The Effect of Teachers' Beliefs and Curricular Enactments on Student Learning in High School Science

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Abstract: This study focuses on a high school urban ecology curriculum that was enacted by twenty-two teachers. We investigated how teachers' beliefs about science instruction and enactment of the curriculum impacted student learning. Results from the hierarchical linear model suggest that teachers' use of lecture, incorporation of group work, level of adaptation of the curriculum and beliefs about argumentation all significantly impact student achievement.

Theoretical Framework

Learning environments consist of a variety of different social and material supports that can interact synergistically to support students in developing rich disciplinary knowledge (Tabak, 2004). Historically, the role of the teacher has been overlooked when examining the impact of curriculum on student learning (Ball & Cohen, 1996). Yet the teacher is essential in enacting curriculum materials in terms of the culture of inquiry that is fostered in the classroom, which ultimately impacts students' development of rich conceptual understandings (Puntambekar, Stylianou & Goldstein, 2007). Teachers' understanding of the curriculum as well as their beliefs about teaching and learning influence their enactment of curriculum (Ball & Cohen, 1996).

Recent research emphasizes the importance of moving away from a traditional model of instruction in which the teacher's main role is that of transmission of information to a new model of a community of learners in which students actively construct their own conceptual understandings (Sawyer, 2006). Although there are numerous qualitative studies investigating the role of such environments, large-scale quantitative studies still need to be conducted to validate these findings and link teaching practices to student outcomes (Thadani, Stevens & Tao, 2009). The large scale studies that have been conducted in science education provide mixed results on student achievement with studies finding that standards-based inquiry teaching practices have a positive effect (Kahle, Meece & Scantlebury, 2000), both positive and negative effects (Von Secker & Lissitz, 1999), and no significant positive or negative effects (Lee, Penfield, Maerten-Rivera, 2009) on student learning. Furthermore, none of these studies investigate teacher beliefs in conjunction with their instructional practices. Consequently, our research question is: How do teachers' beliefs about science instruction and their enactment of an inquiry-oriented high school science curriculum impact students' learning in science?

Study Design

This study took place in the context of a year-long high school urban ecology curriculum entitled *Urban EcoLab: How Can We Develop Healthy Cities?*. The curriculum consists of eight modules covering different topics including patterns of land use, climate change, hazardous waste, public health and biodiversity. Each module consists of approximately 10 lessons that include different activity structures such as inquiry investigations, development of models, role-play, computer simulations, field investigations of their city, and environmental action plans.

The participants in this study included 22 teachers from 21 different schools piloting the urban ecology curriculum and 366 students. The schools were located in three regions of the United States: Northeast, Midwest, and Southwest. Student demographics among schools varied within a spectrum with some schools serving predominantly one race (Black, Hispanic or White) of student and others serving a more diverse group of learners with similar representations of two or more races. Over 50% of the students in most schools participated in a free or reduced lunch plan with only five schools falling below 20% participation. Teacher experience ranged from 1-29 years with an average of 10 years for all teachers.

We collected a variety of data sources to address our research question. Teachers completed a pre-survey, which asked questions about their beliefs about science content, scientific inquiry, and instructional practices. During the enactment, teachers completed module surveys that asked about the level of completion, the level of adaptation, and the amount of time using different activity structures (e.g. lecture, discussion, group work, etc.). The students completed an identical two-day pre and posttest that consisted of twenty-one multiple-choice items and four open ended questions. The open-ended responses were scored by one rater using a rubric. Twenty percent of these open-ended test items were randomly sampled and scored by a second independent rater. Estimates of inter-rater reliability were calculated by percent agreement. Interrater reliabilities for the four questions were 94%, 88%, 96%, and 95% respectively.

Determining the impact of teachers' beliefs and curricular enactment on student achievement is complex because students in the same class are not independent. Multi-level modeling recognizes the

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dependence and grouping of data, which leads to a more correct estimation of effects and variance. We used Hierarchical Linear Modeling (HLM) in a two-level format to investigate the teachers' beliefs and enactments on student learning (Raudenbush & Bryk, 2001). The creation of the model consisted of three steps. First, we created a fully unconditional model (FUM) to compute the intraclass correlation coefficient (ICC). Next we created a level 1 or within-teacher model to examine the effect of student level variables (e.g. demographics and pre-test) on student achievement. Finally, we developed a level 2 or between-teacher model to examine the effect of teacher level variables (e.g. teacher beliefs and curricular enactments) on student achievement.

