INTRODUCTION

The Next Generation Science Standards establish a shift toward integrating engineering into K-12 science education. This shift presents significant challenges to school districts due to a lack of (1) teacher professional development that strengthens teachers’ abilities to integrate engineering design concepts and practices with science learning; and (2) the consonant instructional materials appropriate for classrooms. The INSPIRES (Rising Student Participation & Recruitment in Engineering & Science) research program supports the integration of engineering design into high school science and technology curricula and classroom practices, and strategically addresses these critical needs (NSF DGE-0921304, awarded 2009; NSF DRL-0822286, awarded 2008; NSF DRL-1431883, awarded 2014).

In the current research, we implement the INSPIRES professional development (PD) model to investigate teacher pedagogical development over three years as a function of two distinct STEM learning environments: high school biology and technology education. The broad goal is to characterize the benefits and limitations of utilizing an educational, curriculum-based PD model as a mechanism for strengthening teacher pedagogical skills for integrating engineering practices in high school STEM classrooms. Here, we present findings from the first three years of the longitudinal study.

RESEARCH QUESTIONS

1. Did teachers’ classroom practice change as a function of the Project-based PD and curriculum enactment experience?

2. Did pedagogical skill development differ between biology and technology education teachers?

METHODS

The study followed a longitudinal triangulation mixed methods design. Biology (n=7) and technology education (n=12) teachers from a large suburban school district in the Mid-Atlantic region participated in the study. The PD program consisted of a 5-day summer institute followed by after-school sessions throughout the academic years. Selected lessons were recorded according to the following timeline:

Science and Engineering Lessons are from the INSPIRES Hemodialysis curriculum; they contain engineering design and reform, student-centered pedagogies (Fig. 1). The Baseline and Transfer lessons are non-INSPIRES lessons selected by the teacher that incorporate the NGSS Engineering Design standard (HS-ETS1).

RESULTS

Lesson recordings were scored on the RTOP rubric and inter-rater reliability indicated correlations in the good-to-excellent range. Mean total scores were compared using repeated measures ANOVA (Fig. 2, Table 1) and mean scores comparing five RTOP item subcategories were determined (Table 2, Fig. 3).

Qualitative trends were examined for Year 1 lessons from a subsample of randomly-selected teachers (n = 6). Observers used an inductive content analysis approach to identify common themes and divergent cases.

Table 1. Pairwise Comparisons for IC Maps

<table>
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<th>Year 1 Baseline</th>
<th>Year 1 Transfer 1</th>
<th>Year 1 Transfer 2</th>
<th>Year 1 Transfer 3a</th>
<th>Year 1 Transfer 3b</th>
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<td>1.000</td>
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<tr>
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<td>Transfer 3b</td>
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Fig. 2. Mean RTOP Scores Across All Categories

Fig. 3. Mean Scores Across RTOP Subcategories (n = 17)

Fig. 4. RTOP Control Comparison

DISCUSSION

The results suggest that reform pedagogy improved significantly during this longitudinal study. Gains in reformed practice (RTOP scores) as well as the integration of Engineering practices (IC-Map scores) were evident in lessons associated with the INSPIRES curriculum, particularly the “Engineering Lesson” (Lesson 11). This finding implies that providing teachers with lesson exemplars can serve as effective scaffolding.

One reason why Lesson 11 may be more reform-oriented than the other lessons is because the design-based lesson may have pushed teachers from their comfort zones and encouraged the following lesson to be structured differently. Evidence for this speculation is presented when teachers enact specific pedagogical strategies in the Lesson 11, but not Lesson 7 (Science Lesson), even though the lesson-plagued prompts the use of these strategies in both lessons. For example, using student artifacts from prior lessons are explicitly encouraged in the guides for both Lessons 7 and 11, although we observed teachers enacting student artifact sharing more in Lesson 11 than in Lesson 7. Similarly, both lesson plan guides encourage teachers to prompt students in asking their experimental systems. Within our qualitative subsample, we found that only technology education teachers followed this strategy during Lesson 7, while both biology and technology education teachers prompted design sketches in Lesson 11. In the latter example, technology education teachers may have followed the science lesson plan more closely than biology teachers during Lesson 7.

Teachers ability to “transfer” these practices into their own lessons was mixed. RTOP comparisons between Baseline and Transfer lesson did demonstrate significant gains in sub-categories associated with Procedural Knowledge and Classroom Culture. A similar pattern of growth, however, was not demonstrated with explicit Engineering Design Practices as measured by the IC Maps instrument.

Additionally, there is not a significant difference between biology and technology education teachers’ ideological gradients at this time; however, one or subsequent Year 3 Transfer lessons may reveal differences between teachers of different disciplines and/or school environments. Initial engagement is expected to yield further reform in pedagogical skills and the integration of engineering practices into STEM classrooms (Fig. 5). To date, these findings provide insights for refining the structure of PD, particularly in the integrated use of an educational curriculum aligned with intended PD goals.

NEXT STEPS

The next step of the study is two fold. One is to analyze data at the individual teacher level. Extensive longitudinal classroom observation data (RTOP and IC maps) as well as teacher efficacy measures and qualitative interview data has provided several interesting directions for further analysis.

The second track is to explore relationships and patterns among the different measures.

REFERENCES


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