



NATIONAL SCIENCE FOUNDATION
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NSF 18-017

Dear Colleague Letter: Principles for the Design of Digital Science, Technology, Engineering, and Mathematics (STEM) Learning Environments

October 23, 2017

Dear Colleagues:

With this Dear Colleague Letter (DCL), the National Science Foundation's (NSF) Directorates for Education and Human Resources (EHR) and Computer and Information Science and Engineering (CISE) wish to notify the community of their intention to fund research to support the design of the next generation of digital learning environments for science, technology, engineering, and mathematics (STEM) content, and in support of STEM education research more broadly. As an important first step in this direction, this DCL encourages a series of synthesis, integration, and design workshops.

This DCL echoes themes that are also important to NSF's long-running [Cyberlearning for Work at the Human-Technology Frontier \(Cyberlearning\) program](#), which encourages exploratory research in learning technologies to prepare learners to excel in future work at the human-technology frontier.

BACKGROUND

NSF challenges interdisciplinary science and engineering teams to produce plans for developing forward-looking, highly adaptable, distributed digital environments that can personalize learning for individual, diverse learners in collaborative settings with potential applications across multiple and varying: (a) domains of knowledge, (b) learning contexts (including formal and informal education), and (c) time spans.

Next-generation learning architectures should significantly surpass: (a) learning management systems (LMS) or massively open online courses (MOOCs) that primarily organize, coordinate, and deliver resources (e.g., syllabi, video clips, quizzes); (b) intelligent tutoring systems (ITS) and related activities that narrowly scope learning tasks; and (c) non-adaptive education environments in general.

NSF seeks ideas for rich and highly adaptable environments for learners that may: (a) serve as a forum for active research and development studies by researchers; (b) serve as a testbed for

analytics that support the environment's adaptability; and (c) in the spirit of design-based research, serve as a collaborative space for teachers, mentors, and learners to work with researchers as co-developers of the learning environment.

NSF encourages the engagement of a range of disciplines, such as education research, cognitive science, the learning sciences, the science of team science, linguistics, computer science, information science, computational science, mathematics, and statistics. This engagement may encompass experts from areas such as human-computer interaction; data streaming, assimilation, visualization, and analytics; machine learning and deep learning; multi-modal analytics; social network analyses; and adaptive rapid experimental design. While NSF primarily funds domestic institutions, expert advisors may come from academia, industry, or non-profits - both within the US or internationally.

In the spirit of NSF's commitment to broadening participation, activities pursuant to this DCL must strive to be responsive to the needs of each and every learner for access to resources, support for the use of those resources, and achievement of individual learning goals.

While the DCL encourages open exploration of ideas, prospective principal investigators (PIs) should remain cognizant of addressing privacy and security concerns in their proposed activities.

PROPOSAL PREPARATION INSTRUCTIONS

With this DCL, NSF anticipates funding up to 9 synthesis and design workshops for up to \$100,000 each for one year of support. Proposals submitted in response to this DCL must be prepared and submitted in accordance with the guidance for Conference proposals contained in Chapter II.E.7 of the *NSF Proposal & Award Policies & Procedures Guide (PAPPG)*:

https://www.nsf.gov/pubs/policydocs/pappg17_1/pappg_2.jsp#II.E.7. The "Conference" type of proposal should be selected in the proposal preparation module in FastLane and proposals should be directed to the EHR Core Research and Development (R&D) Program. Proposal titles should begin with the phrase, "DCL: Synthesis and design workshop:". Each workshop proposal should budget support for its personnel, including organizing committee members, its workshop meetings and activities, and its travel costs for selected project personnel to attend a two-day summit meeting near NSF. Meaningful involvement of graduate student(s) and/or postdoctoral researcher(s) in all projects is strongly encouraged.

A competitive workshop proposal should evidence a deep understanding of the theme of the proposed workshop (sample themes are provided below). The PI should propose a diverse interdisciplinary team with clear potential to: (a) describe the proposed perspective(s); (b) engage innovative design thinking to outline blueprint designs for a future learning environment; and (c) describe any potential theoretical, methodological or programming obstacles that are likely to require further research and development. PIs should submit project timelines for open workshops meetings (i.e., not invitation-only). The times and locations of the workshops should be posted on the project websites.

DISSEMINATION

White Papers

Each workshop project should post a draft white paper on a public project website, and share this white paper with NSF staff, approximately 9 months post-award. A final white paper should be posted and shared 12 months post-award. The white paper should inform a broad audience about: (a) the state of the art for the workshop theme; (b) which aspects of the theme were deemed sufficiently mature to inform near-term design of learning environments (e.g., in one to three years); (c) which aspects of the theme would require additional design and development research (e.g., be deployable in three to five years); and (d) which aspects would require longer-term basic or foundational research.

All PIs must propose a creative dissemination plan that goes beyond publishing research papers and presenting at research conferences, i.e., one that is likely to impact a range of audiences.

Synthesis and Design Workshop Themes

To promote generative proposals, sample research questions are provided below; alternative research questions are also encouraged.

- What advances in learning environment design are required to support multi-modal learning for individual or team-based learning? What new research or data analytic methods may help overcome any barriers?
- What innovative approaches to research methods, statistical techniques and modeling formalisms are necessary to capture, characterize and support causal claims about individual or team-based learning, especially for complex, multi-source streaming data?
- How can learning environments collect data to systematically inform our understanding of learners' current state of knowledge, their achievements in challenging STEM content, their motivations for learning and perseverance, or the formation of effective teams that are both diverse and inclusive?
- How can advances from data science inform innovative formative, continuous, or summative assessments that provide rich diagnostic information on learning?
- How can educational digital resources (e.g., videos, animations, images, or audio files) be analyzed and exploited to support significant progress in student learning, assessment, or program evaluation? How can instructors, mentors and learners modify and exploit these resources?
- How can learning environments be designed to scale successful efforts across: (a) different content areas, (b) diverse student populations, (c) different contexts, or (d) variable time spans?
- How can the findings of discipline-based educational research (DBER) or other findings from undergraduate education be incorporated into learning environment design?
- How can the design approaches and resources from public participation in STEM research (PPSR) and the Maker movement be integrated into learning environment design?
- How can learning environments capitalize on teacher or learner "presence" via virtual or immersive technologies such as augmented or virtual reality?

DUE DATE

Workshop proposals must be submitted by January 22, 2018.

POINTS OF CONTACT

Specific questions pertaining to this DCL can be directed to the following program directors:

- Amy Baylor, Program Director, EHR Division of Research on Learning in Formal and Informal Settings (DRL), (703) 292-5126, abaylor@nsf.gov; and
- Tanya Korelsky, Program Director, CISE Division of Information and Intelligent Systems (IIS), (703) 292-8930, tkorelsk@nsf.gov.

Sincerely,

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Jim Kurose
Assistant Director, CISE