Synthesis and Design Workshop: Distributed Collaboration in STEM-Rich Project Based Learning

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Driving Questions / Purpose


Global STEM Project meet-up with students and teachers from New York, NY; Las Vegas, NV; Mainga Brazil; and Nairobi, Kenya

Why did we meet:

- This project's thematic area of **distributed, project-based collaboration in STEM learning** emphasizes K16 collaborations whose participants cross **cultural, national, economic, generational, STEM background, or linguistic** boundaries in ways that are new to the participants.
- In practical terms, this has entailed students working in virtual collaborations, usually with video, on substantive or complex STEM projects. The project that motivated the original proposal is an international digital makerspace effort that DRL-AISL supports, but the applications cut across all STEM education contexts, both formal and informal.
- Emerging cybertools enable the potential for distributed collaboration, especially boundary-crossing collaboration, to function as ***a natural, abundant, and seamless aspect of next generation STEM learning***.
- This type of learning setting offers the opportunity to reach some of the most elusive goals of the national STEM education enterprise.

The purpose of this workshop is thus to frame a research agenda NSF can use that will articulate:

- **foundational research issues in distributed or virtual collaboration in STEM project-based learning, and competence formation, especially when students must cross boundaries to participate in such collaborations; and**
- **important design principles for such boundary-crossing collaboration in STEM learning and competence formation**

Participants

- The workshop included an eclectic and international collection of approximately 25 individuals, excluding another five who were unable to attend but will convene later in order to revise and polish the draft output before final submission.
- Participants included prominent research methodologists, learning scientists and technologists, a highly-regarded education futurist, a university president widely published in areas essential to this topic, nationally prominent experts in computational thinking, and data scientists. Collectively, they represented education service and leadership from the US, Kenya, Brazil, Singapore, and Finland.

Process

This workshop initially entailed three webinars, in February, March, and April of 2019. The webinars helped "set the table" for the workshop that took place on 13-14 May, 2019.

The opening session of the workshop on 13 May involved a "priming" exercise. Each of three different exemplars of boundary-crossing collaboration was presented. Then, each of the core team of invitees spent 90 minutes creating a "response" presentation of 20-30 minutes addressing the five questions below. They gave these presentations over the second half of the first day and all of the second day, **spurring a lively rich discussion and a corpus of inputs for the workshop paper**. It proved an effective approach for sustained and substantive engagement of the participants. The questions each expert addressed, from the vantage of the exemplar settings and other contexts with which they were familiar, include:

- Insights on how boundary-crossing impacts learning
- Theoretical directions/frameworks ("What existing frameworks that can be built on? How do we develop theoretical gravitas around boundary crossing? Who are most influential thinkers in this area that we have not yet evoked?")
- Curiosity around this topic ("What questions are emerging from these exemplars and your colleagues' presentations?")
- Ideas for future learning environments ("What is the potential for boundary-crossing impact in learning?")
- Intersection of boundary-crossing with current work ("How does your work pertain to, inform, or contribute to synthesis and design of this construct?")

Findings

- Heterogeneous (i.e. boundary-crossing) STEM problem-solving contexts were routinely reported to elicit sophisticated STEM learning and complex reasoning. That is, diversity of participation in trust-rich contexts appears to stimulate diversity of applied reasoning.
- Virtual collaboration in STEM problem-solving that takes place in ways that lead students to cross new boundaries routinely elicits complementary sentiments of curiosity, pleasure, and joy in learning - in addition to STEM learning and competence formation.
- Interest-driven creator theory may prove an important aspect of driving collaborations envisioned as a routine aspect of future learning environments.
- Cyber-enabled boundary-crossing is important in areas such as cultural, national, or economic categories, enabling a metaphor of **virtual migration of students to a shared space**.
    - This important metaphor also applies to students who are alienated or otherwise withdrawn from learning, even if they do not otherwise appear outside of the boundaries of their learning setting. This is one of the most crucial re-conceptualizations of boundaries in the workshop.

Principles

The workshop participants either presented or conjectured on many design principles that reasonably belong in a high-end research agenda. Two of the most salient:

- Building a testable research agenda with live instancing in this thematic area requires **theoretical clarity around constructs such as boundaries, barriers, virtual presence, virtual migration, cultural competence in online settings, and boundary objects**.
    - Such theoretical clarity will enable attention to important variables such as intercultural scaffolding for different phases of virtual collaboration and learning mechanisms within boundary-crossing.
- Participants repeatedly converged on building **social trust** as a crucial or transcendent factor or variance account in virtual collaboration that crosses new boundaries for students.

Surprises & Tensions

- Every workshop participant's conceptual model of boundary-crossing significantly expanded.
    - The workshop theme is more substantive and consequential than the organizers envisioned.
- Participants who did not feel they fit into to the workshop's academic setting and who did not quite understand the role they should assume in the workshop - since papers in advance were explicitly discouraged, and instead created on-site to respond to the exemplars - proved especially engaged and invested in the work of the workshop. This technical detail is a small metaphor of the subject of the workshop.
- Important philosophical considerations that are of little relevance in production style and bounded classroom settings become richer and more germane in settings that have fewer boundaries.
- "If everything is a boundary, nothing is a boundary" ~ this aphorism by one of the participants helped reinforce the importance of theoretical clarity in defining the new boundaries students can cross in envisioned future learning settings.

Recommendations

Short-term

- Examine linkages between cognitive/social/affective dimensions of virtual STEM project-based learning collaboration settings. If possible, incorporate biometrics as a research strand.
- Provide theoretical specification to collaborative artifacts and intermediate outputs as boundary objects.
- The workshop participants have agreed to develop a set of essays or special issue proposal to articulate issues emerging from the workshop.

Medium-term

- Explore distributed collaborative learning in other contexts such as gaming and social media.

Long-term

- Reconceptualize virtual learning spaces to capture newly emerging technologies (e.g. collaborative VR, biometric data), roles (e.g. creators, participatory teachers), and processes (e.g. new forms of interaction).