STEM + Computing Partnerships (STEM+C)

PROGRAM SOLICITATION
NSF 17-535

REPLACES DOCUMENT(S):
NSF 16-527

National Science Foundation

Directorate for Education & Human Resources
   Research on Learning in Formal and Informal Settings

Directorate for Computer & Information Science & Engineering

Full Proposal Deadline(s) (due by 5 p.m. submitter's local time):

   March 29, 2017

IMPORTANT INFORMATION AND REVISION NOTES

This Solicitation updates NSF 16-527. The updates are as follows:

- The former STEM+C Track 2 categories for funding, Computing Education Knowledge and Capacity Building and Research on Education and Broadening Participation, have been removed from the current solicitation and incorporated into the *Computer Science for All* solicitation: https://www.nsf.gov/pubs/2017/nsf17525/nsf17525.htm

Any proposal submitted in response to this solicitation should be submitted in accordance with the revised *NSF Proposal & Award Policies & Procedures Guide* (PAPPG) (NSF 17-1), which is effective for proposals submitted, or due, on or after January 30, 2017. Please be advised that proposers who opt to submit prior to January 30, 2017, must also follow the guidelines contained in NSF 17-1.

SUMMARY OF PROGRAM REQUIREMENTS

General Information

Program Title:

   STEM + Computing Partnerships (STEM+C)

Synopsis of Program:

   As computing has become an integral part of the practice of modern science, technology, engineering and mathematics (STEM), the STEM + Computing Partnerships program seeks to address the urgent need to prepare students from the early grades through high school in the essential skills, competencies, and dispositions needed to succeed in a computationally-dependent world. Thus, STEM+C advances the integration of computational thinking and computing activities in early childhood education through high school (pre-K-12) to provide a strong and developmental foundation in computing and computational thinking through the integration of computing in STEM teaching and learning, and/or the applied integration of STEM content in pre-K-12 computer science education.

Cognizant Program Officer(s):

Please note that the following information is current at the time of publishing. See program website for any updates to the points of contact.

- Arlene M. de Strulle, EHR/DRL, telephone: (703) 292-5117, email: adestrul@nsf.gov

- Michael Ford, EHR/DRL, telephone: (703) 292-5153, email: miford@nsf.gov

- Amy Baylor, EHR/DRL, telephone: (703) 292-5126, email: abaylor@nsf.gov

- Janice Cuny, CISE/CNS, telephone: (703) 292-8900, email: jcuny@nsf.gov

- Catherine Eberbach, EHR/DRL, telephone: (703) 292-4960, email: ceberbac@nsf.gov

- David L. Haury, EHR/DRL, telephone: (703) 292-8614, email: dhaury@nsf.gov

- Margret Hjalmarson, EHR/DRL, telephone: (703) 292-4313, email: mhjalmar@nsf.gov

- Paul W. Jennings, EHR/DRL, telephone: (703) 292-5307, email: pjenning@nsf.gov

- Rebecca Kruse, EHR/DRL, telephone: (703) 292-4211, email: rkruse@nsf.gov

- Julio E. Lopez-Ferrao, EHR/DRL, telephone: (703)292-5183, email: jlopezfe@nsf.gov

- Chia Shen, EHR/DRL, telephone: (703) 292-8447, email: cshen@nsf.gov

Applicable Catalog of Federal Domestic Assistance (CFDA) Number(s):

- 47.070 --- Computer and Information Science and Engineering
- 47.076 --- Education and Human Resources

Award Information

Anticipated Type of Award:

Standard Grant or Continuing Grant

Estimated Number of Awards:

25 to 35

Anticipated Funding Amount:

$49,895,000

Estimated program budget, number of awards and average award size/duration are subject to the availability of funds.

Eligibility Information

Who May Submit Proposals:

The categories of proposers eligible to submit proposals to the National Science Foundation are identified in the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG), Chapter I.E.

Who May Serve as PI:

There are no restrictions or limits.

Limit on Number of Proposals per Organization:

There are no restrictions or limits.

