Learning Progressions in Environmental Science: The Impact of a Professional Development on Teacher Practice

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Problem: The *Framework for K-12 Science Education* (NRC, 2012) and the *Next Generation Science Standards* (NGSS Lead States, 2013) have set ambitious new goals for student learning. They also identified learning progressions as a promising tool for helping teachers facilitate the achievement of these goals. However, despite their promising nature, few studies have examined how teachers understand and use learning progressions in their teaching, and little is known about how professional development can support teachers in developing the knowledge and skills required for effective implementation of learning progression-based approaches (Corcoran, 2009).

This study was designed to address this issue through an examination of the impact of a multi-region, multi-year professional development (PD) effort designed to facilitate teachers' use of learning progressions to teach core strands of environmental science to secondary students. Curricular units, or teaching experiments (TEs), were developed for three strands of environmental science content including biodiversity, the carbon cycle, and the water cycle. The PD, in addition to building teacher content knowledge, pedagogical content knowledge, motivation, and self efficacy, was geared toward enabling and encouraging the teachers to both implement the learning progression-based TEs and to use the key teaching pedagogies emphasized in the unit. These key pedagogies include focusing on big ideas, responding to student thinking, connecting to real world issues and local contexts, and engaging students in evidence- and principle-based reasoning. To better understand the impact of this PD on teacher practices, we addressed the following research questions: 1) To what extent did teachers implement the TEs and use the key pedagogies? 2) What factors are correlated with the variation in implementation of the TEs and key pedagogies?

Conceptual Frame and Design: This study operates from the perspective that teacher learning manifests itself most tangibly in the form of classroom practice. Although there are other means of measuring teacher learning, we recognize practice as the cornerstone of the teaching profession and thus coherent and comprehensive implementation as a meaningful indicator of teachers' professional learning (Ball & Cohen, 1999). From this perspective, the extent of the teachers' implementation of the TEs and key pedagogies are viewed as important measures of the impact of the PD. We also recognize that a variety of factors influence teacher learning, including the school, the learning activity, and personal factors related to the teachers themselves (Opfer & Pedder, 2011). For this reason, we examine aspects of all three of these factors in our attempt to understand what supported and constrained learning (as manifest in their self-reported practice) for the teachers who participated in this study.

The findings from this study are based on the analysis of survey data from 92 teachers who participated in the final year of this project. These participants included individuals

from four regions across the United States, including the West Coast, Rocky Mountain, Great Lakes and East Coast. They also included teachers from a variety of different schools, grade levels (6-12) and subject areas. Project collaborators from each of the four regions conducted the PD independently, and as a result, there were differences in the areas of emphasis at each site. However, the PD experiences provided at each site were all based on the same general model, including an emphasis on supporting teachers in their implementation of the learning progression-based TEs and use of the associated pedagogies. All engaged teachers in learning via the TEs and targeted pedagogies, explicit consideration of learning progression (LP) frameworks for each topic, interpretation of sample student responses using the LP frameworks , and reflection on pedagogies and instructional responses that might be effective in fostering student learning.

Analysis: The surveys administered included questions about teachers' practice, the factors supporting and constraining their practice, and the influence of the PD on these factors and on their practice. The practices items allowed us to describe three distinct but overlapping aspects of their teaching: 1) TE Implementation (the number and the degree of completeness of their teaching of the units); 2) Use of Key Pedagogies (the frequency of use of 18 separate teaching techniques grouped into 4 main pedagogies); and 3) What's New (the topics and/or pedagogies that were new to their teaching as a result of the PD). The factors question included 15 personal and contextual items covering widely recognized influence on innovative practice. Teachers rated these as being supportive, constraining or having no impact. Finally, there were closed ended items about the extent of PD influence on these factors, and on their use of each of the 18 teaching techniques, as well as open ended items where teachers discussed PD influences more broadly.

For the present analysis, we addressed our first question for each of the three measures of practice separately. Multivariate analyses are underway. For TE Implementation and Use of Key Pedagogies we looked for groups with increasing levels of practices, while the What's New results were categories into qualitatively distinct groups (but not levels). We then addressed our second question by looking for patterns or associations between each measure of practice and the influencing factors (supports and constraints, and PD). In order to get a more complete picture of teacher practice, we also considered contextual factors including the PD site and the content strand most focused on.