Results and Discussion

The fully unconditional model (FUM) suggests that there was a significant difference in student achievement between teachers, $\chi^2 = 255.58$ ($df = 21$), $p < .001$. The reliability of the FUM is high, 0.87, suggesting that it is appropriate to use the adjusted ICC ($\tau/(\tau + (\lambda\sigma^2))$). The adjusted ICC is 0.426, which suggests that 42.6% of the variance in student achievement exists between teachers.

The within-teacher model explored the effects of students' gender and pretest scores. The preliminary results suggest that gender did not have a significant effect, while students' pretest scores did significantly predict their achievement on the posttests, t = 6.746 ($df = 363$), $p < .001$. Adding students' pretest scores to the model explained 12% of the variation at level 1.

The between teacher model investigated the impact of teacher beliefs and enactments on student achievement. We first examined the effect of eight enactment variables and seven teacher belief variables on student achievement separately. Three enactment variables had a significant effect on student achievement: the more group work students completed had a positive effect, the more a teacher lectured had a negative effect and the more the teacher adapted the curriculum had a negative effect. Only one of the teacher belief variables significantly impacted student achievement: the more frequently a teacher reported the importance of having students engage in argumentation and the sharing of ideas, the greater student achievement. We then examined each combination of two variables. The only significant combination included both that 1) the more group work students completed had a positive effect on student achievement, t = 2.096 ($df = 19$), $p < .05$, and 2) the more the teacher adapted the curriculum had a negative effect on student achievement, t = -2.248 ($df = 19$), $p < .05$. Including these two teacher level variables in the model explained 48% of the variance at level 2.

One limitation of this study is that it is dependent on teacher self-report. Self-report of teacher practices can be limited in part because of a lack of shared language between teachers and researchers (Thadani, 2009). Yet these findings suggest that teachers who report having classrooms that align more with a community of learners perspective in which students actively construct their own knowledge (Sawyer, 2006), specifically through argumentation, group work and less lecture, results in greater student learning. Previous research suggests that teacher instructional practices in inquiry science instruction can have different impacts on students' conceptual understanding when measured by multiple-choice items competed to open-ended questions (Puntambekar, et al., 2007). For the final version of this poster, we will extend our analysis to include two separate models for the multiple-choice and open-ended items to investigate whether the effect of teachers' beliefs and enactments was different depending on the measure of students' disciplinary knowledge.

References

Ball, D. L., & Cohen, D. K. (1996). Reform by the book: What is—or might be—the role of curriculum materials in teacher learning and instructional reform? *Educational Researcher, 25*(9), 6-8, 14.

Kahle, J. B., Meece, J. & Scantlebury, K. (2000). Urban African-American middle school science students: Does standards-based teaching make a difference? *Journal of Research in Science Teaching, 37*(9), 1019-1041.

Lee, O., Penfield, R., & Maerten-Rivera, J. (2009). Effects of fidelity of implementation on science achievement gains among English language learners. *Journal of Research in Science Teaching, 46*(7), 836-859.

Puntambekar, S., Stylianou, A., & Goldstein, J. (2007). Comparing classroom enactments of an inquiry curriculum: Lessons learned from two teachers. *The Journal of the Learning Sciences, 16*(1), 81-130.

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical Linear Models: Applications and Data Analysis Methods, 2nd Edition.* Newbury Park, CA: Sage Publications

Sawyer, R. K. (2006). Analyzing collaborative discourse. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 187-204). New York, NY: Cambridge University Press.

Tabak, I. (2004). Synergy: A complement to emerging patterns in distributed scaffolding. *The Journal of the Learning Sciences, 13*(3), 305-335.

Thadani, V., Stevens, R. H., & Tao, A. (2009). Measuring complex features of science instruction: Developing tools to investigate the link between teaching and learning. *The Journal of the Learning Sciences, 18*(2), 285-322.

Von Secker, C. E. & Lissitz, R. W. (1999). Estimating the impact of instructional practices on student achievement in science. *Journal of Research in Science Teaching, 36*(10), 1110-1126.

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