The kindergarten science classroom: Designing learning environments towards equity and participation for emergent bilingual students

Purpose

We know from literature that young children come to school with rich knowledge foundations built before they enter school and have the cognitive capacity for engaging in scientific practices (Metz, 1995; NRC 2012). In addition, we know that primary aged students learn science through active participation in a wide variety of scientific practices (NRC, 2012; Achieve, Inc., 2013). But there is a lack of understanding related to elementary science instruction, trajectories of learning, & science engagement in early science learning experiences (Samarapungavan, Mantzicopulous, Patrick, 2008; Suarez and Otero, 2014; Monteria and Jimenez-Aleixandre, 2015)

There exists well-documented and significant gaps in standardized measures of science achievement, particularly among students from Hispanic backgrounds (NRC, 2012; Santu et al., 2011). The linguistic and cultural differences between teachers and emerging bilingual Spanish-English students contribute to these learners being often marginalized in science classrooms (Suarez & Otero, 2013). In addition to marginalization, young children of color and their ways of knowing and doing science are often viewed from deficit perspectives, as they can appear to be distinct from normed ways of learning science (Bang et al. 2012).

Herrenkohl and Guerra (1998) suggest that in order to encourage student engagement and increase student ownership, it is necessary to rethink and reorganize how students are interacting with each other both socially and intellectually. As teachers seek equitable approaches to working with students in utilizing the Next Generation Science Standards, we must consider the elements of a learning environment that support marginalized students in engaging and participating with each other and the science content. Our study is the result of a three-year, teacher-researcher partnership focused on the implementation of the forces and motion standards in an urban kindergarten classroom. We used design principles adapted from a framework informed by a literature review and summarized by Windschitl and Calabrese Barton (2016). The framework is comprised of eight elements that represent conditions that support student learning and participation within discussions as being a central feature of that learning (Resnick et al., 2015).

In this study, science instruction relied on the importance of responsive discourse strategies intended to create a dynamic and responsive learning environment used to promote participation. We utilized the Ambitious Science Teaching framework and discourse strategies to position students in particular ways in order to “mediate increasingly productive forms of reasoning and activity by students” (Windschitl & Calabrese Barton, 2016). We observed students emergently using their models as mediators for explanatory talk and were able to build in opportunities for sensemaking that allowed students to act on ideas, revise their thinking, and make applications to different situations.
In focusing on primary students, the purpose for this study will be aiming to contribute research to expand on the current literature gap as it relates to learning environments that support scientific modeling and discourse during early learning science experiences (Samarapungavan et al., 2011; Suarez & Otero, 2013; Danish & Phelps, 2011).

Research Questions: 1. What learning conditions were present during the beginning, middle, and ending phases of the unit that supported students in engaging with scientific models and with the ideas of their peers? 2. What particular elements of the designed learning environment were resourced by students to engage in the modeling process?

**Perspective**

In this study we attended to a situative perspective (Gresfali & Greeno, 2008) where learning occurs within the activity systems utilized by social worlds and actively provides opportunities to participate to learn. Authority figures in the classroom, actively problematized the assumption that participation and understanding are solely attributes of the student (Gresfali et al., 2008) and instead, views students as epistemic agents capable of co-creating a collaborative classroom culture (Stroupe, 2014). Using this perspective allows for a shift in how this teacher-researcher partnership opens a hybrid space (Gutierrez et al., 2009) where we consider how we view, frame, and track the participation trajectories of young learners and consider how we participate with students.

During the unit, we made explicit design choices to create a learning environment that would reorganize the participation hierarchy that emerged during a previous science unit earlier in the year. Our conceptual lens blends key elements of Ambitious Science Teaching (Author, 2012) with principles of Productive Disciplinary Engagement (Engle & Conant, 2002). The approach of our framework is equity based, with teacher as mediator and facilitator who places student talk, reasoning, and modeling at the center for designing effective instruction. Productive Disciplinary Engagement (Engle & Conant, 2002) recognizes the social practice that is learning (Wenger, 1998). This approach also recognizes the need for sustaining a nurturing, developmentally appropriate, metacognitive, and reflective learning environment (Brown & Campione, 1996) for learners to be able to co-construct knowledge related to localized science concepts and phenomena. In this study, we observed the design elements of the learning environment that were present when students engaged in the modeling process to participate in shared discourse during the different activity structures within a lesson.