Findings: Results are presented for questions 1 and 2 for each of the three measures of teacher practice. Comparisons across these measures are taken up in the Discussion.

TE Implementation. Based on our analysis of survey data describing the number of TEs taught, and the extent to which they were taught, we categorized the participating teachers into three implementation groups (see Table 1). Extensive implementers taught all of 2 or some of 3 TEs, Intermediate implementers taught all of 1 or some of 2 TEs and Limited implementers did not teach any TEs or taught just some of one TE. Most (45%) of the teachers were Intermediate implementers, with roughly equal numbers of Extensive and Limited.

Table 1. Teacher Practice Measure 1 - TE Implementation. Three groupings with

increasing levels of implementation are shown, along with the number of teachers in each level (n=92).

TE Implementation Level	Number and Amount of TE's Taught	Number of Teachers
Extensive	Some of 3 or all of 2	24
Intermediate	All of 1 and/or some of 2	41
Limited	None, or some of 1	27

Based on these categorizations, we explored a variety of factors to see which are correlated with and could potentially explain differences in TE Implementation. There were no clear relationships with site, class level, or topic strand most focused on. However, analyses of teachers' self reports on factors that supported and constrained their TE Implementation indicate that teachers in the Limited group were the most likely to report time for preparation and planning and the curriculum and/or state standards they are required to teach by their district as having constrained their teaching (see Figure 1).

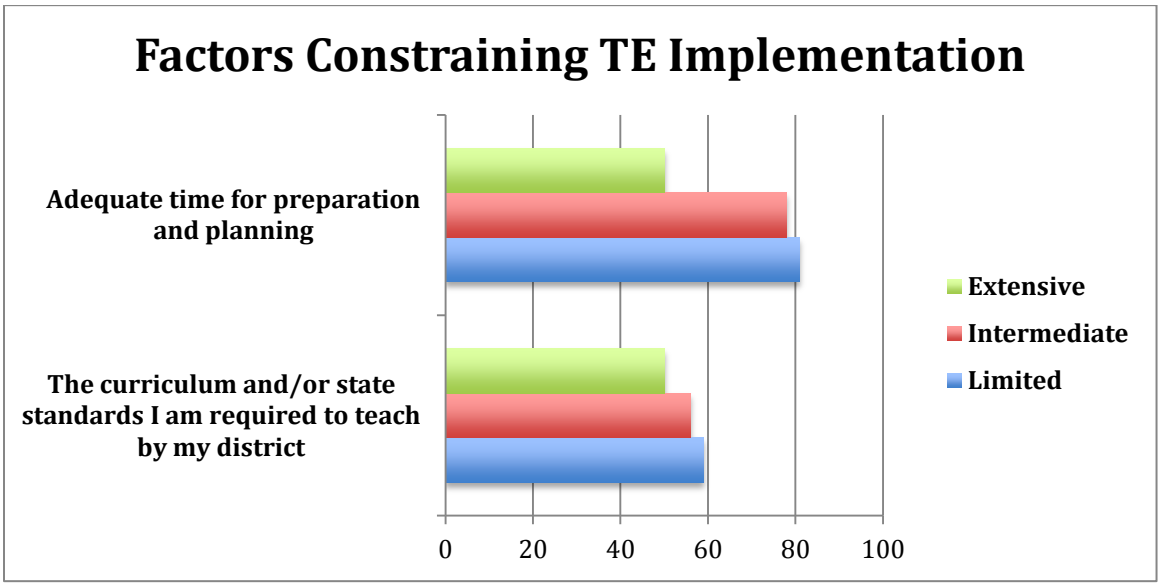

Figure 1. Percentage of teachers in each TE Implementation group that mentioned these factors as constraining their teaching.