Limit on Number of Proposals per PI or Co-PI:

There are no restrictions or limits.

Proposal Preparation and Submission Instructions

A. Proposal Preparation Instructions

- **Letters of Intent:** Not required

- **Preliminary Proposal Submission:** Not required

- **Full Proposals:**

    - Full Proposals submitted via FastLane: *NSF Proposal and Award Policies and Procedures Guide* (PAPPG) guidelines apply. The complete text of the PAPPG is available electronically on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=papp.
    - Full Proposals submitted via Grants.gov: *NSF Grants.gov Application Guide: A Guide for the Preparation and Submission of NSF Applications via Grants.gov* guidelines apply (Note: The *NSF Grants.gov Application Guide* is available on the Grants.gov website and on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=grantsgovguide).

B. Budgetary Information

- **Cost Sharing Requirements:**

    Inclusion of voluntary committed cost sharing is prohibited.

- **Indirect Cost (F&A) Limitations:**

    Not Applicable

- **Other Budgetary Limitations:**

    Not Applicable

C. Due Dates

- **Full Proposal Deadline(s)** (due by 5 p.m. submitter's local time):

    March 29, 2017

Proposal Review Information Criteria

Merit Review Criteria:

National Science Board approved criteria. Additional merit review considerations apply. Please see the full text of this solicitation for further information.

Award Administration Information

Award Conditions:

Standard NSF award conditions apply.

Reporting Requirements:

Standard NSF reporting requirements apply.

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I. INTRODUCTION

The STEM + Computing Partnerships (STEM+C) program seeks to advance a 21st century conceptualization of education in science, technology, engineering and mathematics (STEM) that explicitly includes computing as a STEM discipline and as a discipline integral to the practice of all other STEM disciplines.[1]

Computing has become an integral part of the practice of modern science, technology, engineering and math. As a result, computational and computational thinking approaches are dramatically increasing the understanding of the world and society—from particle physics to biological and social systems to Earth systems science. Computation is so central to the practice of science and engineering that the President's Information Technology Advisory Committee's Report to the President, Computational Science: Insuring America's Competitiveness(2005)[2], called computation the "third pillar of scientific practice," joining the two classical approaches of theoretical/analytical and experimental/observational. The translation of mathematical models of phenomena into computer simulations allows scientists to analyze systems, predict the future and reconstruct the past, on a scale far greater in complexity than previously possible. In addition, scientists now have the ability to collect, query, visualize and analyze unprecedented amounts of data. These computational capabilities are revolutionizing STEM disciplines.

All students—but particularly students in science, technology, engineering and mathematics disciplines—need to understand the role of computation and computational thinking within disciplinary problem solving. Too few students, however, have the opportunity to gain these understandings and skills in or outside of school.

A report by the National Research Council underscores that computational thinking skills are essential in the K-12 curriculum for reasons including, "succeeding in a technological society, increasing interest in the information technology professions, maintaining and enhancing U.S. economic competitiveness, supporting inquiry in other disciplines, and enabling personal empowerment" (NRC, 2011)[3]. The NRC report also points to a scarcity of research informing the teaching of computational thinking in the early grades. As a result, computational thinking and computer science in pre-K-12 is often taught without consideration for age-appropriate teaching and learning. The STEM + Computing Partnerships program targets these research gaps—seeking to build the evidence base for effective pedagogy and pedagogical environments that will make the integration of computing within STEM disciplines more age-appropriate and contemporaneously relevant to pre-K-12 STEM education.

Computational thinking is a fundamental skill for everyone, not just for computer scientists. To reading, writing, and arithmetic, we

should add computational thinking to every child's analytical ability (Wing, 2006, p. 33-35)[4]. Students can gain a better understanding of STEM and computing fields if they can see the creative modes of scientific exploration made possible by advances in computation, such as visualizations of scientific concepts, modeling and simulation in engineering design, use of high performance computing for physics, climate research and weather modeling, molecular chemistry, computational biology, and bioinformatics. Keeping in mind that computational thinking involves more than the mere use of computers, STEM+C expects to contribute to the discovery of the nature of computational thinking itself and how it is demonstrated within many disciplines.

