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Supportive Structures For Successful Science Teachers' Professional Development

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SUPPORTIVE STRUCTURES FOR SUCCESSFUL SCIENCE TEACHERS' PROFESSIONAL DEVELOPMENT

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Abstract

The Omaha Public Schools (OPS) Science Office collaborates closely with community partners to facilitate a private foundation grant that seeks to improve science education by focusing on in-service, science teachers' professional learning in the context of professional development (PD) experiences and targeted graduate coursework. The three goals of the K-12 Comprehensive Science Teaching and Learning Grant are to 1) increase student achievement in science, 2) increase teacher effectiveness, and to 3) align and enhance science curriculum. At the end of year one, 83 teacher participants have taken graduate courses, attended professional conferences, completed action research projects, and/or have participated in content immersion workshops based on personalized professional learning plans. All of the participating teachers complete an action research portfolio and are assisted by one of 11 science instructional coaches—master teachers who ensure that the teachers' professional learning is translated into improved classroom practice.

The science instructional coaches' preparation included training from the Institute for Inquiry affiliated with San Francisco's Exploratorium, Discipline-Based Educational Research and other graduate courses through the University of Nebraska at Omaha (UNO), The Art of Instructional Coaching Training and consulting from Elena Aguilar, and a series of Science Research Immersion Workshops by Omaha's Henry Doorly Zoo and Aquarium, as well as the University of Wisconsin-Extension affiliated with Upham Woods Outdoor Learning Center. The OPS K-12 Science Supervisor is the principal investigator and the UNO STEM Community Chair and the UNO Science Community Chair are the co-PIs for the collaborative grant effort. The shared-leadership model in OPS also includes two Elementary Supervisors and the Science Lead Teacher to ensure full alignment among district goals, participants' plans for growth, and partners' agendas. Additionally, a grant advisory team including district-level leadership and grant officers participates in quarterly meetings to oversee the progress. Education Northwest conducts the external grant evaluation.

Included in this report is the structural context of the project and implementation data from year one. These preliminary data are collected from surveys, interviews, observations, field reports, and standardized tests. Briefly, the data from assessments of youth in science from standardized test results showed slight district-wide gains at elementary school (+2% of students meeting standards) and middle school (+3% of students meeting standards) while high school standardized scores remained unchanged. Although the initial student data are encouraging, at this point in the project timeline the focus of this paper is on three of the four main structures of PD opportunities within the grant (i.e. graduate course work, conference attendance, and content immersions). The authors will discuss the details of these structures and identify potential and valuable next steps for research.

Keywords: Professional development, innovation, instructional coaching, content immersion, science teachers, inquiry, and collaboration.

1 INTRODUCTION

Studying science teachers' professional development (PD) is a complex but worthy endeavour [1]. Consider, for example, that in the 2013-2014 school year about 40% of the annual allotment of Title IIA funds (40% of nearly $2.5 billion USD) were spent on PD for educators [2]. The investment by the United States government is meant to increase student achievement, close achievement gaps, and reduce disparity in education. Although some advancement has been made on these fronts, significant achievement gaps in science still exist among student groups based on race and economics [3]. The large investment of funds coupled with limited gains on goals suggests the need to better understand teachers' PD.

Urban education in the United States also contends with the reality that inexperienced teachers are disproportionally concentrated in high need schools [4]. As an urban school district serving more than 50,000 students [5], the Omaha Public Schools (OPS) context also includes other academic achievement challenges. For example, the English as a Second Language (ESL) program membership has increased 403% in the past 20 years. In the 2015-2016 school year, 36% of OPS students received ESL program services, and 112 languages were spoken in OPS student homes [6]. OPS also had 74% of students eligible for free and reduced-price lunch [7]. Finally, OPS is a majority minority school district with an enrollment of approximately 68% minority students [5].

In 2010 the Nebraska Department of Education adopted new science standards, and OPS officially adopted the Nebraska Science Standards as a district in 2011. Along with the adoption of these new science standards, OPS changed its high school course sequence, purchased and implemented new curriculum materials, and started administering the Nebraska State Accountability Science (NeSA-S) assessment [8]. OPS has made gains in student achievement from the inception of the NeSA-S. Overall, the number of students meeting or exceeding the standards as measured on the NeSA-S show 10%, 8%, and 8% gains respectively for grades 5, 8, and 11. However, the early gains in the percent of students successful have slowed more recently, and the scores still lag behind state averages—namely, only 56% of students in fifth grade, 48% in eighth grade, and 49% in 11th grade met or exceeded the state science test standards in 2014-2015 as compared to 73%, 70%, and 73%, respectively, statewide [5].