Teachers in the Limited group also were the least likely to indicate personal factors such as their personal commitment to the environment, motivation to teach the subject, and confidence that students will learn and succeed if taught using the key pedagogies as being supportive influences (see Figure 2). In contrast, the teachers in the Extensive

group were the least likely to report time and school factors as constraints and the most likely to report personal factors as supporting influences. Not surprisingly, we also found that the teachers in the Extensive group reported the most extensive influence of the PD on their implementation of the key pedagogies and the teachers in the Limited group the least extensive influence (see Figure 3).

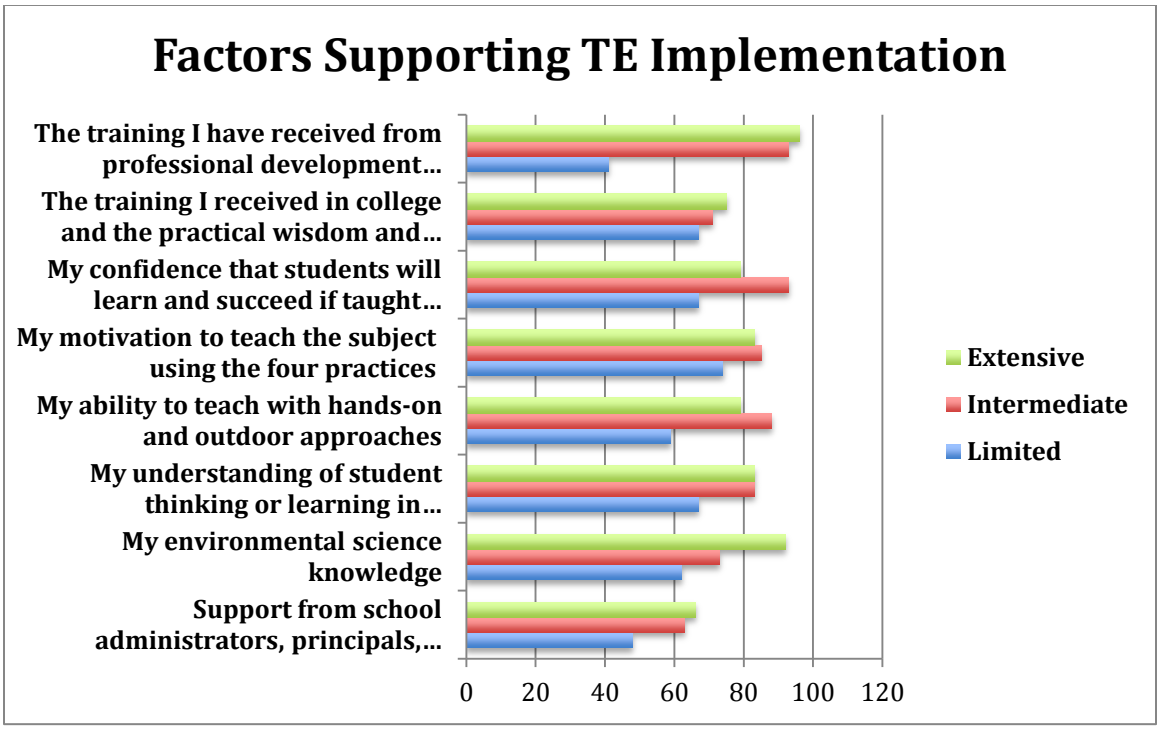

Figure 2. Percentage of teachers in each TE Implementation group that mentioned these factors as supporting their teaching.

