Research Statement

The collaborative design of technologies that scaffold and assess during web-based science inquiry

Camillia Matuk, University of California, Berkeley, mailto:cmatuk@berkeley.edu

Abstract: I am a postdoctoral scholar with Marcia Linn at the Technology Enhanced Learning in Science (TELS, telscenter.org) center. I play leading roles in research, technology design, grant writing, and teacher professional development. I am particularly involved in the NSF-funded projects, *Visualizing to Integrate Science Understanding for All Learners* (VISUAL), and *Continuous Learning and Automated Scoring in Science* (CLASS). More on my work can be found at https://sites.google.com/site/cfmatuk/

Research Overview

My current research is organized around two main questions, each concerned with the creative, collaborative, and learning processes surrounding educational technologies: (1) How can we best design tools that address the challenges of managing information during inquiry-based STEM learning and instruction? And (2) how can we support successful collaborations surrounding designing innovative educational technologies? I conduct design-based research into the cognitive, social, and representational issues surrounding the uses of technology in teaching, learning, and design, particularly among middle and high school students, science teachers, and learning scientists.

Two main perspectives guide my work. One is Knowledge Integration (KI), a pedagogical framework that views students' initial understanding as fragmentary and idiosyncratic; and that specifies effective instruction as supporting the elicitation of ideas, the addition of scientifically normative ideas, and personally meaningful activities that help students sort, organize, and distinguish among those ideas toward an integrated conceptual understanding (Linn & Eylon, 2011). The second perspective integrates user-centered design (UCD) and Agile development (da Silva et al., 2011) to emphasize the early and regular involvement of users in rapid iteration between establishing requirements, designing alternatives, and building and evaluating prototypes. This dual approach enables me to simultaneously elaborate principles behind successful collaborative learning technologies; refine their design; and understand how they mediate learning and instruction within integrated socio-technical systems of practice.

Current and Ongoing Projects

Tools to Continuously Scaffold and Assess During Science Inquiry

How do learners track, distinguish, and reconcile new and existing information? And how do teachers insights from student work to adapt their instruction? To some extent, the challenges of science inquiry learning and instruction are in managing the large amounts of information encountered. Recently, I have been leading the design and implementation of new tools in the Web-based Inquiry Learning Environment (WISE, wise.berkeley.edu) intended to support student inquiry and teacher decision-making by providing better ways for them to interact with information over the course of extended web-based activities.

Two tools integrated into the WISE student interface are designed to scaffold key processes in science inquiry, and to provide alternative outlets through which students with diverse abilities may demonstrate their understanding. For example, the *Image Annotator* promotes observation by allowing students to label given pieces of visual evidence. Integrated into WISE, the *Annotator* logs students' revisions to their labels along with their other interactions in a unit. Classroom trials with a unit on mitosis (http://wise.berkeley.edu/webapp/preview.html?projectId=6498)showed the *Annotator* to support discussions of microscopic evidence, as well as to reveal students' developing observational skills (Matuk & Linn, 2013).

Another tool, the *Idea Manager*, breaks down the process of writing scientific explanations into discrete, more manageable steps. The Idea Manager supports reflection by providing students with a virtual space within which to collect, sort, and organize information in preparation to write a narrative explanation. Classroom trials of the tool show how it encouraged students to negotiate shared criteria for distinguishing their ideas (Matuk et al., 2012); made students' ideas visible for teachers to provide formative guidance (Matuk & Linn, 2013); and provided a record of students' changing ideas over time. This record allowed researchers to identify what ideas are most difficult, in what ways, and for whom (McElhaney et al., 2012).

We are currently testing collaborative features in the Idea Manager, which allow students to exchange ideas (Matuk et al., 2013). In recent classroom trials, we see how students decide to select from and share ideas with their peers, and the impacts of sharing on students' individual repertoires of ideas.

Altogether, these tools (1) Give researchers insight into how people learn by providing a richer picture of students' trajectories than typical end-of-unit tests; (2) allow designers to identify specific impacts of online materials on students' understanding, which can inform targeted design revisions; and (3) inform teachers how to adapt their instruction toward students' individual needs.

Tools to Orchestrate Classroom Inquiry

With the development of the tools above, as well as of new automated scoring systems in WISE, teachers will have access to more nuanced data on their students' progress. Capitalizing on this affordance, I have begun to investigate ways to integrate tools into teachers' uses of WISE that would help them better adapt their instruction and assessment during extended science inquiry activities. These investigations involve ethnographic observations of teachers' classroom management practices, in-depth participant interviews, focus groups, user studies, and professional development activities. This work will inform the iterative design of data visualizations and real-time classroom monitoring and communication tools to support teachers adopting effective guidance practices during science inquiry.

Factors that Support Collaborative Design Communities

In addition to investigating the learning outcomes of designed educational technologies, I have recently been seeking to understand how technology mediates design collaborations among cross-disciplinary participants. Thus, I actively document the collaborative design process between myself and my collaborators through such means as archived electronic correspondence and intermediate design artifacts. In doing so, I expect to draw insights into the factors that sustain hybrid online/offline collaborations among teachers, students, researchers, and technology designers, and to better understand the design practices that make educational tools successful.

Conclusion

I am committed to an iterative approach to design that is both a participatory and reflective process. Not only does this approach inform design, but it also reveals more about how people create, learn, and collaborate with technology. As I extend my research to other tools and contexts, I will continue to pursue what it means for people to engage in design as learners, educators, and researchers, with a focus on how technology mediates creativity, cognition, and collaboration. Moreover, I will continue to investigate how the practice of design can inform both theory and practice.

References

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