ISEP Interdisciplinary Science and Engineering Partnership

Annual Report to NSF

1. Activities and Findings
2. Management Report
3. Financial Report
4. Evaluator's Report and Partnership Response
5. 2017-2018 Implementation Plan

Interdisciplinary Science and Engineering Partnership (ISEP) with Buffalo Public Schools

Year 6: 2016 – 2017

Section 1: Activities and Findings

Interdisciplinary Science and Engineering Partnership (ISEP) with Buffalo Public Schools

Year 6: 2016 – 2017 No Cost Extension 1

1. Introduction and Summary: Activities and Findings

This Activities and Findings report from the sixth year[1] of the NSF MSP supported expansion of the ISEP program focuses work related to the four research questions being investigated in ISEP.

- What are science teachers' conceptions of interdisciplinary science inquiry? How do their conceptions change through intensive summer research and ongoing professional developments?
- How do science teachers translate interdisciplinary science inquiry experiences and understanding gained in university research laboratories into their classroom inquiry instructional practices, i.e. how do science teachers develop interdisciplinary science inquiry PCK?
- How do professional learning communities (PLC's) support teacher development of interdisciplinary science inquiry PCK?
- What are the processes of STEM students developing understanding of interdisciplinary science inquiry and abilities to communicating science to middle and high school science teachers and students?

As ISEP has developed from a pilot study in 2005-2010, five major activities have been identified as central to the ISEP mission as described in the Strategic Plan:

i. ***School based Wrap Around Support***: the introduction of STEM Ph.D. graduate assistants and undergraduate service learning students to support science, technology, English as a New Language (ENL, formerly English as Second Language (ESL) and special education teachers in twelve schools in the Buffalo City School District (aka Buffalo Public Schools, BPS),

ii. ***Teacher Professional Development***: the development of school based focus areas for STEM education in each school and recruitment and placement of teachers from all twelve schools in summer interdisciplinary research,

iii. ***Professional Learning Communities (PLC***): the development of networks that focus on middle and high school teachers working on content development and alignment across the STEM fields, with special focus on linking feeder middle schools to high schools, inclusion of parents into the PLC, defining the roles and participation of ISEP faculty and graduate students,

iv. ***Research on Teachers and STEM Graduate and Undergraduate Students***: Development, validation and implementation of tools for data collection, collection of baseline data and research into key questions outlined in the 5 year strategic plan and

v. ***Support for summer activities (research/camps) for middle and high school students and support for field trips for students during academic year.***

The reports of activities will focus on the MSP five key features: Partnership Driven, Teacher Quality, Quantity and Diversity, Challenging Courses and Curricula, Evidence-Based Design and Outcomes and Institutional Change and Sustainability.

Separate files are submitted for the Sections 2 through 5, the Management Report, Financial Report, Evaluator's Report and Partnership Response, and Implementation Plan for 2017-2018.

Highlights from the sixth year of the NSF support for ISEP include:

- ***Research results reported in two new papers from a Ph.D. dissertation*** detailed in the research section of this portion of the report (part 5 below).
- ***Support for implementation and dissemination of research based placement of 71 teachers in summer professional development (PD) in 2016***, including 56 teachers in research opportunities, 8 ESL teachers working on translation of STEM curricula, 4 teachers in support roles at schools and 5 teachers in the BSC Course,
- ***application and placement of 7 teachers for summer PD along with 7 other teachers identified and supported by ISEP's ITEST funded project in 2017***

[1] This report represents the results from a first year (Sept 1, 2016- August 31, 2017) no cost extension for the NSF MSP Funding for the program components led by funding supporting activities at the University at Buffalo, Buffalo Public Schools, Buffalo State College, Buffalo Museum of Science and Miami University. A second, six month no cost extension was approved by Dr. David Haury at NSF for Sept 1, 2017-February 28, 2018) which will complete the grant funded programs in ISEP.

- ***development of a focused implementation plan*** and documentation of implementation by consulting with ISEP teachers, resulting in reporting of substantive classroom implementation in academic year 2016-2017,
- ***development of a focused dissemination plan for other teacher in Buffalo Schools with*** completion of a third year of funding awarded for the a BPS/ISEP application to New York State Education Department MSP that brings ISEP work into the academic year PD for all 7/8th science teachers,
- ***implementation of the strategic plan for ISEP sustainability*** following the end of NSF MSP support in a series of grant submissions to supplement and expand ISEP work, including New York State funding, NSF INCLUDES, ITEST, AISL and STEM+C, US Dept of Defense/Office of Naval Research and US Dept. of Education IES and an award as a STEM Ecosystem from the STEM Funders Network of 27 private foundations, building toward integration of ISEP collaboration with higher-ed, corporate partners for STEM PD and support into the BPS budget,
- ***The award from NSF for an application to the ITEST program based on the*** development of a novel GIS Summer teacher and student camp to teach programming and mapping for GIS analysis using smartphones and drones, with year round after school programs and year round career counseling for students.
- ***The continued development of a STEM Ecosystem based Theory of Action for ISEP, with support from the STEM Funders Network STEM Ecosystem national program,***
- ***The further utilization of the STEM/ENL initiative of translated 8th/9th grade Living Environment (NYS Regents Biology course) into languages of importance to Buffalo's growing Immigrant/Refugee population,*** including oral and written translations into Arabic, Burmese, Somali and Nepali. Furthermore, aligned with the NYS standards of learning language through content, ISEP created a Pictionary of tier I and tier II vocabularies.
- ***Development and implementation of a computer science initiative at the middle and high school level that included development of partnerships with small information tech businesses and local start-ups. In particular, ISEP has piloted Thimble.io at Bennett High School with ISEP teacher Pat McQuaid*** with continuous visions to expand the partnership model and materials.
- ***ISEP sponsored public events,*** including the Annual Teacher Poster Presentation on December 13, the Student Science Summit on March 11 (see narrative below in PLC report), school based STEM or Science Nights.
- ***ISEP Videos this year included an invited video for NSTA TV at the 2017 meeting in Los Angeles, created in collaboration with WebsEdge. The link is*** https://www.youtube.com/watch?v=yKs3p-Xwp3Y , ***ISEP was also featured in a video for the University at Buffalo's celebration of student academic excellence in April 2017.***
- ***Pilot and development of STEM Community School Events that are supported by BPS Community School Initiative***
- ***The newer and mobile friendly version of the ISEP website has been created and additional information is being added gradually.*** The ISEP website will has increased materials discussing the specifics of the teacher projects in a user-friendly resolution. But more significantly, a platform of ISEP work has been documented through a shared Google Drive.
- ***award of additional funds from Praxair to expand corporate commitment to ISEP***

The issues that have complicated ISEP progress in year 6 include:

- Due to budget limitations, ISEP was not able to fund many field trips and supplies were purchased on a need-only basis. Many funding requests for supplies which were deemed expensive were denied. This has caused a bit of low morale amongst teachers.
- Leadership and action in Buffalo Schools has been complicated by a Board of Education that is split along racial lines, with some members introducing political and ideological evaluation of BPS leadership. This has complicated ISEP work with schools and partners, often being pitted against NY State Ed School Turnaround initiatives. Some of the tension has been relieved by the removal of one member of the Board. As noted above, the Superintendent and his leadership team has engaged ISEP higher education faculty in planning new high school programs.

- Understanding of ISEP mission, goals and operation has increased throughout the district and principal leadership has made up for some of the political issues. This is reflected in the continuing strength of teacher applications to ISEP for summer PD.

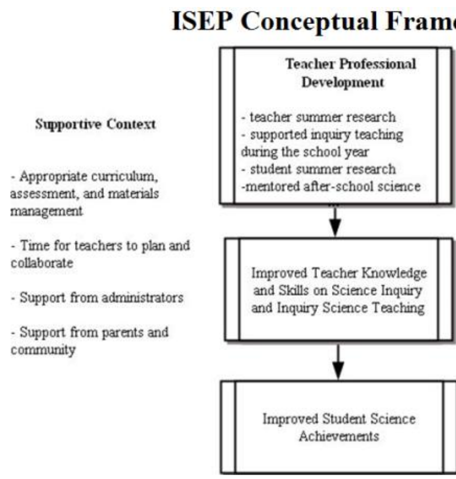
Besides UB's participation in hosting many of the summer research opportunities for teachers, and participation (see Management Report) of Buffalo Public Schools leadership in collaborating on management of the ISEP program, other Core and Supporting partners made significant commitments in the past year that should be highlighted.

- ***Buffalo State College (core partner) report in Appendix 1*** Buffalo State College faculty provided strong support for Ecosystem activities. BSC also provided exceptional collaborative support in the development of a computer science PD initiative, with existing CS collaborations between BSC, UB and the local CSTA chapter creating the environment to propose a specific initiative between CS and Career and Technical Educators (CTE, aka Technology) in BPS (see report, Appendix 1)
- ***Buffalo Museum of Science (core partner) report in Appendix 2*** continued their support for informal science opportunities, summer enrichment, quarterly Family Science Nights, along with the curricular support and after school programs for School 59. Many events are held regularly at the Museum, such as the ISEP Student Science Summit (see PLC report below) and planning to optimize the major exhibitions are complemented by the completed renovation of space to make more hands on workstations for use daily by School 59, which is adjacent/connected to the museum, along with other hosted field trips by ISEP schools. Further BMS Director of Science Learning Karen Wallace has led the submission of an ISEP application to the AISL program in fall, 2015, which was declined. Resubmission is being planned presently.
- ***Praxair Technology Center (Corporate supporting partner)*** hosted three teachers each summer with partial support of the finances in 2016 and 2017.
- ***District Parent Coordinating Council (DPCC, supporting partner), complemented by the Buffalo Parent Teacher Organization (BPTO)*** have come together to form a consistent parent leadership for the district's academic plan and initiatives like ISEP. Following five years of developing parent involvement specific for ISEP, we collaborated directly with parent leadership on events and community school activities.
- ***Over the past six years, a number of service learning students made long term commitments to ISEP schools and classrooms.*** 2017 saw the graduation of four students from UB's Honors College who had represented ISEP in schools for four straight years. These and many other students have consistently utilized their experiences in ISEP service learning as part of their dedication to broader impacts from their education to compete for major scholarships and fellowships. ISEP students have been awarded 2 Marshall Fellowships (Phillip Tucciarone presently a Ph.D. candidate at Oxford in Chemistry and Sean Kaczmarek who completed his MSc Social Policy and Social Research, Institute of Education, University College London on the effects of teacher professional development methods), numerous Fulbright Fellowships, and been finalists and Honorary Mention for Truman Fellowships. The University at Buffalo has an annual award dinner for these students. Each year, Professor Gardella gathers the students who participated in ISEP for a picture, and here is the 2017 picture. Shown from left to right are Walker Gosrich, Matthew Falcone, Hannah Santanam, Prof. Gardella, Sushmita Gelda, Antara Majumdar (Sushmita and Antara both worked for four years at School 31), Jacob Caldwell and Andrew Stewart.

- **ISEP Programmatic Highlights**

  a. Development of an ecosystem based Theory of Action for ISEP

As noted above, the development of an Ecosystem model for describing and documenting the theory of action is underway, using general organizational thought brought by Bronfenbrenner (Bronfenbrenner 1977, 1986, 1994, Gunn, Goelman, 2011) and recent work on an Ecosystem model by Zhao and Frank on technology K-12 education (Zhao, Frank, 2003). Further refinement of the theories supporting STEM Ecosystems have come from recent work by led by the Noyce Foundation (Traphagen, Trail, 2014) and documented by major publications from the National Academies Press (NRC Board on Science Education, 2015, NAS, NAE, IOM, 2016) and by work done by the STEM Funders Network (SFN) (www.stemecoystems.org), of which ISEP is a designated Ecosystem.



The ISEP STEM Ecosystem theory of action, we have added a fourth hypothesis to the first three reported last year as a means to understand the relationship between student

Figure 1.1. a: (left) General descriptive ecosystem model for ISEP adapted from Bronfenbrunner b: (right) ISEP Conceptual Framework

outcomes and the result of work in ISEP:

1. Development of interdisciplinary classroom materials will increase student interest and performance by providing links between science and technology classes, real world applications and college and career opportunities.
2. Teachers' increased understanding of interdisciplinary science results in innovative classroom materials for early engagement in middle school with inquiry based hands on experimental work will sustain student interest in STEM in high school.
3. Parent involvement in STEM curricula and careers will help engage students and support teachers.
4. Classroom and after-school support of students and teachers by STEM Ph.D. students and undergraduate service learning students will promote better engagement and more inquiry based STEM learning for middle and high school students, resulting in higher grades, better scores on standardized tests and more interest in STEM careers.

Mapping these hypotheses into the three dimensional ecosystem models such as shown in Figure 1.1a will involve efforts to define the web of intersections of actions of partners and programs and translate the ISEP conceptual framework (Figure 1.1b) of ISEP into this Theory of Action.

The following is a summary of the published work (see below Part 5 Research). The ISEP Ecosystem model of collaboration from a wide variety of partners (higher education faculty, graduate student and undergraduate service learning students, informal/out of classroom STEM educators at the Buffalo Museum of Science, corporate partners and research organizations) interacting with middle and high school teachers for professional development and middle and high school students in classrooms, after school programs, summer STEM camps and research opportunities has been developed since 2005. Starting in 2011 with the NSF MPS, four key research questions (repeated from page 3 above) were posed:

1. What are STEM teachers' conceptions of interdisciplinary science inquiry and how do they change through professional development?
2. How do STEM teachers translate research experiences into their classroom instructional practices?
3. How do professional learning communities (PLC's) support teacher development in classroom?
4. How do STEM students develop understanding and abilities to communicating science to middle and high school science teachers and students?

Listed in the reference section listing ISEP publications are peer reviewed papers that were published related to questions 1 and 2 (Chi, et. al. 2016, Yang et. al, 2017, Yang, et. al (in press)) along with presentations at national and international conferences . On the issue of STEM graduate students and service learning students peer reviewed papers (Grant, et. al (2015) and Chi, et. al, 2016) and presentations the NARST international conference. Five Ph.D. dissertations were the basis for this work.

A first effort in STEM+C outcomes was reported by Razieh Fathi (ISEP (Ph.D.) Grad Assistant specializing in computer science education and Daniel Hildreth (chemistry teacher at South Park High School, ISEP active teacher for six years). The paper (Fathi, R. & Hildreth, D. (2017)) focused on integrating computational work into a high school chemistry class in a high needs school. The paper describes how a cross-curricular approach can help students reach a deeper understanding of both subjects (chemistry and computer science). A classroom backward design (Wiggins and McTighe's *Understanding by Design)* methodology was used. Using this method, computer-programming concepts were introduced in Mr. Hildreth's high school chemistry classroom using Microsoft Excel.

The most significant recent results (Yang, 2017, Yang (in press) come from the analysis of several thousand surveys as part of the ISEP evaluation program headed by Professor Sarah Woodruff and Yue Li of Miami University of Ohio's Discovery Center. Dr. Yang Yang (Yang, et. al, (in press)) has shown, in his article "Impact of Professional Development on Teacher Knowledge, Practice and Student Understanding of Science in an Interdisciplinary Science and Engineering Partnership", coauthored by Professors Liu and Gardella, that the ISEP professional development model has direct impact on student learning with specific components of teacher followup.

The conclusions show the relationships between Professional Development (PD) and teacher pedagogical content knowledge (PCK) assessment/classroom practice are sensitive to the content and duration of the PD program. Teacher PCK positively correlates with the participation in PD that targets methods of instruction, the effects of which appear after a certain period of time. However, teacher classroom practices in terms of support in science inquiry and attitude/expectation on student work show no relationship with the PD intervention. The significantly increased scores of teacher attitude/expectation on student work during the academic year might be captured by other factors of the PD intervention that have not been discussed in this study. It might take a longer period of time to determine whether the inquiry strategy of instruction is improved or not, and the reasons behind the change. Furthermore, the overall PD hours positively relate to student test scores and a significant increase is found at the point of 150 hours per year, thus it supports the idea that a certain amount of PD is required to show the effects on student achievement. Of course, this conclusion assumes that the PD must be of high quality and is highly relevant to the participating teachers. Moreover, the relationship between PD and student test scores is partially mediated by student understanding of NOS, though how this happens through the mediation of teacher knowledge/practice remains unclear.

This study broadens the knowledge of PD and teacher/student achievement in science teaching and learning. The statistical results of the study provide empirical evidence on the effectiveness of PD programs in terms of coherence and duration. Also, the study sheds light on how the effects of PD could finally benefit student-learning outcomes. According to the results, a certain amount of PD every academic year is needed to positively affect student understanding of interdisciplinary science, as one of the mediation factors is student understanding of NOS. Furthermore, findings of this study can inform science teacher PD programs. First, for any PD program with a well-defined purpose, the duration of PD is essential to the overall effects. Thus, teacher PD programs that are intense and of a short duration, should be viewed with caution. Second, measurements of PD outcomes should be specific, aligned with the purpose, and allow a time period for PD to exhibit effectiveness. For example, assessment of teacher achievement after joining a research project must start with something directly related to the project. Third, the length of PD intervention is found to be effective in improving student understanding of NOS and thereby increasing the understanding of interdisciplinary science. Therefore, teachers are suggested to consistently attend PD programs and incorporate NOS into their lessons.

b. Development of a strategic plan for ISEP sustainability

As reported in the 2015 and 2016 Annual Report, with the help of ISEP Steering Committee Chair UB President Satish Tripathi and ISEP Partners we began implementing a strategy for future support of ISEP (extension and expansion) in late summer 2014. While initially focused on a submission of a new STEM-C Partnership application in 2016 and enhancement of NY State support, the phase-out of the STEM-C Partnership option initiated a more serious conversation with President Tripathi, Buffalo Schools leadership, New York State Education Department leadership and ISEP leadership. With the addition of the SFN funding for the STEM Ecosystem, and following site visits in July 2015 from NSF (David Haury and Rebecca Kruse) and Gerald Solomon from the Samueli Foundation/SFN in May 2016, a more detailed request to New York State has been developed for extension and expansion of the teacher professional development mission to teachers in all 58 Buffalo Public Schools, and a variety of increased after school and out of classroom informal STEM collaborators for support of students.

The longer term goal of sustainability planning is to develop the ISEP model of STEM teacher professional development and wrap around support activities into the budgets of the core (and some supporting) partners. This would lead to a sustainable ISEP program that would be present in ***every school*** in the Buffalo Public Schools and be translated, including a transitional funding plan, to other urban and rural high needs schools. Well-funded suburban schools would be able to support ISEP programs as part of their internal budgets.

In particular, the Buffalo Public Schools, UB, Buffalo State and Museum of Science, as core partners would commit to an ongoing internally funded program following the ISEP model of collaboration. Important corporate partners and research partners would also be engaged as part of the long term sustainable funding of such a program. This approach is founded on the definition of a core partner in NSF Math Science Partnerships, Core Partners agree to Institutional Change as part of Sustainability.

> *"Core partner organizations share responsibility and accountability for the MSP project. Core partner organizations **are required** to identify the institutional change(s) that will occur and provide evidence of their commitment to undergo the institutional change necessary to sustain the work of the partnership beyond the funding period. This is what distinguishes Core Partner organizations from supporting partner organizations."*

Besides institutional changes in practice as a result of the ISEP program, an institutional commitment to building the program into the regular budget of both higher education partners and the Buffalo Public Schools would demonstrate true sustainability and significant institutional change. One of the current Buffalo Public Schools Board of Education members, Larry Quinn, said it best "the long term success of ISEP depends on it being part of the normal BPS budget".

The major component of the sustainability plan is a funding request from UB's President to New York State for substantial multimillion dollar support of a level and timeframe similar to the initial MSP (5 years, $10M). This would continue a base operation for extension of the existing program and expansion over five years to all 58 BPS schools. With ***recently completed*** NY State Ed MSP funding dissemination is underway to all 7/8th grade science teachers and selected special-ed and technology teachers.

The request to New York State funding is guided by the structure of the Buffalo Public Schools budget sources. The Buffalo Public Schools budget is funded primarily by New York State, as one of New York's "Big Five" school districts. The five city school districts with populations over 125,000 people are New York City, Yonkers, Rochester, Syracuse and Buffalo. The cities of the Big Five districts do not collect school taxes or millage funding, they are primarily funded by New York State through direct funding, programmatic grants and other support mechanisms, including pass through of federal Department of Education funding. For the Big 5 Districts, the local City municipal budget is expected to directly support the district budget. For Buffalo, in particular, State support, including pass through funding from federal sources, constitutes 83 percent of the 2015-2016 budget, with the City of Buffalo providing 8.3 percent, Erie County, through sales taxes, supporting 5 percent of the budget. ***Thus, working with New York State for primary funding of ISEP is consistent with the overall approach to sustainability, since NY State would have to approve funding components of BPS budget for ISEP in the longer term.***

Within the first transition step is a complementary approach to the base New York State funding that includes targeted grant applications to NSF, the US Department of Education and private foundations combined with increased emphasis on funding and participation from additional corporate partners. Table 1.1 includes a list of potential NSF, US Department of Education and private foundation funding programs that are being pursued and/or targeted for applications in 2017/2018. Descriptions of innovative present and new ISEP components that would be funded by these programs are also provided. The ITEST application was funded in January 2017. Yellow highlighted rows indicate grant applications that have been submitted and are pending. The orange listing, to the Office of Naval Research, will be submitted in April 2018. Gray areas are those grant applications that were submitted and declined, but will be resubmitted in 2018. The planned work includes monthly organizational meetings in each potential NSF grant listed.

An early point of institutional commitment of UB is the integration of ISEP within a new "Community of Excellence" internally funded interdisciplinary research and education program at UB, in the "Genome, Environment and Microbiome (GEM)". Profs Norma Nowak and Jennifer Surtees have integrated funding for ISEP summer teacher PD and grad student support into the GEM base budget supported by the UB Provost. A second major new Institute, "Research and Education in Energy, Environment and Water" (RENEW) has also been established and ISEP Director Gardella has been conversations with the Director of RENEW about a K-12 component to the outreach and public policy component of the research and education plan.

Table 1.1 Grant Opportunities for ISEP Sustainability in Near Term

Source	Name	ISEP Project Component	Topic of Grant	Potential PIs
New York State	Core Funding for ISEP	Interdisciplinary PD for Teachers, Grad Assistant Support, Wrap Around Services for Teachers and Students	Extension and Expansion of ISEP to broader base of Buffalo Public Schools	Gardella, Liu, Baudo, MacIsaac, Wallace, others as appropriate
National Science Foundation (NSF)	STEM-C	Computer Science and Engineering Teacher Prof. Development	Implementation for middle and transition to high school	Ziarek, Alphonce, Banerjee, ISEP Leadership Team
NSF	INCLUDES Design and Development Pilot Project	Expanded out of classroom opportunities for students, ENL development, Parent involvement and Corporate Partners.	Planning: expansion of ISEP focus to pathways to college and career	Gardella, Karen Wallace, MacIsaac,
NSF	ITEST	GIS Workshop	Geotechnology Experiences for Students and Teachers (GTEST)	Bian, Gardella, Liu, Sodano
NSF	AISL	Informal STEM learning for pre service teachers	Informal STEM education for pre-service teachers	Wallace, Gardella, Lange, Museum
Office of Naval Research	STEM Workforce Development (preproposal)	Support for ISEP at four BPS high schools	Teacher professional development	Gardella
US Department of Education	ISE	ISEP English as New Language/STEM research and implementation	Rapid integration of Immigrant and Refugee ENL students in STEM education	Professor Janina Brutt-Griffler, UB GSE, Gardella
STEM Funders Network (SFN) Funded	STEM Ecosystem	Partnership Development	Aligning STEM Eco-system theory of action to practice	Gardella, Liu, Baudo, MacIsaac, Wallace, Huff
Citizen Schools US2020 Learning Network	National STEM Coalition Challenge	STEM Mentoring	In class support	Gardella, MacIsaac, Wallace, Baudo, Megan, Baudo

2. School Based Wrap-Around Support for Implementation in Year 6

a. Graduate and Service-Learning Undergraduate Students: Recruitment, Placement and Training

In year 6 of the program, support for the number of STEM Ph.D. graduate assistants decreased to 2 full time grad assistants (two semesters) and one half time (one semester) to find a sustainable balance from funding. Each graduate assistant committed to 16-20 hours/week with support from over 70 service learning students, comprised of credit bearing course and internships for undergraduates. The graduate assistants in the schools work with teachers, classes and the principal, and meet at Common Planning time to facilitate all teachers participating in wrap around support, including science, technology, mathematics and special education.

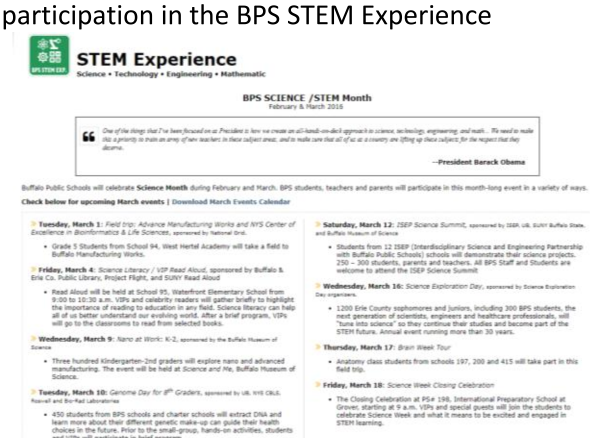
The participation of undergraduates in service-learning continued from UB. This allowed for every school to be staffed in-class and after-school with at up to four students. A list of all participants in classroom and after school is provided in the management plan, Section 2. Additional undergraduates came from the UB Honors College Colloquium service learning programs, where 20 undergraduates, under the direction of a TA who was a former ISEP service learning student each provided 20 hours of service learning support in the schools. Undergraduate students participated in extensive training through the UB service-learning course, which included content on mentoring, K-12 urban education, introduction to the Buffalo Public Schools and other topics. Research studies and evaluation results related to student involvement were significant in guiding preparation for the student work.

b. In-Class and After School programs

With the placement of undergraduate students in schools, new opportunities were developed for in-class and additional after-school programs were developed. After school program support was also offered to teachers who participated in the Buffalo State College course and materials that resulted from the program were presented and displayed at the Annual Science Summit.

c. Informal Science Activities

ISEP continued leadership and participation in the BPS STEM Experience



STEM Experience
Science • Technology • Engineering • Mathematic

BPS SCIENCE /STEM Month
February & March 2016

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.

—President Barack Obama

Buffalo Public Schools will celebrate **Science Month** during February and March. BPS students, teachers and parents will participate in this month-long event in a variety of ways.

Check below for upcoming March events | Download March Events Calendar

Tuesday, March 1: *Field trip: Advance Manufacturing Works and NYS Center of Excellence in Bioinformatics & Life Sciences*, sponsored by National Grid.

- Grade 5 Students from School 94, West Hertel Academy will take a field to Buffalo Manufacturing Works.

Friday, March 4: *Science Literacy / VIP Read Aloud*, sponsored by Buffalo & Erie Co. Public Library, Project Flight, and SUNY Read Aloud

- Read Aloud will be held at School 95, Waterfront Elementary School from 9:00 to 10:30 a.m. VIPs and celebrity readers will gather briefly to highlight the importance of reading to education in any field. Science literacy can help all of us better understand our evolving world. After a brief program, VIPs will go to the classrooms to read from selected books.

Wednesday, March 9: *Nano at Work: K-2*, sponsored by the Buffalo Museum of Science

- Three hundred Kindergarten-2nd graders will explore nano and advanced manufacturing. The event will be held at *Science and Me*, Buffalo Museum of Science.

Tuesday, March 10: *Genome Day for 8th Graders*, sponsored by UB, NYS CBLS, Roswell and Bio-Rad Laboratories

- 450 students from BPS schools and charter schools will extract DNA and learn more about their different genetic make-up can guide their health choices in the future. Prior to the small-group, hands-on activities, students and VIPs will participate in brief program.

Saturday, March 12: *ISEP Science Summit*, sponsored by ISEP, UB, SUNY Buffalo State, and Buffalo Museum of Science

- Students from 12 ISEP (Interdisciplinary Science and Engineering Partnership with Buffalo Public Schools) schools will demonstrate their science projects. 250 – 300 students, parents and teachers. All BPS Staff and Students are welcome to attend the ISEP Science Summit

Wednesday, March 16: *Science Exploration Day*, sponsored by Science Exploration Day organizers.

- 1200 Erie County sophomores and juniors, including 300 BPS students, the next generation of scientists, engineers and healthcare professionals, will "tune into science" so they continue their studies and become part of the STEM future. Annual event running more than 30 years.

Thursday, March 17: *Brain Week Tour*

- Anatomy class students from schools 197, 200 and 415 will take part in this field trip.

Friday, March 18: *Science Week Closing Celebration*

- The Closing Celebration at PS# 198, International Preparatory School at Grover, starting at 9 a.m. VIPs and special guests will join the students to celebrate Science Week and what it means to be excited and engaged in STEM learning.

The STEM Experience was again announced by Mayor Byron Brown of the City of Buffalo at a press conference. ISEP sponsored the Science Summit and Brain Week Tour and was involved in the planning of the other events. In addition, BPS students participated in larger numbers at the annual Science Exploration Day at UB on March 16th, where 25 tours, presentations and lectures attract nearly 1200 middle and high school students, sponsored by UB and NY NSTA chapter (STANYS).

On March 12th, the ISEP organized the 4th Annual ISEP Student Science Summit at core partner Buffalo Museum of Science. Each ISEP school prepared a research team and displayed their projects. This year, the judging ceremony was omitted from the event as several teachers felt that the ceremony was very time consuming in nature. Also, participation was opened to BSC course teachers as well. Nearly 200 people came to the event, including parents, teachers, students and community leadership.

In addition, ISEP partnered with a local not-for profit, HEAL International, for a college open house titled UB 360. The purpose of the event was to expose immigrant and refugee students to STEM careers and available academic options. Approximately 75 BPS immigrant/refugee students were able to participate in a laboratory experience for the first time.

Photos from the event can be accessed here: https://photos.app.goo.gl/UtJVsFKsV5yQTjwL2

d. Pilot of Community School Events at BPS

Community Schools are public schools that emphasize family engagement in addition to strong community partnerships so that it can improve the student learning experience. During the 2016-2017 school year, thirteen Buffalo Public Schools have been designated as community schools for learning events. This was possible because the Buffalo Public Schools have received funding from the Foundation Aid for Community Schools programs.

ISEP has been at the forefront as a community partner and piloted events during the school year. ISEP adopted a learning series model for the pilot and have titled it as "Serious About Science" or SAS.

On March 4th and April 22, ISEP hosted the "Serious About Science" events at South Park High School. Students from the Student Affiliates of the American Chemical Society (SAACS) and UB Chemical Engineering hosted workshops for parents and students to work on together.

In the upcoming year(s), ISEP would like to continue to be a strong partner of the Community Schools Initiative by coordinating STEM workshops hosted by university students.

e. Parent Partnership

Previously, ISEP had a strong partnership with the District Parent Coordinating Council (DPCC). In the 2016-2017 school year, ISEP established a working relationship with the Buffalo Parent Teacher Organization (BPTO).

The BPS Superintendent, Dr. Kriner Cash, appointed Dr. Ramona Reynolds as the Director of the Office of Parent and Family Engagement, and she helped build collaboration in Parent leadership. The structures of the parent groups have become a collective voice by the end of the school year. ISEP staff have participated and observed in individual parent meetings.

In previous years, ISEP Parent Engagement was through independent parent PLC's. Due to the restructuring of district-wide parent engagement as well as the initiation of community schools, ISEP no longer hosts independent meetings. Instead, parents are invited to ISEP working meetings, and ISEP staff is also present at independent parent meetings that discuss a host of topics. This has allowed a free flow of exchange of ideas on multiple levels.

For example, when ISEP leadership meeting to discuss how higher education partners can stimulate workforce development, parents were invited to the table to provide their input. In addition, ISEP is invited at parent meetings to provide input to the dialogue. An example of this is that at both BPTO and DPCC meetings, parents have expressed that they would like to understand the science content more so that they can work with their children. In response, ISEP began piloting (and will continue to host) Serious About Science (SAS) programs during the Saturday Academy as well as "Science for Parents" at the Parent Center.

A true demarcation that ISEP has become a landmark for parents in regards to STEM is when parent leadership from both BPTO and DPCC have contacted ISEP to host the STEM segment during the annual parent summit.

ISEP was able to provide three different experiments in different sessions for approximately 90 parents and children.

Photos from the Parent Summit can be accessed here: https://photos.app.goo.gl/WPlb88Y7CY9XHVfC2

f. Workforce Development

A recurring theme in Buffalo is workforce development. ISEP is part of the continuum of conversations. While we have corporate partnerships with Praxair, we have endeavored to forge relationships with other manufacturers and smaller businesses.

This has lead to ISEP creating conversations with Buffalo Manufacturing Works (with help from our corporate partner Dr. Larry Megan) as well as conversations with the Buffalo Niagara Medical Campus/Innovation Center as well as the Foundry.

To pilot partnerships with small businesses and create a model, ISEP began working with Thimble.io, a small start-up that creates fun electronics that teach robotics and programming. Thimble works with Mr. Pat McQuaid at Bennett High School for the after-school program.

On a more expanded base in 2017, ISEP has introduced Thimble at a community school event with the possibility of creating a ten week program at a Saturday Academy to

g. Further development of a STEM/ENL initiative

ISEP continued the formal teacher PD based STEM/ENL program which enrolled 10 ESL teachers and 2 science teachers in 2014 increased to 14 ENL teachers in 2015 and decreased to 8 ENL teaches in 2016 (see Tables 1.3 and 1.5) working to develop translations of curriculum and pacing guides for $8^{th}/9^{th}$ grade Living Environment (NYS Regents Biology course) into languages of importance to Buffalo's growing Immigrant/Refugee population, including oral and written translation into Arabic, Burmese, Somali and Bhutanese. These translations are found at https://www.joomag.com/en/newsstand/living-environment-translated/M0634930001412743925.

In 2015 and 2016 teachers developed Pictionary type materials and Visual Vocabularies that can support all ENL students regardless of English language proficiency. The purpose of the creation of the ENL Pictionary is to support and complement already completed SIOP (sheltered instruction observation protocol) lesson plans for co-taught Living Environment classes. It introduces, reviews and practices all Tier 1, 2 and some Tier 3 vocabulary words.

Many schools in NYS have adopted the learning language through content focus; thus many classes are co-taught by ESL and content teachers. ISEP was able to provide professional development support for ESL teachers who had limited training in STEM fields but can now work in coordination with their STEM field co-teacher.

The Pictionary type materials are not limited to usage by ESL students; they are also being utilized by students who are native English speakers because both tier I and tier II vocabulary are being presented. The Pictionary can be accessed here:
https://drive.google.com/a/buffalo.edu/file/d/0B0C5Na0culGdcWdEbGtISmFyRUhQdlhBSmJVaE1iNjV3WkpB/view?usp=sharing

In addition to direct STEM vocabulary building and direct translated resources, two of the ESL teachers have hosted STEM diversity workforce workshops at their school so that students are aware of STEM jobs and how to prepare for it.

h.

i. GIS Summer teacher and student camp

ISEP was awarded an ITEST grant in January 2017 to fund a GIS Summer teacher and student camp for three years, including aerial drone mapping and career counseling.

j. Development of an NSF INCLUDES Design and Development Pilot Application

ISEP submitted a preproposal in April 2016 and was selected to submit a full proposal in June of 2016. The proposal was declined, but has become a key portion of planning for potential sustainability of ISEP as a STEM Ecosystem. The program describes planning and potential pilot projects over two years, and focuses on expanding ISEP programs focused on increasing participation of female students and those from under-represented minority groups from Buffalo Public Schools and urban districts in Western New York. ISEP would collaborate and expand with higher education partners Jamestown Community College and SUNY Fredonia, along with the core ISEP Parent Professional Learning Community and Corporate Partners to study three key areas; transition from K-12 to college and career, expansion of informal and out of classroom partners building on connecting informal STEM learning experiences and methods to complement classroom work and focusing on the intersection of ENL activities to STEM learning. Cross cutting focus areas would include corporate participation and expansion of corporate partners and parent participation across all activities. The logic model for the proposed program is given below, in Figure 1.2.