One expectation of the STEM+C program is that it will prepare students to confront the emerging challenges in computational and data-enabled science and engineering. Accordingly, the solicitation broadens the definition of computing to include computational science, data science, human computer interfaces, and cybersecurity.

Integration of computing and computational thinking within other STEM disciplines may well have profound effects on pre-K-12 STEM education—reflecting the increasing role of computational approaches and computational thinking in the STEM disciplines.

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[1] Public Law No: 114-59, STEM Education Act of 2015.

[2] President's Information Technology Advisory Committee (PITAC 2005, p.1). Computational Science: Insuring America's Competitiveness, Report to the President. National Coordination Office for Information Technology Research and Development, Washington, DC.

[3] National Research Council (NRC, 2011) Report of a Workshop of Pedagogical Aspects of Computational Thinking. Washington, DC: National Academy Press.

[4] Wing, J. (2006) Computational Thinking, Communications of the ACM, March, Vol. 49, No. 3.

II. PROGRAM DESCRIPTION

The STEM+C program seeks to build evidence to inform development of new pedagogical strategies and pedagogical environments for integrating computing and computational thinking in the teaching and learning of pre-K-12 science, technology, engineering, and mathematics (STEM), and/or to integrate science, mathematics, and engineering in the applied teaching and learning of computer science in pre-K-12 education.

To prepare students from early childhood through high school, proposed research and development efforts should address interdisciplinary integration of computing and computational thinking in one or more of the STEM disciplines, with a focus on student learning pre-K-12, and/or professional development of inservice pre-K-12 teachers, and/or pre-service pre-K-12 teacher education, including preparation of teachers to integrate science, mathematics, and engineering in the applied teaching and learning of computer science in pre-K-12 education.

Applied research and development efforts may include, but are not limited to: studies of pedagogy that integrate computational thinking in one or more STEM content areas within grade bands (from pre-school to high school); research on, and development of new pedagogical environments that can better support interdisciplinary integration of computing in STEM learning; development of new technological tools that can more innovatively integrate computing into one or more other STEM disciplines or integrate STEM content into the teaching and learning of computing, and specifically, the use of technologies that go beyond the mere use of computers to teach students about computing concepts by encouraging the integration of computing and computational concepts in disciplinary-specific ways; modification or development of an entirely new curriculum and/or course materials; improvements in teaching and learning that incorporate learning that can transition between school and informal settings; and innovative pre-service teacher education programs and inservice teacher professional development to prepare teachers to integrate computational thinking or computing in their STEM teaching; modification of instructional strategies; and modifications of programs or any curricular activities in or out of school that are synergistic to school-based content acquisition.

The program encourages investigators to consider situating their work in the context of a more comprehensive interdisciplinary approach by integrating computing and computational thinking across an entire STEM curriculum.

REQUIRED ELEMENTS OF PROPOSALS

1. Research

Exploratory Integration and *Design and Development* proposals are required to build knowledge through research. Potential results of proposed research are expected to be of sufficient significance and quality to warrant peer-review and broader publication. Rigorous quantitative, qualitative, or mixed methods approaches are welcome and may be designed to be consistent with the Common Guidelines for Education Research and Development, a report from the Institute of Education Sciences, U.S. Department of Education and the National Science Foundation (August 2013). For more information on the Common Guidelines: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf13126

A suggested reference for proposals with interventions studying learning with technology, is the publication, Expanding Evidence Approaches for Learning in a Digital World, by the U.S. Department of Education, Office of Educational Technology (2013): https://tech.ed.gov/expanding-evidence/

Proposals should include the following research components:

- Explicitly stated research questions and theory of action leading development efforts; details on methods used to answer research questions and that build an understanding of the research issues; types of data to be collected, methods for data collection, and management of data. Discuss the rationale for sample selection and criteria for recruitment of the sample size and population.
- A strategy for reaching a diversified audience with dissemination to STEM-education researchers, disciplinary educators, pre-K-12 practitioners, public audiences; and related professional audiences and organizations. Discuss whether the design is premised on special needs and interests due to educational level, gender, race, ethnicity, economic status, or disability.

