An Instructional Planning Framework for Elementary Science:

Supporting Pre-Service Teachers' Use of Instructional Materials to Construct the Planned Curriculum

Jennifer L. Cartier, Wendy M. Sink, Jeanetta Lee Kochhar, *University of Pittsburgh*

GOALS & COURSE DESIGN

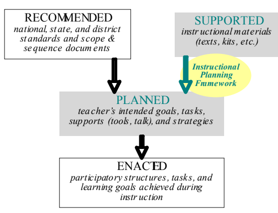
In *Elementary Science Methods*, we strive to build on general pedagogical skills that cross disciplines (*e.g.* providing opportunities for active engagement in learning, supporting accountable talk, etc.) while also helping pre-service elementary teachers (PETs) develop pedagogical content knowledge in science. Like most elementary teacher educators, we realize that it is not possible to do everything in the span of a 15-week course and that choices about where to place emphasis must be made. Most influential to the design of our course were the following considerations:

(1) the majority of PETs have little formal science background and therefore struggle to learn science content themselves in preparation for teaching it (Davis, Petish, & Smithey, 2006);

(2) teaching science at the elementary level is not of high priority, particularly in light of the high stakes assessments associated with student performance in mathematics and language arts (Cavanaugh, 2004); and

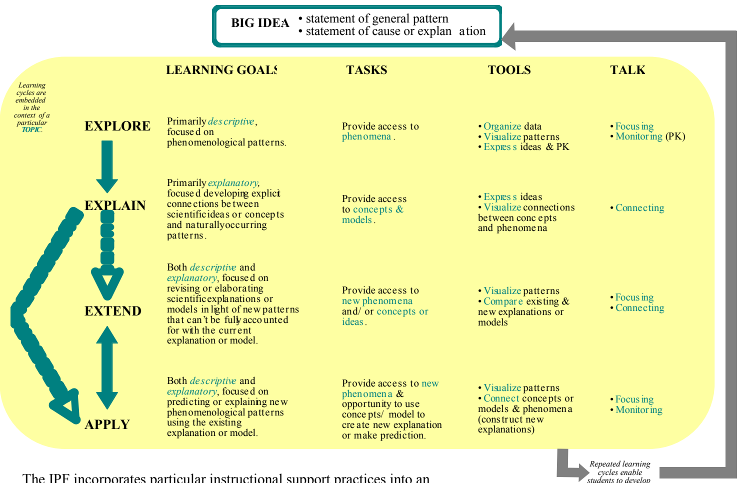
(3) given these constraints and contextual considerations, it makes most sense for elementary teachers to take advantage of prepared instructional materials in science rather than attempt to create their own.

Consequently, our *Elementary Science Methods* course is anchored in instructional materials. Our primary goal is to help PETs develop the skills necessary to draw on such materials (the *supported curriculum*) to plan for learning experiences that are congruent with fundamental practices in science. To this end, we have developed an **Instructional Planning Framework** (IPF) to guide PETs' critique, selection, and use of *supported curriculum* resources in the construction of the *planned curriculum*.



Throughout the Science Methods course, PETs use the IPF as a lens to describe, critique, and plan science instruction. They participate in learning cycles as students and subsequently analyze the structure and support features of these cycles, critique and present lessons developed using various instructional materials, critique video and print cases of science instruction, and collaboratively develop detailed lesson plans for one complete science learning cycle.

INSTRUCTIONAL PLANNING FRAMEWORK (IPF)



The IPF incorporates particular instructional support practices into an overarching organizational structure. At the core of the IPF are the following beliefs and commitments:

- instructional **tasks** should allow students to engage in authentic scientific practices such as data collection and representation and the development of explanations;
- teachers should provide **tools** to make students' ideas public (accessible to the learning community), help them visualize important patterns in data, and reinforce important connections between concepts and phenomenological experiences;
- teachers should support learning through engagement in various types of **talk** (tuning, connecting, and monitoring; see Newton, 2002);
- a **learning cycle** framework mirrors scientific inquiry in significant ways and should be employed (at least some of the time) to organize and sequence lessons that build to understanding of overall **Big Ideas**.