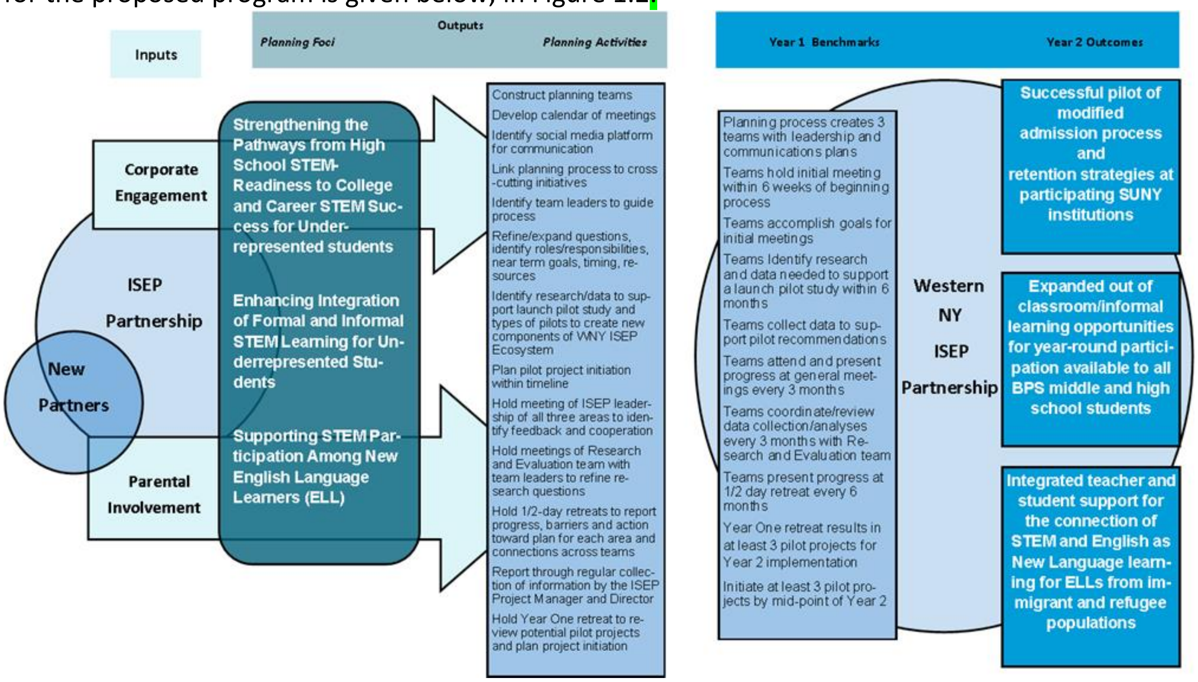


Figure 1.2 Logic Model for Proposed WNY ISEP INCLUDES Design and Development Pilot

k. Summary impact

The continued placement of graduate assistants, undergraduates and corporate partner staffing for wrap-around service support allowed the development of new opportunities and programs in-class and after school. Additional Informal Science activities in the evenings and in collaboration with the Buffalo Museum of Science were also made possible. These outcomes are ***partnership driven*** as UB, Buffalo State, the Museum of Science collaborated in planning with the BPS, as core partners, and supporting partners Praxair and WNY SLC have been engaged in recruitment of participants. Buffalo State faculty members have been engaged in training programs for the mentoring and in-school orientation. The work of these students allows for teacher implementation of ***challenging courses and curricula*** providing a means to overcome the limitations of large class sizes and limited funding to implement laboratory, field, inquiry based experimental work and new class content that aligns across middle and high school. Using ***evidence based design and outcomes*** is the basis for the wrap around support, but extensive research work focused on these students serves as the work of one of the science education graduate assistants, Shaohui Chi and Yang Yang , directed by Professor Xiufeng Liu (Co-PI, head of the research team), the alignment of the ISEP program within other on-campus curricula at UB and Buffalo State, notably for the institutional work to expand service learning along with a serious plan to reach a goal of internal funding commitments from core partners to fund ISEP in the future contributes to both ***institutional change and sustainability.*** Thus, four of the five key features are central to this area of the ISEP program.

3. Summer Teacher Professional Development Year 5, Summer 2016 and Year 6, Summer 2017

a. Interdisciplinary Research Placements and Results for Summer 2016

Table 1.2 shows the assignments, subjects and numbers of teachers summarized for each school for summer 2016. The organization of the teacher placements into these interdisciplinary subject "clusters" continued in 2016. (Table 1.3). Table 1.4 shows the listing of 14 teachers for 2017 with remaining funds.

These outcomes of the development teacher recruitment and placement are ***partnership driven*** as UB, Buffalo State and the BPS leadership collaborated in planning, as core partners, and supporting partners Praxair, Roswell Park Cancer Institute and Hauptman Woodward Research Institute have been engaged in aligning proposed ideas to placements in their laboratories. ISEP teacher professional development is responsive to the key theme of ***Teacher Quality, Quantity and Diversity.*** These major professional development opportunities, as aligned with school based themes may build loyalty and collaboration in the school. Examination of this hypothesis must be evaluated in ISEP. The work of the PD must allow for teacher implementation of ***challenging courses and curricula*** to implement laboratory, field, inquiry based experimental work and new class content that aligns across middle and high school. Using ***evidence based design and outcomes*** is the basis for professional development, but extensive research work focused on this planning is the work of the research team, directed by Professor Xiufeng Liu (coPI). His current work following ISEP teachers is discussed below. Finally, embedding and aligning the research opportunities within other on-campus curricula at UB and Buffalo State, contributes to both ***institutional change and sustainability.*** Thus, all five key features are central to this area of the ISEP program.

Table 1.2: Summary of 2016 teacher summer assignments organized by school.

School Name	Course areas represented	# of Teachers	Type of Participation
K-8 Schools			
Harriet Ross Tubman School 31	7/8th Grade Living Env, Special Ed, Literacy, 4th grade	11	**7 Research placements**, Roswell Cancer Res, Botany, Engineering Design, 2 BSC Course
Charles Drew Sci Magnet School 59	7/8th Grade Living Environment, Element Sci	4	**2 Research Placements**, Cross Cutting Sci/Social Studies, GIS, 3 BSC Course
Lorraine Academy School 72	4th Grade, 7/8th Grade Science and Special Ed	1	**1 Research Placement**, Environmental Sci/Eng
Southside Elementary School 93	4-8th Grade	15	**11 Research placements**, GIS, Computer Science, Curriculum writing support, 2 on ENL Team
Native American Magnet School 19	7/8th Sci, Living Environment, 6th grade Social Studies	3	**2 Research Placements**, Cross Cutting Sci/Social Studies/Native American Studies, 1 on ENL Team
Combined 5-12			
MST Prep School School 197	Eight Grade Sci, Research Living Env, Special Ed, Earth Science, Chemistry	3	**3 Research placements**, Cross Cutting Sci/Social Studies, Genetics, Chemistry/Materials
High Schools			
East High School 307	Living Env, Chemistry Anat/Physio	2	**2 Research Placements**, Computer Science, Molecular Botany
Bennett High School 200	Living Env, Earth Science, Chemistry, Special Ed	8	**8 Research Placements**, Environmental Sci/Eng, Extreme Events, Genomics/Genetics
South Park High School 206	Living Env, Chemistry, Earth Science Special Ed	3	**3 Research Placements**, Cross Cutting Sci/Social Studies Environmental Sci/Eng, Chemistry/Materials
Riverside Institute of Technology School 205	Living Environment, Earth Science, English as New Language, Special Ed.	9	**6 Research Placements**, Environmental Sci/Eng, GIS Genetics/Pharmacology/Toxicology 3 on ENL Team
Burgard High School 301	Earth Science, Welding, ENL	3	**1 Research Placement**, Extreme Events/GIS 2 on ENL Team
Hutchinson Central Technical High School 304	Living Enviroment, Chemistry, Biochemistry, Physics	9	**9 Research Placements** Genomics, Engineering Design, Chemistry/Materials, Computer Sci

Table 1.3 2016 Teacher Research/PLC Placement Summary (71 total) 56 teachers in research, 8 ENL teachers, 4 support teachers 5 teachers in BSC Course (2 teachers in course and research)

Subject Area	Course areas represented	Number of Teachers	UB2020 Strategic Areas and Faculty Departments
Environmental Science and Engineering	Chemistry, Earth Science, Living Environment (Bio), Middle Schools	7	ERIE IGERT, Chemistry, Geology, Geography, Pharmaceutical Sciences
Geographic Information Systems	Living Env, Middle School, Math	6	NCGIA, ERIE IGERT, Geography, Geology, Chemistry
Genomics, Genetics, Molecular Bio, Pharma/Tox	Living Environment, Medical Careers, Middle School	9	GEM: Genomics, Environment & Microbiome Biochemistry, Pharmacology & Toxicology, Roswell Park Cancer Inst.
Molecular Botany	Middle School, Living Environment	6 2[1]	Biology/Ecology
Chemistry/Materials	Chemistry	5	Biosynthesis, Polymer Materials Science, Surface Chemistry
Extreme Events	Earth Science, Welding	4	Extreme Events, Civil, Structural and Environmental Engineering
Computer Science/Engineering	Computer Science, Middle School, Bioinformatics	9	Computer Science and Engineering, Bioinformatics
Engineering Design	Physics, Technology, Engineering	5 2[1]	3 D Printing/Systems Eng, Praxair
Cross Cutting Science and Social Studies	Middle School, Living Environment, Research	5	NCGIA, American Studies
English as New Language Translation	Middle School, Living Environment	8 ENL 3[2]	Grad School of Education, International Students
BSC Course	Physics and Technology education	5	Buffalo State

[1] Number of additional teachers performing specific collaborative work under hourly payments

[2] Number of teachers with dual certification in science and ENL

Table 1.4 2017 Teacher Research/PLC Placement Summary (14 teachers in research)

Subject Area	Course areas represented	Number of Teachers	Strategic Areas and Faculty Departments
Geographic Information Systems (ITEST Funded)	Earth Science, Living Env, Middle School,	7	NCGIA, ERIE IGERT, Geography, Geology, Chemistry
Chemistry/Materials Tissue Engineering	Chemistry	2	Inorganic Materials for Solar Energy, tissue engineering
Engineering Design, Extreme Events	Earth Science, Physics	3	Extreme Events, 3 D Printing/Systems Eng, Praxair
Curriculum Development, NGSS	Middle School	2	Translating to NYS Science Standards (NY Mod of NGSS)

4. Professional Learning Communities (PLC's)

Professional learning communities have been limited during the 2016-2017 academic school year to the following:

a. **Parent/Guardian Based:** focusing on how to actively partner with your child to keep he/she engaged with ISEP and STEM.

The developmental goals of the ISEP Professional Learning Communities (PLCs) include a partnership driven structure designed to foster collaboration between all of the various ISEP partners. Building from the more traditional conceptions of PLCs (DuFour & Eaker, 1998, DuFour, Eaker and DuFour, 2005, Fullan 2001), ISEP has expanded the PLC to include additional participants. The primary role of PLC's has been to cultivate mentoring partnerships between middle and high school teachers, additionally, to include parents and students; UB and BSC STEM and Education faculty; UB and BSC undergraduate and graduate students and volunteer STEM professionals. Thus, a clear understanding of parent involvement and parent participation was considered in PLCs, (along with other areas), following the Epstein models for parent participation (Epstein, 1986, 1987, 2001, 2006).

- **The ISEP Student Science Summit, March 12, 2016:**
  The purpose of the ISEP Science Summit was to provide an opportunity for parents to see how ISEP was being implemented and to showcase ISEP teachers and students research**.** The event provides an excellent opportunity for parents, teachers, doctoral students, BPS students, BPS administrators and other communality members to take pride in and acknowledge the immense amount work and effort the BPS teachers, UB graduate students and BPS students had dedicated to implementation and presentation of inquiry based science. Continuing to build on the work students and teachers had been doing in the classroom and in after school science clubs year's Summit included more student participation as well as further development of research from prior year, resulting in more sophisticated topics and presentations.

  There were approximately 200 attendees at the summit including: ISEP parents, grandparents and siblings; Buffalo Pubic School Administrators and ISEP building principals. Additionally, we invited summer program providers to the Summit to inform parents and students about potential summer STEM based opportunities for ISEP students.

  All the students who participated where awarded certificates of recognition for their participation.

Fourth Annual Interdisciplinary Science and Engineering (ISEP) Science Summit

Harriet Ross Tubman Academy School #31 **Teachers:** Steven Indalecio Courtney Reynolds Angela Hester Linda Beckman	**Extending Plant Life Through Artificial Feeding:** Ti'aca Johnson Jaziyah Lee Makhi Jones Shaun Ulaszko Jalia Collier Joseph Pennyamon **Do Models Help Students Understand Genetics and Cytogenetics?** Zemenawit Berhe Iyanna Lee Quentin Cloud Samuel Moss Mikel Baylor DieuDonne Malisawa

	Zakaria Kashindi Terrell Pennyamon Demaine Carter
Native American Magnet School #19 **Teachers:** Bonnie General-Vasquez Laurie Smith	**Robotics on the roll** Yousifr Oshala Zander Ground Lucius Casillas Abdi Arbao Vera Arnald Sampson John Jordan Ground Zane Ground-Slauger William Domon Kyla Genera Terrilla Marks Yahaira John
Frederick Law Olmsted School #156 **Teachers:** Yianna Russo Dana Pryor-Moncrieffe	**"The Poppinator"** Cameron May Tamina Aktar Forest Lovullo **"The Lemon Light" -** Jeremias Rivera **"Muscle Machine"** Safayath Rafat **Annotation of the Campylobacter jejuni Genome** June Fortner Mi Rasa Wahida Jannat Kayla Harwell **"Science Day" Science initiative Project designed for 5th-8th grade students** Mohammed Milan Mohammed Arfat Chloe Mazur Montaqaa Oheen Aaron Ettestad **Science Day Energy Apparatus Design Challenge:** Christopher Murphy Niles Gonzalez Latavia Thompson
South Park High School #206 **Teacher:** Kathleen Marren	Zachary Grant Dillon Branham Phillip Harris Carmen Jimenez

Math, Science, Technology Preparatory School #197 **Teacher:** Tammy Furman-Schwab	**Effect of environment on banana glucose concentration** **Magnets and Electricity** Dayna Flood Swar Dakein Rubaiya Toni Kean Koloczynski Motasam Bhuiyan
Lovejoy Discovery School #43 **Teachers:** Caitlin Proietto Monica Ross	**Skills for the 21st Century Classroom** Elizabeth Pearce Ariana Marcucci Dylan Marcucci Daniel Schwarz Robert Burton Brian Hoffman Arionna Davis David Bannister Amanda Hall Dillon Sullivan Daeven Burnett Robert Harris Jack Stiglmeier Dominic Lipczynski Angelo Conti Elric Thomas Jose Cruz III
Middle Early College #415 @ Bennett **Teachers:** Gina O'Kussick Jeffrey Walter Angel Moses	**The Power of WiFi Transmission** Mohammad Ali Chris Irakoze **WiFi Reception Degradation** Ibrahim Marlud **The Effect of Impurities on the Freezing of Water: The Deduction Approach** Shamar Cross Tiarra White Tyler Cartwright Ali Ibrahim Alana Wilbon
Emerson School Of Hospitality #302 **Teacher:** Saveria Rosario	**Dark Chocolate VS White Chocolate: Differences in Adhesive Properties:** Skylar Caldarelli Conner Gore Manuel Pagan Tyrese Parker Nashay Tate

e. Moving Forward

5. Research Report

The research team consists of Dr. Xiufeng Liu (team leader), ShaoHui Chi, and Yang Yang (doctoral student research assistants). During this past year, our research focus was continuing analysis of data we collected in previous years related to teacher professional learning communities in schools and teacher ISI pedagogical content knowledge development with its effect on student learning. The following products have been resulted in:

1. Conference Presentation:

Gould, O., Liu, X., Chi, S., & Yang, Y. (April, 2017). *Mutualism: An ethnographic case study on a school's participation in a professional development program in science*. Paper presented at the annual meeting of the American Educational Research Association, San Antonio, Texas.

2. Publications:

Yang, Y., Liu, X., & Gardella, J. (accepted with minor revision). Impact of professional development on teacher knowledge, practice and student understanding of science in an interdisciplinary science and engineering partnership. *Journal of Science Teacher Education.*

Yang, Y., He, P., & Liu, X. (2017). Validation of an instrument for measuring students' understanding of interdisciplinary science in grades 4-8 over multiple semesters: a Rasch measurement study. *International Journal of Mathematics and Science Education.* DOI: 10.1007/s10763-017-9805-7

3. Completed Dissertation

Yang, Y. (July 2017). *Effects of an interdisciplinary science professional development program on teacher pedagogical content knowledge, science inquiry instruction, and student understanding of science crosscutting concepts in twelve public schools: A multi-level modeling study*. Unpublished doctoral dissertation, University at Buffalo, State University of New York.

Major Research Findings

1. Research on school professional learning community

ISEP Project Snow-ball Expansion

The following findings are based on a multi-year ethnography study in one of ISEP schools. The participants in this study were 20 teachers (three males and 17 females) at an Elementary (Pre-K-through grade 8) public school in one of the Northeastern states of the United States. These 20 teachers joined the ISEP project at different times during the period of 5 years when the ISEP project was in progress. Each of the 20 teachers was teaching students on one of the grade levels ranging from grade 4 to grade 8 at the same elementary school. At a later date, two teachers left for personal reasons.

This research found that collaborative endeavors of the teachers' team lead to increase in their students' motivation and interest in learning processes as well as greater engagement of the schoolchildren, their parents, and community in Science-based educational events and activities. For readers' convenience, in this report, ISEP participating teachers will be referred to as *Beginners,* if they have been in the ISEP project for one or two years, and *Veterans,* if they have worked with the ISEP from three to five years.

Differences in perceptions by Beginners and Veterans might be explained by the fact that psychological effect of excitement and novelty might have subsided over time, giving the way to greater self-confidence and feeling accustomed to innovations and on-going changes, which might be perceived less challenging by Veteran participants due to their forming certain habits over duration of the ISEP grant.

We have collected about 184 minutes of teacher-interviews during the final phase in this project. Though the interviews were structured, the researcher often asked interviewees to clarify or further some of their ideas. So, the interviews often turned to be highly engaging professional conversations where teachers felt free to show multiple sides of selves (e.g., educators, researchers, innovators, explorers, caring classroom teachers, and loving parents of their own children).

Though every particular teacher was distinctly unique by his or her nature, type of personality and temperament, many research participants expressed similar ideas. This fact attracted attention of the researcher team: many themes formed saliently traceable patterns.

For example, practically all teachers indicated that five years ago the ISEP partnership project was launched at their school by three enthusiastic educators. These "founding fathers" were the 8th grade Science teacher Rhonda Jackson, the 7th grade Science teacher John Smith, and the school media specialist Lillian Reed (all names used in this report are pseudo names). Rhonda, John, and Lillian joined the grand project hoping to "discover new horizons in teaching," as they approached it. The three had no intention to facilitate spreading this initiative until they understood how beneficial it might be to both: school children and teachers.

Majority of interviewees stated that ISEP team began snowball-growing after the three initial participants started sharing their highly positive impressions about the opportunities this project had to offer to teachers and their students. According to the trio, the schoolteachers might benefit from entering the ISEP project via receiving such opportunities as continuous professional development, funding for extra-curricular activities, professional support from the participating college and university faculty members etc.

The possible outcomes of participation in the ISEP project, as anticipated by the teachers, might include cognitive growth of school faculty members. Enrolling in the project, some teachers expected to acquire knowledge of the newest educational technologies and the latest methods, techniques, and approaches in teaching Science. The others aimed to further develop their researcher skills. While all of them hoped their students would benefit from receiving customized instruction, which would be tailored to suit modern children's quest for technology-based learning. Many teachers realized that, regardless of great value of the information from the traditional school textbooks, reading per se is not sufficient for students as emergent researchers and scientists striving to the college. The teachers understood that what their students needed in order to succeed at school and get prepared for studies in college was up to date research-based information in multiple scientific fields and areas, and development of academic and researchers skills.

Upon receiving highly enthusiastic and encouraging remarks about the ISEP grant from the first three participants, the upper grade teachers decided to join in the team. As the new project appeared to work well with seventh and eighth graders, the growing team of ISEP participants promoted the new methods to the teachers in lower grades. In this way, by the second year of the grant, the team of the sixth grade teachers was welcomed aboard. In the following year, the project spread through all upper grades, starting at grade eight descending to grade five. By the last year of the grant, Ms Rhonda Jackson, the teachers' team project-coordinator, involved the fourth grade team. By that time, the number of ISEP participating teachers reached 20. No one intended to leave the team.

During the interviews, practically every teacher mentioned that the "secret" of ISEP success in their school was directly connected to supportive attitude from the side of school administration. When questioned about the reasons standing behind the successful teamwork within the project, fifth grade teacher Lynn Adams explained, "Our principal is very supportive."

This phrase recurred in practically every interview in response to the question about the relationship between Mary McLaughlin, this school's principal and ISEP participating teachers. The fact that all of the interviewees granted their leader for success of their team, made obvious the role of skillful and thoughtful leadership. It was the type of leadership that did not target nor watch to penalize, but aimed to listen, collaborate, and support. According to the schoolteachers' revelations, this was the weightiest factor.

Other questions for the researchers to ponder and investigate were, "What factors, in addition to high-skilled leadership, contributed to successful team work at Thompson Elementary school? What helped the teachers' collaborative team to stay strongly bound? What factors helped the team avoid possible professional disintegration?"

According to the interview data, another powerful factor that greatly contributed to successful progress of the ISEP project in this particular school was the highly enthusiastic endeavor from the side of Ms Rhonda Jackson, the ISEP school coordinator. Similar ideas were expressed by the teachers in multiple interviews.

Rhonda is wonderful! Oh, Rhonda is fantastic! I mean she is the one that comes to us. She came to me and said, 'Do you want to do this? I ***WANT*** *you to do this! Get your team do this. We really enjoyed doing this.' And Rhonda does a lot of stuff for us. I mean, whatever we need, she gets it for us. (Baker)*

When asked to share her understanding of the nature of friendly and fruitful collaboration between the ISEP-participating team of teachers at this school, the project coordinator shed some light on this issue.
Rhonda Jackson passionately explained,
I don't think there is a teacher at our program that does not honestly believe that, no matter what's going on, we got their back. I mean, in this building, we have all been together for quite a while… We just ***trust*** *in each other. The administration* ***trusts us****. And* ***our parents trust*** *that we know better what is* ***best*** *for their kids. (Jackson)*

The importance of mutual trust between the school community members was clearly noted by Rhonda Jackson. She obviously viewed it as a key-factor to this school team's collaborative success. The fact that this theme recurred and could be heard in many other interviews by this school's teachers confirmed the researchers' guess about the significant role of developing strong professional inter-relationships within a team has the potential to contribute to maintaining good ideological and moral atmosphere in a school community. Just like in a natural symbiotic relationship, where all members do not only co-exist, but cooperate, and collaborate without anyone tending to dominate, over-power, outlive, or leave out the others.

Teachers' Perceptions of Benefits from the ISEP

According to the data from interviews, 91% of Beginners and 86% of Veterans expressed their appreciation of Interdisciplinary Science Inquiry approach. Same numeric ratio (91% against 86%) appears in participants' reflections on the ISEP methods focused on teaching learning skills rather than requesting from students exact answers or the result of their work.
About 84% of all teachers highly appreciated hands-on teaching and learning approach promoted by the ISEP. 73% of Beginners and 86% of Veterans noticed higher motivation and engagement in their students due to technology-based teaching and learning methods they mastered during their Summer Institute studies. For example, Veteran participant John Smith pointed out significance of technology-based instruction to the modern days' students, who he characterized as "digital native."
John Smith shared,
I notice I am more willing to use some modern media. It does not necessarily fascinate me personally. But I can see where it gets the child's attention. Even while it does not suit my personal learning style or teaching style, [laughs] if I can get to the kids, and get to pull across, that part is valuable. (Smith)

Intermediate grades teacher Ms Jane Allen expressed her fascination with the benefits of technology-based learning to students with special needs.

Ms Allen shared,
Watching how they flourish with the program and watching how they interact with code.org, and what they are doing really opened my eyes to. And even some of the low functioning students were really able to grasp it. It made me say, "These students might have harder times with the traditional curriculum in Science." (Allen)

About 64% of Beginners and 43% of Veterans noticed increase in students' interest in learning processes and activities. 64% of Beginners and 86% of Veterans noticed significant benefits to their students' involvement and understanding content of classes after thematic out-of-school educational opportunities, content of which corresponded with the curriculum material taught in class. John Smith who sponsored the Rocket Club as one of the after-school extra-curricular ISEP-based activities, shared his impressions on the role of hands-on real-life learning for students' engagement. As this teacher believed it is very important for students to see the practical results and implementation of the product of their joined work.
This participant explained,

This year, we included an accelerated program with the software, which creates animation, graphic design and that kind of stuff, which is fascinating some of them [students]. We are planning next month or so to get into some of more robotic end of what we are doing. We are just trying to give them a new stepping-stone from the code.org, just learning the basic algorithm principles where they are trying to put it into the product. There is a product on the other end. (Smith)

Nearly 64% of Beginners and 43% of Veterans recognized advantages of students' collaborative teamwork. About 44% of all teachers also noticed increase in self-confidence in their students in response to the ISEP teaching philosophy appropriated by schoolteachers. Susan Bailey pointed out noticeable difference between collaborative experiential and explorative classroom activities versus traditional text-book-based learning.

Ms Bailey explained,
For Science, textbooks have their place. And I think they are useful tools. But in a subject like Science, there are so many things that kids ***can do!*** *I do not just think that this all needs to be textbook driven. (Bailey)*

Due to PD opportunities offered by faculty members from colleges and universities, about 56% of all teachers felt academically and professionally supported, guided, and advised. 64% of Beginners and 43% of Veterans noticed their own professional and cognitive growth and reported the tendency to develop, explore, and implement new ideas of their own. When fourth grade teacher Mr. Steve Hall was questioned in what way his approach to teaching Science changed since he joined the project, this participant directly credited the influence from the ISEP team.

Mr. Hall shared,
It [approach to Science teaching] has changed because it has been in the circle of different professionals that engage in Science in different roles. It brought me to a different circle of people that I was not around before. And when you are in the circle of people who enjoy doing Science, you are engaged in different things and peer learning that I wasn't around before. (Hall)

Among other advantages of the ISEP project, many teachers in both categories mentioned benefits to English as a New Language (ENL) speakers and special education students. Teachers appreciated greater access to new resources and noted lesser dependence on textbooks, due to greater employment of multimodality, including but not limited to technology, whiteboards, visuals, real life experiences, hands-on activities, after-school learning opportunities, and support by graduate project assistant and graduate student assistants.
Teachers recognized multiple factors that contributed to effective progress of the ISEP grant project work at their school. As the major positive factor, 86% of Veterans and 64% of Beginners named long-time clustered supportive and collaborative practices of professional learning community (PLC) at their school, where the faculty members merged into one strongly interconnected entity, in which people trust, respect, and support each other. 82% of Beginners and 71% of Veterans found paired teaching and co-teaching highly beneficial for supporting students' ability to focus on their studies. About 72% of all ISEP teachers found useful their co-planning practices in the form of on-going formal and informal communication.
Large percentage of all teachers recognized significance of skillful leadership of their school administrators and energetic input in the ISEP processes from teacher-project-coordinator. John Smith directly pointed the leading role of the school principal, Mrs. McLaughlin. He shared, "We were one of the first schools. That was because our principal bought in right away…Her commitment and belief in the system allowed us to take a great advantage of the grant in the program."
Many teachers valued support from the graduate project assistant assigned to this school. Among other factors that contributed to successful progress of the ISEP project at this school, teachers named support from university and college faculty members, summer research and co-planning opportunities, availability of new resources from Summer Institute, and financial affordances of the grant. For example, Mr. Hall expressed his

high appreciation of the PD lead by university professors. He shared, “The team, and the professionals, and collaboration was wonderful! It was very interesting and very challenging.”

2. Research on Effects of ISEP on Teachers and Students

Four HLM models were applied to examine the relationships among factors of schools, teachers, and students. First, a two-level HLM was used to analyze relationships between factors at school and student level, then another two models were used to investigate relationships between factors of teachers and students, and between factors of schools and teachers. Finally, a three-level HLM was tested to see the relationships among the factors from all three levels.

Two-level HLM between factors of schools and teachers.

The sample in the analysis included 12 schools and 256 teachers. The fully unconditional model showed that around 9% of teacher PCK variance was between schools, which left 91% variance at the teacher level. The two variables in PD program only explained 7% of teacher level variance. Teachers who attended over half of the PLC sessions per year scored 6.88 percent higher than their peers on average. Two school level factors were added in Model III, though significant, they only explained 3% of the school level variance. Average science class size was negatively related to teacher PCK results, one more student in the class than average resulted in 0.86 percent lower of a teacher’s PCK results (Table 1). While the whole school student-teacher ratio was positively associated with PCK results. Teachers in schools with higher student-teacher ratio seemed to score better. Both Model II and Model III were significant.

Table 1

Results of HLM Analyses Between Schools and Teachers

	Model I	Model II B (s.e.)	Model III B (s.e.)
Teacher level			
Summer placement (SP)		1.25(1.53)	3.28(2.32)
PLC Attendance		6.88*** (1.79)	5.22~(2.66)
School level			
Science class size			-0.86~(0.43)
Student – teacher ratio			2.90*(1.05)
u_0	31.03	31.82	30.54
r	300.75	279.48	251.93
Pseudo R2	0.00	0.07	0.03
Deviance change	0.00	26*** (df = 0)	17** (df = 5)

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, ~ $p < 0.1$

Two-level HLM between factors of schools and students.

Overall, 11 schools and 3293 students involved in the analysis. The fully unconditional model (Table 2, Model I) illustrated a significant variance (9%) between schools ($u_0 = 2636.76$, $p < 0.001$). Among student level predictors (Table 2, Model II), student self-efficacy, understanding of NOS, inquiry activities, and parent expectation were positively related to student understanding of CCs (B = 16.58, $p < 0.1$, B = 23.57, $p < 0.01$, and B = 12.74, $p < 0.1$, and B = 12.62, $p < 0.05$, respectively), when race and grade were held constant. Students with one point higher than the grand mean in self-efficacy/NOS/inquiry activity/parent expectation scored 16.58/23.57/12.74/12.62 points higher in their understanding of CCs on average. Parent assistance in student science work negatively associated with the outcome (B = -12.90, $p < 0.05$). Students with one point higher than the grand mean in parent assistance scored 12.90 points lower in their understanding of CCs on average. The variables explained 12% of variance in outcome at student level. The analysis of deviance change indicated the necessity of Model II. After adding school level predictors of demographics (Table 22, Model III), the coefficients of student level variables kept stable. Among school variables, students in a school of 10% higher of attendance rate than the average scored 57.08 points higher in understanding of CCs, while suspension rate and teacher-student ratio played a negative role. Students in a school of 10% higher in suspension rate and one more student in teacher-student ratio scored 29.06 and 21.92 points lower. The school level variables explained 71% (out of 8%) of school level variance in student understanding of CCs and the model was significant based on the deviance change.

Table 2

Results of HLM Analyses Between Schools and Students

	Model I	Model II B (s.e.)	Model III B (s.e.)
Student level			
Self efficacy		16.58~(7.67)	17.69*(7.54)
NOS		23.57** (5.92)	22.87***(5.42)
Inquiry Activity		12.74~ (6.15)	12.13~(6.40)
Parent Assistance		-12.90* (4.18)	-13.02*(4.39)
Parent Expectation		16.12* (6.32)	17.06*(6.14)
School level			
Attendance rate			57.08***(8.90)
Suspension rate			-29.06*(8.08)
Science class size			-1.25(1.35)
Teacher – student ratio >150			-21.92*(7.58)
u_0	2636.76	2742.97	763.63
r	27461.35	24212.70	24233.56
Pseudo R2	0.00	0.12	0.71
Deviance change	0.00	12546*** (df = 35)	42*** (df = 8)

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, ~ $p < 0.1$

Two-level HLM between factors of teachers and students.

Overall, 85 teachers and 2546 students involved in the analysis. The fully unconditional model (Table 3, Model I) illustrated a significant variance (19%) between teachers ($u_0 = 7100.51$, $p < 0.001$). Among student level predictors (Table 3, Model II), student self-efficacy, understanding of NOS, and parent expectation were positively related to student understanding of CCs (B = 21.98, $p < 0.001$, B = 14.33, $p < 0.1$, and B = 18.90, $p < 0.001$, respectively), when race and grade were held constant. Students with one point higher than the grand mean in self-efficacy/NOS/parent expectation scored 21.98/14.33/18.90 points higher in their understanding of CCs on average; parent assistance in student science work were negatively associated with the outcome (B = -11.81, $p < 0.001$). Students with one point higher than the grand mean in parent assistance scored 11.80 points lower in their understanding of CCs on average. The variables explained 12% of variance in outcome at student level.

After adding school level predictors of demographics (Table 3, Model III), the coefficients of student level variables kept stable. Two teacher level factors were significantly related to student understanding of CCs. Students whose teacher attended over half of the PLC per year seemed to be higher of 22.26 points on average than their peers while students whose teachers participated in 6 weeks summer placement scored 28.05 points higher on average than their peers. The variance at the teacher level was explained for 7%. However, Model II and Model III were all significant.

Table 3

Results of HLM Analyses Between Teachers and Students

	Model I	Model II B (s.e.)	Model III B (s.e.)
Student level			
Self efficacy		21.98***(6.20)	22.10***(6.09)
NOS		14.33~ (7.33)	14.85*(7.30)
Inquiry Activity		5.57 (7.20)	5.36(7.13)
Parent Assistance		-11.81*** (3.25)	-11.61***(3.03)
Parent Expectation		18.90*** (5.22)	18.24***(5.21)
Teacher level			
Science degree			-3.25(11.06)
Teaching experience			8.41(11.06)
PLC			22.26*(8.28)
SP			28.05*(13.66)
PCK			0.17(0.41)
u_0	7100.51	6817.52	6329.46
r	24578.71	21662.91	21696.91
Pseudo R2	0.00	0.12	0.07
Deviance change	0.00	5611*** (df = 32)	39***(df=0)

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, ~ $p < 0.1$

Three-level HLM among factors of schools, teachers, and students.

The results from this model were used to answer research question 2 (or 2 c): what are the relationships, if any, between PD intervention and student understanding of CCs when student, teacher, and school demographics are controlled?

The three-level HLM was built based on the results from previous two-level models and significant variables of research focus were selected from all three levels. Overall, 11 schools, 191 teachers, and 3353 students involved in the analysis. The fully unconditional model (Table 4, Model I) illustrated significant variances of student understanding of CCs among schools (7.5%) and teachers (12.5%), while the other 80% of variance remained in the student level.

In Model II, student understanding of NOS, inquiry activities, and parent expectation were positively related to student understanding of CCs (B = 29.80, $p < 0.001$, and B = 13.52, $p < 0.05$, and B = 18.06, $p < 0.01$, respectively), when race was controlled; whereas parent assistance in student science work was negatively associated with the outcome (B = -12.65, $p < 0.01$). The results were similar as shown in the previous two-level models. The variables explained 9% of variance in outcome at student level. The deviance statistics showed a significant decrease in Chi-square, which indicated the necessity of Model II.

Two variables of PD intervention were added in Model III. Attendance of PLC was not related to student understanding of CCs, but students whose teachers participated in 6 weeks of summer placement scored 47.02 higher than their peers. The variables explained 19% of teacher level variance (19%*12.5% = 2.4%, which was the overall variance of student understanding of CCs explained). Because of the tiny variance explained, Model III did not have a significant deviance change. Model IV included two more school level variables, suspension rate and teacher-student ratio. Both of them were negatively related to student understanding of CCs. When suspension rate was 10% more than the grand mean, the average score was 47.02 points lower. For student-teacher ratio, one more student than the grand mean ratio resulted in 18.19 points lower in the average scores. The two variables explained 79% of variance in school level, and an overall 7% of total variance in student understanding of CCs.

Table 4

Results of 3-level HLM

	Model I	Model II B (s.e.)	Model III B (s.e.)	Model IV B (s.e.)
Student level				
NOS		29.80***(5.44)	30.20***(5.44)	30.49***(5.51)
Inquiry Activity		13.52*(4.98)	13.40*(5.44)	12.60*(4.93)
Parent Assistance		-12.65**(3.63)	-13.09**(3.59)	-13.47**(3.60)
Parent Expectation		18.06**(5.41)	18.00**(5.34)	21.42**(5.12)
Teacher level				
PLC			-0.29 (18.88)	-7.91 (19.25)
SP			47.02~(22.97)	52.88*(22.88)
School level				
Suspension rate				-41.96**(10.61)
Student – teacher ratio				-18.19~(9.77)
u_{00}	2250.53	2065.05	2122.70	475.79
r_0	3762.45	3805.14	3086.75	3062.04
e	24144.19	21920.44	21934.73	21926.82
Pseudo R2	0.00	0.09	0.19	0.79
Deviance change	0.00	11400*** (df = 45)	17 (df = 17)	11** (df = 2)

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, ~ $p < 0.1$

Multi-level path analysis.

The results from this model were used to answer the research question: how does PD intervention finally influence student understanding of CCs through both teacher and student level factors?

Based on the framework proposed and results of HLM analyses, a two-level path analysis was conducted by using M-plus software. The sample contained 198 teachers and 5500 students. Teacher PCK results were not related to student level variables from previous HLM analyses, thus, the variable was excluded from the following analysis, and the corresponding paths in the theoretical model were not shown in the results. Nevertheless, most paths remained the same as they were shown in the theoretical model. Teacher level variables included inquiry instruction, dummy coded summer placement and monthly PLC session, and student level variables included student understanding of NOS, self-efficacy in science, experience in inquiry activities, parent assistance in science work, and parent expectation. The outcome was student understanding of CCs. All control variables that significantly related to the outcomes from previous analyses were not shown in the picture. The full path model with significant coefficients of each path in solid line is shown in Figure 1 and the four non-significant paths are shown in broken lines. The model fit was presented by Chi-square = 126.39 (df = 15, $p < 0.001$), RMSEA = .037, CFI/TLI = .973/.927, and SRMR (within/between) = .036/.071. The indices suggest a great fit between the data and the model according to the criteria proposed in previous literature, in which CFI/TLI should be larger than .900 and RMSEA/SRMR should be smaller than .080.