The following are examples of research questions related to core objectives of the STEM+C program. Proposers are encouraged to consider other important research concepts and questions in support of STEM+C objectives:

- What pedagogical environments and learning strategies are needed for developing computing skills within the context of specific STEM disciplines? How do such strategies need to be modified for integrating computing within different disciplines?

What are the learning progressions in computational thinking that can be identified from the early grades through high school? How do these differ with respect to various disciplines?

- Under what conditions does the integration of computing into one or more STEM disciplinary areas or STEM content into computer science education, increase student content acquisition, interest, motivation, and/or performance?

2. Interdisciplinary Partnerships and/or Collaborations

Investigators must include computing and/or computational thinking in one or more disciplinary-specific fields of science, technology, engineering or math (STEM) and/or STEM content integration in computer science education; thus, it is essential to have interdisciplinary expertise on the project team.

In addition to the required interdisciplinary collaboration/partnership in STEM and computing, investigators are encouraged to broaden the expertise of the project team by including discipline-specific teachers and faculty; school personnel and district leadership; educational, developmental, and social psychologists; social and learning scientists; education technologists; out-of-school practitioners, researchers, and informal educators; education media and technology developers; representatives from business, industry, and school districts to inform workforce career direction; or other expertise specific to the needs of the project to advance objectives. If the project is addressing issues of underrepresentation in STEM and computing, proposals must include appropriate expertise representative of the respective communities and populations participating in the project.

Projects may propose to test ideas in a range of learning settings and demographic contexts. Investigators are encouraged to consider multisector partnerships, such as industries with vested interest in evolving skills and competencies in STEM and computing for the current and future workforce, or engaging schools and organizations for informal learning to collaborate on the testing of ideas and tools for potential classroom adoption. Collaborations should be substantive - seeking to create innovative pedagogical solutions, strategies, and research that could not be achieved without such collaboration, and that will be responsive to advancing of both knowledge and practice of STEM including computing education.

3. External Independent Review

All proposals must include a strategy for objective independent review of the project. An external review panel, advisory board, or a third-party evaluator may be proposed (see NSF proposal preparation guidelines). The external critical review should be sufficiently independent and rigorous to influence the project's activities and improve the quality of its findings. Competitive proposals will (1) describe the expertise of the external reviewer(s); (2) explain how that expertise relates to the goals and objectives of the proposal; and (3) specify how the PI will report and use results of the project's external critical review process.

The Advisory Board and/or external evaluator should have sufficient methodological expertise to provide an independent review of the integrity of proposed education research activity and review of designs and activities (including theoretical frameworks, data collection plans, analysis plans, and reporting plans). Proposers should identify ways to determine levels of technical quality as needed.

Further information and guidance can be found in the publication: Common Guidelines for Education Research and Development: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf13126

TYPES OF PROPOSED INTERVENTIONS

The range of anticipated projects is quite broad; however, common to each project is that it should articulate research questions, the importance of the research to the field, formative and summative assessment, and data collection that, in aggregate, will provide evidence-based insights to inform and advance the field.

Integrating Computational Approaches in STEM Learning

- Investigators who have research-based hypotheses about how to effectively support student learning of computing and science or other STEM concepts might propose to develop learning progressions across grade bands, modules, or courses to study their impact on student understanding.
- Investigators who have research-based hypotheses for improving student engagement in STEM and computing using various types of education media and technologies, might propose innovations to game-based learning and virtual/augmented reality, and or new technology applications/platforms for computational thinking.
- Investigators who have research-based hypotheses for the design of new tools might propose to create, build, and invent products or computational solutions to domain-specific problems, including interventions or learning across settings (in and out of school). Products and tools might seek to engage learners in reasoning, systems thinking, and understanding of scientific models, simulations, and visualizations that depict phenomena or any intervention that might potentially improve teaching and learning within the discipline through integration of computing.