Therefore, to address these challenges within the OPS district and to provide relevant and structured PD in both science content and pedagogy for science teachers, OPS and its community partners initiated the OPS K-12 Comprehensive Science Teaching and Learning Grant. The $4.2 million USD, three-year grant seeks to improve student achievement, teacher effectiveness, and the quality of OPS science curriculum. Herein, we will describe the design and initial implementation efforts.

2 GRANT DESIGN

Recent research regarding in-service science teachers' PD suggests a need for a flexible design where teachers select PD opportunities based on their perceived needs and are bounded within district and grant goals [9]. The major premise of this grant effort is that a bounded and flexible PD design will increase program relevance and engagement for the participating science teachers. Further, instructional coaches were included in the design to help teachers and the district negotiate the appropriate goals and boundaries. Fig. 1 is a logic model developed collaboratively by program leaders and Education Northwest. It describes the major components of the grant effort. Professional learning options for teachers to engage in the grant effort are found on the left side of fig. 1 and the outcomes are on the right.

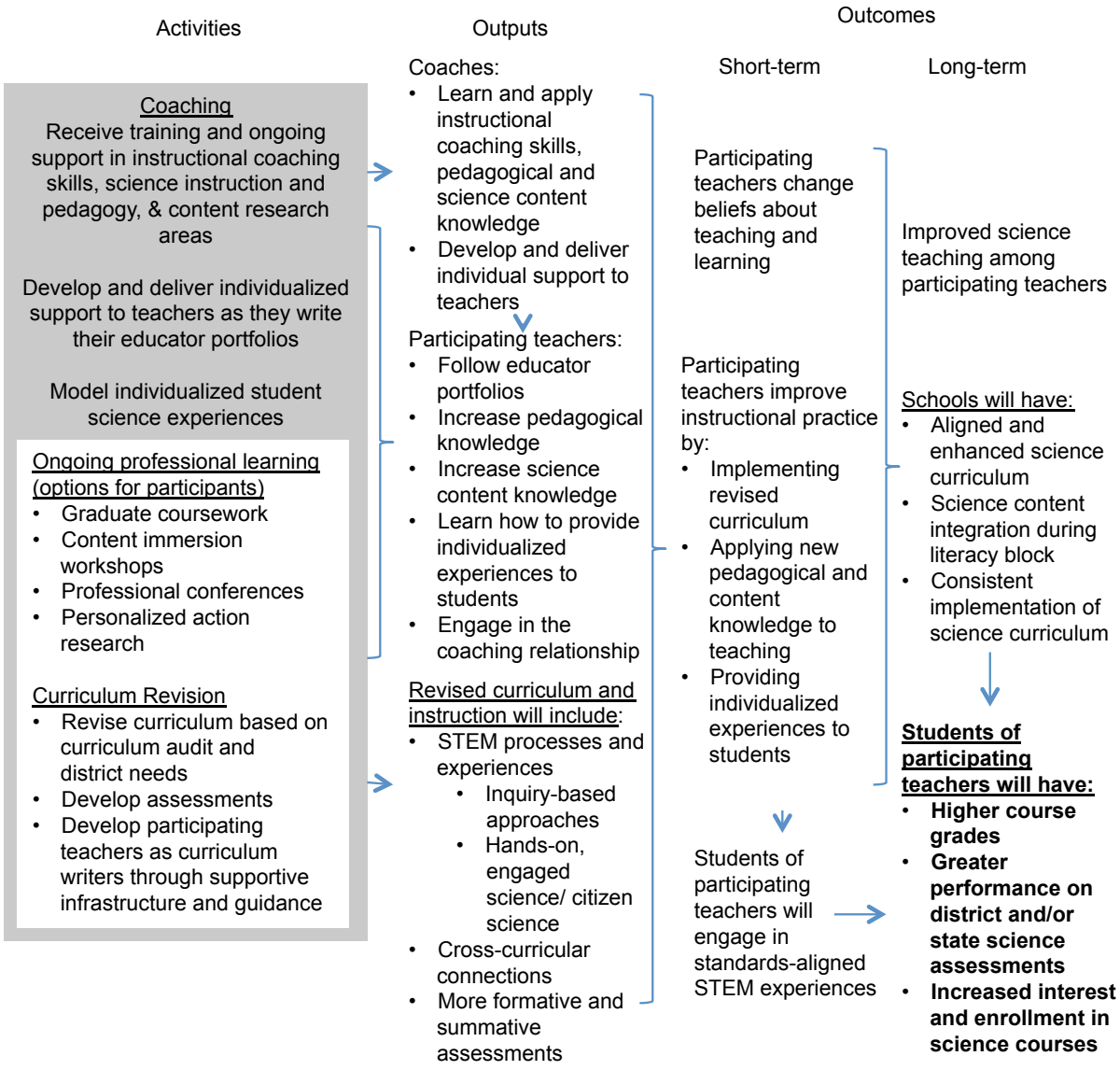

Figure 1 Logic Model to Describe the Grant Effort.

2.1 Grant goals

The grant goals are to 1) increase student achievement in science, 2) increase teacher effectiveness, and 3) align and enhance science curriculum. Thus, the grant is intended to improve student achievement in science through improved teaching practice and enhanced science curriculum. The PD activities are structured to increase teacher content knowledge and pedagogical skill and are based on teachers' self-selected professional learning goals. This model was designed to support teachers' inquiry of their own craft. Each teacher applies to be a participant in the grant. During the application process, 94% of teacher participants indicated that their primary goal was increasing student achievement in science; 4% selected increasing teacher effectiveness, and 2% said aligning and enhancing science curriculum would be their primary focus [10].

2.2 Supportive professional development structures

PD is central to the grant effort in which teachers take graduate courses in science content or pedagogy, participate in content immersion workshops, attend professional conferences, or complete action research based on their personalized professional learning plan. All participants are also engaged in instructional coaching as facilitated by a coach who was previously a master teacher. The grant provides funding for eleven instructional coaches, eight of whom were active in year one. Each instructional coach works with no more than eleven participating teachers to reify PD activities into classroom practice.

2.2.1 Portfolio