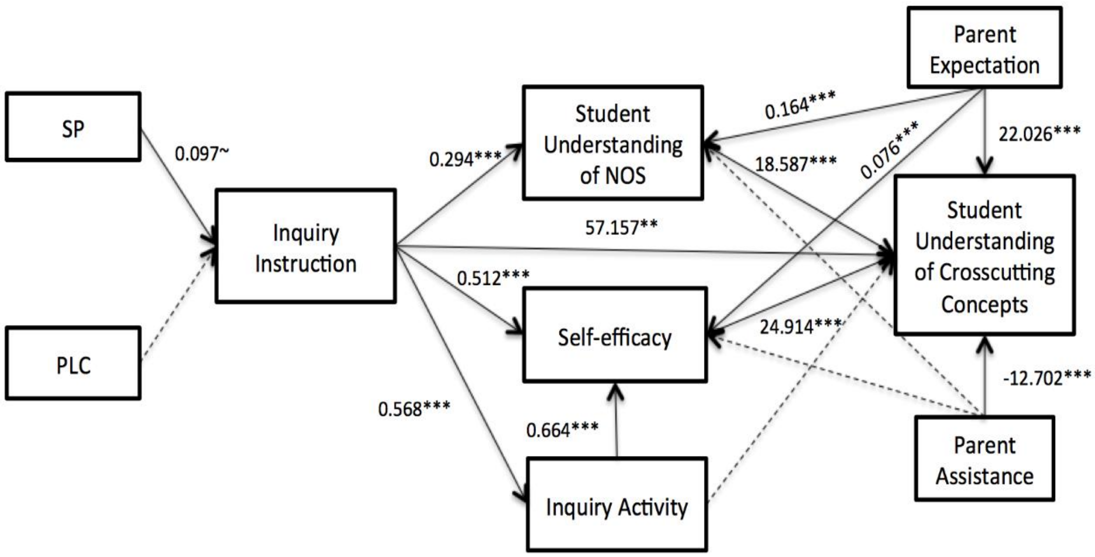


Figure 1. Diagram of full path model with coefficients

The intra-class correlations showed that 15% of variance of student understanding of CCs, 7% of variance of student self-efficacy, 7% of variance of student understanding of NOS, and 8% of student experience in inquiry activity were at teacher level. Furthermore, 6 weeks summer placement had a small effect on scores of inquiry instruction, and then the inquiry instruction positively associated with student understanding of NOS, self-efficacy, and experience in inquiry activities. One point higher in inquiry instruction resulted in 0.29, 0.51, and 0.57 points higher in these three variables, respectively. Furthermore, the relationships between student understanding of Crosscutting Concepts and the background predictors, which included parent expectation, parent assistance in science work, and race, were similar with previous HLM analyses. Inquiry instruction, student understanding of NOS, and self-efficacy in science were directly related to student understanding of CCs, with one point higher in these predictors, the scores increased by 57.16, 18.59, and 24.91 points respectively. No direct effect was found between student experience in inquiry activities and the outcome. However, a few mediation effects could be identified. First, the effect of inquiry instruction on student understanding of CCs could be mediated by student understanding of NOS and self-efficacy. Second, student experience in inquiry activities was also mediated by self-efficacy.

Summary of Results

First, teacher attendance of PLC session was a marginally significant predictor of PCK test scores when science class size and teacher-student ratio were controlled. In other words, participating more PLC sessions helped teacher improved their scores on the PCK test. However, the scores on the PCK test were not related to teacher practice of inquiry instruction in classrooms. Although marginally significant, the 6-week experience in summer research was the only variable related to inquiry teaching of teachers. Adequate experience in authentic science and engineering research helped teachers implement inquiry teaching in classrooms.

Second, attendance rate of the school was positively associate with student understanding of CCs, while suspension rate, and teacher-student ratio of the school were negatively related to student understanding of CCs. It meant that students from schools with low suspension rates, low teacher-to-student ratios, and high attendance rate were likely to achieve higher scores in understanding of CCs. Furthermore, students whose teachers attended PLC session frequently (over half of the sessions per semester) or participated in 6-week summer research scored significantly higher than their peers when teachers' teaching experience and science degree were controlled. Teacher PCK test scores were not related to student understanding of CCs. In addition, the relationship between 6-week research experience and student understanding of CCs remained significant when other school and teacher variables were controlled. At the same time, student self-efficacy, understanding of NOS, experience in inquiry activity, parent expectation, and parent assistance were all significantly related to student understanding of CCs.

Third, the relationships between student understanding of CCs and the variables of teacher and student were revealed as follows: (1) teachers' adequate experience in science and engineering research could help them use more inquiry teaching strategies, which was associated with higher student self-efficacy, understanding of NOS, and better experience of inquiry activities for students; (2) students with higher self-efficacy and deeper understanding of NOS were more likely to achieve higher scores in the understanding of CCs, while the effect of student experience in inquiry activities was fully mediated by student self-efficacy, which meant participating in more inquiry activities helped student build self-efficacy in science learning, and in turn improved their understanding of CCs; (3) parent expectation positively influenced student understanding of CCs, self-efficacy, and student understanding of NOS, while parent assistance seemed to negatively relate to student understanding of CCs only. Therefore, students whose parents held higher expectations for their science learning showed higher self-efficacy, a deeper understanding of NOS, and higher scores in understanding of CCs. The overall effects on the latter variable accumulated. However, parent assistance of science work at home directly and negatively predicted student understanding of CCs, but it did not predict student self-efficacy and understanding of NOS. However, the factor may have potential relationships with other student-level variables, which required further research.

6. References

Ajzen, I. (2002). Perceived behavioural control, self-efficacy, locus of control, and the theory of planned behaviour, *Journal of Applied Social Psychology, 32*, 1-20.

Banchi, H. & Bell, R. (2008). The many levels of inquiry. *Science and Children*, *46*(2), 26-29.

Bronfenbrenner, U. (1977). Toward an Experimental Ecology of Human Development, *American Psychologist, 7, 1977,* 513-31.

Bronfenbrenner, U. (1986). Ecology of the Family as a Context for Human Development: Research Perspectives, *Developmental Psychology, 33(6),* 723-42.

Bronfenbrenner, U. (1994). Ecological Models of Human Development, *International Encyclopedia of Education, Elsevier Sciences, Ltd., Oxford, England, 3, I1643-47.*

Cheuk, T. (2013). *Relationships and Convergences among The Mathematics, Science and ELA Practices. Refined Version of Diagram Created by the Understanding Language Initiative for ELP Standards.* Stanford, CA: Stanford University.

Darling-Hammond, L., & Richardson, N. (2009). Teacher learning: What matters? *Educational Leadership, 66*(5), 46-53.

Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher, 38*, 181-200.

DuFour, Richard, Eaker, R., and DuFour, Rebecca, Editors, (2005) *On Common Ground: The Power of Professional Learning Communities*, Solution Tree, National Educational Services: Bloomington, IN.

Epstein, J. L. (1986), Parents' Reactions to Teacher Practices of Parent Involvement, *The Elementary School Journal,* 86 (3), 277-294.

Epstein, J. L. (1987), Toward a theory of family-school connections: Teacher practices and parent involvement, *Education and Urban Society*, 19 (2), 119-136.

Epstein, J. L. (2001). *School, family, and community partnerships: Preparing educators and improving schools*. Boulder, CO: Westview Press.

Epstein, J. L. & Sanders, M. G. (2006). Prospects for change: Preparing educators for school, family, and community partnerships. *Peabody Journal of Education*, 81(2), 81-120.

Ernest, P. (1988). *The Impact of Beliefs on the Teaching of Mathematics*. Paper was presented as at 6th International Congress of Mathematical Education, Budapest, August

Fullan, M. (2001). *The new meaning of educational change.* New York: Teachers College Press.

Guskey, T. R. (2002). Professional development and teacher change. *Teachers and Teaching: Theory and Practice, 8*(3), 381-391.

Gunn, M. Goelman, H. (2011), Bioecological Theory, Early Child Development and the Validation of the population-Level Early Development Instrument, *Social Indicators Research*, 103 (2), VALIDATION THEORY AND RESEARCH FOR A POPULATION-LEVEL MEASURE OF CHILDREN'S DEVELOPMENT, WELLBEING, AND SCHOOL READINESS , 193-21.

Haney, J. J., Lumpe, A. T., Czernaik, C. M., & Egan, V. (2002). From beliefs to actions: The beliefs and actions of teachers implementing change. *Journal of Science Teacher Education, 13*(3), 171-187.

Hord, S.M. (1997). *Professional learning communities: Communities of continuous inquiry and improvement.* Austin: Southwest Educational Development Laboratory.

Lave, J. (1993). The practice of learning. In S. Chaiklin & J. Lave (Eds.), *Understanding practice: Perspectives on activity and context* (pp. 3-32). Cambridge: Cambridge University Press.
Lederman, N. (1992). Students' and teachers' conceptions of the nature of science: a review of research. *Journal of Research in Science Teaching, 29* (4), 331-359.

Luft, J. A. (2001). Changing inquiry practices and beliefs: The impact of an inquiry-based professional development programme on beginning and experienced secondary science teachers. *International Journal of Science Education, 23*(5). 517-534.

Magnusson, S., Krajcik, J., & Borko, H. (1999). Nature, sources and development of pedagogical content knowledge for science teaching. In J. Gess-Newsome & N. G. Lederman (Eds.), *Examining pedagogical content knowledge: The construct and its implications for science education* (pp. 95–132). Dordrecht, the Netherlands: Kluwer.

Mansour, N. (2009). Science teachers' beliefs and practices: Issues, implications and research agenda. *International Journal of Environmental & Science Education, 4*(1). 25-48.

Maxion, S. P. (1996). *The influence of teachers' beliefs on literacy development for at-risk first grade students*. Paper presented at the annual meeting of the American Association of Colleges for Teacher Education (48th, Chicago, IL, February 21-24).

Nargund-Joshi, V. & Liu, X. (2013). *Understanding in-service teachers' Orientation towards Interdisciplinary Science.* Paper presented at the National Association for Research in Science Teaching. Annual Conference Rio Grande, Puerto Rico. April, 2013.

National Research Council. (1996). *The national science education standards*. Washington, DC: The National Academy Press.

National Research Council. (2000). *Inquiry and the national science education standards: A guide to teaching and learning*. Washington, DC: The National Academy Press.
National Research Council, Board on Science Education. (2015). *Identifying and Supporting Productive STEM Programs in Out- of- School Settings.* Washington, DC: The National Academies Press.

National Academies of Sciences, Engineering, and Medicine. (2016). *Promising Practices for Strengthening the Regional STEM Workforce Development Ecosystem*. Washington, DC: The National Academies Press.

O'Donnell, C. (2008). Defining, conceptualizing, and measuring fidelity of implementation and its relationship to outcomes in K-12 curriculum intervention research. *Review of Educational Research, 78*(1), 33-84.

Powell, K. C., & Kalina, C. J. (2009). Cognitive and social constructivism: Developing tools for an effective classroom. *Education, 130*(3), 241-250.

Shanahan, T., & Shanahan, C. (2012). What is disciplinary literacy and why does it matter? *Top Language Disorders, 32*(1), 7-18.

Stage, E.K., Asturias, H., Cheuk, T., Daro, P.A., and Hampton, S.B. (2013). Opportunities and challenges in next generation standards. *Science, 340*(6130), 276-277.

Stein, M. K., Smith, M. S., & Silver, E. A. (1999). The development of professional developers: Learning to assist teachers in new settings in new ways. *Harvard Educational Review, 69*(3), 237–269DuFour, R., Eaker, R. (1998). *Professional learning communities at work: Best practices for enhancing student Achievement.* Alexandria, VA: Association for Supervision and Curriculum Development.

Traphagen, K. & Traill, S. (2014) Working paper: How cross-section collaborations are advancing STEM learning. *Noyce Foundation*.

Zhao, Y. Frank, K. A. (2003) Factors Affecting Technology Uses in Schools: An Ecological Perspective, *American Educational Research Journal 40(4)*, 807-40.

ISEP Publications

Liu, X. (April, 2013). *Promoting interdisciplinary science teaching and learning in schools*.Paper presented at the annual meeting of the NARST – A Worldwide Association for Promoting Science Teaching and Learning through Research, Río Grande, Puerto Rico.

Gould, O., Liu, X., Chi, S., & Yang, Y. (April, 2017). *Mutualism: An ethnographic case study on a school's participation in a professional development program in science*. Paper presented at the annual meeting of the American Educational Research Association, San Antonio, Texas.

Liu, X., & Fu, L. (April, 2014). *Measuring university students' science communication self-efficacy in middle and high school*. Paper presented at the annual meeting of the NARST – A Worldwide Association for Promoting Science Teaching and Learning through Research, Pittsburgh, PA.

Grant, B., Liu, X., & Gardella, J. A. (2015). Supporting the development of science communication skills in STEM university students: Understanding their learning experiences as they work in middle and high school classrooms. *International Journal of Science Education: Part B,* 5(2), 139–160.

Chi, S., Liu, X., & Gardella, J. A. (2016). Measuring university students' perceived self-efficacy in science communication in middle and high schools. *Universal Journal of Educational Research, 4*(5), 1089-1102.

Chowdhary, B., Liu, X., Yerrick, R., Smith, E., & Grant, B. (2014). Examining science teachers' development of interdisciplinary science inquiry pedagogical knowledge and practices. *Journal of Science Teacher Education, 25*(8), 865-884.

Smith, E., & Liu, X. (April, 2014). *The development of in-service science teachers' pedagogical content knowledge related to interdisciplinary science inquiry*. Paper presented at the annual meeting of the NARST – A Worldwide Association for Promoting Science Teaching and Learning through Research, Pittsburgh, PA.

Eades-Baird, Liu, X., & Chowdhary, B. (April, 2015). *Urban Science Teachers' Beliefs, Perceptions and Implementation of CCSS for ELA/Literacy within Interdisciplinary Science Inquiry*. Paper presented at the annual meeting of the NARST-A Worldwide Organization for Improving Science Teaching and Learning through Research, Chicago, IL.

Smith, E., & Liu, X. (April, 2015). *Interdisciplinary science inquiry within a school-university partnership: Understanding in-service science teacher's interpretation and implementation of interdisciplinary science inquiry as part of their practice.* Paper presented at the annual meeting of the NARST-A Worldwide Organization for Improving Science Teaching and Learning through Research, Chicago, IL.

Smith, E., & Liu, X. (April, 2015). *The Impact of Science Teachers' Orientations on their Understanding and Implementation of Interdisciplinary Science Inquiry*). Paper presented at the annual meeting of the NARST-A Worldwide Organization for Improving Science Teaching and Learning through Research, Chicago, IL.

Chudyk, S. A., Liu, X., Eades-Baird, M., Waight, N., & Yang, Y. (April, 2016). *The implementation of interdisciplinary science inquiry of biology teachers compared to physical science teachers.* Paper presented at the annual meeting of the NARST-A Worldwide Organization for Improving Science Teaching and Learning through Research, Baltimore, MD.

Eades-Baird, M., & Liu, X. (April, 2016). U*rban science teachers' implementation of common core state standards for ELA within the context of interdisciplinary science inquiry.* Paper presented at the annual meeting of the NARST-A Worldwide Organization for Improving Science Teaching and Learning through Research, Baltimore, MD.

Yang, Y., Liu, X., & Eades-Baird, M. (April, 2016). *Effects of an ISEP professional development on teachers' PCK and students' understanding of science*. Paper presented at the annual meeting of the NARST-A Worldwide Organization for Improving Science Teaching and Learning through Research, Baltimore, MD.

Yang, Y., Peng, H., Liu, X., & Eades-Baird, M. (April, 2016). *Validation of an instrument for measuring students' understanding of science in grades 4-8 over multiple semesters: A Rasch measurement study*. Paper presented at the annual meeting of the NARST-A Worldwide Organization for Improving Science Teaching and Learning through Research, Baltimore, MD.

Fathi, R. & Hildreth, D. (2017), "Computational thinking and application – a cross-curricular approach to teach computer science in high school chemistry classrooms", 2017 Proceedings of the EDSIG Conference, Austin, TX ISSN: 2473-3857 v3 n4357, weblink: proc.iscap.info/2017/pdf/4357.pdf.

Yang, Y., He, P., & Liu, X. (2017). Validation of an instrument for measuring students' understanding of interdisciplinary science in grades 4-8 over multiple semesters: a Rasch measurement study. *International Journal of Mathematics and Science Education.* DOI: 10.1007/s10763-017-9805-7

Yang, Y., Liu, X., & Gardella, J.A., Jr. (in press). Impact of professional development on teacher knowledge, practice and student understanding of science in an interdisciplinary science and engineering partnership. *Journal of Science Teacher Education*.

Unpublished Doctoral Dissertations

Chowdhary, B. (May, 2015). *Reflective pedagogical practices in an era of standards based reform: What do teachers do? An examination of science teachers' communities and their contribution to the facilitation of professional growth through authentic reflection*. Unpublished Doctoral of Philosophy dissertation, University at Buffalo.

Eades-Baird, M. (May, 2015). *Exploring urban science teachers' beliefs, perceptions and implementation of common core state standards for ELA within the context of interdisciplinary science inquiry: A mixed methods study*. Unpublished Doctoral of Philosophy dissertation, University at Buffalo.

Grant, B. (May, 2014). *Building capacity within a school-university partnership: An exploration into the perspectives, experiences, and approaches of various stakeholders*. Unpublished Doctoral of Philosophy dissertation, University at Buffalo.

Smith, E. (Aug., 2014). *The development of in-service science teachers' pedagogical content knowledge related to interdisciplinary science inquiry*. Unpublished Doctoral of Philosophy dissertation, University at Buffalo.

Yang, Y. (July 2017). *Effects of an interdisciplinary science professional development program on teacher pedagogical content knowledge, science inquiry instruction, and student understanding of science crosscutting concepts in twelve public schools: A multi-level modeling study*. Unpublished doctoral dissertation, University at Buffalo, State University of New York.

Part 1, Activities and Findings, Appendix 1 ISEP activity at SUNY Buffalo State College 9/1/16 and 8/31/17

Funding related activity:
- New proposals: Noyce S&S in July 2017; INCLUDES May 2017
- Attended STEM Ecosystems Community of Practice in Denver CO 10/17-17/2016 (only person from BSC) and Tampa FL 5/24-25/2017 with Joe Zawicki (2 BSC ISEP participants)
- Presented to NYS Legislative Delegation requesting state funded instantiation of ISEP activity on March 10th.

Follow-up stipends to ISEP teachers from Summer 2016 course for enacting STEM projects in their classrooms: $3,000 of follow up honoraria to 13 Buffalo Public Schools STEM teachers

MacIsaac participated in ISEP YouTube video presented at NSTA; also contributed $4,000 to supporting that video from BSC subaward funds

Buffalo State Physics undergraduates Chrissy Colson and Ariadne Salerno volunteered to assist with S.Finn at PS59/Drew Science Magnet School for 2 afterschool science clubs: Solar Cars and Sea Perch tele-operated submarine in Spring 2017. BSC African American undergraduate engineering student Keziya Raleigh was also hired to help with ISEP activities including the I*SEP Annual Poster Fair, Science Summit and WNY Physics Olympics.*

Judged / participated in / coordinated BSC contributions to *ISEP Annual Poster Presentation Fair* 13 December 2016 @ Bennett HS. Working in teams, all teachers participating in the ISEP summer 2016 course PHY596 had posters presented at the Summit, and described recently initiated STEM innovations from their schools that were proposed during the summer course. Students did not attend this event. BSC did final layout and printing of these posters, including duplicate copies to all members of teachers teams.

Judged / participated in / coordinated BSC contributions to *ISEP Science Summit* in March 2017 at Buffalo Museum of Science. All teachers participating in the ISEP summer 2016 course PHY596 presented posters at the Summit, and *several teachers brought teams of students* presenting examples of student STEM project work from their schools that were proposed and developed during the summer course and enacted in the 2016-7 school year (Eg Y Russo Science club, etc).

Loaned various physics demonstration equipment (Bell Jar and vacuum pump, Van deGraaff generator) and purchased STEM teaching supplies (whiteboards and markers; solar car kits, SONAR rangers, carts and tracks and probeware) for BPS teachers.

Worked with Brad Gearhart on his ISEP HS physics Shadowgraph project and physics students making learning video project throughout year. This work was presented at multiple venues, including local, state and national (GA 2/17) AAPT meetings, Master Teachers workshops etc. We are still working on one publication on each project for *The Physics Teacher*. Appended find a list of presentations.

Participated in BPS/SUNY STEM Read Aloud week with Buffalo Public Library in March 2017.

Funded Mr Russel J. Lis for a Botanical Identification and Instructional walk-around for the camp staff of Cradle Beach Camp in Summer 2016. In Oct 2016, we also paid $3,300 for CB Camp Scholarships in summer 2016.

Presented on physics of magnets and simple machines for the BPS Superintendant's Professional Development days for Middle School STEM teachers on Nov 16th; ISEP also supplied classroom sets of magnets for teachers attending this event.

Part 1, Activities and Findings, Appendix 2 ISEP activity at Buffalo Museum of Science 9/1/16 and 8/31/17

A sixth year subcontract was negotiated to fund activities at the Buffalo Museum of Science, a core partner.

The Buffalo Museum of Science, provided support to the Charles R. Drew Science Magnet School through classroom team teaching and differentiated learning for students for all grades, pre-k through eight. Weekly afterschool programming supported sixth and seventh grade students from January 2016 through May 2015 culminating with participation in the regional Solar Sprint Competition. Two teams entered their designed and built solar cars this year. They were the only Buffalo Public Schools entered in the competition that was hosted at the Buffalo Museum of Science. Summer Enrichment Scholarships to the Museum's weekly Discovery Camps was offered to over thirty students from #59 and #50 Annex..

Wrap around support was also offered to the Parent Professional Learning Community through 30 free Museum family memberships to the participating parents from all the ISEP schools. For the fourth year the Museum played host to the annual ISEP Student Summit in March, 2016. The Museum supports the Teacher Professional Development PLC hosting the monthly workshops and presenting informal science best practices.

EXHIBIT 1: IMPLEMENTATION MATRIX

Goal 1: Improve middle school science teachers' knowledge and skills related to science inquiry through interdisciplinary science research and engineering design with university STEM faculty								
(a)	(b)	(c)	(d)					(e)
Objective	**Activity**	**MSP Key Feature**	**Progress to date (check one)**					**Brief Explanation of Progress**
			Activity carried out as planned	Activity delayed	Activity revised	Activity eliminated	New activity substituted	
Objective 1: To enhance science teachers' ability to demonstrate advanced knowledge and skills in conducting scientific research and engineering design	Activity 1a: Introduction of STEM Ph.D. graduate assistants and undergraduate service learning students to support science, technology and special education teachers in 12 participating BPS schools	• Partnership Driven • Teacher Quality, Quantity & Diversity • Challenging Courses & Curricula • Evidence-based design & Outcomes • Institutional Change & Sustainability	✓					
Improve understanding of science and science inquiry teaching.	Activity 1b: All participating schools establish in-class and afterschool programs and informal science activities	• Partnership Driven • Teacher Quality, Quantity & Diversity • Challenging Courses & Curricula • Evidence-based design & Outcomes • Institutional Change & Sustainability	✓					All schools established either after-school programs or informal science activities including Science Fun Nights and /or Science –based field trips including trips to UB labs, Tifft Nature Farm and the Buffalo Science Museum. All Schools participated in ISEP Student Science Summit

	Activity 1c: Teacher Professional Development: engage teachers in interdisciplinary science research and engineering design with University STEM faculty	• Partnership Driven • Teacher Quality, Quantity & Diversity • Challenging Courses & Curricula • Evidence-based design & Outcomes • Institutional Change & Sustainability			✓			
	Activity 1d: Monthly pedagogical professional learning community meetings with a focus on implementing interdisciplinary science inquiry teaching and learning		✓					
	Activity 1e: External project evaluators administered and analyzed the ISEP Teacher Pre- and Post-Questionnaire to collect demographic, perception data, assess teachers' knowledge and skills in conducting inquiry in science & engineering		✓					

Goal 2: Increase science teacher quantity, quality, diversity, and retention in urban schools.									
Objective 2: Increase the total number of highly-qualified science teachers teaching in the participating schools; hence the diversity of the science teacher population will increase, as well as increased retention for participating science teachers in their urban teaching positions.	Activity 2a: School based Wrap Around Support: the introduction of STEM Ph.D. graduate assistants and undergraduate service learning students to support science, technology and special education teachers in twelve schools in the Buffalo City School District	• Partnership Driven, • Teacher Quality, Quantity & Diversity • Challenging Courses & Curricula • Evidence-Based Design & Outcomes • Institutional Change & Sustainability	✓						

Engage teachers (with a focus on beginning and under-represented teachers) in professional development offerings. Provide support and resources in and after school. Engage teachers in PLC’s.	Activity 2b: Teacher Professional Development: development of school based focus areas for STEM education in each school, and recruitment and placement of teachers from all twelve schools in summer interdisciplinary research. Activity 2c: Providing teachers with interdisciplinary science inquiry pedagogical support through monthly professional development workshops	• Partnership Driven, • Teacher Quality, Quantity & Diversity • Challenging Courses & Curricula • Evidence-Based Design & Outcomes • Institutional Change & Sustainability • Partnership Driven • Teacher Quality, Quantity & Diversity • Challenging Courses & Curricula • Evidence-based design & Outcomes	✓ ✓					

	Activity 2c: PLC's: Participating teachers will form and sustain professional learning communities with other teachers in their school and district. Utilizing mentoring models with help from university STEM faculty and graduate students; participants will utilize social media, blogs and hold regularly scheduled face to face meetings. Activity 2e: External project evaluators collected and compared baseline. Year 1 and Year 2 teacher, student, and school demographic data	• Partnership Driven, • Teacher Quality, Quantity & Diversity • Challenging Courses & Curricula • Evidence-Based Design & Outcomes • Institutional Change & Sustainability	✓ ✓					Teacher based PLC continued throughout 2014-15 school year. The PLC's focused on ISI and pedagogical content knowledge.

Goal 3: Develop and sustain professional learning communities in urban schools, based on mentoring models, using university STEM faculty and graduate students.								
Objective 3: The ISEP Professional Learning Communities are partnership driven and designed to foster collaboration. The ISEP combines novel mentoring approaches and expanded Professional Learning Communities (PLC's) to build leadership and resources for improving science education in high needs/high potential urban schools. The objective of PLC will be to cultivate mentoring partnerships with middle and high school teachers and students; UB and BSC STEM and Education faculty; UB and BSC undergraduate and graduate students; volunteer STEM professionals; and parents.	Activity 3a: Face to face meetings, virtual communication platforms: blogs, electronic professional communications network. ISEP Partners provide access to their interdisciplinary research programs Parent PLC; DPCC will also help organize school-based parent participation; as well as focus groups that identify best practices for parent participation in science and engineering education. Activity 3b: External project evaluators collected and analyzed data from parents in PLC in 2015	• Partnership Driven, • Teacher Quality, Quantity & Diversity • Challenging Courses & Curricula • Evidence-Based Design & Outcomes • Institutional Change & Sustainability	✓ ✓					Currently all PLC's are being conducted face-to-face. Initial PLC Clusters were created and implemented. PLC Clusters created opportunities for teachers within school buildings to work together in groups and as a team for upcoming summer 2014 research and 2014-15 school year. ISEP Coordinating Teachers created collaborative opportunities between middle and high school teachers via the formation of topic based PLC clusters including a ESL environmental science and GIS. A Principal based PLC was also implemented this year, establishing opportunities for ISEP principals to collaborative and leverage resources. An ISEP corporate/research partner PLC was implemented this year. The focus of this PLC includes examining ways the corporate comminute can play a stronger role in creating sustainable models that yield greater impacts regarding their partnerships with the BPS and the higher education community. Graduate students created collaborative opportunities between middle and high school teachers and students Parent PLC created opportunities for parents to collaborate with STEM faculty and BPS teachers through the ISEP STEM Social Justice Conference the ISEP Student Science Summit and the ISEP Parent Retreat.

Goal 4: Extend interdisciplinary inquiry based science and engineering learning to high school								
Objective 4: Students of participating middle school teachers will continue to experience interdisciplinary science inquiry learning in high school. Students of participating high school teachers will continue experiencing interdisciplinary science inquiry learning in high school and will achieve higher than other students.	Activity 4a: Expansion of the roster of ISEP participating schools, to include more high schools.	• Partnership Driven, • Teacher Quality, Quantity & Diversity • Challenging Courses & Curricula • Evidence-Based Design & Outcomes • Institutional Change & Sustainability	✓					
	Activity 4b: Informal science activities both in and out of class.	• Partnership Driven, • Teacher Quality, Quantity & Diversity • Challenging Courses & Curricula • Evidence-Based Design & Outcomes • Institutional Change & Sustainability	✓					
	Activity 4c: ISEP offerings will also include summer enrichment and university research internships for BPS students starting in Summer 2013.	• Partnership Driven, • Teacher Quality, Quantity & Diversity • Challenging Courses & Curricula • Evidence-Based Design & Outcomes • Institutional Change & Sustainability	✓					Summer opportunities for ISEP middle and high school students during the summer of 2014 included a GIS camp at the UB working BPS teachers, UB doctor students, and faculty; a school based camp at MST organized by ISSEP doctoral students and ISEP coordinating teachers, a middle school camp at the Buffalo Museum of Science, a middle school camp at Cradle Beach; internship opportunities with UB Chemistry faculty for high school students, and a two week research camp at HWI.

Goal 5: Improve student achievement in science, attitude toward science-technology-society, and interest in pursuing advanced science studies								
Objective 5: Students of participating teachers will continue to experience interdisciplinary science inquiry learning in elementary, middle and high school. Participating science teachers will maintain involvement and STEM faculty and students will be actively involved in activities improving k-12 science education; parents will become more involved in school-based in/after-school programs.	Activity 5a: Teachers implement interdisciplinary science inquiry teaching and learning in their classrooms. Activity 5b: STEM Ph.D. graduate assistants & service learning students support teacher implementation of inquiry science teaching Activity 5c: STEM PhD students organize after-school opportunities for students e.g. clubs, tutoring, etc. to pedagogical content knowledge Activity 5e: External evaluators administered ISEP BPS Student Questionnaire to compare BPS students to assess differences in students' interest in science careers	Partnership Driven, Teacher Quality, Quantity & Diversity Challenging Courses & Curricula Evidence-Based Design & Outcomes Partnership Driven, Teacher Quality, Quantity & Diversity Challenging Courses & Curricula Evidence-Based Design & Outcomes Partnership Driven, Teacher Quality, Quantity & Diversity Challenging Courses & Curricula Evidence-Based Design & Outcomes	✓ ✓ ✓ ? ?					

Goal 6: Improve collaboration in student learning among university, school, and parents									
Objective 6: Participating science teachers will maintain involvement and STEM faculty and students will be actively involved in activities improving k-12 science education; parents will become more involved in school-based after-school programs and PLC's. Engage faculty, grad students, undergraduates, UB and BSC STEM faculty, corporate and research partners and parents in PLC's and other programmatic components and leadership structures.	Activity 6a: Engagement of faculty, staff and students, as well as corporate and research partners through informal science activities, both in and out of class.	• Partnership Driven, • Teacher Quality, Quantity & Diversity • Challenging Courses & Curricula • Evidence-Based Design & Outcomes • Institutional Change & Sustainability	✓					ISEP teachers, students, UB doctoral students and faculty collaborated on a summer GIS Camp during the summer of 2014 and will continue in an expanded two week camp this summer, 2015. The middle and high school students were instrumental in assisting teachers becoming more comfortable working with smart phone technology. The collaborative environment continued throughout the school year in after school programs and presentations at the ISEP Student Science Summit in March 2014.
	Activity 6b: Implement The District Parent Coordinating Council into the ISEP program involvement.	• Partnership Driven, • Teacher Quality, Quantity & Diversity • Challenging Courses & Curricula • Evidence-Based Design & Outcomes • Institutional Change & Sustainability	✓					Parent PLC created opportunities for parents to collaborate with STEM faculty and BPS teachers, corporate, research and community partners through STEM Social Justice Conference and ISEP Student Science Summit and the ISEP Parent Summer Retreat. Parents collaborated with STEM faculty, doctoral students, and ISEP Corporate partners in developing a yearlong agenda of pertinent issues the parent group wanted to address including sustained student engagement in STEM and the education to career pipeline.

	Activity 6c: Create active and constructive interactions amongst the parents and teachers through PLCs. Activity 6d: Administered and analyzed parent survey to measure parents' perceptions of the parent PLC and expectations for students' STEM learning in Spring 2013 - Spring 2014	• Partnership Driven, • Teacher Quality, Quantity & Diversity • Challenging Courses & Curricula • Evidence-Based Design & Outcomes • Institutional Change & Sustainability	✓ ✓					Parent based PLC commenced in spring 2012 and continued to meet during 2014-15 school year and met during summer the 2015. Additionally, a parent executive committee was formed that includes one parent representative from each of the 12 ISEP schools. This group met bi-monthly during the 2015-16 school year. The main focus of this group includes the overarching themes of sustained student engagement, engaging ENL (English as a new language) parents and creating more exposure to STEM related career opportunities for ISEP students. Parents partook in a parent retreat that focused on upcoming programmatic events for 2015-16 school year as well as presentations from BPS teachers, UB STEM faculty, doctoral students, and corporate partners as well as discussed strategies regarding how to keep their students engaged in interdisciplinary science and engineering and preparations for higher education and career opportunities. Parent participated in a new initiative; The ISEP STEM Ecosystems retreat in January 2016; which focused on sustainability and possible expansion into additional BPS schools.

Section 2: Management Report

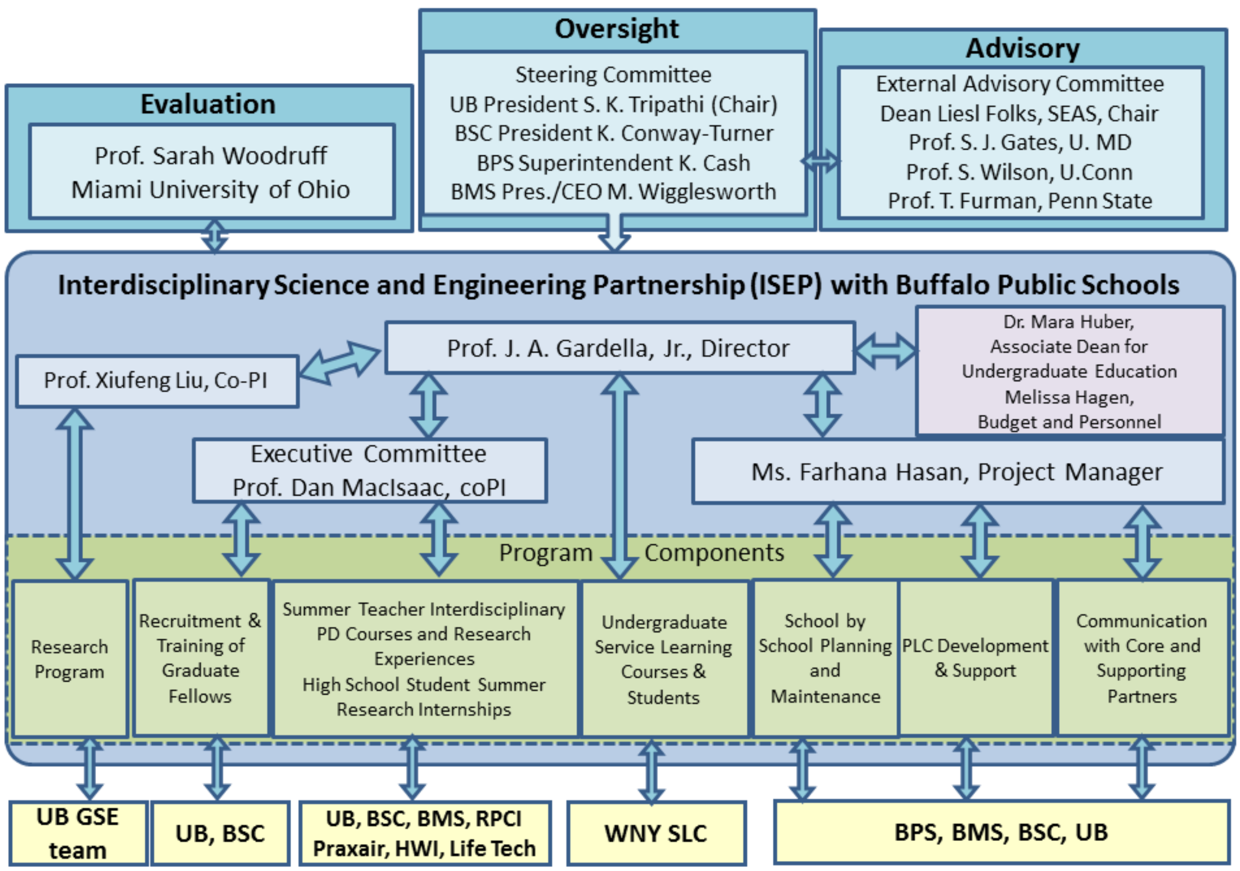
Interdisciplinary Science and Engineering Partnership (ISEP) with Buffalo Public Schools

Year 6: 2016 – 2017 No Cost Extension

Overview

Year 6, as in year 5 ISEP leadership focused on core activities to enhance wrap around support for ***implementation*** of teacher research projects as classroom activities in academic year 2016/2017. The ISEP management team, led by the PIs (Gardella, Liu, Wallace, MacIsaac and Baudo) were supported by Ms. Farhana Hasan and a commitment of support for this position through the no cost extension in year 6 was received from the Vice President for Research and Economic Development at the University at Buffalo. Part time support came again from Mrs. Melissa Hagen, handling budget, purchasing and personnel. The Executive Committee did not meet in whole as smaller planning groups were developed for a series of initiatives as part of the implementation of the sustainability plan.