Teacher Education and Professional Development Interventions

- Investigators who have research-based hypotheses on how to support pre-service and in-service teachers in understanding STEM + computing in their instruction might propose to study new pedagogical approaches to teacher education or invent, pilot, or modify one or more courses or a curriculum to infuse computational approaches into traditional science, technology, or infuse any STEM content into computer science, or both, or develop a new curriculum, course materials, assessments, pedagogy, design new pedagogical environments, or new foci for pre-service education and in-service teacher professional development.
- Investigators who have research-based hypotheses on how to advance new pedagogy or teaching practices that prepare teachers to effectively facilitate students' computational learning and thinking might propose to study new strategies for teacher preparation.
- Investigators who have research-based hypotheses on pre-service teacher education might engage two- and four-year institutions to improve prospective teachers' understanding of computation and computational thinking sufficient to engage pre-K-12 students in real-world science and engineering problems.

CATEGORIES FOR FUNDING

1. Exploratory Integration: (up to $1,250,000); maximum duration three years.

Exploratory Integration supports creative, highly innovative work, such as development of prototypes; pilot testing of new tools and models; conducting innovative research on teaching and learning; designing and studying new pedagogical environments; identifying, adapting, or designing instruments to measure learning processes; modifying instructional practice; or conducting research to provide proof-of-concept and preliminary evidence.

Investigators may propose smaller scale exploratory work for a lower budget and shorter duration period under this category. Projects in this category, depending on research findings, may serve as prototypes or pilots for ideas to be expanded in future proposals.

Exploratory proposals may associate proposed work with the *Early Stages and Exploratory* type of research and development in the

Common Guidelines for Educational Research and Development: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf13126

2. Design and Development: (up to $2,500,000); maximum duration three years.

Design and Development supports proposals that build on prior evidence demonstrating promise for impact on student or teacher learning in classrooms, schools, out-of-school environments, or other learning settings. Investigators may propose interventions for design, research, implementation, and testing that, *based upon prior evidence*, can potentially advance and innovate new learning, teaching, and pedagogical environments suitable for advancing integration of computing in one or more STEM disciplines.

Projects in this category are expected to contribute substantial research findings to advance pre-K-12 STEM teaching or learning and/or computer science education, pre-K-12. Plans should be articulated for dissemination of results to researchers, practitioners, and if applicable, industry.

Design and Development proposals may associate proposed work with the Design and Development type of research and development in the Common Guidelines for Educational Research and Development: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf13126

3. Field-Building Conferences and Workshops: (up to $250,000); maximum duration two years.

The program encourages proposals that have potential to expand the field of STEM + computing and evidence leading to effective, interdisciplinary integration of computing within other STEM disciplines. Budgets for conferences and workshops are expected to be consistent with the duration of the event and the number of participants. It is expected that proposed work will be outcome based. Conference proposals must be prepared in accordance with the specific instructions in PAPPG, Chapter II.E.7 and any additional instructions contained in this solicitation.

III. AWARD INFORMATION

Anticipated Type of Award: Continuing Grant or Standard Grant

Estimated Number of Awards: 25 to 35

Anticipated Funding Amount: $49,895,000

Estimated program budget, number of awards and average award size/duration are subject to the availability of funds.

IV. ELIGIBILITY INFORMATION

Who May Submit Proposals:

> The categories of proposers eligible to submit proposals to the National Science Foundation are identified in the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG), Chapter I.E.

Who May Serve as PI:

> There are no restrictions or limits.

Limit on Number of Proposals per Organization:

> There are no restrictions or limits.

Limit on Number of Proposals per PI or Co-PI:

> There are no restrictions or limits.

V. PROPOSAL PREPARATION AND SUBMISSION INSTRUCTIONS

A. Proposal Preparation Instructions

Full Proposal Preparation Instructions: Proposers may opt to submit proposals in response to this Program Solicitation via Grants.gov or via the NSF FastLane system.