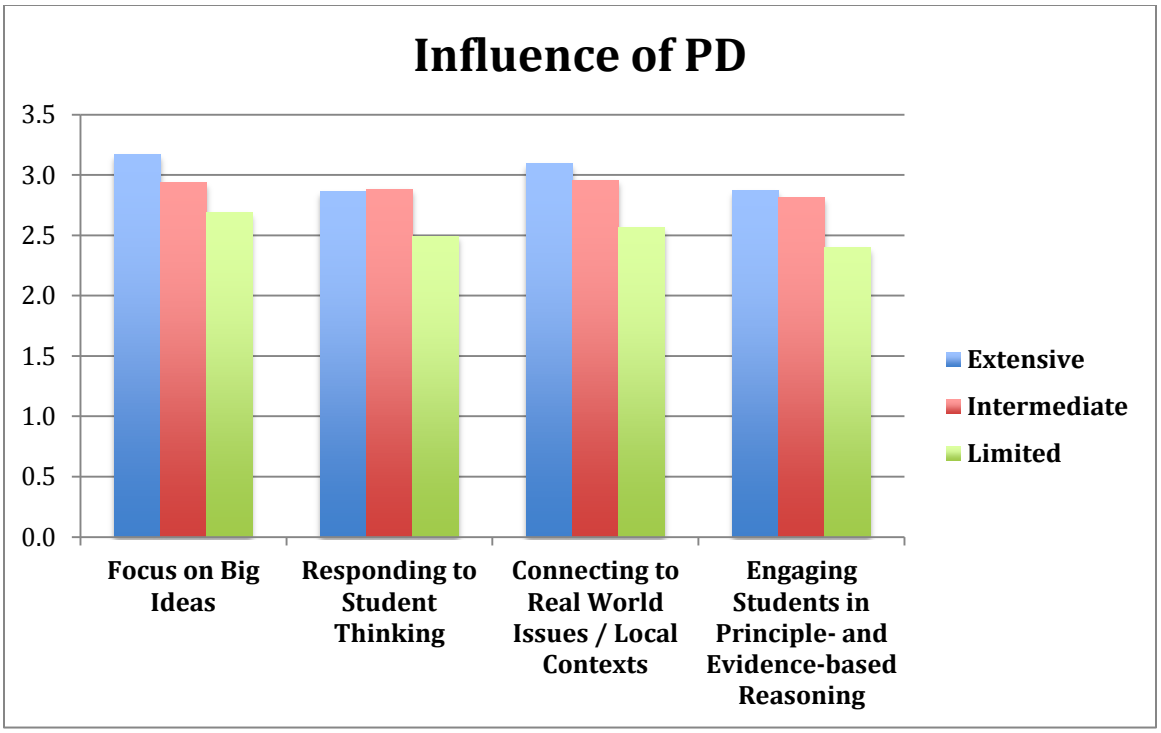

Figure 3. Mean scores for teachers' close-ended responses to items about the extent of influence of the PD on their use of the teaching techniques grouped into the 4 main pedagogies shown. The scale given to the teachers was 1=not at all; 2=somewhat; 3=moderately; 4=a great deal of influence. Results are shown for the three TE Implementation groups separately.

Use of Key Pedagogies. Teachers spanned a broad range of use of the key pedagogies targeted by the project. We indentified four groups or levels based on the average score for using the 18 teaching techniques (see Table 2). Teachers in the Limited Use of Key Pedagogy group consistently used each of the four main pedagogies less (Figure 4). This suggests that, in general, teachers reported extent of use consistently across the main pedagogies, rather than having reporting variation from pedagogy to pedagogy.

Table 2. Levels of use of the key pedagogies based on teachers' self reported use of the 18 targeted teaching techniques.

Use of Key Pedagogies	Mean Scores (1- never; 2-very rarely; 3-occasionally; 4-frequently; 5-very frequently)	Number of Teachers
Extensive	Mean score of 4.0 - 5.0	26
Intermediate	Mean score of 3.7 - 3.9	23
Semi-Limited	Mean score of 3.4 – 3.6	24
Limited	Mean score of 2.4 – 3.3	19