Figure2.1: ISEP: Current (2017) Organizational Chart



Core Partner Management and Coordination

Core partner participation in all activities has continued to follow the identifications described in Figure 1. In particular, leadership and faculty from UB and BSC worked together regularly on every aspect of higher education participation, regular meetings with the Buffalo Museum of Science leadership occurred to plan programs as described in the Strategic Plan. Core partner leadership communicates effectively through the Project Manager Farhana Hasan as envisioned in the Strategic Plan. The Project Manager has created email lists for all categories of participants.

ISEP leadership has begun the next stage of the ISEP program's relationship with Buffalo Public Schools, involving expanding access to ISEP teacher based projects and support to schools beyond the 12 schools planned for the 5 year MSP grant. Ms. Hasan established several PLCs in summer 2016, these meetings have created networks of parents, graduate assistants and coordinating teachers and initiated communication between BPS science leadership and principals on ISEP related topics. Her report details subject based PLC's and the Parent PLC as part of the Activities and Findings, Part 1.

Important management activities were both expanded from years 1-5 and new activities were established, according to the strategic plan in year 6. Project Manager Farhana Hasan and input from the Parent Professional Learning Community, as discussed in the Activities and Findings.

Table 2.1 summarizes school leadership from year 6. Results of the school based theme development are discussed in Activities and Findings.

Collaboration with BPS

This year we had significant stability in leadership (after ten different people serving as Superintendent or Interim Superintendent since 2011). Dr. Kriner Cash has aggressively moved to reorganize and develop a strong academic plan with professional development of teachers as a central aspect. Many aspects of our parent involvement have been POSTIVELY affected by Dr. Cash's leadership team. Dr. Ramona Reynolds, Director of the Office of Parent and Family Engagement worked closely with the BPS District Parent Coordinating Council (a supporting partner of ISEP) and the Buffalo Parent Teacher Organization (BPTO) to develop a consolidated parent participation policy in BPS. ISEP collaborates with both organizations to get input on our program and enhance parent participation in STEM education in BPS. Farhana Hasan, ISEP Project Manager regularly attended meetings of both organizations. The new agreement has made the collaboration easier.

Thankfully, ISEP Partnership collaboration between the BPS Science Department leadership and ISEP activities continues to be a major focus of Ms. Kelly Baudo, Supervisor of Science. Ms. Baudo continued her exceptional collaboration with ISEP by participating in all planning efforts, and served on the Executive Committee. She met with UB and Buffalo State ISEP leadership at every school-based meeting. Ms. Baudo is very active in the approval chain for all informal science activities such as field trips and other off campus activities. A process of consultation with the Science Department, and development of criteria for alignment of requests to learning goals and standards produced a clearer means for teachers to justify requests for ISEP funding in support of these activities.

Our funding from NY State Ed for MSP funding for a program to disseminate ISEP middle school interdisciplinary teacher projects to all 7/8th grade BPS science teachers, along with selected technology and special ed teachers continued in 2016 but was concluded. No state funding has been announced for continuing STEM support in NY.

As the primary point of contact for BPS leadership, and now coPI on the NSF grant, Ms. Baudo continues to be an important intellectual collaborator and remains the point person for all teacher selection processes and decision-making for summer research and in school activities in collaboration with principals.

A particular responsibility engaging Ms. Baudo along with Principals is ISEP school based leadership transitions. This year saw several major changes in coordinating teachers, the passing of Bruce Allen (Burgard High), the retirement of Susan Wade (after 45 years of teaching), the movement of Michelle Zimmerman to a middle school as part of a separation of MST's middle school and high school components and the hiring of Pat McQuaid, formerly coordinating teacher at East High, by the new Computer Science program at Bennett High. Lorraine Academy School 72 lost coordinating teacher Reva Gilbert because of a medical leave, and when she returned to service, she was shifted to a different school. As usual there were a number of shifts of principals. As a reminder in our operational plan, School based coordinating teachers serve a 9 month paid academic year appointment on ISEP to serve the following responsibilities:

- Point of contact with ALL ISEP leadership (UB, BSC, BPS, Museum, Roswell, etc.)
- Primary oversight of graduate assistants and undergraduate service learning students; training, orientation, classroom placements.
- Coordination of all ISEP associated teachers in the building. Research design, courses, PD alignment with school based goals.
- Point person between principal, UB ISEP leadership and district (Kelly Baudo) on ISEP related research, in class support and professional development.
- Responsible to meet with other coordinating teachers in PLC.
- Distribute summer PD applications, recruit teachers to ISEP,
- Vet and help submit applications for equipment, supplies, field trips.
- Responsible for coordinating with fellow ISEP teachers and doctoral students:
    - after-school science program and or building based science night,
    - full participation in ISEP Student Science Summit, including collaborating with fellow ISEP teachers, doctoral students and other core partners on ISEP grant.

Coordinating teachers are paid a stipend and this stipend was reduced to an academic year stipend. Some coordinating teachers were supported separately for research based PD from either ISEP residual funds or as part of the ITEST funded GIS Camp, as noted in Section 1 .

Supporting Partner Development

Supporting partners for research development, Praxair, hosted three teachers in Summer 2017. Roswell Park Cancer Institute and Thermo Life Technologies did not host teachers this past summer, pursuing other options for K-12 STEM support of BPS. Further, Roswell leadership has worked on developing cancer genetics and cancer biology classroom materials at three schools and directing these to one of the high schools as a themed program.

Coordination with supporting partners for program development, the Western New York Service Learning Coalition and the District Parent Coordinating Council (DPCC) has been excellent.

These outcomes of the Core Partner management and Supporting Partner Development are obviously ***partnership driven.*** Using ***evidence based design and outcomes*** as developed by the Joyce Epstein models of parent involvement, outlined in our ISEP proposal, guiding participation at all levels. Finally, effective collaborations contribute to both ***institutional change and sustainability***.

Table 2. 1 on the next two pages shows ISEP Schools, Research Themes, Coordinating Teachers & STEM Graduate and Undergraduates that support classroom and after school activities so that teachers may implement results of ISEP professional development. Only three graduate students were hired and were spread among all ISEP teachers/schools. Michael Gallisdorfer and Angelina Montes are veteran ISEP Gas who organized special projects at requests from teachers. Razie Fathi was hired as a Computer Science expert and splits time at several schools supporting CS initiatives of the teachers, other part time masters students provide specific classroom support in various engineering and chemistry areas. STEM undergraduates include those taking service learning classes (SL Student), advanced internship credit or pay for continuing work (Intern) or freshman Honors Students required to do service learning during spring Honors Colloquium (25 hours for each student during the semester). Riverside High, School 19, School 31 School 93 and were popular spots for students interested in working with refugee and immigrant ESL (now English as New Language) students in STEM classes and after school programs.

Table 2.1 ISEP Personnel by School, Year 6 of MSP funding (no cost extension), Sept 1, 2016 to August 31, 2017.

School Name	Coord. Teacher	STEM Themes	Graduate and Undergraduate Student Classroom/After School Support	Other Partners
Available for efforts at all schools			Ph.D. students: Michael Gallisdorfer and Angelina Montes (Fall 2016-Winter 2018), Razie Fathi (Computer Science Consulting Ph.D. student	
Native American Magnet 19 (K-8)	Heather Gerber	Environmental Science, Forensics, Anatomy/Physiology	Elizabeth Fung (SL Course and Intern), Victorial Gosy. Christina Swiatowy, (SL Course) Mattew Mondt, Sean Dineen, Victorial Patti, (Honors colloquium)	
Harriett Tubman 31 (K-8) PS	Steven Indalecio	Biomedical, GIS Environmental Science	Antara Majumdar (Intern), Sushmita Gelda (Intern), Matthew McGregor, Basel Ahmad, Patrick Mogenhan, Michelina Strangio (SL Course) Hannah Scott. Pooja Prabhakar (Honors colloquium)	Roswell Park Cancer Institute Praxair
Lovejoy Discover 43 (K-8)	Caitlin Proietto	GIS, Environmental	Marissa Nemitz, Kennedy Burns, Abby Silverman, Ephraim Gardner (Honors Colloquium)	
Science Magnet 59 (K-8) PS	Stephanie Finn	Biomedical and Environmental Sciences	Gunnar Haberl, Racheal Whiteside (Interns), Michael Greene (SL Course)	Museum of Science
Lorraine Academy 72 (K-8)	Reva Gilbert Medical Leave, 2017	Medical Careers Environmental Science	Alexis Ziegler (SL Course)	Mercy Hospital
Southside Academy 93 (K-8)	Sarah Gallian	Environmental Science, Link to South Park High Middle School Computer Science	Amber Bartlett, Clarissa Cardarelli, Brandon Kornowski, Allison Smith (SL Course) Catherine Carter, Danielle Drury, Katherine Kio (Honors colloquium)	
MST Seneca 197 (Grades 5-12)	Tammy Furman-Schwab	Environmental Science and Engineering	Cullan Donnelly, Gillian Gitlin, Abigail Grapes (SL Course)	
Bennett High 200 (Grades 9-12)PS	Gina O'Kussick Pat McQuaid	GIS Environmental, Extreme Events, Computer Science, Forensics	Esteven Tineo Mateo, Tara-Jeneil Fenton, (Interns) Priscilla Esadah, Tiffany A Mcbean, Ndidiamaka Akudo Okorozo, Katherine James, Emily Williams, Veronica Zieba (SL Course) Whitney Spencer, Alyssa Reese (Honors colloquium)	
Burgard 301 (Grades 9-12) PS	Bruce Allen (decesased) Charles Harding	Advanced Manufacturing, Welding Auto Technology,	Thomas Deering, Mattie Fredsell, Alexandra Fuller, Jason Ripple (SL Course)	Praxair

Riverside Tech 205 (Grades 9-12) PS	Anne Kokolus	Medical Careers	Christina White, Gimmar Haberl) Alena Haskins, Alexander Percy (SL Course) , Kaitlyn Meyer, Alexandra DiLillo (Honors colloquium)	Medaille College
South Park 206 (Grades 9-12) PS	Kathleen Marren	GIS Environmental Science and Social Sciences	Megan Corcoran, Maggie Petrella (Interns) Andrew Stewart, Jack Walker (SL Course) ,Aaron Anderson (Honors colloquium)	
Hutch Tech 304 (Grades 9-12)	Jason Mayle	Engineering, Physics, Biochemistry	Alexander Schwartz (Intern), Julia Quebral, Kwang Jin Chung (SL Course), Kirstin Dean Honors Colloquim	
East High 307 (Grades 9-12) PS			No undergraduates requested because of phase out of school	

Section 3: Financial Report

Interdisciplinary Science and Engineering Partnership (ISEP) with Buffalo Public Schools

Year 6: 2016 – 2017 No Cost Extension

3.1 Status

Spreadsheet reconciliation (below) reflects approximately 20% of UB's portion award was left at the end of the year six (August 31, 2017.) The calculations include a rebalancing of indirect costs related to actual expenditures of direct costs for years one through six. Actual Participant Support costs exceeded original projections, which resulted in a shift $119,927 of indirect costs to direct (participant support) costs. With the remaining funds available, UB is requesting an additional six month no cost extension through February 28, 2018.

In year six, UB's partnership with the Buffalo Museum of Science (BMS) extended for an additional year. In line with the first five years, BMS requested an additional $29,759 of funding. At the end of year six, the subcontract funding for BMS was expended as anticipated. Miami University of Ohio (evaluation) also continued its subcontract partnership with UB in year six. In early 2017, Miami U financial services determined the budget was over forecasted by $55,000, which was returned to UB. The difference between the subcontract increase for BMS and decrease for Miami U totaled $25,241 and was allocated toward additional Participant Support costs. Miami U reflected an approximate subcontract balance of 4% at the end of year six. This is consistent with the level of support needed to complete final evaluation services in conjunction with UB's requested final no cost extension period ending February 28, 2018.

We are requested and were approved for carry over through February 2018 for five major categories:

- Staff support
- Graduate student support
- Supplies

and within the yellow highlighted Participant Support Costs:

- Support for teachers, in the form of travel support
- Support for our student research programs, including stipend support for middle and high school students

3.2 Background related to shortfalls and justification for use of carryover to 2017-2018.

The reduction of UB's administrative budget plus the net amount returned from a subcontracting partner, allowed for a sixth summer of teacher participation. As anticipated, and seen in year five, an increased number of teachers were supported by travel funding to present their ISEP research to national and regional conferences.

The remaining requested carryover budget outside of participant support costs is projected to be used toward completion of data collection and summarization using a minimal number of staff and graduate students.

Details of the expenditures are in the spreadsheet in categories utilized in the NSF budget. An additional table has been inserted to project the six-month NCE (Y7) budget.

Budget Summary
Year 1 (2011-2012)

Category	Funds Budgeted	Funds Expended	Funds Carried Over
Faculty Salaries	$ 41,502.00	$ 35,239.55	$ 6,262.45
Staff Salary	$ 3,517.00	$ 10,502.95	$ (6,985.95)
Graduate Students	$ 398,000.00	$ 399,416.75	$ (1,416.75)
Undergraduates	$ 64,000.00	$ 20,601.07	$ 43,398.93
Fringe Benefits	$ 70,954.00	$ 70,152.25	$ 801.75
Participant Support Costs			
Stipends			
Teachers	$ 282,000.00	$ 269,850.00	$ 12,150.00
Middle/High School Students	$ 84,000.00	$ 8,100.00	$ 75,900.00
PT grad assistants	$ 48,000.00	$ 17,000.00	$ 31,000.00
Parents	$ 1,800.00	$ -	$ 1,800.00
Travel	$ 48,000.00	$ 2,358.93	$ 45,641.07
Supplies	$ 72,000.00	$ 39,579.97	$ 32,420.03
Supplies	$ 38,400.00	$ 2,335.56	$ 36,064.44
Tuition	$ 12,876.00	$ 38,208.00	$ (25,332.00)
Travel	$ -	$ 6,251.93	$ (6,251.93)
Total UB Direct Costs	$ 1,165,049.00	$ 919,596.96	$ 245,452.04
			$ -
			$ -
			$ -
			$ -
			21.07%

Budget Summary
Year 2 (2012-2013)

Category	Funds Budgeted	Carry Over from Y1	Total Funds Available	Funds Expended	Funds Carried Over
Faculty Salaries	$ 43,577.00	$ 6,262.45	$ 49,839.45	$ 26,868.83	$ 22,970.62
Staff Salary	$ 3,693.00	$ (6,985.95)	$ (3,292.95)	$ 53,602.57	$ (56,895.52)
Graduate Students	$ 417,900.00	$ (1,416.75)	$ 416,483.25	$ 568,351.82	$ (151,868.57)
Undergraduates	$ 67,200.00	$ 43,398.93	$ 110,598.93	$ 17,675.00	$ 92,923.93
Fringe Benefits	$ 79,202.00	$ 801.75	$ 80,003.75	$ 111,100.27	$ (31,096.52)
Participant Support Costs					
Stipends					
Teachers	$ 282,000.00	$ 12,150.00	$ 294,150.00	$ 389,400.00	$ (95,250.00)
Middle/High School Students	$ 84,000.00	$ 75,900.00	$ 159,900.00	$ 8,200.00	$ 151,700.00
PT grad assistants	$ 48,000.00	$ 31,000.00	$ 79,000.00	$ 49,732.00	$ 29,268.00
Parents	$ 1,800.00	$ 1,800.00	$ 3,600.00	$ 200.00	$ 3,400.00
Travel	$ 48,000.00	$ 45,641.07	$ 93,641.07	$ 39,556.00	$ 54,085.07
Supplies	$ 72,000.00	$ 32,420.03	$ 104,420.03	$ 88,804.00	$ 15,616.03
Supplies	$ 38,400.00	$ 36,064.44	$ 74,464.44	$ (34,072.31)	$ 108,536.75
Tuition	$ 12,876.00	$ (25,332.00)	$ (12,456.00)	$ 66,457.00	$ (78,913.00)
Travel	$ -	$ (6,251.93)	$ (6,251.93)	$ 7,324.25	$ (13,576.18)
Total UB Direct Costs	$ 1,198,648.00	$ 245,452.04	$ 1,444,100.04	$ 1,393,199.43	$ 50,900.61
					3.52%

Budget Summary
Year 3 (2013-2014)

Category	Funds Budgeted	Carry Over from Y2	Total Funds Available	Funds Expended	Summer 2014 Committed Funds	Total Expected to Expend	Projected Carryover Funds
Faculty Salaries	$ 45,756.00	$ 22,970.62	$ 68,726.62	$ 43,326.73	$ 17,464.00	$ 60,790.73	$ 7,935.89
Staff Salary	$ 3,877.00	$ (56,895.52)	$ (53,018.52)	$ 7,687.96	$ 1,450.00	$ 9,137.96	$ (62,156.48)
Graduate Students	$ 438,795.00	$ (151,868.57)	$ 286,926.43	$ 355,235.70	$ 9,000.00	$ 364,235.70	$ (77,309.27)
Undergraduates	$ 70,560.00	$ 92,923.93	$ 163,483.93	$ 5,718.75	$ 2,500.00	$ 8,218.75	$ 155,265.18
Fringe Benefits	$ 89,498.00	$ (31,096.52)	$ 58,401.48	$ 80,386.89	$ 5,150.13	$ 85,537.02	$ (27,135.54)
Participant Support Costs							
Stipends							
Teachers	$ 282,000.00	$ (95,250.00)	$ 186,750.00	$ 25,570.00	$ 210,000.00	$ 235,570.00	$ (48,820.00)
Middle/High School Students	$ 84,000.00	$ 151,700.00	$ 235,700.00	$ 7,850.00	$ 25,000.00	$ 32,850.00	$ 202,850.00
PT grad assistants	$ 48,000.00	$ 29,268.00	$ 77,268.00	$ 7,169.00	$ 105,000.00	$ 112,169.00	$ (34,901.00)
Parents	$ 1,800.00	$ 3,400.00	$ 5,200.00	$ 1,450.00	$ 1,800.00	$ 3,250.00	$ 1,950.00
Travel	$ 48,000.00	$ 54,085.07	$ 102,085.07	$ 19,100.00	$ 5,000.00	$ 24,100.00	$ 77,985.07
Supplies	$ 72,000.00	$ 15,616.03	$ 87,616.03	$ 46,148.00	$ 75,000.00	$ 121,148.00	$ (33,531.97)
Supplies	$ 38,400.00	$ 108,536.75	$ 146,936.75	$ -	$ -	$ -	$ 146,936.75
Tuition	$ 12,876.00	$ (78,913.00)	$ (66,037.00)	$ 63,993.00	$ -	$ 63,993.00	$ (130,030.00)
Travel	$ -	$ (13,576.18)	$ (13,576.18)	$ 2,047.58	$ -	$ 2,047.58	$ (15,623.76)
Total UB Direct Costs	$ 1,235,562.00	$ 50,900.61	$ 1,286,462.61	$ 665,683.61	$ 457,364.13	$ 1,123,047.74	$ 163,414.87
							12.70%

Budget Summary
Year 4 (2014-2015)

Category	Funds Budgeted	Carry Over from Y3	Total Funds Available	Funds Expended	Summer 2015 Committed Funds	Total Expected to Expend	Projected Carryover Funds
Faculty Salaries	$ 48,044.00	$ (480.78)	$ 47,563.22	$ 15,406.61	$ 14,856.86	$ 30,263.47	$ 17,299.75
Staff Salary	$ 4,071.00	$ (61,863.67)	$ (57,792.67)	$ 6,324.12	$ 1,108.08	$ 7,432.20	$ (65,224.87)
Graduate Students	$ 460,735.00	$ (133,945.45)	$ 326,789.55	$ 299,031.92	$ 7,338.61	$ 306,370.53	$ 20,419.02
Undergraduates	$ 74,088.00	$ 157,765.18	$ 231,853.18	$ 2,643.75	$ -	$ 2,643.75	$ 229,209.43
Fringe Benefits	$ 93,972.00	$ (50,218.39)	$ 43,753.61	$ 50,947.66	$ 4,187.40	$ 55,135.06	$ (11,381.45)
Participant Support Costs							
Stipends							
Teachers	$ 282,000.00	$ (132,910.00)	$ 149,090.00	$ 16,358.00	$ 210,000.00	$ 226,358.00	$ (77,268.00)
Middle/High School Students	$ 84,000.00	$ 199,395.00	$ 283,395.00	$ 20,951.00	$ 15,500.00	$ 36,451.00	$ 246,944.00
PT grad assistants	$ 48,000.00	$ 28,006.00	$ 76,006.00	$ 150,019.94	$ 7,000.00	$ 157,019.94	$ (81,013.94)
Parents	$ 1,800.00	$ 3,100.00	$ 4,900.00	$ 11,450.00	$ 1,800.00	$ 13,250.00	$ (8,350.00)
Travel	$ 48,000.00	$ 82,517.68	$ 130,517.68	$ 4,223.73	$ 4,700.00	$ 8,923.73	$ 121,593.95
Supplies	$ 72,000.00	$ 18,945.82	$ 90,945.82	$ 199,116.98	$ 86,000.00	$ 285,116.98	$ (194,171.16)
Supplies	$ 38,400.00	$ 111,362.14	$ 149,762.14	$ -	$ 1,000.00	$ 1,000.00	$ 148,762.14
Tuition	$ 12,876.00	$ (136,964.00)	$ (124,088.00)	$ 40,102.00	$ -	$ 40,102.00	$ (164,190.00)
Travel	$ -	$ (16,027.82)	$ (16,027.82)	$ 2,380.10	$ 12,500.00	$ 14,880.10	$ (30,907.92)
Total UB Direct Costs	$ 1,267,986.00	$ 68,681.71	$ 1,336,667.71	$ 818,955.81	$ 365,990.95	$ 1,184,946.76	$ 151,720.95
							11.35%

Budget Summary
Year 5 (2015-2016)

Category	Funds Budgeted	Carry Over from Y4	Total Funds Available	Funds Expended	Summer 2016 Committed Funds	Total Expected to Expend	Projected Carryover Funds
Faculty Salaries	$ 50,446.00	$ 12,153.76	$ 62,599.76	$ 12,892.29	$ 16,565.00	$ 29,457.29	$ 33,142.47
Staff Salary	$ 4,275.00	$ (64,649.85)	$ (60,374.85)	$ 5,766.79	$ 1,187.00	$ 6,953.79	$ (67,328.64)
Graduate Students	$ 483,771.00	$ 22,819.08	$ 506,590.08	$ 285,621.50	$ 83,726.00	$ 369,347.50	$ 137,242.58
Undergraduates	$ 77,792.00	$ 229,209.43	$ 307,001.43	$ -	$ -	$ -	$ 307,001.43
Fringe Benefits	$ 98,671.00	$ (12,211.39)	$ 86,459.61	$ 53,508.51	$ 16,420.00	$ 69,928.51	$ 16,531.10
Participant Support Costs							
Stipends							
Teachers	$ 282,000.00	$ 15,732.00	$ 297,732.00	$ 256,321.00	$ 118,620.00	$ 374,941.00	$ (77,209.00)
Middle/High School Students	$ 84,000.00	$ 246,524.00	$ 330,524.00	$ 15,150.00	$ 15,500.00	$ 30,650.00	$ 299,874.00
PT grad assistants	$ 48,000.00	$ (101,862.69)	$ (53,862.69)	$ 34,696.25	$ 7,000.00	$ 41,696.25	$ (95,558.94)
Parents	$ 1,800.00	$ (7,500.00)	$ (5,700.00)	$ 8,100.00	$ 1,800.00	$ 9,900.00	$ (15,600.00)
Travel	$ 48,000.00	$ 125,362.80	$ 173,362.80	$ 1,512.70	$ 2,500.00	$ 4,012.70	$ 169,350.10
Supplies	$ 72,000.00	$ (157,738.71)	$ (85,738.71)	$ 148,248.11	$ 25,000.00	$ 173,248.11	$ (258,986.82)
Supplies	$ 38,400.00	$ 149,762.14	$ 188,162.14	$ 5,631.64	$ 11,000.00	$ 16,631.64	$ 171,530.50
Tuition	$ 12,876.00	$ (164,190.00)	$ (151,314.00)	$ 71,732.00	$ 1,840.00	$ 73,572.00	$ (224,886.00)
Travel	$ -	$ (18,507.92)	$ (18,507.92)	$ 9,382.64	$ -	$ 9,382.64	$ (27,890.56)
Total UB Direct Costs	$ 1,302,031.00	$ 274,902.65	$ 1,576,933.65	$ 908,563.43	$ 301,158.00	$ 1,209,721.43	$ 367,212.22
							23.29%

Budget Summary
Year 6 (2016-2017)

Category	Funds Budgeted[1]	Carry Over from Y5[2]	Total Funds Available	Funds Expended	Intentionally Blank	Intentionally Blank2	Projected Carryover Funds
Faculty Salaries		$ 36,594.34	$ 36,594.34	$ 10,059.40			$ 26,534.94
Staff Salary		$ (66,637.97)	$ (66,637.97)	$ 5,107.00			$ (71,744.97)
Graduate Students		$ 144,595.86	$ 144,595.86	$ 93,625.67			$ 50,970.19
Undergraduates		$ 307,001.43	$ 307,001.43	$ 825.00			$ 306,176.43
Fringe Benefits		$ 29,366.19	$ 29,366.19	$ 16,837.45			$ 12,528.74
Participant Support Costs			$ -				
Stipends							
Teachers	$ 69,479.17	$ (28,596.21)	$ 40,882.96	$ 99,032.00			$ (58,149.04)
Middle/High School Students		$ 329,475.77	$ 329,475.77	$ 7,150.00			$ 322,325.77
PT grad assistants		$ (148,559.89)	$ (148,559.89)	$ 11,343.75			$ (159,903.64)
Parents		$ (22,851.98)	$ (22,851.98)	$ -			$ (22,851.98)
Travel		$ 139,709.29	$ 139,709.29	$ 5,792.04			$ 133,917.25
Supplies	$ 75,689.10	$ (424,125.24)	$ (348,436.14)	$ 71,906.10			$ (420,342.24)
Supplies		$ 170,865.10	$ 170,865.10	$ 19,961.16			$ 150,903.94
Tuition	$ 89,774.80	$ (224,886.00)	$ (135,111.20)	$ 18,350.00			$ (153,461.20)
Travel		$ (27,890.56)	$ (27,890.56)	$ -			$ (27,890.56)
Total UB Direct Costs	$ 234,943.07	$ 214,060.13	$ 449,003.20	$ 359,989.57			$ 89,013.63
							19.82%

Notes:

1: Amounts listed are a reflection of budget rebalancing amongst subcontracting partners and rebalanced indirect costs. See narrative for details.

2: Updated to reflect actual expenditures through 8/31/2016. Carry-over was projected at the time of the last report submission.

Section 4

a: Evaluator's Report
b: Response to Evaluator's Report

Interdisciplinary Science and Engineering Partnership (ISEP) with Buffalo Public Schools

Year 6: 2016 – 2017

MIAMI UNIVERSITY

DISCOVERY CENTER

Evaluation · Research · Professional Learning

Evaluation of University at Buffalo/Buffalo Public Schools (UB/BPS) Interdisciplinary Science and Engineering Partnership

Annual Report 2016-2017

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Distributed by Discovery Center for Evaluation, Research, and Professional Learning
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Introduction

Discovery Center for Evaluation, Research, and Professional Learning (Discovery Center, formerly Ohio's Evaluation and Assessment Center for Mathematics and Science Education) is the project evaluator for the University at Buffalo/Buffalo Public Schools (UB/BPS) Interdisciplinary Science and Engineering Partnership (ISEP) project. The UB/BPS ISEP project is funded through a Mathematics and Science Partnership (MSP) grant from the National Science Foundation (NSF). Dr. Sarah Woodruff, Miami University, is the Principal Investigator for the evaluation, and Ms. Yue Li is the Senior Research Associate and Project Team Leader for the evaluation.

Project Description

The University at Buffalo, Buffalo Public Schools Interdisciplinary Science and Engineering Partnership project is a National Science Foundation Mathematics and Science Partnership project working to establish and sustain a comprehensive partnership that targets middle and high school science and technology, with a focus on strengthening teacher professional development (PD) during the critical transition from middle to high school. This project addresses the critical need (documented nationally and locally) for improved student learning in standard areas of science by enhancing science inquiry knowledge and skills, enabling the implementation of interdisciplinary inquiry-based science teaching across all content standards, and supporting the BPS vision for inquiry-based science and engineering curricula. The ISEP project has six major goals:

- **GOAL 1:** Improve middle school science teachers' knowledge and skills related to science inquiry through interdisciplinary science research and engineering design with university STEM faculty.
- **GOAL 2:** Increase science teacher quantity, quality, diversity, and retention in urban schools.
- **GOAL 3:** Develop and sustain professional learning communities in urban schools, based on mentoring models, with help from university STEM faculty and graduate students.
- **GOAL 4:** Extend interdisciplinary inquiry based science and engineering learning to high school.
- **GOAL 5:** Improve student achievement in science, attitude toward science-technology-society, and interest in pursuing advanced science studies.
- **GOAL 6:** Improve collaboration in student learning among university, school, and parents.

In order to achieve these goals, UB in collaboration with the Buffalo Public Schools, Buffalo State College, and Buffalo Museum of Science are engaged in the following activities:

- Science and technology teacher professional development with a focus on science inquiry content and pedagogical content knowledge through interdisciplinary science and engineering research and workshops led by UB and BSC STEM faculty and students.
- School-based support for teacher implementation of interdisciplinary inquiry-based science instruction by UB STEM graduate students assigned to BPS classrooms and after-school and weekend science clubs designed to expand student inquiry learning opportunities. Additional support comes from service learning students from UB, BSC, and area colleges. ISEP offerings include summer enrichment and university research internships for BPS students.
- Expanded professional learning communities (PLC) with mentoring relationships among UB STEM faculty members, undergraduate and graduate students, and BPS students and parents.

Additionally, the project conducts research on the processes and conditions in which teachers develop interdisciplinary science inquiry knowledge; how this information may be translated into pedagogical content knowledge that ultimately improves students' science learning; and how professional learning communities may support the development of this pedagogical content knowledge. The project also is studying the impact of associated activities on participating STEM graduate students.

Evaluation

The Discovery Center was contracted to conduct summative, external evaluation activities for the UB/BPS ISEP project. Overarching evaluation efforts focus on assessing progress towards project goals and monitoring project implementation at the project, school, and classroom levels. The Discovery Center works closely with the internal evaluation and research team, led by Dr. Xiufeng Liu, to provide formative feedback for project improvement.

The Discovery Center employs a mixed methods approach with both formative and summative data collection and analysis. The evaluation design utilizes a combination of pre/post, quasi-experimental, as well as causal comparative quantitative measures; and collects relevant qualitative and descriptive data on project participants, their students, and participating schools. The evaluator also utilizes data and findings provided by the internal evaluation team to create annual and final reports that synthesize findings from all measures. During project Year 6 (the no-cost-extension year), the evaluation collected and/or analyzed quantitative data from ISEP participating teachers, students of ISEP and comparison teachers, and UB STEM graduate and undergraduate students.

The external summative evaluation plan submitted with the project's proposal to the NSF was last updated in June 2016 to ensure coordination of ISEP project activities, internal research/evaluation, and the external evaluation. This plan will continue to be modified in response to emerging needs or changes in project plans. Table 1 shows an updated timeline of annual evaluation activities.

Table 1. *Discovery Center Annual Evaluation Activities and Timeline, 2016 – 2017*

Evaluation Activity	**Jul – Sept**	**Oct – Dec**	**Jan – Mar**	**Apr – Jun**
Administer Teacher Questionnaire	**X (pre)**			**X (post)**
Analyze pre/post Teacher Questionnaire	**X**			
Administer BPS Student Questionnaire		**X (pre)**		
Analyze pre/post BPS Student Questionnaire Data	**X**			
Administer STEM Student Questionnaire		**X (Sem 1)**		
Analyze STEM Student Questionnaire Data			**X**	
Administer Teacher CK/PCK instrument (ISEP Research Team)	**X (pre/post)**			
Analyze Teacher CK/PCK Data				**X**
Collect and Analyze School/Teacher-level Data				**X**

During Year 6 of the project, the Discovery Center and ISEP Project Team communicated via email, conference calls, and face-to-face meetings to discuss the progress of the evaluation and project. External evaluation activities conducted this year include: (a) researching/testing evaluation instruments; (b) administering online instruments for teacher participants and UB STEM students; (c) administering paper instruments for student participants; (d) collecting school-level demographic data; (e) analyzing data from project instruments; (f) preparing and submitting the Year 6 annual evaluation report; and (g) contributing to sustainability planning and related activities.

Participants

Participants in the evaluation of the ISEP project include Buffalo Public School, elementary, middle, and high school teachers from the 12 participating ISEP schools, their students in Grades 4 through 12, as well as University at Buffalo and Buffalo State College STEM faculty, undergraduate students, and graduate students. Other key informants include BPS district and building administrators, ISEP project personnel, corporate partner teacher mentors, and non-participating BPS elementary, middle, and high school teachers.

Instrument, Data Collection, and Data Analysis

School-Level Enrollment and Report Card Data

In Spring 2017, the evaluation team collected school-level enrollment and report card data for each of the 12 ISEP partner schools for the 2015-2016 school years in the same manner as previous years in order to follow the project's progress toward its goals.

Descriptive statistics (e.g., frequencies and percentages) were used to report year-to-year changes between baseline (2010-2011) and the most up-to-date school-level data (2015-2016).

UB/BPS ISEP Teacher Questionnaire (Summer 2016)

The *UB/BPS ISEP Teacher Questionnaire* was developed with permission from instruments previously used in NSF and USDOE MSP projects and in DRK12 projects.[1] The Summer 2016 teacher questionnaire is composed of 7 sections, total of 218 items, for both teacher groups. The Demographic section contained 34 items asking for comprehensive demographics, including teachers' professional development history. Items in this section were modified with permission from RMC Research (2009). The remaining 6 sections were exactly the same as the Summer 2015 version, which included items asking teachers' mathematics preparation, science preparation, understanding of scientific inquiry and the nature of science, design engineering and technology, attitudes and beliefs about teaching science, and their knowledge, value, and practice of Common Core State Standards (CCSS) for ELA-literacy in science teaching.

A full description of this instrument, factor analysis, and reliability results can be found in the *Evaluation of University at Buffalo/Buffalo Public Schools (UB/BPS) Interdisciplinary Science and Engineering Partnership: Annual Report 2012-2013* (Woodruff & Li, 2013) and in the *Evaluation of University at*

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[1] Lederman, N. G. (2006). Syntax of Nature of Science within inquiry and science instruction. In L. B. Flick and N. G. Lederman (Eds.), *Scientific Inquiry and Nature of Science* (pp. 301-317). Netherlands: Springer.
National Research Council. (2000). *Inquiry and the National Science Education Standards: A guide for teaching and learning.* Washington, DC: The National Academies Press.
Liang, L. L., Chen, S. Chen, X., Kaya, O. N., Adams, A. D., Macklin, M., & Ebenezer, J. (2008). Assessing preservice elementary teachers' views on the nature of scientific knowledge: A dual-response instrument. *Asia-Pacific Forum on Science Learning and Teaching, 9*(1), 1-19.
National Science Teachers Association (2000). *The Nature of Science—A position statement of NSTA*. Washington, DC.
McGinnis, J. R., Kramer, S., Shama, G., Graeber, A. O., Parker, C. A., & Watanabe, T. (2002). Undergraduates' attitudes and beliefs about subject matter and pedagogy measured periodically in a reform-based mathematics and science teacher preparation program. *Journal of Research in Science Teaching, 39*(3), 713-737.
Yasar, S., Baker, D., Robinson-Kurpius, S., Krause, S., & Roberts, C. (2006). Development of a survey to assess K-12 teachers' perceptions of engineers and familiarity with teaching design, engineering, and technology. *Journal of Engineering Education*, 205-216.
National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas.* Washington, DC: The National Academies Press.
RMC Research. (2009). *Needs Assessment Survey for evaluation of the Nebraska Mathematics and Science Partnership projects.* Denver, CO: Author.

Buffalo/Buffalo Public Schools (UB/BPS) Interdisciplinary Science and Engineering Partnership: Annual Report 2014-2015 (Woodruff & Li, 2015).

In Summer 2016, the *UB/BPS ISEP Teacher Questionnaire* was administered by Discovery Center using Qualtrics® to collect data from two groups of teachers: 1) teachers who had participated in ISEP since Summer 2012, Summer 2013, Summer 2014, or Summer 2015, and 2) teachers who began participating in ISEP in Summer 2016 and completed the questionnaire before their participation in project activities. Summer 2016 Teacher Questionnaire data serves as post-questionnaire data for the first group and as pre-questionnaire data for the second group. The link to the instrument was sent to the teacher groups participating in the ISEP summer institute on June 28, 2016, and the questionnaires remained active online until July 29, 2016. Of the 145 teachers who participated in Summer 2012, Summer 2013, Summer 2014, Summer 2015, and/or Summer 2016 PD activities, 54 responded to this questionnaire (48 returning teachers and 6 new to ISEP in Summer 2016). The response rate was 37%.