The portfolio process associated with the grant is based in part on the reflective practices established in an earlier district grant initiative where action research and reflection on teaching practices was used to change practices [11]. The portfolio process was also informed by work from the Knowles Science Teaching Foundation as presented at the National Science Teachers Association (NSTA) conference session, "Using Portfolios to Promote Reflective Thinking in New Teachers," [12]. All of the teacher participants complete the portfolio (updated, 2015) that includes a student-centered professional learning goal, a rationale for their goal, a plan for growth, a PD plan, and artifacts that eventually are utilized as evidence for growth as they complete an argument for their growth. Teachers also complete multiple reflections included in the portfolio, which help the participants to complete a final reflection.

After the first year of implementation, only one participant had completed all of the portfolio requirements. The duration of the participant's program is dependent upon his/her goals, and to some degree, the type of PD they choose to participate in during the grant activities. For example, one participant may choose to attend a conference and initiate change in his/her classroom based on that experience with support from a coach in a relatively quick manner. Whereas, another participant may choose to engage with graduate course work, which could require more time to complete the process. The science leadership team expects many more participants to complete their portfolio in 18 to 24 months of being active in the program. Participant progress on the portfolio is tracked on a log by the coaches and shared with the external evaluators and the science leadership team.

2.2.2 Coaching Model

The coaching model for this grant prescribes that the instructional coaches spend 10% of their time engaging in PD, 10% of their time supporting students in scientific research opportunities, and 80% of their time providing coaching and classroom support. The instructional coaches were selected through an interview process by the science leadership team and were all high performing OPS teachers who were also highly involved in district-level initiatives. The coaches also took part in several PD activities during the implementation of the grant. These activities included training in inquiry (*Fundamentals of Inquiry,* a 30 hour training with support from the Institute for Inquiry). Coaches also received training student research (e.g. high altitude balloon research, experiences in science research at the American Association for the Advancement of Science [AAAS] annual conference, and state, local, and national science fairs). The coaches participated in an intensive content immersion experience in Costa Rica (including pre and post experiences, graduate course work, and a ten day immersion in the country). Finally, the coaches also received instructional coaching training (*The Art of Coaching*, by Elena Aguilar, district training, and experiences at conferences).

