was aligned with explicitly stated CSU SYSTEMWIDE priorities.

Please choose only one of the following:

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

8 In preparing our initial Noyce proposal, we had a sufficient number of meetings with our external partners.

Please choose only one of the following:

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

9 In designing and implementing our Noyce project, we built upon existing initiatives (such as relationships with federal research labs in California, the CSU STAR Program, MSTI, other campus programs, and other grants) to leverage resources and opportunities.

Please choose only one of the following:

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

10 Please name each initiative your Noyce project built upon and describe how your project built upon these initiatives.

Please write your answer here:

Questions regarding the IMPLEMENTATION phase of your Noyce project

11 We provided sufficient training or professional development to university faculty (e.g., workshops on best practices for recruitment, diversity training, etc.) to implement the Noyce project.

Please choose only one of the following:

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

12 During implementation of our Noyce project, we had a sufficient number of meetings with the external partners on the project.

Please choose only one of the following:

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

13 Our Noyce project provided sufficient formal training or professional development to the secondary-level teachers who mentored Noyce Scholars.

Please choose only one of the following:

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

14 During the implementation phase of the Noyce project, we made changes to the project design based on formative assessment.

Please choose only one of the following:

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

15 If changes to the project design were made based on formative assessment, please describe the changes you made. Do you believe these changes will contribute to the sustainability of the project beyond the end of funding? If so, please describe how.

Please write your answer here:

Questions regarding the PERIOD AFTER NOYCE FUNDING EXPIRED

16 Student scholarships for STEM majors and professionals to become STEM teachers will continue on our campus after expiration of Noyce funding.

Please choose only one of the following:

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

Not Applicable as this was never part of our Noyce project design

17 Recruiting math and science majors on our campus into the teaching profession will continue after expiration of Noyce funding.

Please choose only one of the following:

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

Not Applicable as this was never part of our Noyce project design

18 Our campus will continue recruiting math and science career professionals into the STEM teaching profession after expiration of Noyce funding.

Please choose only one of the following:

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

Not Applicable as this was never part of our Noyce project design

19 In-person seminars of mentor teachers, former Noyce Scholars and current Noyce Scholars, university faculty, and district support personnel will continue on our campus after expiration of Noyce funding.

Please choose only one of the following:

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

Not Applicable as this was never part of our Noyce project design

20 Online seminars of our mentor teachers, our former and current Noyce Scholars, our university faculty, and our district support personnel will continue after expiration of Noyce funding. *

Please choose only one of the following:

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

Not Applicable as this was never part of our Noyce project design

21 Early teaching field experiences for freshman and sophomore math and science majors will continue at our campus after expiration of Noyce funding.

Please choose only one of the following:

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

Not Applicable as this was never part of our Noyce project design

22 Our campus will continue helping to organize promotional events at community colleges to attract math and science majors to teaching after expiration of Noyce funding. *

Please choose only one of the following:

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

Not Applicable as this was never part of our Noyce project design

23 Our campus will continue to arrange research experiences at a campus lab or local federal laboratory for teacher candidates after expiration of Noyce funding.

Please choose only one of the following:

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

Not Applicable as this was never part of our Noyce project design

24 My Noyce project built in provisions for assessing or evaluating any of the project activities or broader impacts that continue beyond the end of Noyce funding.

PROJECT ACTIVITIES might include recruiting, professional development, seminars, online support, monthly seminars, etc. BROADER IMPACTS might include changes in pedagogy among faculty members, deeper connections among partners, increased math and science achievement in local K-12 schools, increased access to STEM education and careers among historically underrepresented populations in high-need school districts,

improved teacher preparation, increased involvement of subject matter faculty in teacher preparation, and change in disposition of faculty towards high-need schools.

Please choose only one of the following:

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

Not applicable as not part of my Noyce design

25 Beyond the sustainability of specific project activities, do you believe there have been or will be lasting broader impacts? If so, please describe them.

Please write your answer here:

26 List factors INTERNAL to your campus (such as supportive campus administration, access to equipment, etc.) that you believe CONTRIBUTE (or will contribute) to sustaining Noyce project activities and broader impacts beyond the end of funding. *

Please write your answer here:

27 List factors INTERNAL to your campus (such as resistant faculty colleagues, insufficient resources, etc.) that you believe HINDERED (or that you suspect will hinder) the sustaining of Noyce project activities and broader impacts beyond the end of funding.