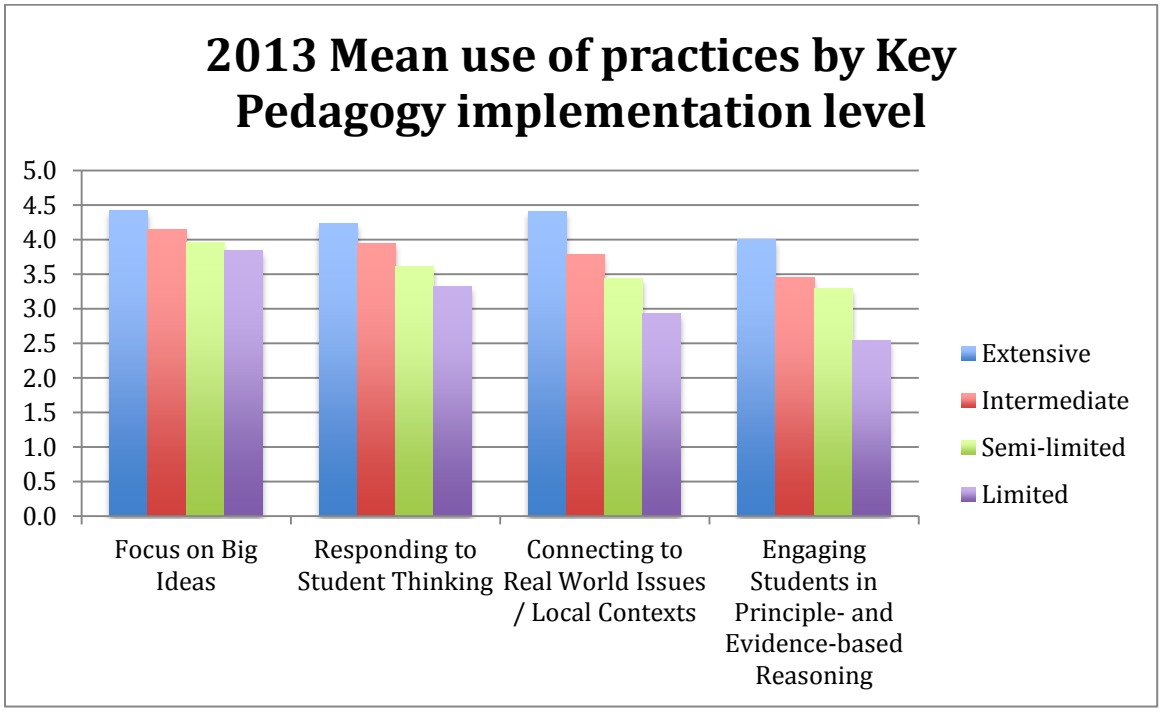

Figure 4. Teachers' use of the four key pedagogies calculated as the means of their ratings of extent of use (1=never, 2=very rarely or only a little, 3=somewhat, occasionally, 4=frequently, 5=very frequently) of the specific teaching techniques associated with each main pedagogy. Results are disaggregated for the four overall Use of Pedagogy groups (Limited to Extensive, the different bars for each pedagogy).

Similar to our findings for TE Implementation, there was no clear relationship between the Use of Pedagogies groups and PD site, grade taught or topical strand most focused on. In contrast to the pattern for TE Implementation, teachers in the Extensive group for Use of Pedagogies were more likely to describe time as a constraining factor than those who used these less (see Figure 5). However, the Extensive users were less likely to describe the curriculum or state standards as a constraint to implementation (see Figure 5).

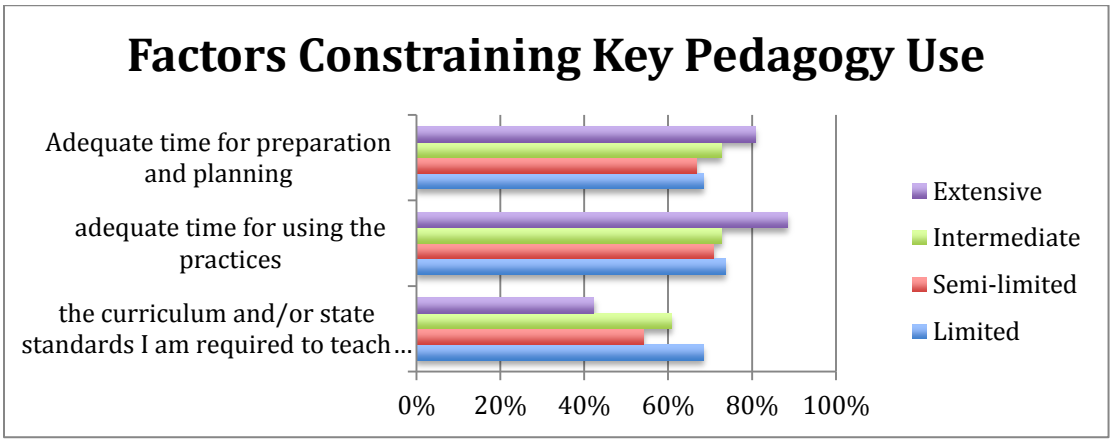

Figure 5. Percentage of teachers in each Use of Pedagogy group that mentioned the factors shown as constraining their teaching.

