

# Students' Responses to Curricular Activities as Indicator of Coherence in Project-Based Science

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**Abstract:** Project-based learning seeks to engage students through sustained investigation of real-world problems or design challenges. Weekly mini-surveys were administered to students during an 8-week project-based learning unit to understand students' perceptions of alignment of lessons to the overall challenge, their affective responses to lessons, and how these varied across lesson types and teachers. Results from a multilevel model revealed significant teacher level variance; no differences across lesson types were found.

**Keywords:** project-based learning, science, practical measurement, coherence, student affect

## Introduction

Project-based learning aims to support the development of deep understanding of subject matter by engaging students in sustained investigation of problems (Blumenfeld, Soloway, Marx, Guzdial, & Palincsar, 1991; Edelson, 2001). Organizing projects around specific questions or design challenges is intended to make projects cohere from students' point of view (Krajcik & Mamlok-Naaman, 2006). Challenges also provide motivation for students to develop knowledge components related to disciplinary core ideas (Schwartz & Bransford, 1998).

Successful projects require students' sustained effort, since answering driving questions and solving design challenges unfolds typically over many lessons and weeks (Blumenfeld et al., 1991). Projects with sufficient novelty and authenticity are hypothesized to capture and sustain student interest in subject matter learning, by helping students connect disciplinary ideas to real-world phenomena (Blumenfeld et al., 1991; Polman, 2012).

However, developers cannot presume that a particular driving question will sustain students' attention. Student motivation depends on their perceptions of the value of the tasks, and the alignment of the specific tasks with the overall phenomenon (Pitts, 2006). Moreover, engagement may vary across lessons of a unit, in ways that are attributable to both lesson characteristics and individual differences of students (Pitt, 2006). When youth view tasks as contributing toward answering a driving question or design challenge, they may perceive tasks as more valuable. Different lesson structures may also influence these perceptions.

We know that variation in teaching practices explains differences in student outcomes in project-based science instruction (e.g., Fogleman, McNeill, & Krajcik, 2011; Harris, Phillips, & Penuel, 2012). We expect, then, that student experiences of project-based learning vary not only by lesson but also by teacher. In classrooms where teachers' enactments of lessons emphasize connections between tasks and driving questions or challenges, students are likely to experience tasks as valuable because they see those connections themselves. To date, research has not examined teacher-level differences in student experiences of project-based learning.

## Methods

In this study within a larger design-based implementation research (Penuel, Fishman, Cheng, & Sabelli, 2011) project, we gathered data from students using an electronic "mini-survey" about their experiences of individual lessons in a project-based unit on ecosystems. Our primary purposes were (1) to develop implementation evidence related to the experienced coherence of the unit and (2) to contribute to knowledge related to student engagement in project-based learning.

The focal unit is an 8-week project-based unit organized around a design challenge: "Select a species of tree to plant in your schoolyard that will maximize biodiversity and ecosystem services." The unit is intended to develop understanding of disciplinary core ideas in the life sciences identified in *A Framework for K-12 Science Education* (National Research Council, 2012). We intended our mini-survey to serve as a "practical measure" (Yeager, Bryk, Muhich, Hausman, & Morales, 2013) that could be implemented by teachers on a regular basis to inform the iterative refinement of individual lessons in the unit.

## Sample

Data from the study come from 592 students of 11 teachers from eight schools in a large urban school district in the United States West region. The majority of students in the district are Hispanic and 69% participate in the free/reduced lunch program. Our data sample consists of 1,223 surveys submitted by participating students from August 25 through October 28, 2015.

## Student mini-survey

Teachers administered the student mini-survey on a weekly basis. The analysis presented here focuses on responses to two items presented in the survey: (1) “We learned about something today that connects to the challenge.” (Yes, No, Not sure), and (2) “Today in science class, I felt...” (Excited, Bored, Like a Scientist). We did not seek to construct scales from these measures, in accordance with practical measurement’s focus on a few indicators judged to be of central concern for implementation (Bryk, Gomez, Grunow, & LeMahieu, 2015).

The first item addresses students’ perceptions of the alignment of the day’s tasks with the overall design question. The second addresses their understanding of the purpose of the day’s lesson. The third addresses their affective response. This item was adapted from an earlier study of students’ responses to an elementary-level project-based unit in science (Morozov et al., 2014), and we used it to allow for comparisons across projects. We conjectured that there would be positive associations among perceptions of alignment, understanding of the purpose for the day’s lesson, and feelings of excitement and identification with science.

## Approach to analysis

We fit multilevel models to the data using the software HLM 7.0, which were appropriate to the nested nature of our data. Models each had three levels: observation or occasion, student, and teacher. Each teacher had multiple students, and each student had between 1 and 8 different observations where they completed surveys. In one model, ratings of connectedness to the challenge over time were outcomes we sought to model in order to understand variation associated with both teacher and lesson type. Lessons were grouped into two types: those emphasizing *discursive* practices (e.g., argumentation) and those emphasizing *investigation* practices (e.g., planning and conducting an investigation). This nesting structured necessitated a three level model. The three level model of our outcomes include time-dependent student predictors in level one (e.g., affective measures and whether or not students rated the lesson as hands-on or discursive). In a second set of models, students’ emotional responses to lessons (excited versus bored) were outcomes, and we modeled variation associated with teacher and with individual students’ ratings of connectedness to the challenge over time.

