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WHEN WE PARTNER WITH TEACHERS: A COMMENTARY ON PARTNERSHIPS, SCAFFOLDING, AND (ACCIDENTAL EMPHASIS ON STEM

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This special issue represents the second issue of a two-part series in which we forefront a number of examples that address our broad question: *what do our designs look like when we partner with teachers?* The result is this issue focusing on partnership implementations of designs intended for K-12 classrooms. From an open call for proposals, we invited manuscripts that reflected differing dimensions of contexts, approaches, and scale. We prioritized papers co-authored with teachers, and across the two issues, the majority of projects foreground teachers' voices.

Three of the papers in this issue characterize partnerships with teachers as designers. Brush and colleagues detail their involvement in a more than two-year partnership that has supported socioscientific inquiry in a 9th grade biology classroom. They designed and developed a suite of online planning and scaffolding tools in addition to capturing the ways in which the teacher's practices have evolved over time. Similarly, McKay, Banks, and Wallace discuss their ongoing partnership in the context of an initiative that brought maker technologies into the classroom, and the work they discuss planning tiny houses with middle school kids is anything but small! Meanwhile, Rinehart, Duncan, Chinn, Atkins, and DiBenedetti bridge the physical and conceptual worlds, and give us new understandings of designs for model-based science inquiry that can be described as novel, nuanced, complex, or all of the above. The examples are rich and detailed and intricate, and the reader is almost instantly transported into the classroom as we take stock of the many moving parts involved in supporting model-based reasoning. We couldn't help but engage in model-based reasoning about genetics, viruses, and proteins ourselves throughout the reading of this paper!

Two of the papers highlight events and decisions throughout taking a project to scale. Unlike some articles which focused more on design and development phases of their projects, Roschelle, Gaudino, and Darling explore the implementation design of Reasoning Mind's instruction program for 5th grade students. They explore the tensions which often occur when scaling-up a project to thousands of users and provide insights for supporting consistent project implementation. Similarly, Ozogul, Reisslein and Reisslein discuss how they used research and pragmatic decisions to develop and implement an engineering outreach project to K-12 schools districts in Arizona. We were intrigued by the many complex decisions as their refinements considered a wide range of teacher and student feedback and other outcomes in order to achieve their goals for scale. Furthermore, this may be the first time in a scholarly paper we've seen the construction of portable laptop boxes so intricately documented.

Finally, the remaining three papers offer glimpses into fine-grained decisions with web-based or mobile application interventions that are teacher-facilitated. Marks, Bernett, and Chase detail the story of *Invention Coach*, an exploratory learning environment intended to support reasoning as students invent rules and formulas that can account for observed patterns of pitching machines and clown busses. Matuk and colleagues describe *Idea Manager*, an application within the Web-based Inquiry Science Environment (WISE) curriculum to scaffold building scientific hypotheses, explanations, and arguments. Their decisions are drawn from combined expertise from decades of research and classroom teaching as they grapple with design tensions concerning the handling and sharing of information, supporting student discourse, targeting authenticity, and making space for teacher facilitation. Kamarainen, Metcalf, Grotzer, Brimhall, and Dede combine mobile augmented reality (AR) and place-based inquiry to support students' learning about the flow of matter in ecosystems through an AR experience called *Atom Tracker*. The authors provide details of their design tensions, decisions, and outcomes while we as readers are transported to the middle school classroom on

a molecular level to walk alongside learners to view of how they learn everything from atoms to the carbon cycle and all points in between.

As we considered these eight papers, three themes came into clearer focus: partnerships, scaffolding, and the meanings of STEM investment.

PARTNERING WITH TEACHERS

Partnerships are a central theme of this special issue by intent. It is clear that these projects reflect many different dimensions of partnership formation: time, resources, mutual benefits, and challenges. The Kamarainen et al. team encountered a cascade of challenges set off by bad weather and Hurricane Sandy, which resulted in adapted conditions for their implementation and left their team to make sense of next steps in their designs from a position of confounded results. While it's certainly not common to reason from a place of hurricane-induced factors, their team's story gives us tremendous insight into how they handled partnership implementations from adapted and unexpected field-testing. Not all of the partnerships documented here discussed such extreme challenges, but all of the teams had to make decisions under challenging conditions that ranged from incomplete information to evolving goals to technical requirements. We appreciate the investments that go into a partnership, and these teams have made strong investments that demonstrate a sustained commitment to the classrooms. Moreover, these teams see themselves as part of what will sustain the intervention and partnership long term as the partnership evolves and grows.

SCAFFOLDING

As teachers know, instructional scaffolding is necessary for a successful engagement that results in deep learning and complex problem solving. It was no less important in these design cases. As the designers discovered either through feedback from their teacher-partner-designers, teacher- project implementers or students, choosing the right scaffolding strategy played an important part in the iterative design process. Whether it was supporting project implementation by creating Implementation Coordinator and Regional Manager roles (Roschelle et al.), supplying students with additional scaffolds to help them select evidence and create a presentation (Brush et al.) or designing a web-based scaffold to guide learners' knowledge creation (Matuk et al.), all of the teams had to design for partner needs (and refine their designs) in order for the project to arrive at intended outcomes. We cannot control or even fully anticipate what will happen when our designs make it to the classroom walls, but we are doing better at understanding what makes for a smoother entry: strong partnerships, early information for our refinements, and a commitment to mutual engagement.

AN ACCIDENTAL STEM EMPHASIS

We did not intend to establish a STEM theme across these two special issues, which is why we have termed this an accidental emphasis as all of the 14 papers (six from the first issue and eight represented here) are related to STEM. In the commentary from the first issue, we speculated that this represents an investment in STEM that creates space and time and resources for these partnerships to form. This does not fully explain our submissions, as there are likely a number of other factors that would account for this result. At the same time, we also noted in this issue that while STEM disciplines are central to the various projects discussed here, many of the teams are tackling cross-disciplinary issues due to the complex and multi-logical nature of their projects. The Brush et al., McKay et al., and Matuk et al. teams describe engagements with problems that require socioscientific reasoning and social responsibility as the authentic nature of the problems require marshaling many forms of reasoning for students to form a position or a design. While the authors do not document formal cross-disciplinary partnerships (aside from McKay et al. in their documentation of the tiny house designs), we note that this is an area in which we can go farther to bring about interest-driven learning, critical reasoning, and complex problem solving.

In summary, we hope that readers will gain insights from these works that broaden and deepen their understanding of designing for classrooms and with teachers. From our perspective, we saw trends of partnerships – in various instantiations – supported by the critical role of scaffolding across all the papers. Readers will likely see other themes and trends. To us, this conversation is important, and we are pleased that these papers have added to it.