Teachers in the Extensive Use of Pedagogy group mentioned a variety of factors as supporting their teaching more frequently than did teachers in the Semi-limited and Limited groups (Figure 6). These factors included: previous PD experiences and training, their motivation to teach the subject, their confidence in their ability to teach with hands on and outdoor approaches and their understanding of student thinking or learning in environmental science.

We examined teachers' responses to the questions about the influence of the PD on their practice by looking across the Use of Pedagogies groups separately for the teaching techniques grouped into the four main pedagogies: focusing on big ideas, responding to student thinking, connecting to real world issues / local contexts, and engaging in principle- and evidence-based reasoning. Patterns were consistent across these four pedagogies. Teachers in the Extensive Use of Pedagogies group reported the most extensive influence of the PD on their implementation of each key pedagogy and the teachers in the Limited group the least extensive influence (see Figure 7).

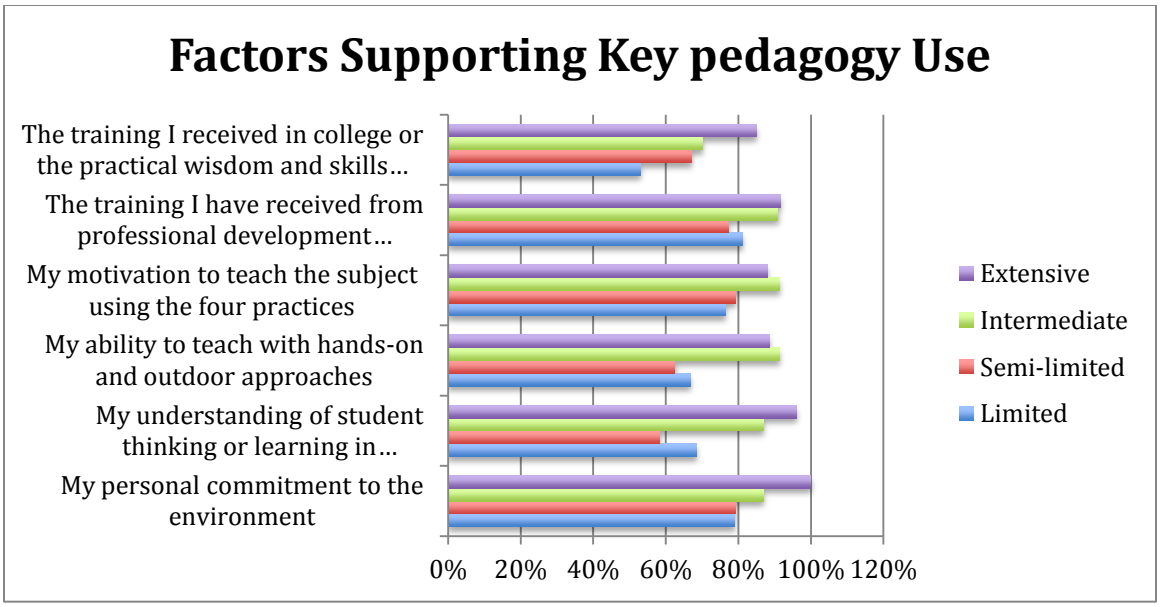

Figure 6. Percentage of teachers in each Use of Pedagogies implementation group that mentioned the factors as supporting their teaching.