3 IMPLEMENTATION

While many other PD initiatives include a prescribed set of experiences that all participants partake in, this grant effort was designed to meet individual teacher's professional needs when the teacher's needs clearly align with the grant and District goals. The participant teacher PD plans are diverse because of the varying participants' professional learning needs. As previously mentioned, during the application process teachers identified the type of PD, one or more, that they wished to participate in from among the categories of content immersion workshops, graduate courses in science content or pedagogy, professional conference attendance, and personalized action research. Table 1 shows that the type of participation selected was spread among all four with the smallest percentage of teachers choosing personalized action research [10]. The totals do not equal 100% as some participants select multiple ways to engage with the grant effort.

Table 1 Percentage of Participants Who Selected Different PD Experiences.

	Percent
Professional conference attendance	45%
Graduate course(s) in science content or pedagogy	45%
Content immersion workshop	40%
Personalized action research	34%

The grant is also designed to allow admission to the program on an on-going basis. However, the science advisory team may change enrolment practices as the effort nears capacity. After the potential participants submit their application, the information is directly emailed to the principal of their school and the principal then gives her input to the science leadership team who reviews each application and ensures alignment among the participants' goals, OPS goals, and the grant goals. In a few cases principals have raised concern for the potential participants. In those instances the science leadership team has worked with the principal and the potential teacher participant to determine if participation was in the teacher's best interest and how the grant could also support the school's mission. A few teacher applicants also had goals that were not clearly aligned in some fashion to the grant goals, OPS goals, or may not have been student-centered. In those cases the science coaches or the science leadership team worked closely with the teacher applicant to update and refine their goals. In this fashion, all teacher applicants have been successful in gaining access to the program with fairly evenly spread admission and a personalized goal refinement. Fig. 2 below shows the number of applicants admitted to the program by quarter as recorded in the portfolio progress log [10].

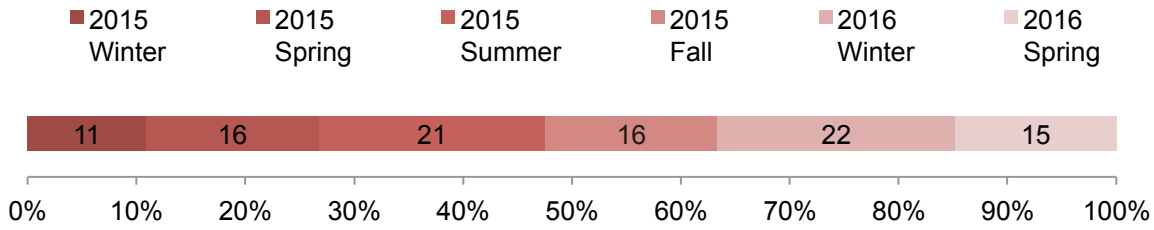

Figure 2 Percentage of Participants Enrolled in the Grant by Quarter.

3.1 Graduate course work

OPS is the lead educational agency and holds fiscal responsibility for the Grant effort, while UNO provides leadership for the effort in multiple ways. While two UNO faculty community chairs serve as co-PIs, UNO also has several other professors and leadership who serve as members of the OPS Science Advisory Board. UNO has also specifically tailored and facilitated graduate courses for the science coaches including, for example: Disciplined Based Education Research, Issues in Bioethics, Data Driven Decision Making and Ecosystem Analysis. In these courses the coaches were encouraged to reflect on their new role as they completed the course requirements. Similarly, UNO has also provided other graduate courses for the teacher participants that align to their specific interests and needs.

The challenge for a university/district partnership is offering courses that are for professionals (i.e. teachers) instead of traditional undergraduates or general graduate student populations, as well as to maintain course rigor and interest for teachers. Additionally, these courses have to be slightly non-conventional in terms of laboratory offerings and meeting times to meet the needs of a working professional. Therefore, UNO has created a science, technology, engineering, and mathematics (STEM) prefix for teacher focused courses, as well as a STEM Certificate pathway. Additional offerings in all sciences for the participation and inclusion of professionals are being designed working closely with the OPS grant leadership team.