Table 2 shows the number of teachers who responded to the Teacher Questionnaire each year, as well as their ISEP starting date. Of the 57 teachers who started ISEP in Summer 2012, two never responded to the Teacher Questionnaire in any of the 5 summers between 2012 and 2016; of the 30 teachers who started in Summer 2013, 19 teacher never responded to the questionnaire; of the 34 teachers who started in Summer 2014, 11 never responded to the questionnaire; of the 34 teachers who started in Summer 2015, 4 never responded the questionnaire in either Summer 2015 or Summer 2016. All new participants in Summer 2016 responded to the questionnaire. Together, 125 ISEP teachers have responded to the questionnaire at least once, with 224 data entries collected from Summer 2012 to Summer 2016. In order to capture project impact using the largest number of teacher responses, paired-samples *t*-test were conducted to compare Baseline-Post Year1, Baseline-Post Year 2, Baseline-Post Year 3, or Baseline-Post Year 4 teacher responses.

Table 2. *Number of Responses, UB/BPS ISEP Teacher Questionnaire, Summer 2012 to Summer 2015*

ISEP Starting Date:	**Responded to Survey in Summer 2012**		**Responded Survey in Summer 2013**		**Responded Survey in Summer 2014**		**Responded Survey in Summer 2015**		**Responded Survey in Summer 2016**	
57 Participated in ISEP since Summer 2012	**Yes**	**46**	**Yes**	**17**	**Yes**	**4**	**Yes**	**3**	**Yes**	**1**
									No	2
							No	1	**Yes**	**0**
									No	1
					No	13	**Yes**	**6**	**Yes**	**5**
									No	1
							No	7	**Yes**	**1**
									No	6
			No	29	**Yes**	**5**	**Yes**	**4**	**Yes**	**1**
									No	3
							No	1	**Yes**	**0**
									No	1
					No	24	**Yes**	**5**	**Yes**	**2**
									No	3
							No	19	**Yes**	**2**
									No	17

	No	11	**Yes**	**3**	**Yes**	**1**	**Yes**	**1**	**Yes**	**1**
									No	0
							No	0	**Yes**	**0**
									No	0
					No	2	**Yes**	**2**	**Yes**	**1**
									No	1
							No	0	**Yes**	**0**
									No	0
			No	8	**Yes**	**2**	**Yes**	**2**	**Yes**	**1**
									No	1
							No	0	**Yes**	**0**
									No	0
					No	6	**Yes**	**3**	**Yes**	**0**
									No	3
							No	3	**Yes**	**1**
									No	2
30 Participated in ISEP since Summer 2013			**Yes**	**8**	**Yes**	**2**	**Yes**	**1**	**Yes**	**1**
									No	0
							No	1	**Yes**	**1**
									No	0
					No	6	**Yes**	**3**	**Yes**	**1**
									No	2
							No	3	**Yes**	**0**
									No	3
			No	22	**Yes**	**1**	**Yes**	**1**	**Yes**	**1**
									No	0
							No	0	**Yes**	**0**
									No	0
					No	21	**Yes**	**2**	**Yes**	**1**
									No	1
							No	19	**Yes**	**0**
									No	19
34 Participated in ISEP since Summer 2014					**Yes**	**9**	**Yes**	**5**	**Yes**	**4**
									No	1
							No	4	**Yes**	**1**
									No	3
					No	25	**Yes**	**11**	**Yes**	**4**
									No	7
							No	14	**Yes**	**3**
									No	11
34 Participated in ISEP since Summer 2015							**Yes**	**28**	**Yes**	**13**

									No	15
							No	6	**Yes**	**2**
									No	4
6 Participated in ISEP since Summer 2016									**Yes**	**6**
									No	0
Total Number of Teacher Questionnaire Responses:	**Su’12**	**46**	**Su’13**	**30**	**Su’14**	**24**	**Su’15**	**78**	**Su’16**	**54**

UB/BPS ISEP Teacher Pedagogical Content Assessment (PCK) Assessment (Summer 2013 to Summer 2016)

The ISEP research team used the following 6 instruments to collect pre and post data on teacher pedagogical content knowledge and knowledge of interdisciplinary science inquiry teaching:[2]

- *Elementary School Pedagogical Content Knowledge (PCK) Assessment (General Science)* consists of 8 multiple-choice questions regarding classroom science teaching vignettes and 4 open-ended questions about Interdisciplinary Science Inquiry teaching. It was developed by the ISEP research team and the evaluation team using a modified version of Schuster and Cobern’s POSTT,[3] with permission, based on input from inservice teachers, results of observations of teaching, and science curriculum standards.
- *Middle School PCK Assessment (General Science)* consists of 8 multiple-choice questions regarding classroom science teaching vignettes and 4 open-ended questions about Interdisciplinary Science Inquiry teaching. It was developed by the ISEP research team and the evaluation team using a modified version of Schuster and Cobern’s POSTT, with permission. It was based on input from in-service teachers, results of observations of teaching, and science curriculum standards.
- *Biology PCK Assessment* consists of 29 multiple-choice items from ATLAST Flow of Matter and Energy[4] and 4 open-ended questions about Interdisciplinary Science Inquiry teaching developed by the ISEP research team.
- *Chemistry PCK Assessment* consists of 30 items from AIM Teacher Assessment Form M4: Properties of and Changes in Matter and 4 open-ended questions about Interdisciplinary Science Inquiry teaching developed by the ISEP research team.[5]
- *Earth Science PCK Assessment* consists of 30 items from ATLAST Plate Tectonics[6] and 4 open-ended questions about Interdisciplinary Science Inquiry teaching developed by the ISEP research team.
- *Engineering & Physics PCK Assessment* consists of 29 items from ATLAST Force and Motion[7] and 4 open-ended questions about Interdisciplinary Science Inquiry teaching developed by the ISEP research team.

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[2] The *Biology, Chemistry, Earth Science, Engineering/Physics, and Physics PCK Assessments* were used, with permission, from the Assessing Teacher Learning About Science Teaching (ATLAST) project at Horizon Research, Inc. ATLAST is funded by the National Science Foundation under grant number DUE-0335328.
[3] Schuster, D. & Cobern, W. W. (2007). *The pedagogy of science teaching test (POSTT).* Western Michigan University, Mallison Institute for Science Education: Kalamazoo, MI.
[4] Horizon Research, Inc. (2011). *ATLAST Flow of Matter and Energy.* Chapel Hill, NC: Author.
[5] Horizon Research, Inc. (2011). *AIM Teacher Assessment, Form M4: Properties of and Changes in Matter*. Chapel Hill, NC: Author.
[6] Horizon Research, Inc. (2011). *ATLAST Plate Tectonics*. Chapel Hill, NC: Author.
[7] Horizon Research, Inc. (2011). *ATLAST Force and Motion.* Chapel Hill, NC: Author.

All instruments used or modified for use in the ISEP project were used with permission.

The *UB/BPS ISEP Teacher PCK Assessment* instruments were administered in hard copy by the ISEP research team to teachers in Summer 2016. Responses from returning teachers were considered as post assessment for their Summer 2013, Summer 2014, and/or Summer 2015 responses.

Table 3 shows the number of responses received in each year. Findings of Biology, Chemistry, Earth Science, and Engineering/Physics assessments using the Summer 2013, Summer 2014, Summer 2015, and Summer 2016 data will be reported by the ISEP research team. Data from the Elementary and Middle School Science Teacher PCK Assessments are closely related to teachers' teaching practices aligned with inquiry. Therefore, pre-post changes using data from these two instruments will be reported by the external evaluation team in this report.

The evaluators considered choices for each item on both assessments scored on a continuum from the most teacher-directed PCK practices (1) to the most student-directed PCK practices (4). In this way, changes in teacher responses can be represented as shifting from teacher-directed practices to student-directed practices over time. Descriptive analysis was conducted to examine trend of teachers' PCK scores by the number of years of participation in ISEP.

Table 3. *Number of Responses by Content Area, UB/BPS ISEP Teacher PCK Assessment, Summer 2013 to Summer 2016*

Instrument	**# of Items**	**# of Responses in Summer 2013**	**# of Responses in Summer 2014**	**# of Responses in Summer 2015**	**# of Responses in Summer 2016**
Elementary School Science	8	11	6	9	10
Middle School Science	8	13	28	22	14
Biology	29	27	21	16	13
Chemistry	30	4	6	6	6
Earth Science	30	6	7	6	5
Engineering/Physics	29	8	9	5	3
Total		**69**	**77**	**64**	**51**

UB/BPS ISEP Student Questionnaire (Spring 2016 and Fall 2016)

The *UB/BPS ISEP Student Questionnaire* was developed by the Discovery Center with input from the ISEP Research Team from instruments previously used in NSF as well as USDOE MSP and DRK12 projects evaluated by the Discovery Center. This questionnaire collected data from elementary, middle, and high school students of ISEP participant and comparison teachers in Fall 2015 (pre for 2015-2016), Spring 2016 (post for 2015-2016), and Fall 2016 (pre for 2016-2017). This instrument has two versions, one for elementary and middle school students (Grades 5-8, ES/MS) and the other for high school students (Grades 9-12, HS). A full description of this instrument, factor analysis, and reliability results can be found in the *Evaluation of University at Buffalo/Buffalo Public Schools (UB/BPS) Interdisciplinary Science and Engineering Partnership: Annual Report 2013-2014* (Woodruff & Li, 2014). Table 4 shows the internal consistency reliability results for Fall 2015 and Spring 2016 data. Overall, Cronbach's alpha values showed that the four attitudinal subscales had high reliabilities and the elementary/middle school content knowledge assessments were moderately reliable. The high school content knowledge assessment showed low reliability using data from Fall 2015 and high reliability using Spring 2016 data.

Table 4. *Reliability of UB/BPS ISEP Student Questionnaire Subscale, Fall 2015, Spring 2016, and Fall 2016*

		Fall 2015		**Spring 2016**		**Fall 2016**	
Subscale	**# of Items**	***n***	**Cronbach's Alpha**	***n***	**Cronbach's Alpha**	***n***	**Cronbach's Alpha**
My opinion about science	12	822	0.80	530	0.78	255	0.75
What teachers do in classrooms	12	815	0.84	516	0.85	247	0.78
What students do in classrooms	12	786	0.88	532	0.85	248	0.74
Parental/adult support at home	7	841	0.81	572	0.80	274	0.82
Content Knowledge for Elementary and Middle School	25	490	0.35	446	0.74	180	0.76
Content Knowledge for High School	25	403	0.60	165	0.76	105	0.68

Hard copies of the *UB/BPS ISEP Student Questionnaire* were administered to students of ISEP participant and comparison teachers, at the 12 ISEP partner schools, in Fall 2015, Spring 2016, and Fall 2016. Fall 2015 data served as pre-data for the 2015-2016 school year; Spring 2016 data served as post-data for the 2015-2016 school year. Fall 2016 data will only be used in the dosage-effect analysis in the final report. Of the 87 teachers who received this instrument (68 ISEP and 19 comparison teachers) in Fall 2015, 47 returned completed student instruments (47 ISEP and 6 comparison teachers, n_{student} = 944). Of the 87 teachers who received this instrument (68 ISEP and 19 comparison teachers) in Spring 2016, 33 returned completed student instruments (32 ISEP and 1 comparison teachers, n_{student} = 629). Of the 63 teachers who received this instrument (49 ISEP and 14 comparison teachers) in Fall 2016, 13 returned completed student instruments (11 ISEP and 2 comparison teachers, n_{student} = 295). The response rates were 54% in Fall 2015, 38% in Spring 2016, and 21% in Fall 2016, based on the number of teachers who were contacted.

Ideally, ANOVA analysis should be conducted for comparison of post-responses of students of ISEP participant teachers and comparison teachers, using students' pre-responses as a covariate variable to control initial perception differences. However, only one comparison teacher returned both pre- to post- student questionnaires during the school year, which did not allow ANOVA tests between ISEP and comparison groups. Instead, independent-samples t-tests were conducted to compare students' responses to the *UB/BPS ISEP Student Questionnaire* before (Fall 2015) and after (Spring 2016) their teachers' participation in ISEP activities for elementary, middle, and high school, separately. All analyses of student questionnaire data were conducted at the item level.

UB/BPS ISEP STEM Student Questionnaire (Fall 2016)

The *UB/BPS ISEP STEM Student Questionnaire* collected data from UB STEM graduate and undergraduate students who participated in project activities in Fall 2016. The instrument was developed by Dr. Liu, internal evaluator and researcher for the ISEP project, and was administered online to new and returning UB STEM students by the Discovery Center at the end of each semester using Qualtrics®.

Section A contains 1 multiple-choice item asking about students' preparedness for aspects of project activities in schools. Section B contains 1 multiple-choice item asking about students' self-reported experiences in schools. Section C contains 1 multiple-choice item, 14 items on a 4-point Likert-type scale, with responses ranging from *strongly disagree* (1) to *strongly agree* (4), and four items on a 5-point Likert-type scale, with responses ranging from *strongly decreased* (1) to *strongly increased* (5), asking about students' perceived value of project experiences. Section D contains 20 items on a 5-point rating scale, with responses ranging from *nothing* (1) to *a great deal* (5), asking about students' self-efficacy in communicating science. Section E contains 8 items requesting students' comprehensive demographics, experiential history, and career plan data.

The *UB/BPS ISEP STEM Student Questionnaire* was administered online by the Discovery Center to new and returning UB STEM students at the end of Fall 2016 using Qualtrics®. Thirteen STEM students completed this questionnaire. Response rate is 50%.

Descriptive statistics (e.g., frequencies and percentages) were used to report findings from the *UB/BPS ISEP STEM Student Questionnaire* data. Independent-samples *t*-tests were used to conduct comparisons at the item level between the responses of STEM undergraduate and STEM graduate students and between the responses of STEM graduate students who participated in the ISEP project for more than 1 year and those who were new to the project.

Findings

School-Level Enrollment and Report Card Data (2010-2011 to 2015-2016)

School-level data were collected and analyzed to compare aggregate teacher information, student demographics, and middle/high school student performance data for each ISEP partner school from 2010-2011 to 2015-2016. Data in 2012-2013, 2013-2014, 2014-2015, and 2015-2016 correspond to the first 4 ISEP project years.

Since aggregated information exclusively for science teachers is not available on the New York State School Report Card or other publicly available data sources, information was reported for all teachers in the building. From 2010-2011 to 2015-2016, the percentage of teachers teaching without an appropriate license/certificate decreased at 2 of the 12 ISEP partner schools; the percentage of teachers with a Master's plus 30 hours or doctorate degree increased at 9 schools; and the percentage of core courses not taught by highly qualified teachers decreased at 3 schools. The turnover rates from 2014-2015 school year to 2015-2016 school year for teachers with fewer than 5 years of experience and for all teachers were not available at the school level (Appendix A, Table A1).

Between 2010-2011 and 2015-2016, the percentage of White students decreased across the state of New York, across the BPS District, and at 6 ISEP partner high schools and 2 K-8 schools. The percentage of students eligible for free or reduced lunch increased at the state level, decreased at the district level, and decreased at 11 of the 12 ISEP partner schools, although all ISEP partner schools had much higher percentages of students who receive free or reduced lunch than the state average. The percentage of students with Limited English Proficiency (LEP) remained the same at the state level, increased at the district level and in 11 of the 12 ISEP partner schools (Appendix A, Tables A2 and A3).

Between 2010-2011 and 2015-2016, high school graduation rates increased at the state level, district level, and 2 of the 7 ISEP partner high schools. Six high schools had graduation rates lower than the BPS District average and only 1 was higher than the district and the New York State averages in 2015-2016. There were no obvious patterns of change regarding graduation rates for students in racial/ethnical or gender subgroups (Appendix A, Table A3).

No obvious patterns were found regarding the percentage of students meeting or exceeding New York State Standards in Grade 8 Science, Regents Earth Science, and/or Regents Chemistry between 2010-2011 and 2015-2016 (Appendix A, Tables A2 and A3).

UB/BPS ISEP Teacher Questionnaire Data, Summer 2012 to Summer 2016

Paired-samples *t*-tests were conducted to compare ISEP participant teachers' perception changes from Pre to Post Year 1, from Pre to Post Year 2, from Pre to Post Year 3, and from Pre to Post Year 4.

Science Preparation and Professional Development Needs

Table 5 shows ISEP teachers' self-reported preparedness for science instruction. Compared to their baseline responses, teachers indicated that they were significantly better prepared to teach science to students from a variety of cultural backgrounds, to encourage participation of females and minorities in science courses, to use a variety of technological tools to enhance student learning, and to teach interdisciplinary science inquiry following one year of ISEP participation. Teachers' preparedness for science instruction has been sustained over the project years. Specifically, teachers reported that they were significantly better prepared to lead students using investigative strategies and to teach interdisciplinary science inquiry following four years of ISEP participation, compared to their baseline responses.

Table 5. *Mean Difference and Standard Deviation of Teachers' Preparedness for Science Instruction, Pre-Post Year 1, Pre-Post Year 2, Pre-Post Year 3, and Pre-Post Year 4, UB/BPS ISEP Teacher Questionnaire*

Q30. Please indicate how well prepared you feel to do each of the following.	**Pre to Post Yr 1**	**Pre to Post Yr 2**	**Pre to Post Yr 3**	**Pre to Post Yr 4**
a. Provide science instruction that meets appropriate standards (district, state, or national).	0.15 (0.60)	0.25 (0.97)	0.33 (0.82)	0.22 (0.67)
b. Teach scientific inquiry.	0.00 (0.77)	-0.17 (0.72)	0.40 (0.91)	0.00 (0.47)
c. Manage a class of students who are using hands-on or laboratory activities.	-0.15 (0.66)	**-0.50 (0.67) ***	0.00 (0.85)	-0.33 (0.87)
d. Lead a class of students using investigative strategies.	-0.15 (0.78)	**-0.50 (1.00)**	-0.20 (0.77)	**-0.44 (0.53) ***
e. Take into account students' prior conceptions about natural phenomena when planning instruction.	-0.08 (0.86)	**-0.58 (1.31)**	**-0.33 (0.98)**	**-0.50 (0.76)**
f. Align standards, curriculum, instruction, and assessment to enhance student science learning.	-0.08 (0.63)	0.00 (1.04)	-0.07 (0.80)	-0.22 (0.67)
g. Sequence (articulation of) science instruction to meet instructional goals across grade levels and courses.	**-0.28 (0.94)**	0.33 (1.37)	**-0.33 (0.98)**	**-0.33 (0.87)**
h. Select and/or adapt instructional materials to implement your written curriculum.	-0.23 (0.76)	**-0.50 (1.09)**	**-0.33 (0.72)**	-0.22 (0.97)
i. Know the major unifying concepts of all sciences and how these concepts relate to other disciplines.	**-0.36 (0.95)**	**-0.33 (0.98)**	-0.07 (1.16)	-0.11 (0.78)
j. Understand how students differ in their approaches to learning and create instructional opportunities that are adapted to diverse learners.	-0.07 (0.68)	**-0.33 (0.89)**	0.00 (1.00)	**-0.33 (0.87)**
k. Teach science to students from a variety of cultural backgrounds.	**-0.33 (0.78) ***	**-0.27 (1.10)**	-0.08 (0.86)	-0.22 (0.44)
l. Teach science to students who have limited English proficiency.	**-0.27 (1.15)**	0.09 (0.70)	**-0.31 (0.75)**	0.25 (0.71)
m. Teach students who have a learning disability which impacts science learning.	**-0.31 (0.84)**	**-0.42 (0.79)**	**-0.33 (1.11)**	-0.11 (0.60)
n. Encourage participation of females and minorities in science courses.	**-0.35 (0.63) ****	-0.17 (0.94)	**-0.33 (1.05)**	0.00 (0.76)
o. Provide a challenging curriculum for all students you teach.	-0.16 (0.69)	0.00 (0.85)	0.07 (1.16)	0.00 (0.50)

Q30. Please indicate how well prepared you feel to do each of the following.	Pre to Post Yr 1	Pre to Post Yr 2	Pre to Post Yr 3	Pre to Post Yr 4
p. Learning the processes involved in reading and how to teach reading in science.	-0.11 (0.64)	-0.09 (1.14)	-0.07 (0.96)	0.00 (0.50)
q. Use a variety of assessment strategies (including objective and open-ended formats) to inform practice.	-0.12 (0.60)	0.18 (1.25)	-0.21 (0.97)	**-0.50 (0.93)**
r. Use a variety of technological tools (student response systems, lab interfaces and probes, etc) to enhance student learning.	**-0.54 (1.03) ***	-0.09 (1.22)	-0.21 (1.05)	**-0.38 (0.92)**
s. Teach interdisciplinary science inquiry.	**-0.32 (0.56) ****	-0.20 (1.03)	**-0.42 (1.00)**	**-0.75 (0.71) ***

* $p < .05$, ** $p < .01$, *** $p < .001$.
p values were calculated based on paired-samples t-tests.
Mean differences were calculated using pre mean scores minus post mean scores.
Absolute values larger than one-quarter of a point were marked as bold or red. Bold indicates that changes from pre to post aligned with ISEP goals/objectives; while red indicates changes towards undesired direction.

Table 6 shows teachers' needs for professional development prior to and following participation in the ISEP project. Before participating in ISEP activities, teachers indicated higher priority professional development needs related to aspects of science teaching closely aligned with NGSS cross-cutting concepts (i.e., scale, proportion, and quantity; systems and system models; and energy and matter) as well as some aspects of inquiry teaching (i.e., helping students develop the ability to communicate with others an argument based on evidence) than they did following one or more years of participation in ISEP. On the other hand, teachers reported higher priority professional development needs related to some aspects of inquiry teaching (i.e., the ability to develop and use valid models and to ask questions and define problems, and the ability to obtain, evaluate, and communicate information) after their participation.

Table 6. *Mean Difference and Standard Deviation of Teachers' Professional Development Needs, Pre-Post Year 1, Pre-Post Year 2, Pre-Post Year 3, and Pre-Post Year 4, UB/BPS ISEP Teacher Questionnaire*

Q31. Professional Development Needs	Pre to Post Yr 1	Pre to Post Yr 2	Pre to Post Yr 3	Pre to Post Yr 4
1). Help students develop the ability to communicate with others an argument based on evidence.	0.19 (0.62)	0.50 (0.52) **	0.07 (0.80)	0.40 (1.17)
2). Help students develop an understanding of scale, proportion, and quantity as these concepts are used to describe the natural world.	0.27 (0.92)	0.17 (0.94)	0.13 (0.64)	0.20 (0.92)
3). Help students develop an understanding of the behavior of organisms.	0.33 (1.07)	0.42 (0.67)	-0.07 (0.88)	0.00 (0.94)
4). Help students develop the ability to use mathematics and computational thinking.	0.00 (0.83)	-0.08 (0.79)	0.00 (0.85)	-0.10 (0.57)
5). Help students develop the ability to construct explanations and design solutions.	0.19 (0.69)	-0.09 (0.94)	0.07 (0.92)	-0.10 (0.57)

Q31. Professional Development Needs	**Pre to Post Yr 1**	**Pre to Post Yr 2**	**Pre to Post Yr 3**	**Pre to Post Yr 4**
6). Help students develop an understanding of chemical reactions.	-0.04 (0.89)	-0.08 (0.51)	**-0.40 (0.99)**	-0.20 (0.63)
7). Help students develop an understanding of patterns in natural events.	0.19 (1.02)	-0.09 (0.83)	0.00 (0.68)	-0.20 (0.63)
8). Help students develop an understanding of the interactions of energy and matter.	0.37 (1.04)	0.36 (0.81)	-0.21 (0.43)	-0.20 (0.79)
9). Help students develop an understanding of form and function.	0.08 (1.14)	0.09 (0.94)	-0.07 (0.73)	**-0.50 (0.71)**
10). Help students develop an understanding of the structure and properties of matter.	0.22 (1.05)	-0.09 (0.94)	**-0.29 (0.61)**	**-0.30 (0.67)**
11). Help students develop an understanding of the conservation of energy and increase in disorder.	0.20 (1.22)	0.18 (0.98)	-0.14 (0.53)	-0.10 (0.74)
12). Help students develop the abilities needed to do scientific inquiry.	0.00 (0.68)	0.08 (1.08)	-0.07 (0.88)	0.00 (0.47)
13). Help students develop an understanding of the structure of the atom.	-0.04 (1.04)	0.00 (0.43)	**-0.36 (0.74)**	-0.10 (0.99)
14). Help students develop an understanding of the molecular basis of heredity.	0.15 (1.05)	0.40 (0.97)	0.07 (0.92)	0.40 (0.97)
15). Help students develop an understanding of energy in the earth system.	0.19 (1.06)	0.18 (0.98)	-0.07 (0.83)	**-0.56 (0.88)**
16). Help students develop an understanding of the theory of biological evolution.	0.30 (0.91)	0.27 (0.79)	0.29 (0.99)	0.40 (1.17)
17). Help students develop the ability to develop and use valid models.	0.04 (1.16)	0.08 (0.79)	-0.07 (0.59)	**-0.30 (0.82)**
18). Help students develop the ability to obtain, evaluate, and communicate information.	0.33 (0.92)	0.09 (0.94)	-0.14 (0.53)	**-0.25 (0.46)**
19). Help students develop the ability to ask questions and define problems.	0.23 (0.86)	0.25 (0.75)	-0.07 (0.59)	0.10 (0.88)
20). Help students develop an understanding of matter, energy, and organization in living systems.	0.33 (1.14)	0.08 (1.00)	0.53 (0.92) *	0.10 (0.88)
21). Help students develop the ability to analyze and interpret data.	0.18 (0.90)	0.18 (0.87)	-0.07 (0.47)	-0.22 (0.44)
22). Help students develop an understanding of systems, order, and organization.	0.31 (1.26)	0.50 (0.90)	0.14 (0.66)	0.44 (1.13)
23). Help students develop an understanding of evidence, models, and explanation.	0.15 (0.86)	0.17 (0.72)	0.07 (0.96)	0.33 (0.71)
24). Help students develop an understanding of the cell.	0.23 (1.07)	0.00 (0.74)	0.33 (0.98)	0.20 (1.14)
25). Help students develop a scientific understanding of the earth in the solar system.	0.19 (0.85)	0.00 (0.82)	0.33 (0.98)	0.50 (0.85)
26). Help students develop an understanding of the interdependence of organisms.	0.31 (0.93)	-0.08 (0.67)	0.07 (0.80)	0.30 (0.95)

Q31. Professional Development Needs	Pre to Post Yr 1	Pre to Post Yr 2	Pre to Post Yr 3	Pre to Post Yr 4
27). Help students develop the ability to plan and carry out investigations.	-0.04 (0.52)	0.25 (0.87)	0.00 (0.68)	-0.10 (0.57)
28). Help students develop an understanding of change, constancy, and measurement.	0.44 (1.00) *	0.17 (0.94)	**-0.27 (0.80)**	0.20 (1.03)
29). Help students develop an understanding of geochemical cycles.	**-0.44 (0.93) ***	-0.09 (0.83)	**-0.38 (0.87)**	0.10 (0.99)
30). Help students develop a scientific understanding of the origins of the earth and the universe.	**-0.37 (1.15)**	**-0.36 (0.92)**	-0.21 (1.05)	0.22 (0.83)

* $p < .05$, ** $p < .01$, *** $p < .001$.
p values were calculated based on paired-samples *t*-tests.
Mean differences were calculated using pre mean scores minus post mean scores.
Absolute values larger than one-quarter of a point were marked as bold or red. Bold indicates that changes from pre to post aligned with ISEP goals/objectives; while red indicates changes towards undesired direction.

Science as Inquiry & Understanding the Nature of Science

Table 7 shows teachers' views of inquiry-based science teaching and learning practices before and after ISEP participation. Compared to their baseline responses, teachers reported that they were able to better clarify some of the misunderstanding of scientific inquiry. For example, following three years of ISEP participation, teachers reported less agreement with the statements that inquiry-based learners first understand basic, key science concepts prior to engaging in inquiry activities and that inquiry-based learning requires learners to engage in hands-on activities.

Although not statistically significant, compared to their baseline responses, teachers reported less agreement with accurate understandings of the teacher's role in inquiry-based teaching following 3 or 4 years of ISEP participation (i.e., inquiry-based teaching requires that the teacher act as a facilitator or guide of student learning, inquiry-based teaching focuses more on what the students do, and inquiry-based teaching requires that the teacher have a strong background in the science content related to the inquiry).

Table 7. *Mean Difference and Standard Deviation of Teachers' Views of Inquiry-Based Science Teaching and Learning, Pre-Post Year 1, Pre-Post Year 2, Pre-Post Year 3, and Pre-Post Year 4, UB/BPS ISEP Teacher Questionnaire*

Q32. Views of inquiry-based science teaching and learning.	Pre to Post Yr 1	Pre to Post Yr 2	Pre to Post Yr 3	Pre to Post Yr 4
1.Inquiry-based learning requires that learners engage in answering a scientifically-oriented question.	-0.12 (0.99)	-0.15 (1.21)	0.12 (0.99)	**-0.30 (0.48)**
2.Inquiry-based learning requires that learners gather (or are given) data to use as evidence for answering a scientifically-oriented question.	-0.15 (0.89)	0.31 (1.18)	-0.07 (0.59)	-0.20 (0.79)
3.Inquiry-based learning requires that learners manipulate and analyze data to develop evidenced-based explanations, by looking for patterns and drawing conclusions.	-0.21 (0.77)	**-0.54 (1.33)**	-0.19 (0.40)	0.00 (0.67)

Q32. Views of inquiry-based science teaching and learning.	**Pre to Post Yr 1**	**Pre to Post Yr 2**	**Pre to Post Yr 3**	**Pre to Post Yr 4**
4.Inquiry-based learning requires that learners connect their explanations with explanations and concepts developed by the scientific community.	-0.06 (0.86)	0.08 (0.76)	0.31 (0.60)	0.00 (0.67)
5.Inquiry-based learning requires that learners communicate, justify, and defend their explanations.	-0.03 (1.07)	**-0.54 (1.56)**	**-0.25 (0.77)**	-0.10 (0.99)
6.Inquiry-based learning requires that learners first understand basic, key science concepts prior to engaging in inquiry activities.	0.18 (1.10)	0.00 (0.71)	**0.38 (0.62) ***	**0.40 (1.17)**
7.Inquiry-based learning assumes that all science subject matter should be taught through inquiry.	-0.03 (1.14)	-0.15 (0.99)	0.19 (0.75)	**0.60 (1.07)**
8.Inquiry-based learning requires that learners generate and investigate their own questions.	-0.03 (0.90)	-0.54 (1.27)	-0.31 (0.79)	0.10 (0.74)
9.Inquiry-based learning requires the use of hands-on or kit-based instructional materials.	0.24 (1.05)	-0.15 (1.21)	**0.31 (1.25)**	**0.70 (1.16)**
10.Inquiry-based learning requires that learners are engaged in hands-on activities.	0.00 (0.82)	0.00 (0.85)	**0.67 (0.72) ****	**0.50 (0.97)**
11.Inquiry, as a process of science, can be taught without attention to specific science content or subject matter.	-0.12 (1.68)	-0.17 (0.94)	0.13 (1.31)	**-0.50 (1.08)**
12.Inquiry-based learning assumes that learners build new knowledge and understanding on what they already know.	0.18 (0.76)	0.25 (0.87)	-0.06 (0.77)	0.10 (0.74)
13.Inquiry-based learning assumes that learners formulate new knowledge by modifying and refining their current concepts and by adding new concepts to what they already know.	-0.12 (0.77)	0.08 (0.67)	**-0.25 (0.77)**	0.00 (0.82)
14.Inquiry-based learning assumes that learning is mediated by the social environment in which learners interact with others.	0.12 (1.09)	**-0.25 (0.87)**	0.06 (0.57)	0.00 (0.67)
15.Inquiry-based learning requires that learners take control of their own learning.	-0.15 (0.71)	**-0.25 (1.06)**	-0.19 (0.66)	0.10 (0.88)
16.Inquiry-based learning assumes that learners develop the ability to apply knowledge to novel situations, and that the transfer of learning is affected by the degree to which learners develop understanding.	-0.12 (0.81)	0.08 (0.67)	-0.19 (0.54)	0.10 (0.88)

Q32. Views of inquiry-based science teaching and learning.	Pre to Post Yr 1	Pre to Post Yr 2	Pre to Post Yr 3	Pre to Post Yr 4
17.Inquiry-based learning requires more sophisticated materials and equipment than other types of classroom learning.	-0.24 (1.50)	0.08 (1.00)	**0.50 (1.10)**	**0.30 (1.25)**
18.Inquiry-based teaching requires that the teacher act as a facilitator or guide of student learning rather than as a disseminator of knowledge.	-0.18 (0.94)	0.00 (0.74)	0.38 (0.89)	0.10 (0.74)
19.Inquiry-based teaching focuses more on what the students do, rather than on what the teacher does.	-0.18 (0.92)	0.00 (0.74)	-0.06 (0.77)	0.40 (0.84)
20.Inquiry-based teaching requires that the teacher have a strong background in the science content related to the inquiry.	0.06 (1.11)	-0.17 (0.72)	0.07 (0.88)	0.30 (1.25)

* $p < .05$, ** $p < .01$, *** $p < .001$.
p values were calculated based on paired-samples t-tests.
Mean differences were calculated using pre mean scores minus post mean scores.
Absolute values larger than one-quarter of a point were marked as bold or red. Bold indicates that changes from pre to post aligned with ISEP goals/objectives; while red indicates changes towards undesired direction.

Table 8 shows data regarding teachers' understanding of the nature of science. Although not statistically significant, following 1 year of participation in ISEP activities, teacher participants agreed more with the accurate understandings that scientific knowledge is reliable and durable so having confidence in scientific knowledge is reasonable; and scientific laws are generalizations or universal relationships about some aspect of the natural world and how it behaves under certain conditions.

Following 2 years of ISEP participation, teachers reported mixed perceptual changes, demonstrating both fewer misconceptions and fewer accurate understandings of the nature of science. Compared to their baseline responses, teachers agreed less that a universal step-by-step scientific method is used by all scientists and scientific experiments are the only means used to develop scientific knowledge; but also agreed less with accurate statements, including that with new evidence and/or interpretation, existing scientific ideas are replaced or supplemented by newer ones; scientific theories are inferred explanations of some aspect of the natural world; scientific conclusions are to some extent influenced by the social and cultural context of the researcher; and scientific observations are to some extent influenced by the observer's experiences and expectations.

Following 4 years of ISEP participation, teachers started to report more positive changes regarding their understanding of the nature of science. For example, after participation in ISEP for 4 years, teachers agreed significantly less that cultural values and expectations do not influence scientific research because scientists are trained to conduct unbiased studies and that scientists do not use their imagination and creativity because these can interfere with objectivity. Although not statistically significant, teachers also reported more agreement with statements, including that scientific knowledge is reliable and durable so having confidence in scientific knowledge is reasonable; with new evidence and/or interpretation, existing scientific ideas are replaced or supplemented by newer ones; the principal product of science is conceptual knowledge about and explanations of the natural world; scientific theories are inferred explanations of some aspect of the natural world; scientific conclusions are to some extent influenced by the social and cultural context of the researcher; and scientific observations are to some extent influenced by the observer's experiences and expectations.