RESEARCH DESIGN

Context & Participants

The PETs in our study were enrolled in a 12-month Masters of Arts in Teaching program at our university. Within this program, PETs complete 2-4 academic courses each semester and simultaneously work as teaching interns 30-35 hours per week during the fall and spring terms. Crosscutting themes in their course work include: (a) a social constructivist perspective about learning; (b) a commitment to teaching for conceptual understanding rather than simply the attainment of factual or procedural knowledge; and (c) the belief that teachers should learn and adopt strong, research-based practices.

PETs in two sections of *Science Methods* were invited to participate in the study (total n = 35; participant n = 27). They had similar formal science backgrounds in terms of the number of courses they completed at the college level: in both sections, the range of courses taken at the undergraduate level was 1-4, with an average of 1.63 (section 1) and 1.82 (section 2). We did see some differences in the educational backgrounds of the PETs when we looked at their undergraduate majors, but none of them majored in a Natural Science discipline (e.g. Biology, Chemistry, etc.).

Methods (Tasks)

Task Selection & Sequencing (TSS)

PETs received a scenario describing the background knowledge of a group of hypothetical 5th-graders and four specific learning goals related to density. They also received copies of 8 instructional materials ranging from short expository texts to inquiry lesson plans. PETs were instructed to select from the available materials (or design their own) and describe a sequence of instructional tasks that would enable them to accomplish the target learning goals. They were also asked to provide rationales for their choices. This task was administered to PETs at the beginning of the term and again in the final two weeks of the course.(Note that this task is based on a similar task designed by the MSU team: Smith, Schwartz, . . .)

Learning Cycle Design (LCD)

In small groups, PETs developed detailed lesson plans (including specific learning goals, task description, and instructional strategies) for a complete learning cycle. This task served as the capstone project for the *Methods* course.

Analysis

We employed a single-subject case study design with one repetition. The unit of analysis was the collective work of PETs in each section of the Methods course. Three researchers independently coded PETs' written work on the TSS and LCD tasks, marking instances of congruence with elements of the IPF. Inter-rater agreement on the TSS was 85%; Cohen's Kappa for the LCD ranged from 86-94%.

RESULTS & DISCUSSION

- Early in the term, most PETs selected and organized instructional **tasks** based on their beliefs and values with respect to students' motivation and enjoyment for learning. Later in the term, their explicit justification for task selection emphasized alignment with conceptual **learning goals** (note that they were not always accurate about the task/LG alignment, but they did use this as a *justification* for their choice) and, to a lesser extent, compatibility with the **learning cycle.**
- Comparing pre/post TSS scores, we noted that PETs in both sections were more likely to select appropriate tasks (i.e. those that had potential to connect to the target learning goals) at the end of the term (Table 1a). However, PETs in section 1 showed greater improvement in terms of *explicitly* and *correctly* connecting tasks to learning goals (Table 1b).
- While PETs strived to organize learning experiences using the **learning cycle,** the extent to which they were able to do this depended in large part on explicit and iterative support from the course instructors. This was particularly true with respect to the "Explore" portion of the LCD task (Table 2), as PETs lacked the necessary understanding of phenomena and their associated explanations to select/structure experiences that would lead students to adequate observations of empirical patterns.

TABLE 1a: Frequency of Task Choice on TSS

	Sect ion 1 n=15	Sect ion 1 n=15	Sect ion 2 n=10	Sect ion 2 n=10
Task	Pre	Post	Pre	Post
A*	53.3	60.0	60.0	20.0
B*	93.3	93.3	90.0	80.0
C	53.3	26.7	60.0	30.0
D	40.0	40.0	20.0	10.0
E*	66.7	100	80.0	100
F*	40.0	33.3	50.0	30.0
G*	40.0	60.0	30.0	60.0
H	60.0	53.3	50.0	60.0

Percentage of PETs selecting the indicated tasks on the TSS. Tasks marked with an * are most appropriate in terms of potential to align with at least one of the four target learning goals. Task E was aligned with all four learning goals.