## Findings

Results from each of the three-level hierarchical linear model we fit revealed significant teacher level variance; no differences across lesson types were found. Specifically, the unconditional model of outcome “connected to challenge” produced significant variance at the teacher level. Of the total variance in the model, 30.5% was at the teacher level. Table 1 shows the results of a model that explores the degree to which lesson type accounts for variation in student ratings that a given lesson was connected to the overall challenge. Neither lesson type was significantly associated with type of lesson, though the probability of an investigation-focused lesson being rated as connected to the challenge was higher than for discursive-focused lessons (43% versus 32%). A significant percent of variance remained at the teacher level, when these predictors were included in the model.

Table 1: Model of lesson connected to the challenge with type of challenge as predictors.

Outcome - Model	Predictor	Coefficient in Log Odds (se)	Coefficient in Probability	% Variance at Teacher Level
Connected to Challenge <i>Unconditional Model</i>				30.5%
Connected to Challenge <i>Type of Lesson</i>	Investigation-focused	-0.28 (0.33)	0.43	34.7%
	Discursive-focused	-0.37 (0.20)	0.32	

A second model focused on predicting whether students reported feeling excited during the lesson. An unconditional model fit to the data revealed a significant percent of variance at the teacher level (13.7%). Once

student ratings of whether the lesson was connected to the challenge were included as a predictor in the model, the percentage of teacher variance changed to 40.1%. Ratings of connectedness to the challenge were significantly associated with students' reports of being excited during the class. Seventy percent of lessons that students reported being connected to the challenge were ones where they also reported being excited.

Table 2: Model of *excited* emotion with lesson connected to the challenge.

Outcome - Model	Predictor	Coefficient in log odds (se)	Coefficient in probability	% of Variance at the Teacher Level
Excited				13.7%
Excited <i>Connected to challenge</i>	Connected to challenge	0.84* (0.37)	0.70	40.1%

A third model focused on predicting whether students reported being bored during the lesson. An unconditional model fit to the data revealed a significant percent of variance at the teacher level (29.9%). Once student ratings of whether the lesson was connected to the challenge were included as a predictor in the model, the percentage of teacher variance jumped to 40.6%. Ratings of connectedness to the challenge were significantly associated with students' reports of being excited during the class. Thirty-one percent of lessons that students reported being connected to the challenge were ones where they also reported being bored.

Table 3: Model of *bored* emotion with lesson connected to the challenge.

Outcome - Model	Predictor	Coefficient in log odds (se)	Coefficient in probability	% of Variance at the Teacher Level
Bored				29.9%
Bored <i>Connected to challenge</i>	Connected to challenge	-0.79 (0.48)	0.31	40.6%

## Conclusions and implications

These findings indicate that teacher-level differences influence student experiences of project-based learning. Teacher-level differences influenced the degree to which students perceived their learning tasks to be connected to the unit's design challenge and the tasks' overall usefulness outside of class. In turn, teachers' abilities to help students connect tasks and lessons to the unit challenge may influence students' affective responses, such as feeling excited during project-based learning tasks. We found no differences across lesson types, which contrasts with the findings reported by Pitt (2006).

These findings have multiple implications for practice and research. First, these findings underscore that teachers need professional development that specifically targets project-based learning instructional practices. Helping students make connections between daily tasks and lessons, and larger unit goals, may be critical for maintaining student interest and engagement during the sustained, in depth investigations typical of science projects. Furthermore, curriculum materials could be enhanced with instructional routines, for instance during lesson opening and closing, that support students in making relevant connections.

Second, our experiences suggest that there is great utility in these relatively simple mini-surveys for gathering rapid feedback from learners as part of a design-based research process. For instance, we have compared student self-report of their affective responses across successive design and implementation cycles to gauge the degree to which changes in unit tasks and materials were "improving" the unit with respect to student engagement. Asking students to assess the degree to which a daily task or lesson is related to a larger unit challenge also offers a new "student-centered" way of looking at and measuring the coherence of instruction. This approach is a potential complement to other assessments of curricular coherence, which focus on analyzing the connectedness of ideas as represented in instructional materials (Kesidou & Roseman, 2002). By asking students directly, we are tapping into the coherence of the "experienced curriculum" rather than the "formal" curriculum (Gehrke, Knapp, & Sirotnik, 1992), thus shifting the measure to better reflect the actual student experience. In future analysis, we will compare these student self-report data with classroom observations conducted as part of this larger research program to develop additional evidence related to validity of this approach to studying coherence as experienced by students.

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