Table 8. *Mean Difference and Standard Deviation of Teachers' Understanding of the Nature of Science, Pre-Post Year 1, Pre-Post Year 2, Pre-Post Year 3, and Pre-Post Year 4, UB/BPS ISEP Teacher Questionnaire*

Q33. Understanding the nature of science.	**Pre to Post Yr 1**	**Pre to Post Yr 2**	**Pre to Post Yr 3**	**Pre to Post Yr 4**
1.Science is a systematic way to gain an understanding of the natural world using naturalistic methods and explanations.	-0.06 (0.83)	0.08 (0.51)	0.12 (0.49)	0.00 (0.67)
2.Scientific knowledge is reliable and durable so having confidence in scientific knowledge is reasonable.	**-0.25 (0.84)**	0.00 (0.77)	0.19 (0.83)	**-0.56 (1.13)**
3.A universal step-by-step scientific method is used by all scientists.	-0.06 (1.09)	**0.33 (0.89)**	-0.24 (0.97)	-0.44 (1.01)
4.Scientific experiments are the only means used to develop scientific knowledge.	-0.15 (1.21)	**0.58 (0.90) ***	**0.41 (1.00)**	0.20 (0.92)
5.Contributions to science are made by people from all cultures around the world.	-0.03 (0.72)	-0.08 (0.67)	0.06 (0.66)	-0.20 (0.63)
6.Scientific observations and conclusions are influenced by the existing state of scientific knowledge.	-0.18 (0.87)	0.00 (0.74)	0.12 (0.49)	0.00 (0.82)
7.With new evidence and/or interpretation, existing scientific ideas are replaced or supplemented by newer ones.	-0.15 (0.70)	0.33 (0.65)	-0.24 (0.66)	**-0.30 (0.48)**
8.Basic scientific research is concerned primarily with practical outcomes related to developing technology.	-0.09 (0.93)	0.08 (0.67)	0.12 (0.86)	0.20 (0.79)
9.The principal product of science is conceptual knowledge about and explanations of the natural world.	0.15 (1.16)	0.09 (0.94)	0.00 (0.89)	**-0.30 (1.06)**
10.Scientific laws are generalizations or universal relationships about some aspect of the natural world and how it behaves under certain conditions.	**-0.26 (0.86)**	0.00 (0.67)	0.00 (1.10)	0.10 (0.57)
11.Scientific theories are inferred explanations of some aspect of the natural world.	0.09 (0.83)	0.25 (0.97)	0.00 (0.87)	**-0.30 (0.82)**
12.All scientific laws have accompanying explanatory theories.	0.00 (0.95)	-0.25 (0.87)	0.00 (0.79)	-0.20 (0.79)
13.Scientific conclusions are to some extent influenced by the social and cultural context of the researcher.	-0.06 (1.10)	0.50 (0.67) *	0.12 (0.78)	**-0.30 (1.34)**
14.Scientific observations are to some extent influenced by the observer's experiences and expectations.	-0.12 (1.04)	0.33 (0.49) *	0.12 (0.78)	**-0.60 (0.84)**
15.Scientists may make different interpretations based on the same observations.	-0.03 (0.87)	-0.17 (0.72)	-0.12 (0.78)	0.30 (1.06)
16.Scientific theories are subject to on-going testing and revision.	-0.21 (0.64)	0.17 (0.83)	-0.13 (0.50)	-0.20 (0.63)
17.Scientific laws are theories that have been proven.	-0.21 (0.59)	-0.17 (0.72)	-0.06 (0.57)	-0.11 (0.78)

Q33. Understanding the nature of science.	**Pre to Post Yr 1**	**Pre to Post Yr 2**	**Pre to Post Yr 3**	**Pre to Post Yr 4**
18.Cultural values and expectations do not influence scientific research because scientists are trained to conduct unbiased studies.	-0.24 (0.83)	0.08 (0.67)	0.18 (1.19)	**0.80 (1.03) ***
19.Scientists do not use their imagination and creativity because these can interfere with objectivity.	-0.24 (1.12)	**0.25 (1.14)**	0.12 (0.93)	**0.60 (0.7) ***
20.Scientific knowledge is tentative and may be abandoned or modified in light of new evidence or reconceptualization of prior evidence and knowledge.	-0.21 (0.78)	-0.08 (1.00)	0.29 (0.92)	-0.20 (1.03)

* $p < .05$, ** $p < .01$, *** $p < .001$.
p values were calculated based on paired-samples t-tests.
Mean differences were calculated using pre mean scores minus post mean scores.
Absolute values larger than one-quarter of a point were marked as bold or red. Bold indicates that changes from pre to post aligned with ISEP goals/objectives; while red indicates changes towards undesired direction.

Design, Engineering, and Technology (DET)

ISEP teachers were asked a number of questions about their familiarity with, beliefs about teaching, and barriers to teaching topics related to design, engineering, and technology prior to and following their participation in ISEP professional development. As shown in Table 9, following one or more years of ISEP participation, teachers reported using more DET activities in classrooms and having more school support for using DET activities.

Table 9. *Mean Difference and Standard Deviation of Teachers' Understanding of Design, Engineering, and Technology, Pre-Post Year 1, Pre-Post Year 2, Pre-Post Year 3, and Pre-Post Year 4, UB/BPS ISEP Teacher Questionnaire*

DET 1: Extent	**Pre to Post Yr 1**	**Pre to Post Yr 2**	**Pre to Post Yr 3**	**Pre to Post Yr 4**
1.How familiar are you with Design/Engineering/Technology as typically demonstrated in the examples given above?	0.16 (1.25)	-0.23 (1.59)	-0.06 (1.21)	**-0.70 (1.16)**
2.Have you had any specific courses in Design/Engineering/Technology outside of your preservice curriculum?	**-0.34 (1.49)**	0.08 (1.44)	-0.11 (1.28)	**-0.60 (1.35)**
3.Did your preservice curriculum include any aspects of Design/Engineering/Technology?	0.10 (1.52)	-0.17 (2.14)	0.00 (0.49)	**-0.30 (1.77)**
4.Was your pre-service curriculum effective in supporting your ability to teach Design/Engineering/Technology at the beginning of your career?	0.37 (1.25)	-0.17 (1.47)	0.12 (0.86)	0.10 (1.66)
5.How confident do you feel about integrating more Design/Engineering/Technology into your curriculum?	0.34 (1.21)	0.50 (1.73)	**-0.39 (1.33)**	**-0.50 (1.35)**
6.How important should pre-service education be for teaching Design/Engineering/Technology?	0.53 (1.22) *	0.83 (1.60)	**-0.39 (1.24)**	**-0.50 (0.97)**
7.Do you use Design/Engineering/Technology activities in the classroom?	**-0.38 (1.62)**	**-0.42 (1.93)**	**-0.65 (1.22) ***	**-0.60 (1.51)**

DET 1: Extent	**Pre to Post Yr 1**	**Pre to Post Yr 2**	**Pre to Post Yr 3**	**Pre to Post Yr 4**
8.Does your school support Design/Engineering/Technology activities?	-0.16 (1.78)	0.17 (1.40)	**-0.59 (1.66)**	**-1.00 (1.25) ***
9.Do you believe Design/Engineering/Technology should be integrated into the K-12 curriculum?	-0.06 (1.41)	**-0.33 (1.23)**	**-0.59 (1.23)**	0.00 (1.05)
DET 2: Agreement				
10.Most people feel that female students can do well in Design/Engineering/Technology.	-0.06 (1.54)	0.23 (0.83)	0.13 (1.50)	0.80 (1.23)
11.Most people feel that minority students (African American, Hispanic / Latino, and American Indian) can do well in Design/Engineering/Technology.	0.00 (1.52)	0.31 (0.85)	0.38 (1.54)	0.60 (1.51)
DET 3: As you teach a science curriculum, it is important to include…				
12.Planning a project.	0.03 (0.91)	0.25 (0.75)	**-0.31 (0.79)**	0.40 (1.35)
13.Using engineering to develop new technologies.	0.17 (1.09)	-0.17 (1.19)	-0.19 (1.05)	0.70 (1.25)
DET 4: I would like to be able to teach my students to understand the…				
14.Design process.	-0.09 (0.77)	0.08 (0.67)	**-0.31 (0.79)**	0.10 (0.88)
15.Use and impact of Design/Engineering/Technology.	0.03 (0.65)	0.08 (0.79)	**-0.44 (0.73) ***	0.20 (0.92)
16.Science underlying Design/Engineering/Technology.	0.06 (0.66)	0.17 (0.72)	**-0.44 (0.81) ***	0.10 (0.88)
17.Types of problems to which Design/Engineering/Technology should be applied.	0.00 (0.61)	0.00 (0.85)	**-0.44 (0.63) ***	0.10 (0.88)
18.Process of communicating technical information.	0.15 (0.67)	0.08 (0.79)	**-0.31 (0.60)**	0.20 (0.92)
DET 5: My motivation for teaching science is…				
19.To prepare young people for the world of work.	0.16 (0.63)	0.08 (0.51)	0.06 (0.66)	-0.10 (0.57)
20.To promote an enjoyment of learning.	0.29 (0.74) *	0.33 (0.49) *	0.18 (0.64)	0.20 (0.63)
21.To develop an understanding of the natural and technical world.	0.03 (0.65)	0.08 (0.67)	0.13 (0.72)	0.10 (0.57)
22.To develop scientists, engineers, and technologists for industry.	-0.06 (0.62)	0.08 (0.67)	0.12 (0.86)	-0.20 (0.79)
23.To promote an understanding of how Design/Engineering/Technology affects society.	0.09 (0.64)	0.17 (0.39)	0.29 (0.99)	0.30 (0.82)
DET 6: Barrier in integrating DET in your classroom				
24.Lack of time for teachers to learn about Design/Engineering/Technology.	-0.27 (1.63)	-0.46 (0.97)	-0.47 (1.42)	-0.80 (1.62)
25.Lack of teacher knowledge.	0.18 (1.65)	-0.77 (1.88)	0.06 (1.30)	0.00 (1.33)

DET 1: Extent	Pre to Post Yr 1	Pre to Post Yr 2	Pre to Post Yr 3	Pre to Post Yr 4
26.Lack of training.	-0.06 (1.41)	-0.62 (1.76)	-0.06 (1.09)	-0.10 (1.37)
27.Lack of administration support.	0.09 (1.63)	-0.85 (1.95)	0.13 (1.59)	-0.33 (1.8)
DET 8: How much do you know about the ...				
29.National science standards related to Design/Engineering/Technology?	-0.23 (1.45)	**-0.25 (2.38)**	0.06 (1.12)	**-0.30 (1.77)**
DET 9: Extent				
30.How enthusiastic do you feel about including Design/Engineering/Technology activities in your teaching?	0.21 (1.24)	0.42 (1.00)	0.18 (1.07)	0.20 (0.63)
31.How prepared do you feel to include Design/Engineering/Technology activities in your teaching?	0.12 (1.39)	**-0.33 (1.44)**	-0.24 (1.71)	**-0.30 (1.06)**
32.How important is it for you that Design/Engineering/Technology activities are aligned to mathematics state and national standards?	0.38 (1.21)	0.25 (1.14)	0.47 (1.33)	-0.10 (0.74)
33.How important is it for you that Design/Engineering/Technology activities are aligned to science state and national standards?	0.27 (0.84)	0.17 (1.53)	0.00 (1.00)	-0.20 (0.63)

* $p < .05$, ** $p < .01$, *** $p < .001$.
p values were calculated based on paired-samples *t*-tests.
Mean differences were calculated using pre mean scores minus post mean scores.
Absolute values larger than one-quarter of a point were marked as bold or red. Bold indicates that changes from pre to post aligned with ISEP goals/objectives; while red indicates changes towards undesired direction.

Attitudes and Beliefs about Teaching Science

Tables 10 shows changes in teachers' attitudes and beliefs about teaching science following ISEP participation. Following ISEP participation, teachers reported more agreement that students should have opportunities to experience manipulating materials in the science classroom before teachers introduce scientific vocabulary and less agreement that they were scared by the idea of teaching engineering design concepts.

Table 10. *Mean Difference and Standard Deviation of Teachers' Attitudes and Beliefs about Teaching Science, Pre-Post Year 1, Pre-Post Year 2, Pre-Post Year 3, and Pre-Post Year 4, UB/BPS ISEP Teacher Questionnaire*

Q46. Attitudes and Beliefs about Teaching Science and Mathematics	Pre to Post Yr 1	Pre to Post Yr 2	Pre to Post Yr 3	Pre to Post Yr 4
k. Using technologies (e.g., calculators, computers) in science lessons will improve students' understanding of science.	0.06 (1.12)	**-0.27 (0.65)**	0.06 (0.85)	0.80 (1.03) *
l. Getting the correct answer to a problem in the science classroom is more important than investigating the problem in a scientific manner.	-0.23 (1.18)	-0.09 (1.04)	-0.06 (0.77)	0.00 (0.67)

Q46. Attitudes and Beliefs about Teaching Science and Mathematics	Pre to Post Yr 1	Pre to Post Yr 2	Pre to Post Yr 3	Pre to Post Yr 4
m. In Grades K-9, truly understanding science in the science classroom requires special abilities that only some people posses.	0.03 (1.20)	0.00 (0.89)	-0.25 (0.93)	-0.30 (0.48)
n. Students should be given regular opportunities to think about what they have learned in the science classroom.	-0.03 (0.75)	-0.10 (0.57)	0.13 (0.96)	0.00 (0.47)
q. To understand science, students must solve many problems following examples provided.	-0.13 (0.82)	0.09 (0.70)	-0.19 (0.98)	-0.10 (0.57)
r. The use of technologies (e.g., calculators, computers) in science is an aid primarily for slow learners.	-0.52 (1.26) *	-0.18 (1.08)	**0.44 (1.31)**	-0.20 (2.04)
s. Students should have opportunities to experience manipulating materials in the science classroom before teachers introduce scientific vocabulary.	-0.13 (1.23)	-0.18 (1.17)	**-0.31 (1.14)**	**-0.50 (1.35)**
t. Science consists of unrelated topics such as biology, chemistry, geology, and physics.	0.06 (1.24)	**0.45 (1.29)**	**0.44 (0.51) ****	-0.56 (2.07)
u. Calculators should always be available for students in science classes.	0.13 (0.94)	**0.70 (0.95) ***	0.19 (0.75)	-0.40 (0.97)
v. The primary reason for learning science is to provide real-life examples for learning mathematics.	-0.27 (1.01)	0.00 (0.50)	0.07 (1.03)	-0.20 (0.79)
w. Small group activity should be a regular part of the science classroom.	0.20 (0.76)	-0.20 (0.42)	0.06 (0.68)	-0.11 (0.78)
x. The idea of teaching science scares me.	-0.03 (0.96)	0.10 (0.74)	-0.06 (0.93)	0.10 (0.99)
y. The idea of teaching engineering design concepts scares me.	0.00 (1.03)	**0.30 (0.67)**	**0.27 (1.53)**	**0.33 (1.32)**
z. I prefer to teach engineering design concepts and science emphasizing connections between the two disciplines.	-0.06 (1.03)	-0.09 (0.70)	**-0.44 (1.36)**	0.10 (1.52)
aa. I feel prepared to teach engineering design concepts and science emphasizing connections between the two disciplines.	**-0.26 (1.12)**	-0.09 (0.83)	**-0.31 (1.08)**	-0.20 (1.03)

* $p < .05$, ** $p < .01$, *** $p < .001$.
p values were calculated based on paired-samples t-tests.
Mean differences were calculated using pre mean scores minus post mean scores.
Absolute values larger than one-quarter of a point were marked as bold or red. Bold indicates that changes from pre to post aligned with ISEP goals/objectives; while red indicates changes towards undesired direction.

Pedagogical Content Knowledge (PCK) Assessment

Table 11 shows teachers' responses to the PCK assessment by their length of participation in ISEP for each subject area. Figure 1 shows teachers' PCK scores by their response year. Overall, no observable patterns of change in scores are shown as teachers participated in ISEP for a longer period.

Table 11. *Percentage of Correctness by Subject by Response Year, Teacher Pedagogical Content Assessment*

	Subject								
	ES Science			MS Science			Biology		
Response Year	***M***	***SD***	***n***	***M***	***SD***	***n***	***M***	***SD***	***n***
Unknown	NA	NA	NA	67.50%	0.06	2	NA	NA	NA
Pre	66.23%	0.11	13	73.75%	0.08	20	47.44%	0.23	9
Post Year 1	70.21%	0.10	14	72.50%	0.09	28	53.56%	0.20	25
Post Year 2	65.71%	0.10	7	74.38%	0.07	16	61.10%	0.23	20
Post Year 3	56.00%	NA	1	70.33%	0.11	6	58.23%	0.24	13
Post Year 4	56.00%	NA	1	75.00%	NA	1	62.40%	0.23	10
Overall	67.11%	0.10	36	72.97%	0.08	73	56.74%	0.22	77
	Subject								
	Chemistry			**Earth Science**			**Physics/Engineering**		
Response Year	***M***	***SD***	***n***	***M***	***SD***	***n***	***M***	***SD***	***n***
Pre	90.00%	0.09	3	62.33%	0.35	3	34.50%	0.05	2
Post Year 1	84.25%	0.11	8	70.89%	0.17	9	62.89%	0.24	9
Post Year 2	82.86%	0.18	7	63.83%	0.17	6	81.43%	0.14	7
Post Year 3	84.67%	0.17	3	70.00%	0.03	3	67.50%	0.17	4
Post Year 4	90.00%	NA	1	75.67%	0.08	3	72.33%	0.19	3
Overall	84.91%	0.13	22	68.54%	0.17	24	67.68%	0.22	25

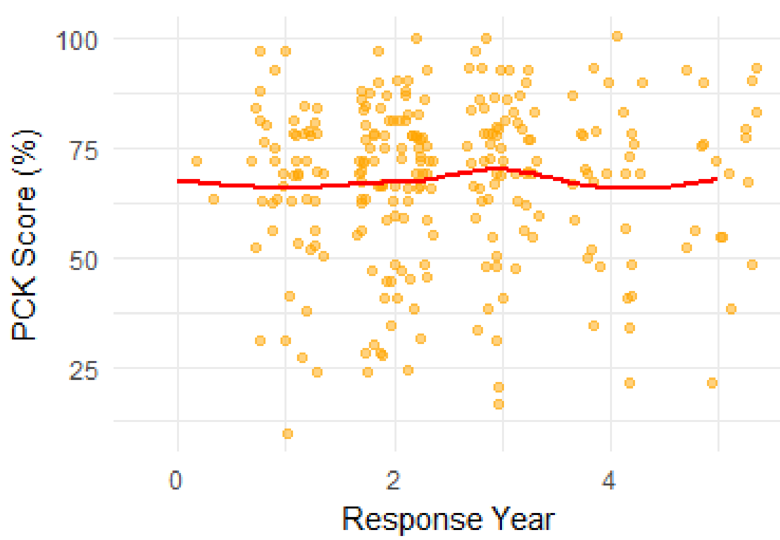

Figure 1. Teachers' PCK scores by response year. (The red line represents a loess curve of the points.)

Figure 2 shows fitted loess curves estimating teachers' PCK scores over their response year for each subject. There are noticeably different patterns in teachers' PCK changes over year for different subjects.

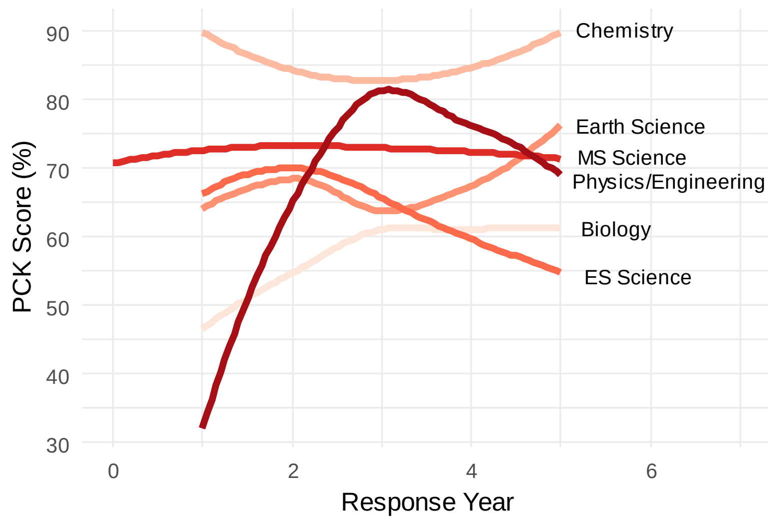

Figure 2. Teachers' PCK scores by subject by response year. (The red lines represent loess curves of the points.)

UB/BPS ISEP Student Questionnaire Data, Fall 2015 – Spring 2016

Demographics

In Fall 2015 and Spring 2016, 944 and 629 students responded to the *UB/BPS ISEP Student Questionnaire*, respectively. Among them, 795 students in Fall 2015 and 607 students in Spring 2016 were taught by ISEP teachers, while 149 students in Fall 2015 and 22 students in Spring 2016 were taught by teachers who were not involved in ISEP, but who also taught in the 12 partner schools. Since a very small number of ISEP students and an even smaller number of comparison student could be matched from Fall 2015 to Spring 2016, independent t-test comparisons were conducted using unmatched samples to examine the ISEP students' changes in their attitudes and content knowledge from Fall 2015 to Spring 2016. Table 12 shows ISEP and comparison students' grade levels.

Table 12. *Respondents' Grade Band by Teacher Participation Status, UB/BPS ISEP Student Questionnaire, Fall 2015 and Spring 2016*

Teacher Participation	Grade	Fall 2015	Spring 2016	Total
Comparison	4	25	0	25
	6	32	22	54
	9	24	0	24
	10	30	0	30
	11	20	0	20
	12	18	0	18
	Comparison Total	**149**	**22**	**171**
ISEP	2	12		12
	4	71	47	118
	5	93	123	216
	6	105	121	226
	7	76	66	142

Teacher Participation	Grade	Fall 2015	Spring 2016	Total
	8	94	79	173
	9	74	43	117
	10	100	71	171
	11	87	20	107
	12	83	37	120
	ISEP Total	**795**	**607**	**1402**

As shown in Table 13, gender distributions in both comparison and ISEP groups are quite even in both semesters.

Table 13. *Respondents' Gender by Teacher Participation Status, UB/BPS ISEP Student Questionnaire, Fall 2015 and Spring 2016*

Teacher Participation	Gender	Fall 2015	Spring 2016	Total
Comparison	Female	73	16	89
	Male	76	6	82
	Comparison Total	149	22	171
ISEP	Female	415	304	719
	Male	373	291	664
	ISEP Total	788	**595**	**1383**

As shown in Table 14, students' race/ethnicity compositions in both comparison and ISEP groups are representative of the Buffalo Public School District with high percentages of African American and Hispanic/Latino(a) students.

Table 14. *Respondents' Race/Ethnicity by Teacher Participation Status, UB/BPS ISEP Student Questionnaire, Fall 2015 and Spring 2016*

Teacher Participation	Race/Ethnicity	Fall 2015	Spring 2016	Total
Comparison	American Indian or Alaska Native	7	2	9
	Asian	24	4	28
	Black or African American	56	7	63
	Hispanic/Latino(a)	33	4	37
	Native Hawaiian Or Other Pacific Islander	2	0	2
	White	14	2	16
	Multi-Race	11	2	13
	Not Hispanic/Latino(a)*	2	1	3
	Comparison Total	**149**	**22**	**171**
ISEP	American Indian or Alaska Native	22	12	34
	Asian	83	68	151
	Black or African American	261	212	473
	Hispanic/Latino(a)	135	98	233
	Native Hawaiian Or Other Pacific Islander	2	6	8
	White	178	125	303
	Multi-Race	63	51	114
	Not Hispanic/Latino(a)*	40	30	70
	ISEP Total	**784**	**602**	**1386**

* Respondents reported ethnicity, but did not report race.

Elementary Grades Students' Attitudes and Perceptions about Science Learning

When comparing pre-post attitudes and opinions of elementary grades students of ISEP participant teachers, students agreed significantly more that science ideas or hypotheses must be supported by evidence; they learned that there are different solutions to science tasks; they used multiple sources of information to learn; they learned about how science is important in the real world, and they worked on science tasks in a group with other students in Spring 2016 than they did in Fall 2015. They also reported receiving more parental support at home with their science homework and projects (Table 15).

Table 15. *Comparisons of ISEP Students' Pre-Post Responses, UB/BPS ISEP Student Questionnaire, Fall 2015 and Spring 2016, Elementary School Students, Unmatched*

Item	Time	*n*	*M*	*SD*	*p*	Mean Diff
Q8. Views of Science						
Q8a. I like science.	Fall 15	266	3.89	1.20	.251	-0.11
	Spring 16	286	4.00	1.10		
Q8b. I am good at science.	Fall 15	266	3.39	1.16	.079	-0.17
	Spring 16	280	3.56	1.09		
Q8c. I would keep on taking science classes even if I did not have to.	Fall 15	265	3.56	1.28	.107	0.19
	Spring 16	276	3.37	1.39		
Q8d. I understand most of what goes on in science.	Fall 15	259	3.66	1.13	.174	-0.12
	Spring 16	278	3.79	0.95		
Q8e. Almost all people use science in their jobs.	Fall 15	264	3.41	1.21	.807	-0.02
	Spring 16	277	3.43	1.08		
Q8f. Science is useful for solving everyday problems.	Fall 15	261	3.20	1.24	.906	-0.01
	Spring 16	274	3.21	1.20		
Q8g. Science is a way to study and understand the natural world.	Fall 15	261	4.14	1.10	.680	0.04
	Spring 16	268	4.10	0.97		
Q8h. Scientists sometimes disagree about scientific knowledge.	Fall 15	260	3.50	1.22	.067	-0.19
	Spring 16	274	3.68	1.11		
Q8i. All scientists do not follow the same step-by-step method to do science.	Fall 15	259	3.41	1.31	.599	0.06
	Spring 16	275	3.35	1.34		
Q8j. Scientists use their imagination when doing science.	Fall 15	261	3.22	1.39	.961	0.01
	Spring 16	277	3.22	1.27		
Q8k. Science ideas or hypotheses must be supported by evidence.	Fall 15	261	3.90	1.12	**.030**	**-0.20**
	Spring 16	275	4.10	1.03		
Q8l. Scientific theories can change when new evidence or a new explanation becomes available.	Fall 15	263	3.88	1.13	.226	-0.11
	Spring 16	275	3.99	0.98		
Q9. In this class, my teacher ...	**Time**	***n***	***M***	***SD***	***p***	**Mean Diff**
Q9a. arranges the classroom so students can have discussion.	Fall 15	266	3.30	1.42	.439	-0.09
	Spring 16	275	3.39	1.35		
Q9b. asks questions that have more than one answer.	Fall 15	265	3.80	1.15	.436	-0.07
	Spring 16	275	3.87	1.01		
Q9c. asks me to give reasons and provide evidence for my answers.	Fall 15	258	4.31	1.12	.319	-0.09
	Spring 16	272	4.40	0.96		
Q9d. encourages me to ask questions.	Fall 15	258	3.71	1.27	.565	0.06
	Spring 16	275	3.65	1.23		
Q9e. lets me work at my own pace.	Fall 15	262	3.40	1.24	.710	-0.04
	Spring 16	267	3.45	1.30		

Q9f. encourages me to explain my ideas to other students.	Fall 15	262	3.56	1.25	.755	0.03
	Spring 16	269	3.53	1.21		
Q9g. encourage me to consider different scientific explanations.	Fall 15	259	3.47	1.26	.684	0.04
	Spring 16	264	3.42	1.14		
Q9h. provides time for me to discuss science ideas with other students.	Fall 15	260	3.59	1.31	.416	-0.09
	Spring 16	272	3.68	1.18		
Q9i. checks that I have completed my assignments.	Fall 15	261	4.31	1.06	.200	-0.11
	Spring 16	266	4.43	0.98		
Q9j. provides meaningful and challenging assignments.	Fall 15	258	3.89	1.11	.434	0.07
	Spring 16	270	3.82	1.03		
Q9k. helps me apply my learning to real life.	Fall 15	264	3.97	1.23	.889	0.01
	Spring 16	267	3.96	1.19		
Q9l. expects me to do well.	Fall 15	265	4.56	0.94	.085	-0.13
	Spring 16	275	4.69	0.78		
Q10. In this class, I ...	**Time**	***n***	***M***	***SD***	***p***	**Mean Diff**
Q10a. use information and data to support my conclusions.	Fall 15	260	4.01	1.24	.076	-0.17
	Spring 16	275	4.18	1.01		
Q10b. talk with other students about how to do a science task or about how to interpret the data from an experiment.	Fall 15	261	3.54	1.26	.138	-0.16
	Spring 16	271	3.70	1.18		
Q10c. learn from other students.	Fall 15	262	3.24	1.38	.128	-0.17
	Spring 16	270	3.41	1.26		
Q10d. consider different scientific explanations.	Fall 15	255	3.47	1.30	.354	-0.10
	Spring 16	269	3.57	1.11		
Q10e. have a say in deciding what activities I do.	Fall 15	254	2.98	1.43	.780	-0.03
	Spring 16	264	3.02	1.39		
Q10f. use a computer or the Internet for science assignments or activities.	Fall 15	259	2.99	1.42	.973	0.00
	Spring 16	273	3.00	1.32		
Q10g. write about how I solved a science task or about what I am learning.	Fall 15	256	3.39	1.38	.165	-0.16
	Spring 16	267	3.55	1.24		
Q10h. learn that there are different solutions to science tasks.	Fall 15	257	3.74	1.23	**.023**	**-0.22**
	Spring 16	268	3.96	0.99		
Q10i. use multiple sources of information to learn.	Fall 15	255	3.77	1.25	**.042**	**-0.21**
	Spring 16	269	3.98	1.09		
Q10j. develop my skills for doing science.	Fall 15	252	3.72	1.26	.098	-0.17
	Spring 16	265	3.89	1.09		
Q10k. learn about how science is important in the real world.	Fall 15	260	3.74	1.33	**.005**	**-0.29**
	Spring 16	271	4.04	1.07		
Q10l. work on science tasks in a group with other students.	Fall 15	258	3.65	1.31	**.003**	**-0.31**
	Spring 16	275	3.96	1.09		
Q11. At least one adult in my home, ...	**Time**	***n***	***M***	***SD***	***p***	**Mean Diff**
Q11a. makes me do my science homework.	Fall 15	258	3.79	1.49	**.006**	**-0.34**
	Spring 16	271	4.13	1.31		
Q11b. asks about what I am learning in science class.	Fall 15	257	3.63	1.45	.342	-0.12
	Spring 16	267	3.74	1.31		
Q11c. helps me with my science homework.	Fall 15	256	3.37	1.48	**.020**	**-0.29**
	Spring 16	274	3.66	1.39		

Q11d. helps me work on my science projects.	Fall 15	255	3.63	1.51	**.014**	**-0.31**
	Spring 16	269	3.93	1.32		
Q11e. expects me to do well in science.	Fall 15	258	4.40	1.11	.111	-0.14
	Spring 16	265	4.55	0.94		
Q11f. expects me to go to college.	Fall 15	255	4.42	1.13	.076	-0.16
	Spring 16	268	4.58	0.94		
Q11g. expects me to have a science-related career.	Fall 15	257	3.19	1.55	.151	0.19
	Spring 16	267	3.00	1.55		

Note. Q8: 1 = Strongly Disagree, 5 = Strongly Agree; and Q9, Q10, & Q11: 1 = Almost Never, 5 = Very Often.
p values were calculated based on independent-samples *t*-tests. *p*-values less or equal to 0.05 were yellow highlighted and bolded.
Mean differences were calculated using Fall 2015 mean scores minus Spring 2016 mean scores.
Absolute values larger than one-quarter of a point were marked as bold or red. Bold indicates that changes from pre to post aligned with ISEP goals/objectives; while red indicates changes towards undesired direction.

Middle Grades Students' Attitudes and Perceptions about Science Learning

When comparing pre-post attitudes and opinions of middle school students of ISEP participant teachers, students agreed significantly more that almost all people used science in their jobs; scientific theories can change when new evidence or a new explanation becomes available; they used information and data to support their conclusions; and they worked on science tasks in a group with other students in Spring 2016 than they did in Fall 2015 (Table 16).

Table 16. *Comparisons of ISEP Students' Pre-Post Responses, UB/BPS ISEP Student Questionnaire, Fall 2015 and Spring 2016, Middle School Students, Unmatched*

Item	**Time**	***n***	***M***	***SD***	***p***	**Mean Diff**
Q8. Views of Science						
Q8a. I like science.	Fall 15	164	3.89	0.97	.570	-0.06
	Spring 16	145	3.95	0.93		
Q8b. I am good at science.	Fall 15	164	3.44	0.92	.312	0.11
	Spring 16	142	3.33	0.94		
Q8c. I would keep on taking science classes even if I did not have to.	Fall 15	162	3.28	1.23	.657	-0.06
	Spring 16	144	3.34	1.22		
Q8d. I understand most of what goes on in science.	Fall 15	165	3.75	0.81	.969	0.00
	Spring 16	143	3.76	0.88		
Q8e. Almost all people use science in their jobs.	Fall 15	165	3.38	0.96	**.019**	**-0.25**
	Spring 16	143	3.63	0.92		
Q8f. Science is useful for solving everyday problems.	Fall 15	163	3.39	1.00	.130	-0.17
	Spring 16	141	3.56	1.00		
Q8g. Science is a way to study and understand the natural world.	Fall 15	159	4.21	0.85	.903	0.01
	Spring 16	139	4.20	0.91		
Q8h. Scientists sometimes disagree about scientific knowledge.	Fall 15	162	3.61	1.05	.092	-0.21
	Spring 16	143	3.82	1.09		
Q8i. All scientists do not follow the same step-by-step method to do science.	Fall 15	163	3.38	1.22	.370	-0.13
	Spring 16	142	3.51	1.24		
Q8j. Scientists use their imagination when doing science.	Fall 15	164	3.08	1.20	.884	-0.02
	Spring 16	141	3.10	1.19		
Q8k. Science ideas or hypotheses must be supported by evidence.	Fall 15	163	4.02	1.03	.076	-0.20
	Spring 16	140	4.22	0.95		

Q8l. Scientific theories can change when new evidence or a new explanation becomes available.	Fall 15	163	4.12	0.90	**.027**	**-0.22**
	Spring 16	138	4.34	0.84		
Q9. In this class, my teacher ...	**Time**	***n***	***M***	***SD***	***p***	**Mean Diff**
Q9a. arranges the classroom so students can have discussion.	Fall 15	163	3.40	1.30	.145	-0.21
	Spring 16	140	3.61	1.17		
Q9b. asks questions that have more than one answer.	Fall 15	163	3.89	1.01	.680	0.05
	Spring 16	138	3.84	1.05		
Q9c. asks me to give reasons and provide evidence for my answers.	Fall 15	164	4.18	0.94	.177	-0.14
	Spring 16	140	4.32	0.92		
Q9d. encourages me to ask questions.	Fall 15	161	3.83	1.08	.777	0.04
	Spring 16	138	3.79	1.13		
Q9e. lets me work at my own pace.	Fall 15	164	3.49	1.10	.606	-0.07
	Spring 16	139	3.56	1.16		
Q9f. encourages me to explain my ideas to other students.	Fall 15	163	3.52	1.13	.545	0.09
	Spring 16	138	3.43	1.32		
Q9g. encourage me to consider different scientific explanations.	Fall 15	161	3.54	1.03	.609	-0.06
	Spring 16	139	3.60	1.13		
Q9h. provides time for me to discuss science ideas with other students.	Fall 15	161	3.57	1.18	.783	0.04
	Spring 16	137	3.53	1.24		
Q9i. checks that I have completed my assignments.	Fall 15	163	4.29	0.93	.434	0.09
	Spring 16	137	4.20	1.08		
Q9j. provides meaningful and challenging assignments.	Fall 15	162	4.03	1.00	.535	-0.07
	Spring 16	137	4.10	0.98		
Q9k. helps me apply my learning to real life.	Fall 15	162	3.98	1.09	.507	0.08
	Spring 16	140	3.89	1.06		
Q9l. expects me to do well.	Fall 15	162	4.56	0.87	.832	0.02
	Spring 16	139	4.53	1.02		
Q10. In this class, I ...	**Time**	***n***	***M***	***SD***	***p***	**Mean Diff**
Q10a. use information and data to support my conclusions.	Fall 15	161	4.04	1.04	**.017**	**-0.26**
	Spring 16	141	4.30	0.81		
Q10b. talk with other students about how to do a science task or about how to interpret the data from an experiment.	Fall 15	158	3.72	1.08	.753	0.04
	Spring 16	141	3.68	1.15		
Q10c. learn from other students.	Fall 15	157	3.58	1.24	.492	0.10
	Spring 16	139	3.48	1.19		
Q10d. consider different scientific explanations.	Fall 15	157	3.58	1.13	.729	-0.04
	Spring 16	141	3.62	1.07		
Q10e. have a say in deciding what activities I do.	Fall 15	154	3.12	1.31	.307	0.15
	Spring 16	140	2.97	1.23		
Q10f. use a computer or the Internet for science assignments or activities.	Fall 15	159	3.07	1.41	.490	0.11
	Spring 16	135	2.96	1.40		
Q10g. write about how I solved a science task or about what I am learning.	Fall 15	159	3.54	1.21	.274	0.15
	Spring 16	139	3.39	1.18		
Q10h. learn that there are different solutions to science tasks.	Fall 15	159	3.98	0.92	.419	0.09
	Spring 16	138	3.89	0.99		
Q10i. use multiple sources of information to learn.	Fall 15	157	3.85	1.04	.736	-0.04
	Spring 16	141	3.89	0.96		

Q10j. develop my skills for doing science.	Fall 15	158	3.89	0.96	.655	0.05
	Spring 16	140	3.84	0.98		
Q10k. learn about how science is important in the real world.	Fall 15	160	3.96	0.99	.140	-0.17
	Spring 16	139	4.12	0.94		
Q10l. work on science tasks in a group with other students.	Fall 15	161	3.83	1.20	**.007**	**-0.35**
	Spring 16	140	4.17	0.99		
Q11. At least one adult in my home, ...	**Time**	***n***	***M***	***SD***	***p***	**Mean Diff**
Q11a. makes me do my science homework.	Fall 15	160	3.84	1.43	.411	0.14
	Spring 16	140	3.71	1.44		
Q11b. asks about what I am learning in science class.	Fall 15	160	3.29	1.53	.926	0.02
	Spring 16	140	3.27	1.43		
Q11c. helps me with my science homework.	Fall 15	159	3.13	1.47	.306	0.18
	Spring 16	138	2.96	1.48		
Q11d. helps me work on my science projects.	Fall 15	157	3.33	1.52	.113	0.28
	Spring 16	140	3.05	1.52		
Q11e. expects me to do well in science.	Fall 15	159	4.52	0.94	.496	0.08
	Spring 16	140	4.44	1.07		
Q11f. expects me to go to college.	Fall 15	160	4.64	0.80	.643	0.04
	Spring 16	140	4.60	0.84		
Q11g. expects me to have a science-related career.	Fall 15	157	3.11	1.43	.162	0.24
	Spring 16	140	2.88	1.47		

Note. Q8: 1 = Strongly Disagree, 5 = Strongly Agree; and Q9, Q10, & Q11: 1 = Almost Never, 5 = Very Often.
p values were calculated based on independent-samples *t*-tests. *p*-values less or equal to 0.05 were yellow highlighted and bolded.
Mean differences were calculated using Fall 2015 mean scores minus Spring 2016 mean scores.
Absolute values larger than one-quarter of a point were marked as bold or red. Bold indicates that changes from pre to post aligned with ISEP goals/objectives; while red indicates changes towards undesired direction.