- Full proposals submitted via FastLane: Proposals submitted in response to this program solicitation should be prepared and submitted in accordance with the general guidelines contained in the NSF Proposal & Award Policies & Procedures Guide (PAPPG). The complete text of the GPG is available electronically on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=papp. Paper copies of the GPG may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-7827 or by e-mail from nsfpubs@nsf.gov. Proposers are reminded to identify this program solicitation number in the program solicitation block on the NSF Cover Sheet For Proposal to the National Science Foundation. Compliance with this requirement is critical to determining the relevant proposal processing guidelines. Failure to submit this information may delay processing.

- Full proposals submitted via Grants.gov: Proposals submitted in response to this program solicitation via Grants.gov should be prepared and submitted in accordance with the NSF Grants.gov Application Guide: A Guide for the Preparation and Submission of NSF Applications via Grants.gov. The complete text of the NSF Grants.gov Application Guide is available on the Grants.gov website and on the NSF website at: (https://www.nsf.gov/publications/pub_summ.jsp?

ods_key=grantsgovguide). To obtain copies of the Application Guide and Application Forms Package, click on the Apply tab on the Grants.gov site, then click on the Apply Step 1: Download a Grant Application Package and Application Instructions link and enter the funding opportunity number, (the program solicitation number without the NSF prefix) and press the Download Package button. Paper copies of the Grants.gov Application Guide also may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-7827 or by e-mail from nsfpubs@nsf.gov.

In determining which method to utilize in the electronic preparation and submission of the proposal, please note the following:

Collaborative Proposals. All collaborative proposals submitted as separate submissions from multiple organizations must be submitted via the NSF FastLane system. PAPPG Chapter II.D.5 provides additional information on collaborative proposals.

See PAPPG Chapter II.C.2 for guidance on the required sections of a full research proposal submitted to NSF. Please note that the proposal preparation instructions provided in this program solicitation may deviate from the PAPPG instructions.

All Submitters Please Note:

- **If you have problems during the submission of your proposal**, please contact the Helpdesk directly for assistance: **NSF Fastlane** (1-800-673-6188) or **Grants.gov** (1-800-518-4726)

Important Proposal Preparation Information

The following instructions supplement guidelines in the PAPPG and NSF Grants.gov Application Guide:

COVER SHEET PAGE

1. **Mark the Human Subjects box** as pending, approved, or exempted (with exemption subsection 2 indicated). **This box should not be left blank.** The **Human Subjects** box should be marked as pending if an IRB is either (1) reviewing the project plan and has not yet determined a ruling of "approved" or "exempt", or (2) the project plan has not yet been submitted to an IRB for review.

2. **To avoid delays in processing award recommendations**, it is strongly recommended that PIs begin the process of obtaining appropriate Institutional Review Board (IRB) approvals or exemptions as needed for projects involving human subjects. No awards will be made without such approvals or exemptions.

3. Select the **STEM+C solicitation number**.

PROJECT SUMMARY

In addition to the guidance provided in the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG NSF 17-1) for Project Summary preparation**, the first line of the overview must indicate the proposal category specified in the Program Description.**

PROJECT DESCRIPTION

To be competitive, a proposal must respond to the STEM+C Program Description in this solicitation. Reviewers will judge the merit of each proposal based on the content of the Project Description. The narrative should include a problem statement, research questions and methods, and project goals and objectives. The discussion should include the theoretical framework that guides the research and development effort and should be informed by the relevant literature. Plans for independent project evaluation and project dissemination are to be articulated.

SPECIAL INFORMATION AND SUPPLEMENTARY DOCUMENTS

Supplementary documents should include **Letters of Collaboration** from project partners, the **Postdoctoral Mentoring Plan** *(if applicable*) and the **Data Management Plan**. Letters of support from persons endorsing the project but not making a substantial commitment to the project, are not allowed.

Appendix: **Not permitted.** The 15 pages Project Description should contain all of the information needed to describe the project. Proposals submitted with an Appendix will be returned without review.