TABLE 1b: Frequency of Explicit Task/LG Alignment

Sect ion 1 n=66	Sect ion 1 n=63	Sect ion 2 n=44	Sect ion 2 n=39
Pre	Post	Pre	Post
37. 9	61.9	43.2	51.3

Percentage of task choice events that were appropriately and explicitly aligned to target learning goals.

TABLE 2: Scores on the LCD Task

Gp.	Sect ion	Big Idea	Explore	Explain	Extend	Total Score
C	1	1	0.958	1	0.95	3.908
B	1	1	0.958	0.750	1	3.708
H	1	1	0.875	0.875	0.900	3.650
A	1	1	0.917	0.833	0.800	3.550
D	1	1	0.833	0.813	0.800	3.446
F	1	1	0.854	0.833	0.750	3.437
M	2	1	0.875	0.750	0.800	3.425
K	2	1	0.625	0.875	0.900	3.400
I	2	0.875	0.625	0.833	0.900	3.233
P	2	1	0.667	0.583	0.70 0	2.950
J	2	0.875	0.562	0.750	0.750	2.937
L	2	0.875	0.542	0.500	0.500	2.417
N	2	0.750	0.500	0.667	0.300	2.217

PETs' LCD projects were coded and scored along various dimensions of the IPF: explicit connection to Big Ideas and adequate design and support (including use of **tools** and **talk**) of three separate phases of the learning cycle (Explore, Explain, Extend/Apply), A rubric was used to score features of each dimension and raw scores were then transformed into percentages (e.g. there were 8 total points awarded for features related to Big Ideas, so a transformed score of 0.875 corresponds to a raw score of 7.) Total scores were then calculated by adding the transformed scores for each dimension (maximum total score of 4). A Mann-Whitney rank sum test showed that PETs in section 1 significantly outscored those in section 2 with respect to overall score ($p = 0.001$) and their ability to design and support an adequate Explore lesson ($p = 0.005$). There were no significant differences in the two sections with respect to scores on the Big Ideas, Explain, and Extend portions of the LCD.

Our results indicate that the IPF is a fruitful tool for new elementary teachers, as it helps them to select more robust instructional tasks and design those tasks in ways that reflect scientific inquiry practices (e.g. exploration and explanation of phenomena, application of concepts, etc.). However, our study also suggests that PETs struggle most with selecting and designing *exploratory* tasks for students (vs. explanatory or application tasks). We believe that the difficulties PETs' experienced in this regard were due in large part to their own lack of content knowledge and that this has important implications both for the design of Methods courses and undergraduate science courses for PETs.

We also found that PETs were more likely to choose "appropriate" tasks (on the TSS) at the end of the term. That is, on the post-TSS task, PETs more frequently chose the tasks that were strongly aligned with the target learning goals. Despite making better choices, however, they did not always plan to use the tasks to teach the learning goals to which they were aligned! This might suggest that PETs first develop an intuitive sense of "good" instructional tasks and their ability to appropriately and explicitly align those tasks to particular learning goals develops at a later point in their learning trajectory. We are continuing to investigate this possibility in the context of a larger longitudinal study funded by the National Science Foundation.

REFERENCES & ACKNOWLEDGEMENTS

Cavanaugh, S. (2004, November). NCLB could alter science teaching. *Education Week*.

Davis, E. A., Petish, D., and Smithey, J. (2006). Challenges new science teachers face. *Review of Educational Research*, 76, 607-651.

Newton, D. P. (2002) *Talking Sense in Science: Helping Children Understand Through Talk*. New York, NY: Routledge Falmer.

The research described herein was partially supported by a grant from the National Science Foundation (ESI-0554486) as administered by the School of Education, University of Pittsburgh and Peabody College of Education, Vanderbilt University. The opinions, findings, and conclusions are solely those of the authors and do not necessarily reflect the views of the supporting agencies.