The grant also allows participants to engage in graduate course work from other Universities. This was important to OPS and to the granting agency so that teachers could capitalize on previous course work and to be open to meet teachers' needs. This also allowed for meaningful partnerships with other Universities as the grant effort unfolded. One example where this flexibility proved fruitful was with the University of Wisconsin-Extension during the development of content immersion experiences.

3.2 Content immersion

The immersion experiences were important to the grant so that some of the participating science teachers would have a manner to learn more about what science is and how it works in the field. The grant has supported participant work with the *Educator Academy in the Amazon Rainforest* by EcoTeach and partnership created experiences in Costa Rica, Trinidad and Tobago, and at Upham Woods Outdoor Learning Center (Operated by University of Wisconsin-Extension). In each immersion

the participants were required to complete pre and post immersion activities. The experiences also had the option for participants to engage in graduate course work related to the experience. In each immersion experience the participants created deliverables that could be used in classrooms or in work with other teachers. It was the responsibility of the science coaches and leadership team to support the integration of lessons, labs, and techniques into the classroom and district curriculum.

Upham Woods, the Henry Doorly Zoo and Aquarium education staff, and OPS facilitated the partnership developed model with logistical support from Green Edventures. This model included utilization of the Digital Observation Tool Skills (D.O.T.S.) kits and conservation, research, and educational insights from the Henry Doorly Zoo and Aquarium. Utilizing experts in the field of conservation and research places teachers in a safe learning environment that allows for them to explore the depth of their content knowledge. Through these immersive learning experiences, teachers take on the role of exploring and observing to stimulate questions they have about content and would like to answer through data collection. The questions developed from individual experiences and prior knowledge guides the participants into an exploration of their surroundings utilizing digital measurement tools. The D.O.T.S. kits are comprised of a suite of digital measurement tools that support educators to compile digital artifacts in the form of daily expedition reports, digital storytelling, and online media venues. The purpose of these tools and this approach is to extend the value of onsite exploration back into the classroom and for the cohort to also reflect on as well as compare later. This approach supports a deeper connection to the places visited, as well as strengthens the use of data to interpret the landscape—locally or globally [13]. The science instructional coaches assisted in leading reflective activities through which teachers were able to create deliverables for their classrooms. The coaches also completed observations and provided feedback for teachers as they taught their lessons.

3.3 Conference attendance

Although conference attendance is usually a short duration of professional activities, the participants who engage the grant in this way also have other expectations. The instructional coaches prepare the participants for conference attendance by co-constructing note making devices that are centered on the participant's goals and used not only to take notes during attendance, but also for reflection and for guided selection of conference sessions. The types of conferences attended are related to science content (such as the AAAS annual conference), or are related to science teaching (such as the NSTA annual conference). The coaches help participants select appropriate conferences to attend based on the participants' learning goals. When possible the coaches will also attend the conference with their teacher participant, and they follow up with the participant shortly after the conference to determine progress on the teacher's professional learning. The coaches support the participants as they make sense of the conference and create deliverables (lessons, labs, techniques, strategies, etc.) for their classrooms. The deliverables become part of the participant's portfolio and evidence for growth as they construct their argument for growth.

Moreover, two OPS teachers participated in the *International Symposium of New Issues in Teacher Education* in Savonlinna, Finland along with a team of UNO STEM faculty. These teachers were able to tour local schools in Finland (which have the number one ranked schools in the world [14]), meet with other teachers to discuss successes and challenges in the classroom, present some of their research, and discuss PD experiences from Omaha. Additional teachers have presented their work at the Geological Society of America meetings. These opportunities provide teachers the platform to discuss and collaborate with professionals on issues affecting science, science education, and/or to identify creative solutions for implementation in the classroom.

3.4 Action research

The completed portfolio is an action research project that explores the participant's teaching based on its design. However, a fourth way that participants can engage with the grant is to complete an action research project on his teaching without engaging in the three previously mentioned methods. These participants also complete the portfolio. As the action research activities are still relatively early in the grant process, this component is just evolving, with the help of the UNO STEM faculty. Although results are emerging and not yet available, there is an encouraging synergy forming between OPS and UNO faculty members, who often share some similar interests.

