Paper #3 - Exploring the Domain of Consequence: Examining Changes in Students' Scientific Reasoning and Affect

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Abstract

This paper examined changes in students' biological reasoning, scientific sensemaking, valuing of science, and fascination in science over the course of a school year after their teacher participated in one of the two professional development programs. One professional development (PD) group emphasized teacher collaboration in revising materials for their classroom, while the other emphasized revision of materials without collaboration among teachers. Results from repeated measures ANOVA showed showed improvements in students' biological reasoning from the beginning to end of the school year when in classrooms lead by teachers who participated in the collaboration-focused PD. Students' scientific sensemaking, valuing of science, or science fascination remained stable across the school year across both PD groups.

Introduction and Research Questions

When students engage in Science-as-Practice, they are planning and conducting investigations about those phenomena, analyzing collected data to argue from evidence, construct explanations, and develop or refine scientific models (NGSS Lead States, 2013; Stroupe, 2014). Such epistemically rich work necessitates students be afforded continuous and consistent opportunities to engage in scientific reasoning to not only grow in their proficiency, but also in understanding the value of such work (Kind & Osborne, 2018). As student learning broadly represents the outcome of teacher PD that is most consequential to a large array of groups involved in education, this study focused on these student outcomes in project teachers' classrooms. The research question guiding this study: *In what ways did students' scientific reasoning and affect develop while experiencing science instruction emphasizing productive talk?*

Methods

Student data for this study included measures of biological reasoning via the Assessment for Biological Reasoning (ABR, Schellinger, 2021), Scientific Sensemaking (Chung et al, 2016a), Valuing Science (Chung et al, 2016b), and Fascination in Science (Chung et al, 2016c). Scientific Sensemaking, Valuing Science, and Fascination in Science were all collected using instruments developed by the Activation Lab. All instruments were administered at the start and end of the 2021-2022 school year. Only students with complete data were included in the analyses. Number of students included in each analysis is presented with the results of each analysis. The ABR included 30 multiple choice questions asking students about biological content, and their reasoning to arrive at the answer. All items were dichotomously scored with 0 for an incorrect answer and 1 for a correct answer. Activation lab instruments were scored in accordance with the authors' direction provided in each measure's technical brief. The Scientific sensemaking instrument was dichotomously coded (0 for incorrect and 1 for correct), while the Valuing Science and Fascination in Science were four-point likert scales. Each of the Activation Lab instruments were scored using Rasch model scoring. Scientific

sensemaking was scored using a traditional Rasch model, and Fascination in Science was scored using the Graded Response Model for polytomous data. The analytic sample for the Valuing Science measure was smaller than for the other two Activation Lab measures, which resulted in some null categories. To accommodate for this, responses to the Valuing science items were collapsed into a dichotomous scoring structure (0 for negative responses, 1 for affirmative responses) and then scored using a traditional Rasch model. The resulting person parameters from each model were used as outcome variables for the three Activation Lab measures. To identify overall changes in students' responses, we conducted paired samples t-tests on student pre and post scores for each of the four measures: ABR total scores, scientific sensemaking, valuing science, and fascination in science. Next, we examined differences in pre-post student changes based on their teacher's professional development group using repeated measures ANOVA.

Findings

The overall paired samples t-tests on student ABR scores showed significant differences between pre and post scores. The average score difference from pre to post was .99 (t=3.337, df= 273, p<.001, n=274). This indicates an average increase of one point on student ABR scores over the school year. The repeated measures ANOVA included time points as a within-person factor and teacher PD group as a between-person factor. The results of this analysis showed a significant interaction of time and PD group (F(1, 272)= 12.325, p<.001, n=274), indicating that students in the different PD classrooms experienced different growth rates. Pairwise comparisons indicated that students in the LCD group had significantly higher post-scores than the LTP group (mean difference = 1.341, p=.005, partial eta-squared = .043).

Table X. Pre and Post ABR Scores by Professional Development Group

	LCD		LTP	
	Pre	Post	Pre	Post
Mean	10.1	12.2	9.8	9.8
Standard Deviation	4.18	5.15	4.36	4.70

Overall, paired samples t-tests showed no significant differences in pre-post scores on each of the three Activation lab measures (scientific sensemaking, valuing science, and fascination in science). This indicated that students' scores on these measures were stable across the school year when examining the overall sample. We also conducted a follow-up repeated measures ANOVA to parse out differences between students in LCD versus LTP classrooms for scientific sensemaking and fascination in science. The analytic sample for the

valuing science measure was too small for this analysis and was excluded. Overall, these analyses indicate that students experienced growth in their biology domain-specific reasoning, but had stable levels of measures related to attitudes towards science as a broader concept, including scientific sensemaking, valuing science, and fascination in science.

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