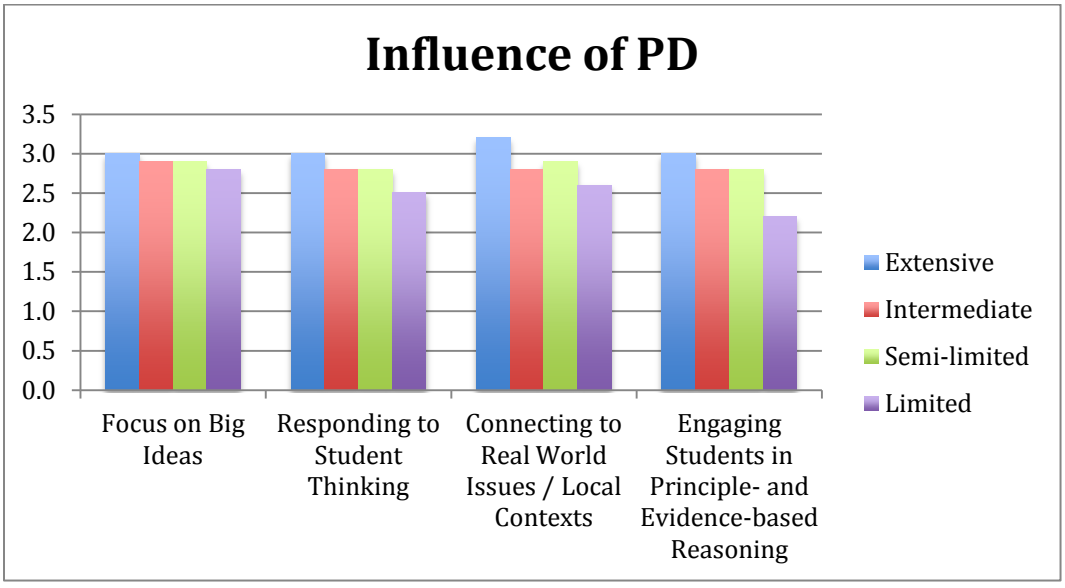

Figure 7. Mean scores for teachers' close-ended responses to items about the extent of influence of the PD on their use of the teaching techniques grouped into the 4 main pedagogies shown. The scale given to the teachers was 1=not at all; 2=somewhat; 3=moderately; 4=a great deal of influence. Results are shown for the 4 overall Use of Pedagogies groups separately.

What's New. Teachers' responses to three open ended items about what was new in their teaching in terms of topics, techniques and assessment strategies were analyzed through a combination of ground-theory and development coding. Responses that could be associated with the four key pedagogies were coded as such, but a new set of codes was developed to capture the many comments about teachers' use of resources provided by the Pathways Project, and a code for teachers who left the questions blank responded that nothing was new in their practice. Thus, three overall categories were identified for the What New data: use of key pedagogies, use of resources, and nothing. Nearly 30% of the teachers fell into this last category, with no substantive new activities described (Figure 8). Many more teachers reported using resource provided by the project compared to those reporting new use of pedagogies (green vs. blue bars in Figure 8). The TE units were the most frequently cited new resource, followed by the formative assessment and pre/post test materials. Interesting, a number of teachers also mentioned using the learning progressions, one of the main goals of the Pathways Project (Figure 8). Finally, a small percentage of teachers mentioned each of the four main pedagogies emphasized by the project, with no apparent patterns or difference among them (Figure 8).