4 RESULTS

As this was the first year of a three-year initiative, the results are limited to the first year findings. Even though these results are preliminary, they are encouraging. Chief among the encouraging data to date is the finding that teachers' self-efficacy for science teaching and the utilization of instructional differentiation have increased [10]. This key finding from the evaluation data is important to OPS because is suggests that teachers are better able to meet students' needs.

There are several other encouraging results. Specifically, we have seen a high number of teachers apply for and participate in PD activities. As of June 2016, the grant supported 83 teacher participants and 34 of OPS's 87 schools (39%) have at least one participant. Additionally, almost half of those schools have one participant, and 21% have two participants. Further, the teacher participants have found the PD useful upon responses to survey questions. Fig. 3 below shows the type of PD and the participants' views of it usefulness. The items in Fig. 3 are based on survey data are ordered according to percentage of participants who found the activity very useful. The data also indicated that participating teachers believed that their practice has changed based on their participation in the grant effort [10].

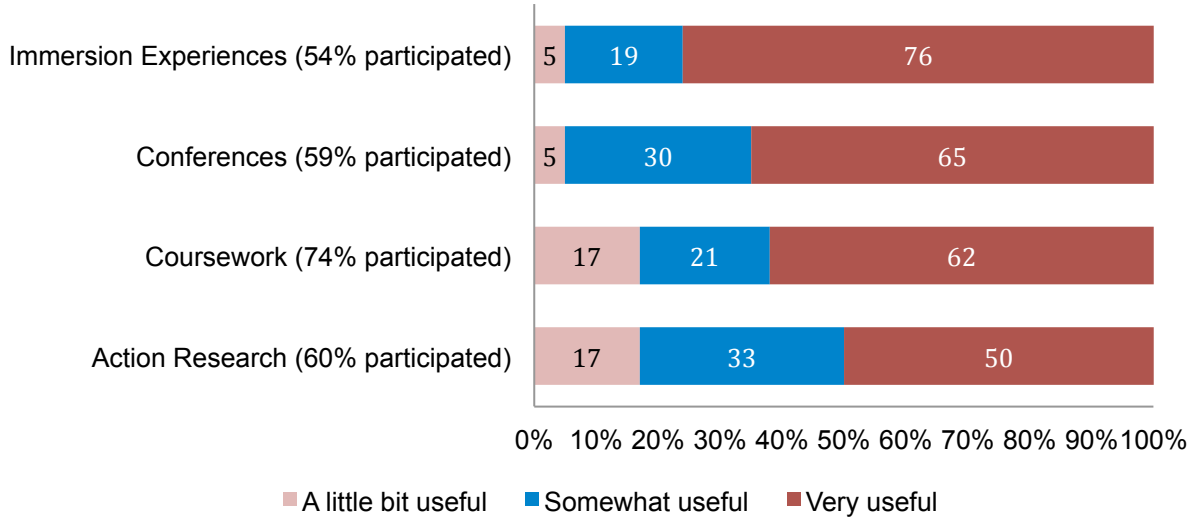

Figure 3 Teacher Reports of Usefulness of PD Activities.

4.1 Graduate course work

Graduate course work was perceived as useful or somewhat useful by 83% of the teacher participants. This is a lower percentage than immersion experiences and conference experiences. However, this could be due to the fact that, at the time of the survey, many graduate courses were not yet complete and were in progress. Also, many of the graduate courses are part of a sequenced degree program and will have content that may be difficult for a participant to easily see an early connection to their work. The coaches are charged with helping the participants reflect on the coursework to make a connection to their work. As teachers move into more of the graduate courses designed with the grant in mind the grant team expects and increasing number of teachers to both select and embrace this more extensive commitment to the grant, which also moves them up on the district salary schedule.

4.2 Content immersions

Fig. 3 above shows that 95% of the participants in the survey believed that content immersions were very useful or somewhat useful with 76% reporting that the experiences were very useful. The high regard the participants reported for content immersions is accompanied by encouraging remarks the participants made in their field reports. Table 2 below shows specific insights the participants reported in their field reports as they align to emerging themes the researchers see in the initial data.

Table 2 Participant Comments Vetted From Content Immersion Field Reports.

