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Designing educative supports for scientific argumentation: a case study of DBR before and during the pandemic

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Abstract: Design-based research is uniquely positioned to adapt instructional resources quickly to meet the needs of teachers and students. This paper explores revisions to an educative support that scaffolds (a) scientific argumentation and (b) student task models, in the context of two middle-school science curricula in Chicago. Iterations were informed by: teacher feedback, student work, classroom observations, and teacher and student surveys. Changes supported student task models, NGSS storyline routines, student argumentation, and online instruction.

Introduction

The COVID-19 pandemic has highlighted the ever-present need for research on the design and improvement of educative resources that support teachers and students. In this paper, we share our ongoing design-based research focused on developing an educative support to scaffold student task modeling and scientific argumentation, in the context of NGSS-aligned middle school science curricula. We also discuss how these educative supports were reconceptualized and adapted following the transition to online learning.

Scientific argumentation is a practice that is central to the work of professional scientists and pivotal for the advancement of knowledge in the field. Nevertheless, students often find scientific argumentation to be challenging (Newell et al., 2011; Osborne et al., 2004). One research-based strategy is to explicitly provide students with instruction about the structure of an argument. (Klein et al., 1997). A second research-based strategy is to is to support student notetaking (Greenleaf et al., 2016; Rapanta & Walton, 2016). Drawing from previous research, our educative support, the *Investigation Steps Chart*, helps students track their inquiry activity by asking a set of 5 questions (e.g., How we will use the materials like a scientist to answer investigation question? What have we learned? What do we still need to know?). These monitoring questions incorporate NGSS storyline routines (Reiser, 2017) and are expected to help students develop a task model spanning the entire science unit (Britt et al., 2018). A task model is a learner's representations of the goals (e.g., what do we need to know) and strategies (e.g., how we can use the materials to figure that out) to guide and regulate structuring of the information. The output from this *Investigation Steps Chart* provides the evidence and reasoning that students use for their final argument.

Methods

This design-based research (Cobb et al., 2003) takes place in 7th-grade classrooms in Chicago Public Schools (CPS). It is a collaboration between The Learning Partnership, Northern Illinois University, CPS teachers and the CPS Office of Science. Participants include CPS middle school teachers and their students. Student demographics across schools were: 81% free and reduced lunch, 14% special education, 12% English language learners and 70% African American, 21% Hispanic, 6% White, 0.9% multiracial, 0.6% Asian, and 0.2% Native American/Alaskan. Data sources include: student work, classroom observations, and teacher feedback collected during professional learning workshops. Written parental consent was obtained for all participating students. The educational context of this design work was two different NGSS-aligned curricula. First, Amplify Science, which is the official curriculum adopted by CPS. Second, Journey to El Yunque, a curriculum where students explore and model ecosystem changes in a Puerto Rican rainforest following disturbance events (McGee et al., 2018; McGee & Zimmerman, 2016). Both curricula were structured around units that had a driving question, which students addressed through multiple investigations.

Design and revision of the Investigation Steps Chart

The *Investigation Steps Chart* consists of a series of questions that students answer before and after the individual science investigations that culminate in a scientific argument. The *Investigation Steps Chart* supports students to develop a task model for each investigation in the science unit, by supporting ongoing and purposeful

reflection. Before each investigation, students reflect on: (1) the investigation question, (2) available materials, and (3) how the materials will be used like a scientist. After the investigation, students reflect on: (4) what they have figured out about the investigation question and (5) what they still need to learn. Revisions to the Investigation Steps Chart based on the DBR process included: (a) changing wording to increase emphasis on scientific practices, (b) supporting students to reason about evidence as they collect it, (c) supporting students to collect and organize information about disciplinary core ideas, (d) creating digital versions of the tools, and (e) creating teacher guides for the tools.

Reflection on engaging in DBR during the pandemic

As we reflect on our experience engaging in design-based research during a world-changing pandemic, we are struck by the powerfully adaptive nature of the design-based research methodology. Design-based research is inherently oriented towards researchers and practitioners coming together to deepen understanding of learning ecologies, including understanding learning pathways and educative supports, and as such is uniquely positioned to continue seeking solutions, even in the midst of crisis (Cobb et al., 2003). While other types of educational research ground to a halt, our research continued using many of the same techniques as before, adapted to occur digitally instead of face-to-face. As the learning ecology shifted rapidly under our feet, regular conversations with practitioners helped all of us identify obstacles to learning and brainstorm potential solutions. In some ways, the intensity of pandemic conditions had the effect of creating a "window for change" as we began to increase the frequency of our conversations with practitioners and to explore a wider range of potential solutions. In particular, the digital tools we developed during the pandemic will offer a wide range of new possibilities for in-person instruction, as well as online instruction. In other ways, the pandemic slowed our collective endeavor, as technological barriers impeded student participation, student absenteeism skyrocketed, and the pace of science instruction slowed drastically. For better or for worse, this has been a year like no other, and we are committed to carrying its lessons forward as we continue to partner with practitioners to deepen opportunities for student learning. As we continue to test and refine our educative supports, we will build on what we learned by adapting the tools to support remote instruction.

References

Britt, M. A., Rouet, J.-F., & Durik, A. M. (2018). *Literacy beyond text comprehension: A theory of purposeful reading*. Routledge.

Cobb, P., Confrey, J., DiSessa, A., Lehrer, R., & Schauble, L. (2003). Design experiments in educational research. *Educational researcher*, *32*(1), 9-13.

Greenleaf, C., Brown, W., Ko, M., Hale, G., Sexton, U., James, K., & George, M. (2016). *Updated Design Rationale, Learning Goals, and Hypothesized Progressions for Text-Based Investigations in Middle and High School Science Classrooms*.

Klein, P., Olson, D. R., & Stanovich, K. (1997). Structuring reflection: Teaching argument concepts and strategies enhances critical thinking. *Canadian Journal of School Psychology*, *13*(1), 38-47.

McGee, S., Durik, A. M., Zimmerman, J. K., McGee-Tekula, R., & Duck, J. (2018). Engaging Middle School Students in Authentic Scientific Practices Can Enhance Their Understanding of Ecosystem Response to Hurricane Disturbance. *Forests*, *9*(10), 658.

McGee, S., & Zimmerman, J. (2016). Taking students on a Journey to El Yunque. *International Journal of Designs for Learning*, *7*(1).

Newell, G. E., Beach, R., Smith, J., & VanDerHeide, J. (2011). Teaching and learning argumentative reading and writing: A review of research. *Reading Research Quarterly*, *46*(3), 273-304.

Osborne, J., Erduran, S., & Simon, S. (2004). Enhancing the quality of argumentation in school science. *Journal of research in science teaching*, *41*(10), 994-1020.

Rapanta, C., & Walton, D. (2016). The use of argument maps as an assessment tool in higher education. *International Journal of Educational Research*, *79*, 211-221.

Reiser, B. J. (2017). Developing coherent storylines to support three-dimensional science learning. Rhode Island Science Teachers Association (RISTA) Conference,

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