High School Grades Students' Attitudes and Perceptions about Science Learning

When comparing pre-post attitudes and opinions of high school students of ISEP participant teachers, students agreed significantly more that they talked with other students about how to do a science task or about how to interpret the data from an experiment; learned from other students; considered different scientific explanations; had a say in deciding what activities they do; used a computer or the Internet for science assignments or activities; wrote about how they solved a science task or about what they were learning; learned that there were different solutions to science tasks, and used multiple sources of information to learn in their science classes in Spring 2016 than they did in Fall 2015 (Table 17). High school ISEP students reported greater likelihood to major in an engineering, science, or engineering technical field in college at the end of the 2015-2016 school year.

Table 17. *Comparisons of ISEP Students' Pre-Post Responses, UB/BPS ISEP Student Questionnaire, Fall 2015 and Spring 2016, High School Students, Matched*

Item	**Time**	***n***	***M***	***SD***	***p***	**Mean Diff**
Q8. Views of Science						
Q8a. I like science.	Fall 15	343	3.72	1.06	.356	0.09
	Spring 16	170	3.63	1.11		
Q8b. I am good at science.	Fall 15	341	3.48	0.93	.703	0.03
	Spring 16	170	3.44	0.98		
	Fall 15	342	3.08	1.22	.939	0.01

Q8c. I would keep on taking science classes even if I did not have to.	Spring 16	171	3.07	1.21		
Q8d. I understand most of what goes on in science.	Fall 15	341	3.62	0.83	.331	0.08
	Spring 16	167	3.54	0.95		
Q8e. Almost all people use science in their jobs.	Fall 15	341	3.21	1.05	.964	0.00
	Spring 16	167	3.21	1.05		
Q8f. Science is useful for solving everyday problems.	Fall 15	337	3.42	1.06	.865	0.02
	Spring 16	168	3.40	0.99		
Q8g. Science is a way to study and understand the natural world.	Fall 15	338	4.12	0.92	.645	0.04
	Spring 16	165	4.08	0.86		
Q8h. Scientists sometimes disagree about scientific knowledge.	Fall 15	332	3.78	0.99	.173	-0.13
	Spring 16	167	3.91	0.96		
Q8i. All scientists do not follow the same step-by-step method to do science.	Fall 15	336	3.64	1.08	.344	0.10
	Spring 16	168	3.54	1.20		
Q8j. Scientists use their imagination when doing science.	Fall 15	337	3.24	1.15	.230	0.13
	Spring 16	168	3.11	1.15		
Q8k. Science ideas or hypotheses must be supported by evidence.	Fall 15	335	4.17	0.98	.829	-0.02
	Spring 16	166	4.19	0.89		
Q8l. Scientific theories can change when new evidence or a new explanation becomes available.	Fall 15	336	4.23	0.94	.355	-0.08
	Spring 16	167	4.31	0.83		
Q9. In this class, my teacher ...	**Time**	***n***	***M***	***SD***	***p***	**Mean Diff**
Q9a. arranges the classroom so students can have discussion.	Fall 15	340	3.42	1.13	.196	-0.14
	Spring 16	167	3.56	1.15		
Q9b. asks questions that have more than one answer.	Fall 15	337	3.60	0.99	.934	0.01
	Spring 16	164	3.59	1.03		
Q9c. asks me to give reasons and provide evidence for my answers.	Fall 15	336	4.11	0.90	.901	0.01
	Spring 16	166	4.10	0.94		
Q9d. encourages me to ask questions.	Fall 15	335	3.96	0.89	.353	0.09
	Spring 16	166	3.87	1.09		
Q9e. lets me work at my own pace.	Fall 15	338	3.76	0.98	.061	0.18
	Spring 16	167	3.58	1.07		
Q9f. encourages me to explain my ideas to other students.	Fall 15	337	3.47	1.08	.053	-0.20
	Spring 16	165	3.67	1.05		
Q9g. encourage me to consider different scientific explanations.	Fall 15	335	3.44	1.08	.202	-0.13
	Spring 16	167	3.57	1.07		
Q9h. provides time for me to discuss science ideas with other students.	Fall 15	335	3.43	1.17	.144	-0.16
	Spring 16	167	3.59	1.12		
Q9i. checks that I have completed my assignments.	Fall 15	336	4.35	0.84	.461	-0.06
	Spring 16	165	4.41	0.79		
Q9j. provides meaningful and challenging assignments.	Fall 15	335	4.01	0.93	.575	-0.05
	Spring 16	166	4.06	0.86		
Q9k. helps me apply my learning to real life.	Fall 15	338	3.72	1.11	.270	0.12
	Spring 16	164	3.60	1.15		
Q9l. expects me to do well.	Fall 15	339	4.55	0.76	.121	0.13
	Spring 16	166	4.42	0.94		
Q10. In this class, I ...	**Time**	***n***	***M***	***SD***	***p***	**Mean Diff**
	Fall 15	335	3.87	0.96	.060	-0.17

Q10a. use information and data to support my conclusions.	Spring 16	167	4.04	0.90		
Q10b. talk with other students about how to do a science task or about how to interpret the data from an experiment.	Fall 15	334	3.60	1.09	**.004**	**-0.29**
	Spring 16	166	3.89	1.02		
Q10c. learn from other students.	Fall 15	333	3.53	1.10	**.004**	**-0.29**
	Spring 16	166	3.82	1.05		
Q10d. consider different scientific explanations.	Fall 15	329	3.44	1.05	**.007**	**-0.25**
	Spring 16	165	3.70	0.93		
Q10e. have a say in deciding what activities I do.	Fall 15	333	2.98	1.18	**.009**	**-0.29**
	Spring 16	165	3.28	1.17		
Q10f. use a computer or the Internet for science assignments or activities.	Fall 15	332	2.85	1.35	**< .001**	**-0.78**
	Spring 16	165	3.62	1.20		
Q10g. write about how I solved a science task or about what I am learning.	Fall 15	330	3.11	1.18	**< .001**	**-0.43**
	Spring 16	163	3.55	1.04		
Q10h. learn that there are different solutions to science tasks.	Fall 15	333	3.64	0.95	**.004**	**-0.25**
	Spring 16	166	3.89	0.91		
Q10i. use multiple sources of information to learn.	Fall 15	331	3.61	1.10	**.049**	**-0.19**
	Spring 16	166	3.80	0.95		
Q10j. develop my skills for doing science.	Fall 15	332	3.76	1.04	.400	-0.08
	Spring 16	166	3.84	0.96		
Q10k. learn about how science is important in the real world.	Fall 15	330	3.76	1.06	.989	0.00
	Spring 16	166	3.77	1.06		
Q10l. work on science tasks in a group with other students.	Fall 15	331	3.71	1.16	.673	-0.05
	Spring 16	166	3.76	1.12		
Q11. At least one adult in my home, ...	**Time**	***n***	***M***	***SD***	***p***	**Mean Diff**
Q11a. makes me do my science homework.	Fall 15	332	3.43	1.41	**.022**	**-0.30**
	Spring 16	166	3.73	1.32		
Q11b. asks about what I am learning in science class.	Fall 15	333	3.09	1.39	.134	-0.20
	Spring 16	166	3.28	1.35		
Q11c. helps me with my science homework.	Fall 15	332	2.70	1.44	.183	-0.18
	Spring 16	166	2.89	1.47		
Q11d. helps me work on my science projects.	Fall 15	331	2.91	1.43	.083	-0.24
	Spring 16	164	3.15	1.43		
Q11e. expects me to do well in science.	Fall 15	331	4.31	1.05	.540	-0.06
	Spring 16	167	4.37	0.99		
Q11f. expects me to go to college.	Fall 15	334	4.46	0.93	.560	-0.05
	Spring 16	166	4.51	0.89		
Q11g. expects me to have a science-related career.	Fall 15	334	2.74	1.40	.116	-0.21
	Spring 16	167	2.95	1.47		
Q12. I plan to . . .	**Time**	***n***	***M***	***SD***	***p***	**Mean Diff**
Q12a. take (or have taken) only the science courses I am required to take in high school.	Fall 15	334	3.54	1.26	.596	-0.06
	Spring 16	167	3.60	1.24		
Q12b. take (or have taken) the most challenging science courses offered in my high school.	Fall 15	333	3.18	1.22	.286	-0.13
	Spring 16	167	3.31	1.27		
Q12c. take (or have taken) 4 years of science courses in high school.	Fall 15	336	3.64	1.21	.863	0.02
	Spring 16	167	3.62	1.25		

Q12d. pursue a science-related career.	Fall 15	335	3.12	1.26	.378	-0.11
	Spring 16	167	3.22	1.26		
Q12e. go to a 2- or 4-year college.	Fall 15	336	4.22	1.00	.133	-0.14
	Spring 16	164	4.36	0.91		
Q12f. take science courses in college.	Fall 15	330	3.60	1.15	.930	0.01
	Spring 16	166	3.59	1.14		
Q12g. major in a science field in college.	Fall 15	336	3.03	1.17	.156	-0.17
	Spring 16	166	3.19	1.26		
Q12h. major in an engineering field in college.	Fall 15	332	3.11	1.25	**.027**	**-0.27**
	Spring 16	167	3.38	1.28		
Q12i. major in a science or engineering technical field in college.	Fall 15	336	3.26	1.28	**.015**	**-0.29**
	Spring 16	166	3.55	1.23		

Note. Q8: 1 = Strongly Disagree, 5 = Strongly Agree; and Q9, Q10, & Q11: 1 = Almost Never, 5 = Very Often.
p values were calculated based on independent-samples *t*-tests. *p*-values less or equal to 0.05 were yellow highlighted and bolded.
Mean differences were calculated using Fall 2015 mean scores minus Spring 2016 mean scores. Significant mean differences were marked as bold or red. Bold indicates that changes from pre to post aligned with ISEP goals/objectives; while red indicates changes towards undesired direction.

Elementary, Middle, and High School Students' Content Knowledge Assessment

Using the unmatched sample, ISEP elementary school students' content knowledge assessment scores improved significantly on 10 of the 20 items as well as for overall assessment score from Fall 2015 to Spring 2016 (Table 18).

Table 18. *Comparisons of ISEP Students' Pre-Post Content Knowledge Assessment, UB/BPS ISEP Student Questionnaire, Fall 2015 and Spring 2016, Elementary School Students, Unmatched*

ES Student Content Knowledge	**Time**	***n***	***M***	***SD***	***p***	**Mean Diff**
Q1	Fall 15	271	0.53	0.50	.893	-0.01
	Spring 16	283	0.54	0.50		
Q2	Fall 15	271	0.51	0.50	.216	-0.05
	Spring 16	283	0.57	0.50		
Q3	Fall 15	271	0.31	0.46	.707	-0.01
	Spring 16	283	0.33	0.47		
Q4	Fall 15	271	0.34	0.48	.551	-0.02
	Spring 16	283	0.37	0.48		
Q5	Fall 15	271	0.46	0.50	**< .001**	**-0.20**
	Spring 16	283	0.66	0.48		
Q6	Fall 15	271	0.28	0.45	**.001**	**-0.14**
	Spring 16	283	0.42	0.49		
Q7	Fall 15	271	0.30	0.46	.081	0.07
	Spring 16	283	0.23	0.42		
Q8	Fall 15	271	0.21	0.41	.151	0.05
	Spring 16	283	0.17	0.37		
Q9	Fall 15	271	0.46	0.50	**.028**	**-0.09**
	Spring 16	283	0.55	0.50		
Q10	Fall 15	271	0.31	0.46	.980	0.00
	Spring 16	283	0.31	0.46		

ES Student Content Knowledge	Time	*n*	*M*	*SD*	*p*	Mean Diff
Q11	Fall 15	271	0.31	0.46	**.018**	**-0.10**
	Spring 16	283	0.41	0.49		
Q12	Fall 15	271	0.32	0.47	.285	-0.04
	Spring 16	283	0.36	0.48		
Q13	Fall 15	271	0.52	0.50	**.001**	**-0.14**
	Spring 16	283	0.66	0.47		
Q14	Fall 15	271	0.33	0.47	.339	-0.04
	Spring 16	283	0.37	0.48		
Q15	Fall 15	271	0.21	0.41	**.023**	**-0.08**
	Spring 16	283	0.29	0.45		
Q16	Fall 15	271	0.41	0.49	**.009**	**-0.11**
	Spring 16	283	0.52	0.50		
Q17	Fall 15	271	0.41	0.49	.078	-0.07
	Spring 16	283	0.48	0.50		
Q18	Fall 15	271	0.28	0.45	**.005**	**-0.11**
	Spring 16	283	0.39	0.49		
Q19	Fall 15	271	0.47	0.50	**.015**	**-0.10**
	Spring 16	283	0.58	0.50		
Q20	Fall 15	271	0.44	0.50	**.005**	**-0.12**
	Spring 16	283	0.56	0.50		
Total Score	Fall 15	271	7.42	3.39	**< .001**	**-1.34**
	Spring 16	283	8.76	2.97		
Percentage	Fall 15	271	37%	0.17	**< .001**	**-0.07**
	Spring 16	283	44%	0.15		

p values were calculated based on independent-samples *t*-tests. *p*-values less or equal to 0.05 were yellow highlighted and bolded.
Mean differences were calculated using Fall 2015 mean scores minus Spring 2016 mean scores. Significant mean differences were marked as bold or red. Bold indicates that changes from pre to post aligned with ISEP goals/objectives; while red indicates changes towards undesired direction.

Using the unmatched sample, ISEP middle school students' content knowledge scores improved significantly on 1 item from Fall 2015 to Spring 2016 (Table 19). Although not statistically significant, middle school students also scored slightly better on 16 other items and for the overall assessment score at the end of the school year.

Table 19. *Comparisons of ISEP Students' Pre-Post Content Knowledge Assessment, UB/BPS ISEP Student Questionnaire, Fall 2015 and Spring 2016, Middle School Students, Unmatched*

MS Student Content Knowledge	Time	*n*	*M*	*SD*	*p*	Mean Diff
Q1	Fall 15	162	0.54	0.50	.438	-0.04
	Spring 16	141	0.58	0.50		
Q2	Fall 15	162	0.58	0.50	.551	0.03
	Spring 16	141	0.55	0.50		
Q3	Fall 15	162	0.47	0.50	.917	-0.01
	Spring 16	141	0.48	0.50		
Q4	Fall 15	162	0.47	0.50	.792	0.02
	Spring 16	141	0.45	0.50		

MS Student Content Knowledge	**Time**	***n***	***M***	***SD***	***p***	**Mean Diff**
Q5	Fall 15	162	0.64	0.48	.097	-0.09
	Spring 16	141	0.73	0.45		
Q6	Fall 15	162	0.58	0.50	.517	-0.04
	Spring 16	141	0.62	0.49		
Q7	Fall 15	162	0.26	0.44	.841	-0.01
	Spring 16	141	0.27	0.45		
Q8	Fall 15	162	0.26	0.44	.827	0.01
	Spring 16	141	0.25	0.43		
Q9	Fall 15	162	0.68	0.47	.973	0.00
	Spring 16	141	0.68	0.47		
Q10	Fall 15	162	0.42	0.50	.335	-0.06
	Spring 16	141	0.48	0.50		
Q11	Fall 15	162	0.43	0.50	**.048**	**-0.11**
	Spring 16	141	0.55	0.50		
Q12	Fall 15	162	0.45	0.50	.427	-0.05
	Spring 16	141	0.50	0.50		
Q13	Fall 15	162	0.69	0.46	.543	-0.03
	Spring 16	141	0.72	0.45		
Q14	Fall 15	162	0.40	0.49	.859	-0.01
	Spring 16	141	0.41	0.49		
Q15	Fall 15	162	0.25	0.44	.385	-0.04
	Spring 16	141	0.30	0.46		
Q16	Fall 15	162	0.52	0.50	.548	-0.03
	Spring 16	141	0.55	0.50		
Q17	Fall 15	162	0.58	0.50	.601	-0.03
	Spring 16	141	0.61	0.49		
Q18	Fall 15	162	0.40	0.49	.433	-0.04
	Spring 16	141	0.44	0.50		
Q19	Fall 15	162	0.62	0.49	.447	-0.04
	Spring 16	141	0.66	0.48		
Q20	Fall 15	162	0.53	0.50	.377	-0.05
	Spring 16	141	0.58	0.50		
Total Score	Fall 15	162	9.77	3.70	.148	-0.63
	Spring 16	141	10.40	3.88		
Percentage	Fall 15	162	49%	0.18	.148	-0.03
	Spring 16	141	52%	0.19		

p values were calculated based on independent-samples *t*-tests. *p*-values less or equal to 0.05 were yellow highlighted and bolded.
Mean differences were calculated using Fall 2015 mean scores minus Spring 2016 mean scores. Significant mean differences were marked as bold or red. Bold indicates that changes from pre to post aligned with ISEP goals/objectives; while red indicates changes towards undesired direction.

Using the unmatched sample, high school students' content knowledge assessment scores decreased significantly on 1 of the 20 items from Fall 2015 to Spring 2016 and improved slightly on 13 items, as well as for the overall assessment score (Table 20).

Table 20. *Comparisons of ISEP Students' Pre-Post Content Knowledge Assessment, UB/BPS ISEP Student Questionnaire, Fall 2015 and Spring 2016, High School Students, Unmatched*

HS Student Content Knowledge	Time	*n*	*M*	*SD*	*p*	Mean Diff
Q1	Fall 15	328	0.55	0.50	.426	-0.04
	Spring 16	168	0.58	0.49		
Q2	Fall 15	328	0.44	0.50	**.010**	0.12
	Spring 16	168	0.32	0.47		
Q3	Fall 15	328	0.36	0.48	.510	-0.03
	Spring 16	168	0.39	0.49		
Q4	Fall 15	328	0.36	0.48	.097	-0.08
	Spring 16	168	0.44	0.50		
Q5	Fall 15	328	0.46	0.50	.519	-0.03
	Spring 16	168	0.49	0.50		
Q6	Fall 15	328	0.30	0.46	.322	-0.04
	Spring 16	168	0.34	0.47		
Q7	Fall 15	328	0.47	0.50	.840	-0.01
	Spring 16	168	0.48	0.50		
Q8	Fall 15	328	0.39	0.49	.557	0.03
	Spring 16	168	0.36	0.48		
Q9	Fall 15	328	0.28	0.45	.875	0.01
	Spring 16	168	0.27	0.45		
Q10	Fall 15	328	0.23	0.42	.545	-0.02
	Spring 16	168	0.25	0.43		
Q11	Fall 15	328	0.42	0.49	.916	0.00
	Spring 16	168	0.42	0.50		
Q12	Fall 15	328	0.24	0.43	.318	-0.04
	Spring 16	168	0.28	0.45		
Q13	Fall 15	328	0.42	0.49	.294	-0.05
	Spring 16	168	0.47	0.50		
Q14	Fall 15	328	0.20	0.40	.387	-0.03
	Spring 16	168	0.24	0.43		
Q15	Fall 15	328	0.36	0.48	.363	-0.04
	Spring 16	168	0.40	0.49		
Q16	Fall 15	328	0.20	0.40	.777	0.01
	Spring 16	168	0.18	0.39		
Q17	Fall 15	328	0.37	0.48	.849	0.01
	Spring 16	168	0.36	0.48		
Q18	Fall 15	328	0.30	0.46	.392	-0.04
	Spring 16	168	0.33	0.47		
Q19	Fall 15	328	0.32	0.47	.971	0.00
	Spring 16	168	0.32	0.47		

HS Student Content Knowledge	Time	*n*	*M*	*SD*	*p*	Mean Diff
Q20	Fall 15	328	0.32	0.47	.816	-0.01
	Spring 16	168	0.33	0.47		
Total Score	Fall 15	328	6.97	3.15	.338	-0.30
	Spring 16	168	7.27	3.60		
Percentage	Fall 15	328	35%	0.16	.338	-0.02
	Spring 16	168	36%	0.18		

p values were calculated based on independent-samples *t*-tests. *p*-values less or equal to 0.05 were yellow highlighted and bolded.
Mean differences were calculated using Fall 2015 mean scores minus Spring 2016 mean scores. Significant mean differences were marked as bold or red. Bold indicates that changes from pre to post aligned with ISEP goals/objectives; while red indicates changes towards undesired direction.

UB/BPS ISEP STEM Student Questionnaire Data, Fall 2016

As shown in Table 21, 11 STEM undergraduate students and two STEM graduate students (master's and doctoral students) who participated in the ISEP project in Fall 2016 and responded to the *UB/BPS ISEP STEM Student Questionnaire*. Among them, five STEM undergraduate and two STEM graduate students indicated that they were returning participants to the ISEP project. Due to small sample size of the Fall 2016 STEM student data, routine analysis of comparing responses between undergraduate and graduate students and between first year and returning participants will not be reported here. Analysis of all *UB/BPS ISEP STEM Student* Questionnaire data collected from Spring 2013 to Fall 2016 will be reported in the final evaluation report.

Table 21. *Respondents' Student Status by Years of Participation, UB/BPS ISEP STEM Student Questionnaire, Spring 2015, Fall 2015, and Spring 2016*

Number of Years in ISEP	Fall 2016		
	STEM Undergraduate	STEM Graduate	Total
This is my first year.	6	0	6
This is my second year.	1	0	1
This is my third year.	2	0	2
This is my fourth year.	2	2	4
Total	**11**	**2**	**13**

Summary and Recommendations

Summary of Evidence of Progress Toward Project Goals

During Year 6 of the ISEP project, the Discovery Center evaluation team turned attention to collecting evidence of project progress toward its major goals. It should be noted that due to data collection cycles that align with the academic year, pre- and post-intervention data analyzed for this report were primarily from ISEP's fifth year of implementation with teachers (Summer 2015 - Summer 2016). Fall 2015 and Spring 2016 data were collected post-Year 4 from students of ISEP teachers and a well-matched comparison group of students of non-ISEP teachers. Although analyses are not reported in this report, Fall 2016 data also were collected (pre-Year 5) from STEM undergraduate and graduate students and from BPS students of ISEP teachers and a well-matched comparison group of students of non-ISEP teachers. Findings reported herein, though more summative in nature than Year 5 findings, are intended for the purpose of project improvement upon reflection by the ISEP project team. Data were not available to evaluate progress toward some project goals; those instances are noted. Limitations of the evaluation to respond to some questions are based upon lack of sufficient data from comparison teachers' students to conduct rigorous analyses. During the second no-cost-extension year, evaluators will work with the ISEP project team to collect additional data from ISEP teachers and STEM students and report findings from data collected from all 6 years cumulatively and triangulate findings from multiple data sources to demonstrate project impact.

Findings from the Year 6 evaluation are summarized under each ISEP project goal.

GOAL 1: Improve elementary/middle school science teachers' knowledge and skills related to science inquiry through interdisciplinary science research and engineering design with university STEM faculty.

Three evaluation questions are associated with ISEP project Goal 1:

*Evaluation Question 1: Have elementary/middle school science **teachers' knowledge and skills** improved as the result of conducting interdisciplinary science research and engineering design with university STEM faculty?*

Before participating in ISEP activities, teachers indicated higher priority professional development needs related to aspects of science teaching closely aligned with NGSS cross-cutting concepts (i.e., scale, proportion, and quantity; systems and system models; and energy and matter) as well as some aspects of inquiry teaching (i.e., helping students develop the ability to communicate with others an argument based on evidence) than they did following one or more years of participation in ISEP, suggesting that their ISEP experiences had provided opportunities to develop their understanding of interdisciplinary science. On the other hand, teachers reported higher priority professional development needs related to some aspects of inquiry teaching (i.e., the ability to develop and use valid models and to ask questions and define problems, and the ability to obtain, evaluate, and communicate information) after their participation.

Regarding development of teachers' knowledge and skills, statistically significant improvements after one or more years of ISEP participation, included better preparedness to teach science to students from a variety of cultural backgrounds, to encourage participation of females and minorities in science courses, to use a variety of technological tools to enhance student learning, and to teach interdisciplinary science inquiry following one year of ISEP participation. Teachers' preparedness for science instruction has been sustained over their years of participation. Specifically, teachers reported that they were significantly better prepared to lead students using investigative strategies and to teach interdisciplinary science inquiry following four years of ISEP participation, compared to their baseline responses.

Following one or more years of ISEP participation, teachers reported using more Design, Engineering, and Technology (DET) activities in classrooms and having more school support in using DET activities.

Evaluation Question 2: Have elementary/middle school science teachers improved their ***understanding of the Nature of Science and inquiry science teaching****?*

Compared to their baseline responses, teachers reported that they were better able to clarify some misunderstanding of scientific inquiry (i.e., less agreement with the statements such as "inquiry-based learning requires learners first understand basic science concepts prior to engaging in inquiry activities" and that "inquiry-based learning requires learners to engage in hands-on activities") after participating in ISEP for one or more years.

Although not statistically significant, compared to their baseline responses, teachers reported less agreement with some accurate understandings of the teacher's role in inquiry-based teaching following three or four years of ISEP participation (i.e., inquiry-based teaching requires that the teacher act as a facilitator or guide of student learning rather than as a disseminator of knowledge., inquiry-based teaching focuses more on what the students do, rather than on what the teacher does, and inquiry-based teaching requires that the teacher have a strong background in the science content related to the inquiry.)

Although not statistically significant, following one year of participation in ISEP activities, teacher participants agreed more with the accurate understandings that scientific knowledge is reliable and durable so having confidence in scientific knowledge is reasonable; and scientific laws are generalizations or universal relationships about some aspect of the natural world and how it behaves under certain conditions.

Following two years of ISEP participation, teachers demonstrated both fewer misconceptions and fewer accurate understandings of the nature of science. Compared to their baseline responses, teachers agreed less that a universal step-by-step scientific method is used by all scientists and scientific experiments are the only means used to develop scientific knowledge; but also agreed less that with new evidence and/or interpretation, existing scientific ideas are replaced or supplemented by newer ones; scientific theories are inferred explanations of some aspect of the natural world; scientific conclusions are to some extent influenced by the social and cultural context of the researcher; and scientific observations are to some extent influenced by the observer's experiences and expectations.

Following four years of ISEP participation, teachers started to report more positive changes regarding their understanding of the nature of science. For example, after participation in ISEP for 4 years, teachers agreed significantly less that cultural values and expectations do not influence scientific research because scientists are trained to conduct unbiased studies and that scientists do not use their imagination and creativity because these can interfere with objectivity. Although not statistically significant, teachers also reported more agreement that scientific knowledge is reliable and durable so having confidence in scientific knowledge is reasonable; with new evidence and/or interpretation, existing scientific ideas are replaced or supplemented by newer ones; the principal product of science is conceptual knowledge about and explanations of the natural world; scientific theories are inferred explanations of some aspect of the natural world; scientific conclusions are to some extent influenced by the social and cultural context of the researcher; and scientific observations are to some extent influenced by the observer's experiences and expectations.

In the final evaluation report, evaluators will use all data collected to date and additional data collected in Fall 2017 to continue to explore ISEP's impact on participating teachers in this area. Evaluators also will utilize teachers' PCK assessment scores to determine the relationships among teachers' beliefs about SI and NOS and their reported uses of inquiry in the classroom. The two-dimensional changes in teachers' accurate understandings and misconceptions of SI and NOS also will be analyzed and demonstrated with data visualizations.

*Evaluation Question 3: Have elementary/middle school science teachers improved their **competence in conducting inquiry science teaching**?*

Data regarding teachers' competence in conducting inquiry science in their classrooms were collected from their students, as well as from their own self-report.

Following ISEP participation, teachers reported more agreement that students should have opportunities to experience manipulating materials in the science classroom before teachers introduce scientific vocabulary and less scared by the idea of teaching engineering design concepts.

When comparing pre-post attitudes and opinions of elementary grades students of ISEP participant teachers, students agreed more that science ideas or hypotheses must be supported by evidence; they learned that there are different solutions to science tasks; they used multiple sources of information to learn; they learned about how science is important in the real world, and they worked on science tasks in a group with other students, at the end of the school year, than at the beginning of the year.

Middle school students agreed more that almost all people used science in their jobs; scientific theories can change when new evidence or a new explanation becomes available; they used information and data to support their conclusions; and they worked on science tasks in a group with other students in Spring 2016, than they did in Fall 2015.

GOAL 2: Increase science teacher quantity, quality, diversity, and retention in urban schools.

Evaluation Question 4: Has the total number of highly-qualified science teachers increased? Has the science teacher population become more diverse? Are highly-qualified science teachers being retained in urban schools?

Data collected prior to their participation in the project indicated that ISEP teachers are primarily experienced teachers, with moderate to high levels of prior participation in professional development experiences. Most teachers were credentialed to teach high school science, so reported adequate pre- and in-service preparation in science content generally.

To respond to questions regarding impact of the project on the Buffalo Public Schools, publically available school-level data were collected and analyzed to compare aggregate teacher information for each ISEP partner school between 2010-2011 and 2015-2016. A limited data set is publically available and data that may respond more directly to the evaluation question will need to be obtained from the BPS central administration. Since aggregated information exclusively for science teachers is not available on the New York State School Report Card or other publicly available data sources, information were reported for all teachers in the ISEP partner schools. Evaluators will continue to work with ISEP project personnel to collect key data that inform questions about improvement in science teacher quality and diversity and impact at the school and district level.

From 2010-2011 to 2015-2016, the percentage of teachers teaching without an appropriate license/certificate decreased at 2 of the 12 ISEP partner schools; the percentage of teachers with a Master's plus 30 hours or doctorate degree increased at 9 schools; and the percentage of core courses <u>not</u> taught by highly qualified teachers decreased at 3 schools. The turnover rates from 2014-2015 school year to 2015-2016 school year for teachers with fewer than 5 years of experience and for all teachers were not available at the school level.

GOAL 3: Develop and sustain professional learning communities in urban schools, based on mentoring models, with help from university STEM faculty and graduate students.

Evaluation Question 9: Are parents actively involved in project activities that support student learning?

No data that are responsive to this question were collected or analyzed by the evaluation team this year. Data regarding parent involvement in ISEP activities are included in the project report.

GOAL 4: Extend interdisciplinary inquiry based science and engineering learning to high school.

Evaluation Question 6: Are high schools with participating students implementing interdisciplinary inquiry in classrooms?

High school students agreed significantly more that they talked with other students about how to do a science task or about how to interpret the data from an experiment; learned from other students; considered different scientific explanations; had a say in deciding what activities they do; used a computer or the Internet for science assignments or activities; wrote about how they solved a science task or about what they were learning; learned that there were different solutions to science tasks, and used multiple sources of information to learn in their science classes in Spring 2016, than they did in Fall 2015.

Teacher reports of implementing inquiry in their classrooms have not been disaggregated by grade level in order to explore if high school teachers' reports of implementing inquiry are congruent with students' perceptions. In the final report, the evaluation team will disaggregate these data to the extent possible (without compromising participant confidentiality) to report on any differences between levels of implementation of inquiry in elementary, middle, and high school classrooms.

GOAL 5: Improve student achievement in science, attitude toward science-technology-society, and interest in pursuing advanced science studies.

Evaluation Question 7: Are students achieving higher learning standards in science?

No obvious patterns of increase regarding the percentage of students meeting or exceeding New York State Standards in Grade 8 Science, Regents Earth Science, and/or Regents Chemistry were found between 2010-2011 and 2015-2016.

As a more proximal measure of students' learning in science, a content assessment was administered in Fall 2015 and Spring 2016 to students of ISEP teachers and to their non-ISEP peers. Analyses using unmatched pre-post responses indicated that elementary school ISEP students' content knowledge assessment scores improved significantly from Fall 2015 to Spring 2016. Middle school students' content knowledge scores improved significantly on 1 item from Fall 2015 to Spring 2016 (Table 19). Although not statistically significant, middle school students also scored slightly better on 16 other items and the overall score at the end of the school year. High school students' content knowledge assessment scores decreased on 1 of the 20 items from Fall 2015 to Spring 2016 and improved slightly on 13 items, as well as the overall score.

Evaluation Question 8: Are students more interested in learning science and pursing advanced studies in science?

When comparing unmatched pre-post attitudes and opinions of high school students of ISEP participant teachers, students reported greater likelihood to major in an engineering, science, or engineering technical field in college at the end of the 2015-2016 school year.

GOAL 6: Improve collaboration in student learning among university, school, and parents.

Evaluation Question 10: Are science teachers actively participating in project activities?

Teacher professional development records indicated that 60 teachers participated in the 4- or 6-week summer research activities, five participated in summer courses offered by BSC, and six participated in ELL-related PD activities in Summer 2016.

Evaluation Question 11: Are university STEM faculty and students actively participating in project activities that improve K-12 science education?

STEM students' self-report of involvement in project activities from Spring 2013 to Fall 2016 will be reported in the final evaluation report.

No data have been collected by the external evaluation team to directly assess the participation of faculty in project activities.

In addition to the six project goals that are focused primarily on BPS teachers and students, the ISEP project has three additional objectives for the professional development of STEM undergraduate and graduate students.

Objective 1: To develop STEM undergraduate students' and graduate students' understanding of the nature of interdisciplinary science inquiry including engineering research.

Objective 2: To develop STEM undergraduate students' and graduate students' communication skills to promote interdisciplinary science inquiry to middle and high school science teachers and students.

Objective 3: To develop STEM undergraduate students' and graduate students' appreciation of professional learning communities and collaborative skills to actively contribute to the PLCs.

These objectives will be evaluated in the final evaluation report with the new *UB/BPS ISEP STEM Student Questionnaire* data that will be collected in Fall 2017 and findings of the ISEP Research Team regarding these objectives. These objectives are:

Observations and Recommendations

Based upon the findings of the external evaluation, the Discovery Center makes the following recommendations for the second no-cost-extension year:

1. Evaluators with collaborate with project internal evaluation and research teams to collect more *UB/BPS ISEP Teacher Questionnaire* and *UB/BPS ISEP STEM Student Questionnaire* data in Fall 2017.
2. Evaluators will synthesize the results from *UB/BPS ISEP Teacher Questionnaire* collected from Summer 2012 to Fall 2017 with teacher PCK data and with data on teachers' participation in school-year project professional development workshop sessions provided by the project team. These analyses will explore the contributions of summer PD experience and school-year follow-up experience to teachers' acquisition of knowledge and skill related to project goals at the individual level, though data will be reported in aggregate. For teachers involved in ISEP multiple years, additional analyses will be conducted to determine if and how teachers' perceptions of preparedness and attitudes toward interdisciplinary science teaching, understandings of the Nature of Science and classroom inquiry, and familiarity with design, engineering and technology changed following participation in ISEP project activities.

3. In order to continue to test the psychometric properties of the *UB/BPS ISEP Teacher* and the *US/BPS ISEP Student Questionnaire,* the Discovery Center will repeat the factor analyses and reliability tests using all teacher and student pre/post data up-to-date to determine if the performance of some subscales, particularly on the student instrument, are improved and will make recommendations for modification to the instruments, if necessary. The objective of the evaluation is to establish valid factors for each instrument subscale with the ISEP target populations so that data can be analyzed at the construct level (factor level) and the Rasch model can be used to transform and compare data across project years and participant groups.
4. Once valid factors can be established for the lower performing subscales (i.e., Science as Inquiry, Understanding the Nature of Science) of the *UB/BPS ISEP Teacher Questionnaire*, evaluators will continue to explore how teachers' progressive acquisition of understanding of the Nature of Science and classroom inquiry interact with teachers' misconceptions regarding scientific inquiry and Nature of Science, as components of the teachers' belief system regarding teaching and learning.
5. Evaluators will synthesize ISEP teachers' knowledge, attitudes, and beliefs data with student attitudes and content knowledge data to estimate the impact of ISEP on student outcomes.
6. Evaluators will combined all STEM student data with the newly collect data in Fall 2017 to estimate ISEP impact on STEM undergraduate and graduate students.

4. b. Response to External Evaluation Report

Joseph A. Gardella, Jr. and Xiufeng Liu

The external evaluation provided useful feedback on the project's progress toward achieving its stated goals. Specifically,

1. Goal 1: Improving teacher knowledge and skills related to inquiry science teaching

We are pleased to see the findings that overall teacher knowledge and skills on interdisciplinary science inquiry has increased as they participate in ISEP activities, and that their understanding of nature of science has also improved as the result of their participation in ISEP.

Last year's decision to plan specific sessions during the academic year to help teachers reflect on their summer research experiences in order to develop more appropriate understanding of the inquiry based teaching and experimental work had strong impact. The new workshop/presentations occurred in academic year professional development as part of ISEP. The new structure of academic year content PD with support from New York State Education MSP funding made this possible to a wide audience of teachers. ISEP teachers will be required to write an essay response to these presentations.

The evaluation also found that students of ISEP teachers reported more learning activities consistent with science inquiry than students of non-ISEP teachers. This is assuring in that ISEP teachers demonstrated change in their teaching approaches. We believe this finding might largely be due to the presence in the classrooms of STEM graduate students and undergraduate service learning students. The variety of out-of-school activities facilitated by STEM students might have also contributed to this positive change in student learning.