Emerging Themes	Example Participant Comments
Inquiry as a science practice	"I think this trip represents data collection/action science at a pure form. Each of us had the opportunity to collect data and continue to ask questions along the way. Though we were in a unique location, we applied the same techniques that can be used anywhere. Moving forward, I think the largest lesson is that the process of field collection and reporting is not limited to those who are in 'science fields.' It simply takes a question and curiosity."
Professional learning	"I want to go back [to my classroom] and seek out connections to give students authentic immersion experiences in our own community. And finally, I want to remember the excitement I felt as I wrote in as much as I could in my journal. I can't wait to go back and match my pictures up to this artifact!"
Applications of immersion experience to science teaching	"I believe the most important part of this trip is the ability to take back what I learned about each of these things to my students. We start the year off with ecology, and I have my students grow plants that we use throughout the year for various projects in our class. I would like to use this existing project; however, morph it into comparing conditions here."
Changes in beliefs and practices	"The biggest take away for me however is the power and impact field research can have on learning. My other big goal is to bring field research into my class more intentionally than in the past."

Overall, the grant evaluation found that teachers considered the immersion experiences and conferences to be the most useful types of PD for helping them achieve their goals [10].

4.3 Conference attendance

Conference attendance was perceived to be very or somewhat useful by 95% of the participants in the survey results in Fig. 3. Through interviews with Education Northwest participants also revealed that they believed that a major benefit from the grant was to attend conferences that they likely would not have been able to otherwise. Further, participants who attended science-teaching conferences such as NSTA easily found direct connections to their classrooms with one participant suggesting that conference attendance "should be mandatory for all teachers" [10].

Attendance at professional conferences that were more focused on science content was also important to the participants. One example of this type of conference was the AAAS annual conference where a mix of twelve participants and coaches attended. The intent of their attendance was to interpret, apply, or make sense of the science that was presented. The participants took notes in a graphic organizer and submitted them for at least two science content sessions. Table 3 shows examples of participants' comments taken from their notes on the conference sessions they attended.

Table 3 Participant Comments Vetted From Participants' Notes On Conferences.

Emerging Themes	Example Participant Comments
Inquiry as a science practice	Even though I did not entirely grasp all of the science, I was able to access portions of the content (four participants)
Professional learning	I thought the content was going to be way over my head, but I was pleasantly surprised to realize how much I understood it (seven participants)
Applications of immersion experience to science teaching	"I was really impressed that I was able to get and understand so much of the content. I thought that was going to be way over my head. I am glad that I was able to sit in on more content specific sessions that help strengthen my science knowledge and see the scientific method being used at such a high level."

Changes in beliefs and practices	My skill set is relevant (three participants) The presentation/presenters made me think of something in a new way (six participants) "I was surprised to find that my skill set is relevant." "I was personally impressed that I understood the presentation as much as I did."

5 CONCLUSION

As described, the grant has used four main structures for participants to engage in professional learning, graduate coursework, content immersions, conference attendance, and action research. Our preliminary results show that year one of the grant effort was a successful effort to engage teachers in personalized PD that was flexible to meet their needs yet responsive to grant, partner, and District goals. In doing so the grant program seeks to improve student achievement, teacher effectiveness, and the quality of OPS science curriculum by providing PD structures that support teachers. Most importantly, teachers are showing signs that they are beginning to shift their beliefs and teaching practices. They are finding ways to incorporate what they are learning through individualized professional learning plans into their teaching. Along the way, they are also becoming more confident in their understandings of both science content and science teaching.

The researchers involved in this grant effort have no shortage of potential directions for future research and the enhancement of their existing efforts. As the grant progresses current research questions include examining teachers' comfort with mobile technology and troubleshooting as they implement digital observation skills in their classrooms. The researchers are also interested in the effects of instructional delivery based on the various PD experiences the participants engage in. Specifically, we expect to see increases in engaging in inquiry-based practices in the classrooms of the participating teachers.

The grant team is encouraged by the initial results and is excited to move through the final two years of the grant effort. As the grant is sustained the results will be more robust, and we are increasingly optimistic that the PD contained within this grant will lead to major gains in teachers' content and science-teaching knowledge, which will have positive outcomes for the urban youth they serve. This grant represents an exemplar of a collaborative effort that is responsive not only to partners and a district's needs, but also responsive to the individual teacher's needs with the end goal of increasing the quality of education for students.

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