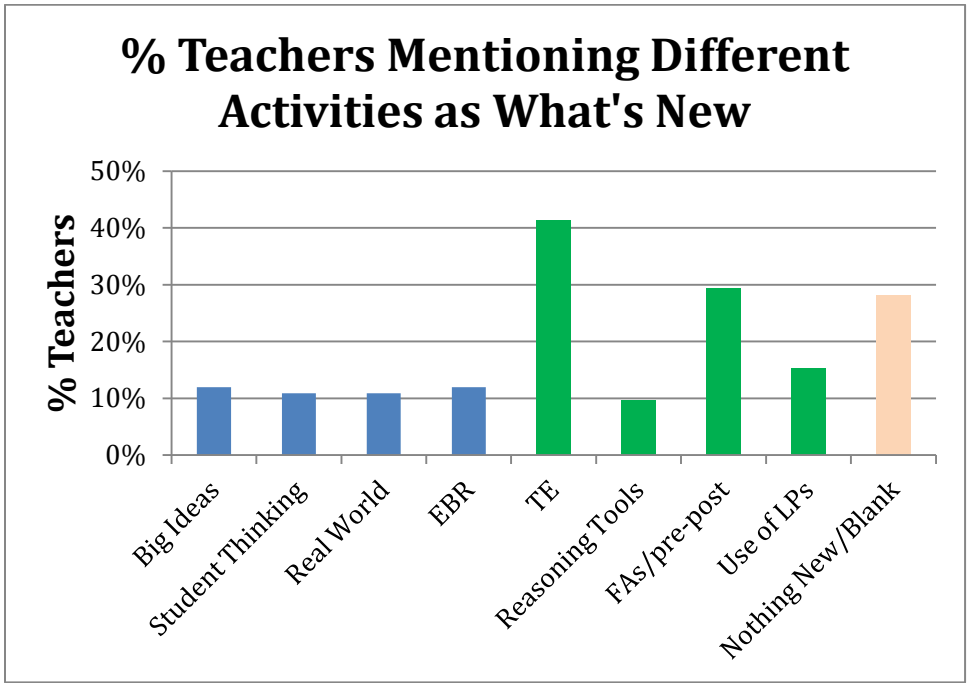

Figure 8.

Overall Patterns. Finally, we examined the relationship between the teachers' TE Implementation and the Use of Key Pedagogies (Table 3). A chi-square analysis of these data indicated that these two groupings are independent ($p=0.186$). In general, teachers' use of the key pedagogies was consistent across TE Implementation group. There were four teachers in the high TE Implementation group that reported lower than expected use of the key pedagogies, suggesting further investigation of these individual cases. A similar lack of pattern was found when looking across the What's New measure of

teacher practice (data not shown) and teachers' use of the key pedagogies.

Table 3. Number of teachers in each of the three TE Implementation groups and the four Use of Pedagogies groups.

		Use of Key Pedagogies Group				Total
		Limited	Semi-Limited	Intermediate	Extensive	
TE Implementation Group	low	5	10	5	7	27
	med	5	11	12	13	41
	hi	9	3	6	6	24
Total		19	24	23	26	92

Discussion: There was considerable variation in teachers' self-reported practice resulting from their participation in the Pathways Project PD. Most teachers reported intermediate levels of TE Implementation (i.e., doing one TE completely or 2 TEs partially), and a range of use of the key pedagogies targeted by the project. These two measures of teacher practice were independent, such that teachers in each TE implementation group showed similar ranges of pedagogy use. Multivariate analyses are underway to explore these relationships further, as are analyses to describe the extent of use of the four main pedagogies. Preliminary results suggest that teachers vary consistently across these pedagogies, with high users using all of the practices more than do lower users.

Results for our second research question were largely consistent across the different measures of teacher practice. In each case, the factors that teachers reported as supporting their teaching were very similar. These included factors identified in the literature as critical to the "interest construct" – self efficacy, motivation, previous training and experience, etc. Also included are contextual factors, including the PD provided by the Pathways Project. Time was mentioned as a constraint more frequently by low TE implementers, but with an interesting difference for those reporting higher use of the key pedagogies. Apparently, several of the teachers in the Extensive Use of Pedagogy group reported significant constraints due to time. Interestingly, these same teachers who used the key pedagogies most were less likely to be constrained by curriculum requirements, suggesting that their infusion of the practices could be accomplished within their on-going instructional activities. On the other hand, in order to implement TEs extensively, teachers would have to feel less constrained by time and this is what was reported.

These findings highlight the important roles that school factors and teachers' personal factors play in the learning process. The new vision of science education put forth by the most current standards documents require many teachers to make significant changes to their practice. We developed and implemented a PD program designed to help teachers

develop the knowledge and practices necessary for successful implementation of the types of lessons and pedagogies that are indicative of the reform required to achieve this vision. The findings from this study highlight important considerations that will, in turn, inform the redesign of professional development efforts to address the particular challenges teachers face in building knowledge of and facility with effective learning progression-based environmental science instruction.

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