Facilitating Young Children's Science Learning through Iterative Cycles of Professional Development: An NSF funded study

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Context of Project:

Professional development is crucial to supporting early childhood teachers' ability to design and implement lessons that promote young children's science literacy as envisioned by the new *Next Generation Science Standards* (NGSS). One immediate challenge in designing effective professional development for teachers is establishing first, that the professional development experiences impact their knowledge, skills and dispositions and secondly, that these enhanced competencies impact the learning of their students. Set within the context of a diverse school district in the New York City Public Schools, the iterative phase cycle of professional development engages a sample of kindergarten and 1st grade teachers in a series of collaborative experiences that enhance their knowledge, skills and disposition at encouraging young children to think and act like a scientist.

Research Questions:

1. To what extent do teachers who participate in the Professional Development Program:
   A. Gain knowledge and skills envisioned by NGSS standards?
   B. Design and implement NGSS lessons integrated with ELA and Math concepts relevant for science?

2. To what extent do students demonstrate learning behaviors envisioned by NGSS Standards and ELA and Math concepts relevant for science?

Data Collection and Analysis Methods:

A case study approach will be used to answer the three research questions. Descriptive analysis of pre-and post- test data from the surveys will generate information about the teachers' perceptions of their knowledge, skills and disposition for NGSS learning and teaching. Similarly, descriptive analysis of baseline and post- PD intervention data from a *Science and Engineering Practices of Teachers and Students Checklist and Rubric* will generate descriptive information about teachers' and students' use of science and engineering practices in science lessons. Descriptive analysis of PD sessions from exit slips, observation notes, questionnaires will generate information about the quality of implementation of the PD intervention. Finally, descriptive analysis of pre-post data from checklists and rubrics will generate information of the quality of teachers' lesson plans and samples of students' work.

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Research Design:

Teacher participants, 10 kindergarten and 10 1st grade teachers participated in the study. Prior to the first cycle of professional development (PD) in the spring of 2017, two baseline measures were administered to the teacher participants - A *Teacher Knowledge about Next Generation Science Standards for Teaching* survey developed by members of the research team and a *Teacher Beliefs about Effective Science Teaching Questionnaire (Smith, Smith and Banilower, (2014)*. Eight PD sessions, each lasting eighty minutes, followed the administration of the baseline measures and served as preparatory experiences for the next two cycles of professional development. These first PD sessions consisted of general topics about science teaching, learning and assessment and included artifacts, research articles, video clips of teachers and children engaged in science tasks and concluded with a questionnaire administered to the teachers about their perceptions of the PD sessions.

Prior to the start of the second PD cycle in the fall of 2017, a third baseline measure developed by members of the research team, *Engagement in Science and Engineering Practices Survey,* was administered to teachers soliciting their perceptions of the frequency of opportunities for their students to engage in science and engineering practices. Another eight PD sessions followed that focused on enhancing the knowledge and skills of participating teachers about NGSS disciplinary core ideas, crosscutting concepts, science and engineering practices as well as its integration with English Language Arts and Mathematics concepts relevant for science. After each session, exit slips were distributed to the teachers soliciting their feedback about the session.

Prior to the start of the third PD cycle in the spring of 2018, teachers were asked to submit a self-generated video science lesson with accompanying plan and samples of student work for that lesson. The third set of PD sessions (still ongoing) comprises both in-person and asynchronous PD activities pertaining to the design and implementation of NGSS-based lesson plans integrated with English Language Arts and Mathematics concepts relevant for science. Upon completion of the third cycle of PD sessions, the three surveys administered earlier as baseline measures will be re-administered to the teachers who will be asked to submit a second self-generated video lesson with accompanying lesson plan and samples of student work. In addition, upon completion of their video lesson, teachers will be asked to complete a reflective prompt about their lesson and lesson plan.

Evidenced-based Results to date:

Teacher Knowledge about Next Generation Science Standards for Teaching

The *Teacher Knowledge about Next Generation Science Standards for Teaching* (TKNGSST) Questionnaire, developed by members of the research team, was used to measure teachers' knowledge about Next Generation Science Standard (NGSS) for teaching. The TKNGSST includes 21 items in three domains of knowledge: a) lesson planning (eight items), b) classroom teaching (10 items), and c) classroom assessment (3 items). The baseline data on the TKNGSST indicated that teacher participants had very low levels of knowledge about NGSS for teaching in term of lesson planning and classroom assessment. However, they reported higher levels of knowledge about certain science related practices - how to sequence tasks in ways that help young children engage in learning activities that are likely to enable them to meet the objectives of a lesson; what types and levels of questions to ask young children in the beginning, middle and end phases of a lesson to enable them meet the objectives of a lesson; and how to pace the activities of a lesson to allow young children the time needed to initiate and sustain their engagement throughout the lesson.