2. Goal 2: Increasing teacher quality, quantity, diversity and retention.

Although the evaluation found some possible signs toward achieving the above stated goal, we are cautious in making any conclusive statement on our progress toward achieving this goal. This is because there are many factors outside the control of the ISEP project working against achieving the above goal. These factors include but not limited to decreasing student enrollment in some ISEP schools, State accountability measures that result in closing or restructuring some ISEP schools, and teacher low morale due to ongoing instability in the school district leadership and stalemate in contract negotiation. Nonetheless, we are pleased that over the past six years, a large number of BPS science teachers have participated in ISEP activities and their quality in terms of their knowledge and understanding of interdisciplary science inquiry and their ability to implemented interdisciplinary science inquiry in their classrooms has increased.

3. Goal 3: Developing and sustaining PLCs

PLCs established over the years in ISEP schools have been sustaining as reported in our year-long ethnographic studies (please refer to the Research section of this report).

The shift away from managing the Parent PLC was a loss for our parents that were used to working directly to link ISEP to their children, but the plan this year to expand attention to parent leadership in collaboration with BPS district initiatives that was described in Section 1 worked well. Creating a more successful model for the teacher based PLCs is underway with a more serious emphasis on a limited and regular set of PLC face to face meetings, and implementation of social network off line discussion using EdWeb. As an outcome of the subject based teacher PLCs with middle and high school teachers that were formed for summer 2016 and met at a regular, fixed time twice during the summer.

4. Extending interdisciplinary science inquiry from middle school to high school

Although evaluation did not find enough evidence on the continuation of interdisciplinary science inquiry from middle school to high school, we expect that as more students progress from middle school to high school in ISEP schools, we will see more positive evidence on this continuation of interdisciplinary inquiry over grades.

5. Improving student achievement, attitude and interest in science

We are very pleased to know that evaluation found improved student attitude and interest in science after participating in ISEP summer activities. This area was a struggle in years 1 and 2 and significant increases were made in summer in year 3 and 4. This seems to confirm that our approach of year round wrap around support for students is a necessary component to keep and grow student interest. Our education research team also found statistically significant causal effects of teacher participation in ISEP and improved student understanding of cross-cutting concepts (please refer to findings in the Research section of this report).

6. Improving collaboration among project partners

We are very pleased that participation of ISEP school teachers, STEM students and undergraduate service learning students was extremely high. Although no data were collected on university STEM faculty, our experiences over the past five years suggest that university faculty are very enthusiastic and supportive of the ISEP project.

The external evaluation also found some positive outcomes related to STEM students. We realized that in the past few years, we focused more on the process of STEM students developing science communication skills. This year we paid more attention to collecting data on STEM students achieving other project goals including understanding the nature of interdisciplinary science inquiry, appreciation of PLCs, and developing collaborative skills. We will facilitate data collection by the external evaluator on the above measures.

This year, and presently during the second no cost extension, we have been concluding our work with our external evaluator to synthesize all pieces of data collected from both external evaluation by the external evaluator and internal evaluation by the research team. As noted we conducted structure equation modeling to test various hypotheses on possible causal relations among variables related to students (e.g., achievement, attitude and interest in science), teachers (e.g., participation in summer research and ongoing professional development along with their demographics), school characteristics, and parent involvement in student learning. These were published in Dr. Yang Yang's dissertation and the two resulting papers highlighted in section 1.

Appendices

Appendix A. Findings from School-Level Enrollment and Report Card Data (2010-2011 to 2015-2016)

Table A1. *Aggregate Teacher Information for ISEP Partner Schools, 2010-2011 to 2015-2016*

		Middle (K-8) Schools					High Schools				CB/Gates Foundation School (6-12)	Vocational Schools			
	Year	**Harriet Ross Tubman Academy**	**Charles Drew Science Magnet**	**Lorraine Academy**	**Southside Elementary**	**Native American Magnet (NAMS)**	**East HS**	**Bennett HS**	**South Park HS**	**Riverside Institute of Technology HS**	**MST Preparatory School at Seneca**	**Burgard Vocational HS**	**Hutchinson Central Technical HS**	**BPS District Average**	**NY State Average**
% w/o Appropriate License/Certificate [a]	2010-2011	1%	12%	0%	0%	4%	7%	0%	4%	8%	0%	8%	5%	3%	3%
	2011-2012	6%	0%	1%	1%	4%	6%	1%	2%	2%	2%	4%	4%	2%	4%
	2012-2013	3%	0%	2%	1%	2%	3%	3%	1%	5%	12%	0%	9%	3%	3%
	2013-2014	1%	-	0%	1%	5%	2%	1%	3%	6%	7%	4%	10%	3%	4%
	2014-2015	7%	1%	2%	3%	2%	6%	5%	10%	11%	15%	8%	8%	6%	6%
	2015-2016	5%	12%	7%	2%	11%	6%	14%	11%	24%	11%	6%	13%	9%	1%
% w/ Master's Plus 30 Hours or Doctorate [a]	2010-2011	20%	27%	35%	34%	20%	12%	36%	32%	27%	24%	24%	27%	29%	36%
	2011-2012	16%	31%	36%	33%	17%	13%	39%	37%	29%	21%	20%	26%	28%	39%
	2012-2013	19%	22%	34%	36%	23%	15%	38%	29%	34%	29%	20%	31%	28%	39%
	2013-2014	26%	-	32%	34%	26%	21%	35%	33%	33%	33%	24%	33%	28%	39%
	2014-2015	22%	14%	31%	33%	32%	27%	44%	35%	36%	34%	23%	40%	28%	39%
	2015-2016	29%	14%	30%	35%	29%	31%	45%	33%	39%	46%	22%	41%	29%	39%
% of Core Courses **NOT** Taught By Highly Qualified Teachers [a]	2010-2011	2%	12%	0%	0%	0%	7%	0%	4%	5%	0%	9%	6%	3%	5% in high-poverty schools statewide; 0% in low-poverty schools statewide
	2011-2012	5%	0%	0%	0%	0%	7%	0%	3%	0%	1%	1%	1%	2%	2%
	2012-2013	0%	0%	0%	0%	2%	3%	0%	0%	0%	2%	0%	1%	2%	3%
	2013-2014	0%	-	0%	6%	4%	0%	1%	0%	0%	7%	3%	9%	4%	4%
	2014-2015	7%	0%	0%	4%	0%	6%	4%	7%	11%	15%	3%	4%	4%	1%

		Middle (K-8) Schools					High Schools				CB/Gates Foundation School (6-12)	Vocational Schools			
	Year	**Harriet Ross Tubman Academy**	**Charles Drew Science Magnet**	**Lorraine Academy**	**Southside Elementary**	**Native American Magnet (NAMS)**	**East HS**	**Bennett HS**	**South Park HS**	**Riverside Institute of Technology HS**	**MST Preparatory School at Seneca**	**Burgard Vocational HS**	**Hutchinson Central Technical HS**	**BPS District Average**	**NY State Average**
	2015-2016	4%	10%	9%	3%	6%	5%	14%	10%	22%	5%	8%	10%	8%	7%
Turnover Rate of Teachers with Fewer than 5 Years of Experience [a]	2010-2011	33%	0%	20%	50%	18%	10%	67%	40%	25%	50%	27%	67%	27%	21%
	2011-2012	63%	0%	50%	33%	18%	47%	50%	33%	40%	63%	27%	40%	35%	25%
	2012-2013	67%	0%	50%	-	0%	0%	33%	0%	20%	40%	40%	33%	22%	23%
	2013-2014	0%	-	-	0%	50%	0%	-	25%	50%	20%	0%	25%	25%	NA
	2014-2015	-	-	-	-	-	-	-	-	-	-	-	-	21%	NA
	2015-2016	-	-	-	-	-	-	-	-	-	-	-	-	14%	21
Turnover Rate of All Teachers [a]	2010-2011	22%	24%	16%	17%	14%	13%	17%	25%	19%	27%	15%	17%	21%	13%
	2011-2012	5%	21%	17%	10%	17%	37%	12%	15%	16%	31%	19%	13%	20%	14%
	2012-2013	30%	12%	11%	7%	12%	7%	12%	12%	14%	21%	25%	8%	16%	14%
	2013-2014	14%	-	14%	6%	23%	20%	23%	18%	16%	20%	11%	8%	17%	NA
	2014-2015	-	-	-	-	-	-	-	-	-	-	-	-	19%	NA
	2015-2016	-	-	-	-	-	-	-	-	-	-	-	-	11%	11
Number of ISEP Teachers	2012-2013	3	1	2	5	2	3	8	5	9	8	6	9	61	NA
	2013-2014	9	1	8	5	6	2	8	5	11	5	4	9	73	NA
	2014-2015	10	2	3	16	8	3	8	4	12	7	2	9	84	NA
	2015-2016	11	4	1	14	2	2	8	3	9	3	2	8	67	NA

[a] Percentage for all teachers in the building, including science teachers.

Table A2. *Middle School Aggregate Student Demographic and Performance Data, 2010-2011 to 2015-2016*

		Middle (K-8) Schools						
	Year	**Harriet Ross Tubman Academy**	**Charles Drew Science Magnet**	**Lorraine Academy**	**Southside Elementary**	**Native American Magnet (NAMS)**	**BPS District Average**	**NY State Average**
Total number of students	2010-2011	455	470	556	957	405	31,590	2,692,649
	2011-2012	480	282	563	951	474	30,831	2,670,548
	2012-2013	450	273	550	1005	488	30,750	2,656,967
	2013-2014	403	-	659	1065	503	31,815	2,652,283
	2014-2015	422	727	711	1072	557	32,165	2,649,039
	2015-2016	444	712	701	1055	450	31,359	2,640,250
% American Indian or Alaska Native	2010-2011	1%	0%	2%	1%	22%	1%	-
	2011-2012	1%	1%	2%	1%	18%	1%	1%
	2012-2013	0%	0%	2%	1%	16%	1%	1%
	2013-2014	1%	-	1%	1%	16%	1%	1%
	2014-2015	0%	0%	1%	1%	12%	1%	1%
	2015-2016	0%	0%	1%	1%	14%	1%	1%
% Black or African American	2010-2011	89%	88%	22%	21%	39%	55%	19%
	2011-2012	84%	69%	23%	20%	36%	53%	19%
	2012-2013	83%	60%	20%	18%	37%	51%	18%
	2013-2014	81%	88%	28%	21%	37%	50%	18%
	2014-2015	78%	74%	33%	22%	39%	49%	18%
	2015-2016	66%	70%	31%	22%	39%	48%	18%
% Hispanic or Latino	2010-2011	4%	3%	10%	10%	16%	15%	22%
	2011-2012	6%	8%	10%	13%	18%	16%	23%
	2012-2013	5%	10%	13%	15%	16%	17%	24%
	2013-2014	5%	-	12%	14%	14%	17%	25%
	2014-2015	5%	8%	14%	14%	13%	18%	25%
	2015-2016	9%	8%	14%	13%	12%	19%	26%
% Asian or Native Hawaiian/ Other Pacific Islander	2010-2011	0%	1%	1%	2%	15%	5%	8%
	2011-2012	0%	2%	2%	2%	19%	6%	9%
	2012-2013	0%	4%	2%	3%	21%	6%	9%
	2013-2014	0%	-	2%	6%	23%	7%	9%
	2014-2015	4%	6%	1%	6%	25%	8%	9%
	2015-2016	9%	9%	1%	6%	27%	9%	9%
% White	2010-2011	5%	7%	63%	64%	6%	23%	50%
	2011-2012	7%	15%	62%	60%	8%	22%	48%
	2012-2013	8%	17%	61%	59%	9%	22%	47%
	2013-2014	9%	-	52%	55%	9%	21%	46%
	2014-2015	9%	8%	47%	52%	9%	21%	45%
	2015-2016	12%	10%	47%	53%	7%	20%	45%
% Multiracial	2010-2011	1%	0%	1%	3%	2%	2%	-
	2011-2012	2%	6%	1%	3%	1%	2%	1%

		Middle (K-8) Schools						
	Year	**Harriet Ross Tubman Academy**	**Charles Drew Science Magnet**	**Lorraine Academy**	**Southside Elementary**	**Native American Magnet (NAMS)**	**BPS District Average**	**NY State Average**
	2012-2013	4%	8%	2%	4%	1%	2%	1%
	2013-2014	2%	-	4%	5%	1%	3%	1%
	2014-2015	3%	4%	5%	5%	2%	3%	2%
	2015-2016	4%	4%	6%	6%	2%	3%	2%
% Limited English Proficient (LEP)	2010-2011	0%	1%	0%	1%	28%	10%	8%
	2011-2012	-	-	-	1%	31%	11%	8%
	2012-2013	0%	5%	0%	2%	33%	12%	8%
	2013-2014	1%	-	0%	7%	33%	13%	8%
	2014-2015	5%	8%	0%	8%	37%	14%	8%
	2015-2016	18%	12%	1%	8%	34%	15%	8%
% Students with disabilities	2010-2011	Data are not available on the New York State School Report Card.						
	2011-2012	27%	36%	26%	28%	15%	20%	15%
	2012-2013	28%	38%	27%	28%	16%	21%	15%
	2013-2014	30%	-	25%	29%	19%	21%	16%
	2014-2015	26%	26%	26%	28%	16%	22%	17%
	2015-2016	27%	30%	28%	29%	18%	22%	17%
% Poverty (% free/reduced lunch)	2010-2011	93%	92%	77%	80%	98%	79%	48%
	2011-2012	91%	94%	81%	86%	96%	77%	50%
	2012-2013	90%	93%	86%	81%	91%	81%	54%
	2013-2014	93%	-	65%	77%	89%	76%	53%
	2014-2015	87%	92%	81%	84%	89%	80%	54%
	2015-2016	70%	77%	65%	71%	84%	68%	52%
% Male	2010-2011	Data are not available on the New York State School Report Card.						
	2011-2012	52%	55%	51%	53%	46%	50%	51%
	2012-2013	52%	55%	51%	52%	48%	50%	51%
	2013-2014	50%	-	51%	52%	49%	51%	51%
	2014-2015	50%	53%	49%	50%	53%	50%	51%
	2015-2016	55%	53%	50%	49%	51%	51%	51%
% Female	2010-2011	Data are not available on the New York State School Report Card.						
	2011-2012	48%	45%	49%	47%	54%	50%	49%
	2012-2013	48%	45%	49%	48%	52%	50%	49%
	2013-2014	50%	-	49%	48%	51%	49%	49%
	2014-2015	50%	47%	51%	50%	47%	50%	49%
	2015-2016	45%	47%	50%	51%	49%	49%	49%
% of Students Meeting or Exceeding NY State Standards (Scoring at Level 3 or 4):								
Grade 4 Science %	2010-2011	32%	72%	96%	87%	74%	68%	88%
	2011-2012	23%	-	92%	65%	74%	62%	89%
	2012-2013	47%	-	90%	82%	58%	68%	90%
	2013-2014	39%	-	85%	76%	60%	62%	87%

	Year	Middle (K-8) Schools						
	Year	Harriet Ross Tubman Academy	Charles Drew Science Magnet	Lorraine Academy	Southside Elementary	Native American Magnet (NAMS)	BPS District Average	NY State Average
	2014-2015	35%	40%	70%	68%	71%	63%	86%
	2015-2016	52%	58%	84%	73%	52%	66%	89%
Grade 8 Science %	2010-2011	50%	23%	50%	51%	47%	42%	72%
	2011-2012	57%	-	39%	54%	45%	40%	69%
	2012-2013	19%	-	50%	54%	51%	40%	69%
	2013-2014	5%	-	35%	47%	49%	29%	61%
	2014-2015	14%	21%	48%	56%	23%	30%	62%
	2015-2016	11%	20%	55%	42%	-	28%	60%
Number of ISEP Teachers	2012-2013	3	1	2	5	2	13	-
	2013-2014	9	1	8	5	6	29	-
	2014-2015	10	2	3	16	8	39	-
	2015-2016	11	4	1	14	2	32	-

Table A3. *High School Aggregate Student Demographic and Performance Data, 2010-2011 to 2015-2016*

		High Schools				College Board / Gates Foundation School (6-12)	Vocational Schools			
	Year	East HS	Bennett HS	South Park HS	Riverside Institute of Technology HS	MST Preparatory School at Seneca	Burgard Vocational HS	Hutchinson Central Technical HS	BPS District Average	NY State Average
Total number of students	2010-2011	610	848	817	762	387	602	1069	31,590	2,692,649
	2011-2012	524	729	773	760	408	590	1052	30,831	2,670,548
	2012-2013	388	661	824	751	398	523	1073	30,750	2,656,967
	2013-2014	390	592	882	768	472	540	1097	31,815	2,652,283
	2014-2015	361	416	866	754	593	531	1108	32,165	2,649,039
	2015-2016	246	206	830	640	649	520	1116	31,359	2,640,250
% American Indian or Alaska Native	2010-2011	0%	0%	1%	4%	0%	1%	3%	1%	-
	2011-2012	0%	1%	1%	4%	1%	1%	2%	1%	1%
	2012-2013	1%	1%	1%	2%	1%	0%	2%	1%	1%
	2013-2014	1%	1%	1%	1%	0%	0%	2%	1%	1%
	2014-2015	0%	1%	1%	1%	1%	0%	1%	1%	1%
	2015-2016	0%	0%	1%	1%	0%	1%	1%	1%	1%
% Black or African American	2010-2011	90%	86%	25%	48%	85%	81%	42%	55%	19%
	2011-2012	88%	84%	23%	45%	81%	78%	39%	53%	19%

		High Schools				College Board / Gates Foundation School (6-12)	Vocational Schools			
	Year	**East HS**	**Bennett HS**	**South Park HS**	**Riverside Institute of Technology HS**	**MST Preparatory School at Seneca**	**Burgard Vocational HS**	**Hutchinson Central Technical HS**	**BPS District Average**	**NY State Average**
	2012-2013	84%	82%	25%	41%	85%	80%	41%	51%	18%
	2013-2014	83%	82%	25%	39%	86%	77%	42%	50%	18%
	2014-2015	86%	84%	28%	37%	84%	79%	42%	49%	18%
	2015-2016	86%	89%	30%	35%	83%	77%	42%	48%	18%
% Hispanic or Latino	2010-2011	5%	5%	16%	23%	6%	7%	10%	15%	22%
	2011-2012	6%	8%	18%	21%	7%	7%	12%	16%	23%
	2012-2013	5%	7%	18%	26%	6%	6%	14%	17%	24%
	2013-2014	5%	7%	19%	26%	5%	6%	16%	17%	25%
	2014-2015	7%	6%	17%	30%	5%	8%	16%	18%	25%
	2015-2016	6%	4%	17%	34%	6%	9%	16%	19%	26%
% Asian or Native Hawaiian/ Other Pacific Islander	2010-2011	1%	2%	2%	9%	1%	4%	6%	5%	8%
	2011-2012	1%	3%	1%	16%	2%	7%	6%	6%	9%
	2012-2013	2%	4%	3%	18%	2%	7%	5%	6%	9%
	2013-2014	4%	4%	2%	21%	4%	9%	6%	7%	9%
	2014-2015	5%	3%	3%	19%	6%	6%	8%	8%	9%
	2015-2016	5%	2%	3%	18%	7%	6%	10%	9%	9%
% White	2010-2011	3%	5%	55%	15%	7%	7%	40%	23%	50%
	2011-2012	2%	5%	55%	13%	8%	7%	41%	22%	48%
	2012-2013	2%	5%	52%	12%	7%	6%	37%	22%	47%
	2013-2014	3%	5%	50%	12%	5%	7%	34%	21%	46%
	2014-2015	1%	4%	50%	12%	4%	6%	31%	21%	45%
	2015-2016	2%	2%	47%	11%	3%	7%	30%	20%	45%
% Multiracial	2010-2011	0%	1%	1%	0%	1%	0%	0%	2%	-
	2011-2012	1%	0%	1%	0%	0%	0%	0%	2%	1%
	2012-2013	2%	1%	2%	0%	0%	0%	4%	2%	1%
	2013-2014	1%	2%	2%	1%	0%	1%	2%	3%	1%
	2014-2015	1%	2%	2%	1%	0%	1%	1%	3%	2%
	2015-2016	1%	1%	2%	1%	1%	1%	1%	3%	2%
% Limited English Proficient (LEP)	2010-2011	1%	4%	6%	20%	2%	6%	1%	10%	8%
	2011-2012	3%	5%	6%	26%	4%	10%	1%	11%	8%
	2012-2013	3%	6%	6%	28%	4%	8%	1%	12%	8%
	2013-2014	5%	7%	7%	34%	4%	9%	1%	13%	8%
	2014-2015	5%	4%	7%	31%	6%	7%	1%	14%	8%
	2015-2016	3%	5%	7%	31%	6%	7%	1%	15%	8%

		High Schools				College Board / Gates Foundation School (6-12)	Vocational Schools			
	Year	**East HS**	**Bennett HS**	**South Park HS**	**Riverside Institute of Technology HS**	**MST Preparatory School at Seneca**	**Burgard Vocational HS**	**Hutchinson Central Technical HS**	**BPS District Average**	**NY State Average**
% Students with disabilities	2010-2011	Data are not available on the New York State School Report Card.								
	2011-2012	21%	22%	27%	21%	16%	27%	5%	20%	15%
	2012-2013	23%	23%	28%	21%	19%	22%	5%	21%	15%
	2013-2014	23%	24%	25%	18%	21%	27%	6%	21%	16%
	2014-2015	23%	22%	24%	16%	23%	24%	8%	22%	17%
	2015-2016	25%	17%	26%	20%	25%	25%	10%	22%	17%
% Poverty (% free/reduced lunch)	2010-2011	80%	73%	73%	77%	68%	72%	66%	79%	48%
	2011-2012	76%	86%	63%	74%	76%	71%	61%	77%	50%
	2012-2013	79%	76%	69%	82%	82%	81%	69%	81%	54%
	2013-2014	74%	74%	63%	73%	74%	68%	61%	76%	53%
	2014-2015	77%	78%	69%	75%	78%	74%	72%	80%	54%
	2015-2016	67%	69%	66%	75%	70%	68%	55%	68%	52%
% Male	2010-2011	Data are not available on the New York State School Report Card.								
	2011-2012	47%	47%	51%	57%	52%	66%	53%	50%	51%
	2012-2013	45%	46%	52%	57%	55%	65%	54%	50%	51%
	2013-2014	46%	49%	52%	54%	54%	62%	53%	51%	51%
	2014-2015	50%	47%	54%	55%	52%	64%	53%	50%	51%
	2015-2016	46%	51%	57%	58%	47%	65%	52%	51%	51%
% Female	2010-2011	Data are not available on the New York State School Report Card.								
	2011-2012	53%	53%	49%	43%	48%	34%	47%	50%	49%
	2012-2013	55%	54%	48%	43%	45%	35%	46%	50%	49%
	2013-2014	54%	51%	48%	46%	46%	38%	47%	49%	49%
	2014-2015	50%	53%	46%	45%	48%	36%	47%	50%	49%
	2015-2016	54%	49%	43%	42%	53%	35%	48%	49%	49%
	Year	**East HS**	**Bennett HS**	**South Park HS**	**Riverside Institute of Technology HS**	**MST Preparatory School at Seneca**	**Burgard Vocational HS**	**Hutchinson Central Technical HS**	**BPS District Average**	**NY State Average**
Graduation rate – All Students[d]	2010-2011	46%	49%	48%	31%	71%	52%	88%	50%	76%
	2011-2012	42%	39%	59%	34%	65%	33%	83%	56%	77%
	2012-2013	47%	37%	56%	22%	72%	28%	87%	53%	75%
	2013-2014	39%	37%	55%	16%	51%	39%	85%	53%	76%
	2014-2015	42%	45%	61%	29%	47%	44%	87%	61%	78%

		High Schools				College Board / Gates Foundation School (6-12)	Vocational Schools			
	Year	**East HS**	**Bennett HS**	**South Park HS**	**Riverside Institute of Technology HS**	**MST Preparatory School at Seneca**	**Burgard Vocational HS**	**Hutchinson Central Technical HS**	**BPS District Average**	**NY State Average**
	2015-2016	34%	46%	56%	32%	48%	52%	84%	62%	79%
Graduation rate - American Indian or Alaska Native[d]	2010-2011	-	-	-	-	-	-	-	47%	63%
	2011-2012	-	-	-	-	-	-	-	52%	63%
	2012-2013	0%	0%	-	-	-	-	-	38%	62%
	2013-2014	0%	-	-	-	-	-	-	55%	61%
	2014-2015	-	-	-	-	0%	0%	-	52%	65%
	2015-2016	0%	-	-	-	0%	-	-	64%	64%
Graduation rate - Black or African American[d]	2010-2011	45%	48%	32%	30%	70%	51%	87%	47%	61%
	2011-2012	44%	39%	48%	31%	69%	36%	84%	54%	63%
	2012-2013	46%	37%	47%	25%	72%	29%	85%	52%	60%
	2013-2014	39%	36%	46%	10%	45%	42%	86%	50%	62%
	2014-2015	43%	48%	64%	30%	48%	46%	86%	61%	65%
	2015-2016	33%	46%	59%	29%	49%	55%	84%	62%	68%
Graduation rate - Hispanic or Latino[d]	2010-2011	-	-	-	34%	-	-	-	41%	60%
	2011-2012	-	-	-	36%	-	-	-	45%	63%
	2012-2013	-	42%	71%	28%	-	25%	92%	44%	59%
	2013-2014	46%	44%	54%	16%	-	33%	77%	43%	62%
	2014-2015	33%	27%	41%	22%	-	29%	92%	50%	65%
	2015-2016	-	38%	49%	31%	33%	67%	77%	52%	68%
Graduation rate - Asian or Native Hawaiian/ Other[d]	2010-2011	-	-	-	-	-	-	-	52%	84%
	2011-2012	-	-	-	-	-	-	-	51%	86%
	2012-2013	-	-	67%	15%	0%	-	-	44%	81%
	2013-2014	-	38%	-	21%	-	31%	80%	38%	82%
	2014-2015	-	54%	40%	40%	-	41%	83%	53%	85%
	2015-2016	60%	-	40%	40%	67%	42%	88%	61%	86%
Graduation rate - White[d]	2010-2011	-	-	56%	33%	-	-	88%	61%	85%
	2011-2012	-	-	66%	38%	-	-	80%	65%	87%
	2012-2013	60%	-	56%	18%	80%	31%	88%	67%	87%
	2013-2014	-	38%	61%	-	100%	-	89%	70%	87%

		High Schools				College Board / Gates Foundation School (6-12)	Vocational Schools			
	Year	East HS	Bennett HS	South Park HS	Riverside Institute of Technology HS	MST Preparatory School at Seneca	Burgard Vocational HS	Hutchinson Central Technical HS	BPS District Average	NY State Average
	2014-2015	-	36%	66%	21%	-	-	86%	72%	88%
	2015-2016	-	-	57%	26%	20%	-	86%	70%	88%
Graduation rate - Multiracial[d]	2010-2011	-	-	-	-	-	-	-	-	70%
	2011-2012	-	-	-	-	-	-	-	-	80%
	2012-2013	0%	0%	-	-	-	0%	-	38%	73%
	2013-2014	0%	-	67%	-	0%	0%	-	59%	77%
	2014-2015	50%	-	-	-	-	-	-	48%	80%
	2015-2016	0%	-	-	-	0%	-	-	62%	80%
Graduation rate - Female[d]	2010-2011	54%	53%	53%	40%	80%	51%	93%	55%	80%
	2011-2012	48%	44%	58%	36%	74%	37%	87%	61%	81%
	2012-2013	54%	47%	64%	23%	79%	25%	91%	59%	79%
	2013-2014	41%	34%	59%	19%	53%	34%	85%	56%	80%
	2014-2015	57%	50%	64%	31%	58%	44%	89%	66%	82%
	2015-2016	39%	51%	56%	39%	58%	48%	88%	68%	83%
Graduation rate - Male[d]	2010-2011	36%	27%	43%	23%	61%	53%	83%	44%	71%
	2011-2012	35%	32%	59%	32%	58%	31%	79%	50%	74%
	2012-2013	35%	27%	49%	22%	66%	30%	83%	48%	71%
	2013-2014	36%	40%	52%	15%	50%	41%	85%	50%	73%
	2014-2015	32%	37%	58%	26%	38%	44%	86%	56%	74%
	2015-2016	29%	42%	56%	25%	39%	56%	80%	56%	76%
% of students attending post-secondary school [b]	2010-2011	82%	83%	67%	89%	97%	88%	88%	83%	82%
	2011-2012	9%	74%	74%	75%	92%	70%	86%	79%	81%
	2012-2013	86%	81%	72%	76%	92%	91%	90%	85%	81%
	2013-2014	87%	79%	74%	77%	93%	85%	89%	82%	80%
	2014-2015	78%	91%	59%	77%	34% (w 61% unknown)	84%	95%	82%	79%
	2015-2016	70%	94%	70%	71%	79%	73%	93%	84%	78%
% of Students Meeting or Exceeding NY State Standards (Scoring at or above 65):										
Regents Living Environments %	2010-2011	42%	61%	57%	32%	58%	53%	93%	61%	78% [c]
	2011-2012	38%	51%	47%	31%	29%	36%	91%	55%	79%

		High Schools				College Board / Gates Foundation School (6-12)	Vocational Schools			
	Year	**East HS**	**Bennett HS**	**South Park HS**	**Riverside Institute of Technology HS**	**MST Preparatory School at Seneca**	**Burgard Vocational HS**	**Hutchinson Central Technical HS**	**BPS District Average**	**NY State Average**
	2012-2013	34%	38%	45%	35%	27%	37%	82%	53%	77%
	2013-2014	36%	33%	56%	38%	37%	41%	90%	57%	78%
	2014-2015	36%	50%	55%	34%	25%	53%	87%	56%	77%
	2015-2016	25%	49%	48%	34%	28%	64%	87%	56%	78%
Regents Physical Setting/Earth Science %	2010-2011	11%	25%	33%	15%	24%	8%	-	37%	74% [c]
	2011-2012	9%	36%	59%	17%	35%	8%	-	38%	73%
	2012-2013	5%	30%	49%	10%	24%	9%	-	33%	72%
	2013-2014	13%	24%	38%	14%	6%	18%	-	39%	72%
	2014-2015	25%	49%	35%	19%	18%	4%	-	43%	72%
	2015-2016	-	33%	34%	12%	10%	7%	-	43%	71%
Regents Physical Setting/Chemistry %	2010-2011	-	10%	11%	50%	64%	-	42%	53%	73% [c]
	2011-2012	0%	44%	17%	17%	40%	-	51%	50%	78%
	2012-2013	16%	20%	0%	18%	55%	-	38%	43%	76%
	2013-2014	13%	46%	0%	14%	0%	-	34%	43%	73%
	2014-2015	13%	-	7%	0%	-	-	43%	48%	75%
	2015-2016	2%	18%	0%	-	30%	-	50%	56%	76%
Regents Physics %	2010-2011	-	-	-	0%	-	-	58%	57%	82% [c]
	2011-2012	-	-	-	-	-	-	61%	63%	79%
	2012-2013	-	-	-	-	-	-	58%	60%	81%
	2013-2014	-	-	-	-	-	-	55%	59%	81%
	2014-2015	-	-	-	-	-	-	53%	55%	82%
	2015-2016	-	-	-	-	-	-	69%	65%	79%
Number of ISEP Teachers	2012-2013	3	8	5	9	8	6	9	48	-
	2013-2014	2	8	5	11	5	4	9	44	-
	2014-2015	3	8	4	12	7	2	9	45	-
	2015-2016	2	8	3	9	3	2	8	35	-

[b] This number was calculated using (Number going to 4 year + Number going to 2 year + Number going to other postsecondary)/Number of Completers.
[c] All State Regents data for 2010-2011 were from 2009-2010.
[d] Graduation rates in 2010-2011 were based on the 2007 four-year cohort for accountability

Section 5: Implementation Plan

University at Buffalo/ Buffalo Public Schools ISEP

Year 6: –2016-2017 No Cost Extension

ISEP Year 7 Plan: August 2017 – February 2018

For Year7 we anticipate full implementation of the results from summer 2016 and 2017 professional development and detailed in grant application and in 5-year plan including the following categories which are detailed in the following chart:

- School-based wrap-around supports, especially results of summer student activities
- PLC's
- Research & evaluation
- Develop and Execute Sustainability Plan for future funding
- Develop an ecosystem based Theory of Action

	July & August 2017	Fall	Spring	Feb 2018
Teacher professional development	Teachers engaging in research experiences and share projects through PLC's; planning for implementation in upcoming school-year Identify continuing and graduate and undergraduate students to work with teachers during the upcoming school-year through consultation with district and school leadership	Monthly pedagogical workshops on inquiry and interdisciplinary inquiry teaching (with graduate credit option from Graduate School of Education) Teacher implementation of inquiry science teaching with support by STEM and STEM education faculty, graduate and undergraduate students as well as retired master teachers	Monthly pedagogical workshops on inquiry and interdisciplinary inquiry teaching (with graduate credit option from Graduate School of Education) Teacher implementation of inquiry science teaching with support by STEM and STEM education faculty, graduate and undergraduate students as well as retired master teachers Ongoing communication with school and district leadership to align and maximize resources, placements, and opportunities	Proposed dissemination plan developed for teachers with standard rubrics for lesson planning and supporting materials for upload onto ISEP website and NYLearns.org.

School-based wrap-Around supports	Reflect on summer research activities and curriculum plans; explore related school needs and collaboratively plan for in-school activities for upcoming year Examine results of students from each school in summer research opportunities or middle school summer camps and identify follow up academic year activities for continuing emphasis on student development Develop student focused leadership and STEM activities to develop mentoring and academic success in STEM with measures reflecting Common Core standards	School meetings to review building plans and activities; identify ongoing needs and changes; assess viability of plans and assign GA/RA and undergraduate support. Meet with school based parent group to plan activities. Review building supplies and equipment requests. GA's and RA's support in-class and afterschool activities and service learning students; in-school and afterschool activities Ongoing purchasing of STEM related equipment as determined through collaborative discussions and planning with school and district leadership	Ongoing activities (begun in fall) with extensive communication between all parties to ensure benefit and alignment with grant and school/district planning Ongoing partner events including family nights at BMS Announcement of summer camps for middle school students and summer research internship opportunities for high school students	Summer camp enrichment opportunities for participating middle school students

PLC's	Communication to invited new member participation in PLCs and initial meeting with participants Teachers engaged in summer research prepare products to share through PLC's Continue social network tools for each PLC	Develop existing EdWeb characteristics for online communication by testing questions to teacher PLCs Scheduled meetings and communication to support PLC's Develop new interfaces and PLC's as needed/ warranted	Ongoing monitoring of PLC activity; communication and meetings to encourage participation and alignment with ongoing STEM related activities associated with ISEP Ongoing interactions with DPCC and Parent PLC to encourage parent involvement Ongoing interactions with core partners to encourage their participation in support of ISEP goals	Plan to incorporate new research activities and new teachers, graduate students, researchers, parents, and teachers in PLC's (existing and evolving)

Evaluation	Analyze UB/BPS ISEP Teacher Questionnaire pre/post comparisons Analyze BPS ISEP Student Questionnaire data from treatment and comparison students- Winter 2018 Collect 2016-2017 School/classroom/teacher-level demographic data Collaborate with the Research Team to develop and pilot test Teacher Content and PCK Assessment Observation and informal interviews of ISEP teacher participants, STEM students, and faculty during summer lab experiences Administer instrument to assess student summer program experiences	Administer pre-intervention instruments to measure changes in BPS students' perceptions of science and engineering (UB/ BPS ISEP Student Questionnaire) Administer UB/BSC Faculty Questionnaire Ongoing collection of data and monitoring of ISEP components and responding to project team needs Administer and analyze STEM Student Survey data Analyze BPS student summer program experience data Meet with ISEP Project Team on site	Administer and analyze fully developed instruments measuring content knowledge and pedagogical content knowledge (UB/ BPS ISEP STEM Teacher Content Knowledge & Pedagogical Content Knowledge Assessments) Ongoing collection of data and monitoring of ISEP components and responding to project team needs Administer and analyze STEM Student Survey Data Meet with ISEP Project Team on site	Administer post-intervention instruments to measure changes in BPS students' perceptions of science and engineering (UB/ BPS ISEP Student Questionnaire) Administer UB/BPS ISEP Teacher Questionnaire Ongoing collection of data and monitoring of ISEP components and responding to project team needs Preparing for evaluation of summer research components and final activities in schools and revision of evaluation plan as necessary

Research	Participant observation of teachers conducting research at university research laboratories and industrial partner sites during the summer 2013 Working with the external evaluator to develop standardized measurement instruments on science teachers' interdisciplinary science inquiry content knowledge and pedagogical content knowledge Participant observation of STEM graduate students conducting research with teachers, summer 2013	Observation of teachers implementing interdisciplinary science inquiry in their classrooms Supporting teachers in implementation interdisciplinary science inquiry through a monthly seminar Periodic interviews of teachers on their changing conceptions of interdisciplinary science inquiry teaching Observation of the undergraduate academy seminar on preparation of STEM students to work in schools Interview of STEM graduate and undergraduate students on their experiences and perceptions of communicating science to students and teachers	Observation of teachers implementing interdisciplinary science inquiry in their classrooms Supporting teachers in implementation interdisciplinary science inquiry through a monthly seminar Ongoing activities related to studying graduate student impacts (continuation of fall activities)	Prepare journal articles and other relevant publications to disseminate research findings