Community Report on Digitally-Mediated Team Learning

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Workshop Purpose

Digitally-Mediated Team Learning (DMTL) encompasses cooperative learning in classroom-based settings with an emphasis on synchronous delivery. Teams consist of two or more learners, with members assuming various roles during learning activities. Team formation occurs through various means with an emphasis on leveraging learning analytics to automate the process. Thus, automated team formation and dynamic re-assignment during the learning activity are feasible. During the DMTL learning activity, the instructor supports, rather than directs, the learning experience via a shared virtual space. DMTL employs emerging pedagogical approaches, data analytics, and the potential of machine learning to advance learning outcomes.

The purpose of the Digitally-Mediated Team Learning Workshop (sponsored by the National Science Foundation through a Dear Colleague Letter [NSF 18-017] via grant 1825007) was to ascertain the current state of the field and future research approaches for DMTL delivered through synchronous modalities in STEM classrooms for students in upper elementary grades through college. The overarching question for the workshop was: "How can we advance effective and scalable digital environments for synchronous team-based learning involving problem-solving and design activities within STEM classrooms for all learners?"

The workshop explored the state of the field and future directions of DMTL through its four tracks: (a) student-facing and instructor-facing tools, (b) learning analytics, (c) pedagogical and andragogical strategies, and (d) inclusivity. Each track developed content specific questions to guide the discussions. Sample questions from each track included:

Track 1 (Tools):

- What would a suitable and even ideal student-facing user interface for DMTL look like?
- What are essential widgets for a student-facing interface: e.g. raise hand, bannering, balloting, note-pinning, up-voting?

- How should instructor-facing user interfaces for DMTL operate and which features would they provide?

Track 2 (Analytics)

- How can we best collect and analyze data from traditionally unconnected sources to inform learning?
- What modeling or analysis techniques can sort through the complex and noisy data of team learning?
- What real-time approaches allow assessment of tasks and assessments against learning outcomes?

Track 3 (Learning Strategies)

- How can we maximize the student role in team management and minimize the instructor role in team management via pedagogical approaches?
- How do group selection approaches (and resulting group dynamics) influence team management strategies implemented?
- Which innovative and emerging DMTL-centric pedagogical approaches hold significant promise for impact over the next 1, 3, and 5 years?

Track 4 (Inclusivity)

- What research topics could be conducted to promote transferability and sustainability of inclusivity in DMTL?
- What research methodologies could be considered to investigate issues of inclusivity?
- Are there ways to contribute to learners' efficacy in DMTL?

In response to the NSF call, the workshop produced a compendium of future research directions and projections for the field per track and these ideas were identified to identify 1+, 3+, and 5+ year research opportunities.

Starting Points and Process

Group problem solving and project collaboration are prominent facets of STEM education and professional practice. In STEM curricula, problem-solving and collaboration are manifested in laboratory experiences, course projects, and senior design courses. As team design skills are receiving increased focus, and the need to design solutions for complex science and engineering problems increases, there is a need to better understand and address team dynamics and its underpinnings (e.g. tools, analytics, strategies, and inclusivity).

The scholarly group was comprised of researchers, educators, practitioners, and authors of recent journal publications and conference papers in the area of DMTL. The workshop was a joint effort between the University of Central Florida, Worcester Polytechnic Institute, and the Colorado School of Mines, and was enhanced by the inclusion of participants from a wide array of backgrounds in areas such as interdisciplinary learning and data sciences, as well as STEM content areas. The cooperation among the diverse group facilitated an extensive collection of perspectives across a range of disciplines, while working towards the common goal of advancing the field of DMTL.

The participants were gathered through an extensive recruitment process that included reviewing recent journals, conference papers, and utilized referrals from journal editors and other leaders in the field. Those identified as potential participants were communicated with and directed to a website designed specifically for the DMTL workshop at the URL https://www.digital-learning-teams.com/. Upon registration, participants were asked to complete an expertise profile and submit a position paper abstract. The project team at the University of Central Florida managed the registration processes, organized the track contents, and communicated relevant conference details leading up to the event.

To identify track composition, participants completed an expertise profile during the registration process. These profiles allowed workshop organizers to organize tracks and panels that balanced the experience of those participating with the subject matter of each individual track. Registrants were asked to cite their publications to ensure that the aims of the individuals aligned with the overall directionality of the workshop track they had selected. The workshop was opened to the public and people from academic communities and related institutions until the maximum workshop capacity was attained.

The in-depth invitation and registration process yielded a diverse group of 84 participants from 44 different universities and organizations. The participants brought experiences from STEM fields and other learning sciences such as digital media, philosophy, medicine, and psychology. This diversity led to unique perspectives and thought-provoking discussions about the current state of DMTL and the path to the continued evolution of the field.

Insights, Issues, and New Ideas

The three-day workshop provided useful insight for advancements in DMTL inclusive of tools, analytics, pedagogical strategies, and broadening participation of underserved and underrepresented learners. The goal was to pursue a vision of change to advance next-generation learning architectures. Each track covered one of the key components related to DMTL.

Track 1: Tools. Discussions spanned the development and advancement of instructional technologies that are capable of efficiently supporting digitally-mediated teams of learners such as tools to facilitate instructor-student interactions, adaptability of strategies, and extended reality (XR) environments. Automations supporting the construction of DMTL exercises primarily focused on face-to-face classroom settings facilitating STEM problem-solving activities. Tools for instructor orchestration to: (a) evaluate in real-time team progress, (b) provide immediate and minimally-intrusive feedback, and (c) promote effective student–student and student–instructor communication were recognized as a research challenge worthy of further development in parallel for elementary education and college-level settings which exhibit distinct team interactions.