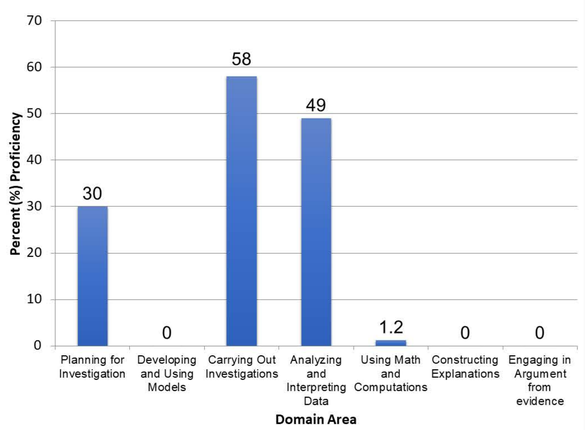
Engagement in Science and Engineering Practices Survey

A survey, *Engagement in Science and Engineering Practices* (ESEP) was developed by members of the research team to assess the participants' perceptions of their students' engagement in NGSS science and engineering practices and was adapted from the *Measuring Science Instructional Practice: A Survey Tool for the Age of NGSS* (2016). Items included (a) asking questions and defining problems, (b) developing and using models, (c) planning and carrying out investigations, (d) analyzing and interpreting data, (e) using mathematics and computational thinking, (f) constructing and explanations and designing solutions, (g) engaging in argument from evidence, and (h) obtaining, evaluating, and communicating information. Each item was rated on a 5-point scale, ranging from one (Never) to five (Daily). A mean of items scores was calculated, with higher scores representing higher levels of engagement in Science and Engineering Practices (S&E).
The baseline data on the ESEP survey indicated that teacher participants reported that their children generally engaged in S&E practices across dimensions at low frequencies, falling between *Rarely* (once or twice a month) and *Sometimes* (once or twice a week) ranges. Particularly, teacher participants reported that their students rarely generated questions about engineering investigations, created their own design to solve an engineering problem, analyzed and interpreted results from scientific investigations, analyzed and interpreted results from engineering investigations, or gathered data to test an engineering design. Relatively, teacher participants reported that their students engaged in NGSS practices slightly more frequently with respect to recording their observations through any form (e.g., drawing, writing, or speaking) and using scientific vocabulary in context of an activity.

Checklist and Rubric for Science and Engineering Practices of Teachers and Students

The *Checklist and Rubric for Science and Engineering Practices of Teachers and Students* were developed by members of the research team and used to rate the presence or absence and quality of teachers' and students' behaviors associated with Science and Engineering Practices, English Language Arts, and Mathematics concepts relevant for science. The measure was adapted from the *Systematic Characterization of Inquiry Instruction in Early Learning Classroom Environments* measure (2015), science and engineering practices described in Appendix F of the *Science Framework for K-12 Science Education* (2013); and the science and engineering practices, English Language Arts and Mathematics concepts relevant for science as described in the *2015-2016 New York City K-5 Science Scope and Sequence.* The descriptive results of the analysis of only the teacher behaviors of the Checklist are presented in Table 1.

Table 1



Total percent proficiency across all domains was 19.74 %. Results indicate that the science teaching domain areas that teachers are most proficient in, are (in order of highest % proficiency): (1) carrying out investigations, (2) analyzing and interpreting data, and (3) planning for investigations. Only one teacher showed evidence for using math and computations on solely one indicator for that domain (the numerical/graphical summary indicator). Across all domains, there are areas of growth; the lowest percentage of proficiency was 0% ranging up to 58% for carrying out investigations. The areas for improving science teaching predominately exist for: (1) developing and using models, (2) using mathematics and computational thinking, (3) constructing explanations, and (4) engaging in argument from evidence.

Evaluation Plan:

A formative evaluation is underway to assess the fidelity of implementation of the professional development intervention to date. Upon completion of the study, a summative evaluation will assess the impact of the professional development intervention.

Next Steps:

After two more PD sessions, the three surveys administered at baseline will be re-administered and the data from them analyzed. In addition the following data will be collected and analyzed: post-PD lesson plans, video lessons and samples of students' work. It is expected that the results will show qualitative differences in terms of the impact of the Professional Development intervention on NGSS teaching and learning.