**Data Sources/Methods**

This study is a multi-case basic qualitative study (Merriam, 2009) and in order to qualify as a case study, we selected one classroom of learners, and 4 focal participants; which represents a bounded system (Merriam, 2009). This study features four student participants taking up the “Forces & Motion: Playground Slides” unit, which took place from February to May. The focal point for each lesson resides in student scientific models and their participation within whole and small group sense-making discussions.
We selected a classroom site that provided an information rich case setting (Merriam, 2009). Participants in this study were four kindergarten students within the same classroom, from an urban public school located in the Pacific Northwest. Utilizing participation data and field notes from a previous science unit earlier in the school year we used purposeful sampling (Merriam, 2009) to select the 4 students; all student participants first and foremost showed a willingness to be interviewed, filmed, and were emergent bilingual (Spanish-English) learners. Each participant in this study encompassed a range of abilities related to scientific modeling and participation analyzed from the previous unit. The school’s demographic composition: 39% Transnational Bilingual; 80% Free and Reduced Lunch; 56% Hispanic/Latino, 21% Asian, 7% African American, 9% white. The selected class had 27 students, with 24 students coming from bilingual families; 19 students were from Spanish or Spanish-English speaking households. In addition, this particular teacher was selected using criterion-based sampling (Merriam, 2009), where the teacher of record had extensive involvement in job-embedded coaching and participation in Ambitious Science Teaching professional development workshops for 18 months prior to the start of the unit of study for this research.

A time-ordered matrix was performed and analyzed on all four focal students (Miles, Huberman, & Saldana, 2014). This matrix included participation data from each student during different activity structures (whole group talk, small group talk, partner talk, student initiated talk with an adult, adult initiated talk with a student) during each of the 12 lessons. This matrix was used to determine participation trajectory similarities and differences between the focal students in conjunction with corresponding elements of the designed learning environment. All twelve lessons were video recorded and transcribed (Derry et al., 2015) and the data corpus includes lesson transcripts, student and teacher interviews, and student model worksheets and artifacts were used as data sources. We attended to students’ growth over time in using models and engaging in scientific talk as well as changes in participation and events of critical significance in response to the learning environment and varying activity structures.

We developed a set of codes from the literature on discourse and modeling; we added codes later that were emergent from the data and that we felt might have explanatory significance. Codes were developed from segmented transcripts and tied closely with our lens on participation and designed learning environments. We used these initial codes to develop themes: 1) students creating and revising models 2) students working with ideas 3) students using models to explain. After coding we looked for themes and patterns in the coded data that corresponded to specific designed elements present during particular activities. These themes were used to develop hypotheses, which were then tested against additional passes through the data corpus. As we analyzed more data we tested the credibility of these hypotheses against additional data. Particular combinations of conditions generated by our coding scheme and emergent themes led to opportunities that were more likely to result in a social or conceptual change in participation and engagement with scientific modeling and model-based explanatory talk.
Results

Our findings indicate the importance of student accessibility to a variety of models, related representations, and simulations; which increased the sophistication of model-based explanatory talk by three of four student participants. We discovered that modeling was much more than drawing and revising inscriptions, but instead in through working and learning from these students we now see that modeling in this context was a set of interconnected activities which iteratively influence a variety of scientific practices meant for shared consumption.

Student learning was reflected more in their participation within a variety of activity structures than in changing the appearance of their own scientific models over time. This design framework afforded students the opportunities to take advantage of a system of supports where they could make intellectual connections between their ideas and scientific concepts. They applied these shared ideas to models using colorful and unique conventions to be able to communicate their models and ideas with others and fully engage as motivated participants in the enterprise of modeling. The distinctions in their participation is important to highlight and consider as the field continues to understand how kindergarten students learn within science classrooms focused on implementing the Next Generation Science Standards.

Data from this study shows that kindergarten students are able to progressively integrate rich scientific practices and skills in order to engage in the enterprise of modeling. This enterprise encompasses not only individual work with models and ideas but engaging in a shared set of interactions within elements of an activity system. It appears that through a supportive learning environment guided by a set of connected design elements, kindergarten students are able to engage in the highly demanding social and cognitive work within the modeling process that utilize the science practices found in the Next Generation Science Standards.

Significance

We explored how elements of the learning environment supported students in leveraging and utilizing scientific models and representations to communicate their thinking with their peers and teacher in order to support the progression of their scientific understanding of the phenomenon. Our findings also highlight the importance of providing diverse opportunities for students to participate in the collaborative discussions that are anchored around accessible scientific models created by students. One particular design element focused on an attention to culture, identity and motivation for our emergent bilingual students in particular. This element was incorporated not only to support and scaffold students’ oral language development in English and science, but also to intellectually challenge and engage them in the rigorous, ambitious work meant to highlight the academic potential of bilingual learners from immigrant and refugee families.

Our findings suggest that these participants engaged with the modeling process in different but productive ways as they used a variety of models to mediate communication. Over the course of the unit students gradually began to associate revision as a part of modeling process and utilized talk to facilitate that process. We consistently observed
students using iconic, representational, and metaphoric gestures both prior to model-mediated talk and during explanatory talk. Through our analysis we have a better understanding of the varied forms of participation that kindergarten students exhibit during an Ambitious Science unit of study and this knowledge can be used to better support responsive teaching as well as curricular and pedagogical decisions that support science learning.

Through this work, we look to advance efforts to support high quality elementary science teaching and we seek to create opportunities for collaborative discussion and partnerships amongst AERA members and non-members around the topics presented in this proposal.

References