Please write your answer here:

28 List factors in your BROADER COMMUNITY ENVIRONMENT (such as an advocate in a school district office, the local congressional office, support from local industry leaders, a partnership with federal research labs, encouragement from the CSU Chancellor's Office, etc.) that CONTRIBUTED or will contribute to sustaining Noyce project activities and broader impacts after the expiration of Noyce funding.

Please write your answer here:

29 List factors in your BROADER COMMUNITY ENVIRONMENT (such as state or federal budget, change in personnel of external partners, etc.) that HINDERED (or you believe will hinder) the sustaining of Noyce project activities and broader impacts beyond expiration of funding.

Please write your answer here:

30 Did your project lead to "systemic" changes, in other words changes that impacted multiple elements of your network of internal and external partners?

(If yes, please describe).

Please write your answer here:

Background information

31 Your role on the Noyce project:

Please choose only one of the following:

Principal Investigator (PI)

Co-Principal Investigator (co-PI)

32 I am a faculty member in the College of ..... (e.g., Education, Engineering, etc.).

(If you are a community partner, please write in COMMUNITY PARTNER).

Please write your answer here:

33 Please list your Department:

(If you a community partner, please write COMMUNITY PARTNER)

Please write your answer here:

34 Are you employed by a community (non-university) partner of the Noyce project?

Please choose only one of the following:

Yes

No

35 How many colleges within your university were involved in your Noyce project design?

Please choose only one of the following:

One college

Two colleges

Three colleges

Four colleges

Five or more colleges

36 How many departments across those colleges were involved in your Noyce project?

Please choose only one of the following:

One department

Two departments

Three departments

Four departments

Five or more departments

37 How many project partners (e.g., community colleges, secondary-level schools, not-for-profits, other CSU campuses, etc.) were external to campus?

Please choose only one of the following:

One partner

Two partners

Three partners

Four partners

Five or more partners

38 Approximately what percentage of your budget was devoted to the evaluation and/or assessment of your project in Phase I?

Please choose only one of the following:

0%

5%

10%

15%

More than 15%

39 Approximately what percentage of your budget was devoted to the evaluation and or assessment of your project in Phase II?

Please choose only one of the following:

0%

5%

10%

15%

More than 15%

Not Applicable as my campus has not received Phase II funding

40 Have you received Phase II funding?

Please choose only one of the following:

Yes

No

41 Have you applied for Phase II funding and been declined?

Please choose only one of the following:

Yes

No

42 Have you applied for Phase II funding and your application is pending?

Please choose only one of the following:

Yes

No

43 If you have not yet applied to Phase II funding, please explain the reasons behind your decision not to apply.

Please choose only one of the following:

Yes

No

44 If you have received Phase II funding, what factors led to your decision to apply for Phase II funding?

What factors do you suspect led to your being awarded that funding?

If you have not received Phase II funding, please type "Not applicable" in the response box.

APPENDIX B: INTERVIEW QUESTIONS

1. When your project's funding comes to an end, what major activities do you envision will continue?

2. You mention (activity). Why do you think this activity will continue? You also talked about (activity). Why do you think this activity will continue?

3. Do you envision an activity, apart from student scholarships, that will not continue? Why do you think this activity will not continue?

4. Did you do anything you would consider "training" for your faculty or mentor teachers as part of your Noyce project? If so, do you expect that this training will have an impact on activities sustaining after expiration of funding?

5. Three months ago I surveyed all CSU Noyce PIs and had two surprising findings. PIs in that survey didn't see any connection between training for faculty and mentor teachers and the ultimate sustainability of Noyce activities after the funding period. This contradicted the literature. Do you have any ideas about why I might have seen this discrepancy?

6. I am defining formative assessment as collecting, analyzing, and using data to make programmatic changes. PIs in my survey also didn't see a connection between formative assessment and the ultimate sustainability of Noyce activities after the funding period. This contradicted the literature. Do you have any ideas about why I might have seen this discrepancy?

7. In your project, did you use the results of formative assessment to improve the project during the funding period? If yes, how?