Track 2: Data Analytics. The discussion focused on promotion of full-engagement and learning by all members within a team through data analytics. Topics included team dynamics, data sets, analytic approaches, and challenges in contexts such as learning STEM in : (a) K–12 classrooms, (b) informal (out of school) settings, (c) higher education, and (d) professional settings (e.g., industry, emergency response teams, military, and so forth). Consensus in the community centered around data analytics related to personalization and collaboration of team learning. The participants developed ideas with the goals of fostering students towards becoming efficient team members for high performing collaboration skill sets while simultaneously expanding their content knowledge and mastery skills.

Track 3: Pedagogy and Andragogy. Teaching and learning strategy discussions were centered around collaborative environments and key characteristics of effective pedagogical strategies in DMTL environments, as well as best practices to support accountability and assessment. The participants in this track explored various pedagogical and andragogical mechanisms to support, extend, and enhance settings for digitally-mediated team and collaborative instructional approaches. Focal points of discussion included: (a) defining pedagogical strategies for active learning in synchronous and asynchronous settings, (b) underpinning the group and collaborative activities within STEM classroom settings and (c) exploring andragogical/pedagogical methods leading to autogradable/reusable/scalable problem design.

Track 4: Inclusivity. The discussion was focused on developing inclusivity in educational STEM environments, specifically as it relates to DMTL settings. The participants in this track explored multiple areas of inclusivity including: (a) ethnicity, (b) gender, (c) neurodiversity, (d) accessibility, (e) culture, (f) intercultural collaborations with global diversity, (g) geographical inequalities, and (h) intergenerational differences. These discussions challenged the norms and sought ways that technologies, such as simulation and virtual reality, could be leveraged to prepare educators for individual and intersectional diversities among students. Track 4 themes were led by exploring equity and diversity, questioning transferability and sustainability, and creating paths for future research.

Representative insights about the benefits of attending the workshop from participants' perspective included: 1. "Designing educational technologies and blended platforms that support inclusivity and personalized adaptive feedback requires engaging all stakeholders"; 2. "The workshop developed me as a professional in that I was motivated to enhance my classroom teaching by using more digitally-mediated learning."

Directions and Recommendations

This workshop responds to the question: "How can we advance effective and scalable digital environments for synchronous team-based learning involving problem-solving and design activities within STEM classrooms for all learners?" In answer to the question, research objectives and a timeline were developed: immediately (within 1 year), in the near term (within 3 years) and the long term (5 or more years). It is the collective objective of the contributors that the capstone findings can help guide future research in DMTL.

Immediate: Conduct literature reviews for evidence on (a) efficacy of real-time classroom-based DMTL across delivery modalities (e.g. co-located, synchronous-but-seated-separately, and mobile-devices); (b) the effectiveness of varied approaches of team formation, peer evaluation, and/or peer feedback; and (c) best practices to provide feedback based on formative assessment data.

Immediate: Assemble a glossary of inclusivity terminology, methods, and metrics relevant to DMTL.

Immediate: Develop standards for data collection and reporting for DMTL.

Immediate: Unpack interdisciplinary approaches that focus on team management which are applicable to DMTL.

Near Term: Create reusable and adaptable DMTL activities supporting STEM-specific tools (e.g. models, programming, equations, simulations) while employing analytics for personalization and instructor orchestration.

Near Term: Create a Virtual Innovation Center showcasing high-impact DMTL practices, users, and an adaptable resource repository.

Near Term: Develop collaborations between learning sciences experts and subject-matter experts to examine approaches to prepare STEM faculty/teachers to support student-centered DMTL.

Near Term: Build and test prototype XR (VR, AR and MR) for STEM content. Assess perceptions of learning, engagement, and actual learning.

Long Term: Design new data science approaches exploring various team formations' impact on

learning outcomes.

Long Term: Apply and extend machine learning and artificial intelligence (AI) technologies within DMTL to: (a) longitudinally suggest (or automatically construct) team learning activities personalized to the learners at-hand, (b) hybridize DMTL with Intelligent Tutoring Systems (ITS) whereby ITS agents have co-instructor roles, and (c) adapt the XR environment to spontaneously insert virtual teammates at pivotal moments (e.g., triggered by retreading the same ground or persisting on a wrong path).

Long Term: Develop tools (including AI) that facilitate and accelerate feedback across varying dimensions of team learning and implement data analysis techniques appropriate for large-scale, noisy data.

The aforementioned goals and objectives are representative of research directions identified during the workshop. Throughout each track, there was consensus that emerging technologies should be leveraged to create new tools, models, and methodologies to engage all learners. These advancements of effective and scalable digital environments for synchronous team-based learning would enhance the delivery and learning outcomes of problem-solving and design activities within STEM classrooms for all learners.

References and Readings

Digitally-Mediated Team Learning (DMTL). (2019). NSF synthesis and design workshop. Retrieved from https://www.digital-learning-teams.com/

Synthesis and design workshop: Digitally-Mediated Team Learning. (2019). *National Science Foundation.* Retrieved from https://www.nsf.gov/awardsearch/showAward?AWD_ID=1825007&HistoricalAwards=false

DeMara, R. F., Beck, J. E., Campbell, L. O., Hartshorne, R., Spiegel, S., Chen, Z., . . . Gibson, T. (2019). Methods and outcomes of the NSF project on synthesizing environments for Digitally-Mediated Team Learning. Retrieved from http://cal.ucf.edu/conf/ASEE-NSF-Poster-Paper-Submitted-pdfa-nsf-only.pdf