8. In your project do you expect that formative assessment you are conducting will have an impact on activities sustaining after funding expires?

9. Will you continue to evaluate any of the activities that continue after funding? If yes, do you think this continued evaluation will foster sustainability?

10. Do you foresee that either internal campus politics or external politics might hinder the sustainability of your Noyce project activities? If so do you have any ideas about how to circumvent this?

11. Do you, in your project, take any actions specifically aimed at fostering deep relationships with any of your partners? [after answers] Did any of these actions in fact deepen your relationship with the partner?"

12. If you were to write another Noyce grant or give advice to another PI applying, what would you advise them to build into their planning or do during implementation that would increase the chances of activities being sustained post-funding?

13. Is there anything else you can tell me about your project and its sustainability that I neglected to ask about?

APPENDIX C: EXCERPTS OF CODED TRANSCRIPTS FROM FOUR INTERVIEWEES

Codes	**Transcript**
	INTERVIEWER: Does your campus have a STEM Center?
Connected network of support	**PI #5:** Science and math education center. I'm the executive director. That developed in 1999 as *an offshoot to the CETP (Collaboratives for Teacher Preparation) project funded by NSF. Comment [EJN 1]: THEME: Linking Noyce to other externally funded projects on campus.* It was real important for us to teach in collaboratives for excellence. Excellence in teaching collaboration – or whatever. But that was real important to the NSF national visitors – we tried to sustain as much of that program as possible and so building a center made a lot of sense and that's how that developed. We've had a center now since 1999.
	INTERVIEWER: And does your Noyce project link to any other projects on campus – maybe another federally funded project?
Connected networks of support	**PI #6:** Yes, it's not necessarily a NSF project but *we had a long association with the HHMI (Howard Hughes Medical Institute). I've been involved with that project as well and in our summer research component we have a high school aspect so we have a high school teacher and high school students that come to spend to do research with our faculty for five weeks each. COMMENT [EJN 2]: THEME: Linking Noyce to other externally funded projects on campus.*
	INTERVIEWER: Are you seeking alternate external funding to sustain Noyce project activities after expiration of Noyce funding?
Connected networks of support	**PI #3:** Right. Well that's been the common theme too that basically rather than just waiting until the money runs out maybe *working with the development office starting in year one or year 2 and knowing that the*

funding is sunsetting in 3 years that you would start working on - maybe with private foundations and this sort of thing. COMMENT [EJN 3]: THEME: Working with campus development office early in the term of the Noyce grant to seek alternate funding for when Noyce funding expires.

INTERVIEWER: In your project do you expect that formative assessment you are conducting will have an impact on activities sustaining after funding expires?

PI #4: Absolutely.

INTERVIEWER: So can you talk about that aspect?

PI #4: One of the things I haven't mentioned and I don't know if it comes up in your future questions or not is how has Noyce, if at all, impacted the pre-service program altogether here and that part of it – that formative assessment sort of reflecting on our work in Noyce has for us has affected our pre-service program – both our math courses and our education courses. So once this influenced the program and the program has changed it is obvious sustainability there.

INTERVIEWER: So are you talking about curriculum changes?

PI #4: Yes.

INTERVIEWER: Can you give me two examples so I can add concrete feeling?

PI #4: Well the easiest obvious one is incorporation of the Common Core Standards of math practice early on in the methods courses in the college of ed. In terms of the math courses for the teaching track we have courses that were designed specifically for the teaching track and a lot of our work in the seminars as we evaluate how scholars and mentors work on the math that Common Core kinds of math - we use that learning to influence the curriculum in our teaching track courses. *So something that went well in highlighting a particular aspect in a seminar we sort of tweak that and bring it into one of these courses. In our campus we have several people teaching the courses so that also means that we discuss it and that also means that there is a ripple effect. COMMENT [EJN 4]: THEME: Curricular change as a sustainable activity.*

Formative assessment

(For tally of number of mentions in interview transcripts by theme see Table 6)

Table 6

Tally of Number of Mentions in Interview Transcripts by Theme

Theme	Number of mentions
Linking Noyce to other externally funded projects on campus.	2
Working with campus development office early in the term of the Noyce grant to seek alternate funding for when Noyce funding expires.	1
Curricular change as a sustainable activity.	1