In addition to guidance provided in the PAPPG (NSF 17-1) on required Special Information and Supplementary Documents, *please provide* current, accurate information for all personnel and institutions involved in the project. NSF staff will use this information in the merit review process to manage reviewer selection. The list should include all PIs, co-PIs, senior personnel, paid/unpaid consultants or collaborators, subawardees, postdocs, project evaluators and project-level advisory committee members. This list should be numbered and include (in this order) Full name, Organization(s), and Role in the project, with each item separated by a semi-colon. Each person listed should start a new numbered line. For example:

- Mary Smith; XYZ University; PI
- John Jones; University of PQR; Senior Personnel
- Jane Brown; XYZ University; Postdoc
- Bob Adams; ABC Community College; Paid Consultant
- Susan White; DEF Corporation; Unpaid Collaborator
- Tim Green; ZZZ University; Subawardee

Collaborators and Other Affiliations Information:

For this solicitation, the *Collaborators & Other Affiliations* information specified in the *PAPPG* should be submitted using the spreadsheet template found at https://www.nsf.gov/cise/collab/. For each proposal, a completed spreadsheet for each PI, co-PI, or senior personnel must be uploaded directly into Fastlane in .xls or .xlsx format as a "Collaborator and Other Affiliations" Single Copy Document. NSF staff use this information in the merit review process to help manage reviewer selection; the spreadsheet will ensure the Collaborator and Other Affiliations information has a common, searchable format.

Note the distinction above for Supplementary Documents: the listing of all project participants is collected by the project lead and entered as a Supplementary Document, which is then automatically included with all proposals in a project. The Collaborators and Other Affiliations are entered for each participant within each proposal and, as Single Copy Documents, are available only to NSF staff. Collaborators and Other Affiliations for participants listed above that are not PIs, co-PIs, or senior personnel can be uploaded under Additional Single Copy Documents using Transfer File.

B. Budgetary Information

Cost Sharing:

Inclusion of voluntary committed cost sharing is prohibited.

Budget Preparation Instructions:

Projects should budget for participation of two project members to attend the annual STEM+C PI meeting.

C. Due Dates

- **Full Proposal Deadline(s)** (due by 5 p.m. submitter's local time):

    March 29, 2017

D. FastLane/Grants.gov Requirements

For Proposals Submitted Via FastLane:

To prepare and submit a proposal via FastLane, see detailed technical instructions available at: https://www.fastlane.nsf.gov/a1/newstan.htm. For FastLane user support, call the FastLane Help Desk at 1-800-673-6188 or e-mail fastlane@nsf.gov. The FastLane Help Desk answers general technical questions related to the use of the FastLane system. Specific questions related to this program solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this funding opportunity.

For Proposals Submitted Via Grants.gov:

Before using Grants.gov for the first time, each organization must register to create an institutional profile. Once registered, the applicant's organization can then apply for any federal grant on the Grants.gov website. Comprehensive information about using Grants.gov is available on the Grants.gov Applicant Resources webpage: http://www.grants.gov/web/grants/applicants.html. In addition, the NSF Grants.gov Application Guide (see link in Section V.A) provides instructions regarding the technical preparation of proposals via Grants.gov. For Grants.gov user support, contact the Grants.gov Contact Center at 1-800-518-4726 or by email: support@grants.gov. The Grants.gov Contact Center answers general technical questions related to the use of Grants.gov. Specific questions related to this program solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this solicitation.

Submitting the Proposal: Once all documents have been completed, the Authorized Organizational Representative (AOR) must submit the application to Grants.gov and verify the desired funding opportunity and agency to which the application is submitted. The AOR must then sign and submit the application to Grants.gov. The completed application will be transferred to the NSF FastLane system for further processing.

Proposers that submitted via FastLane are strongly encouraged to use FastLane to verify the status of their submission to NSF. For proposers that submitted via Grants.gov, until an application has been received and validated by NSF, the Authorized Organizational Representative may check the status of an application on Grants.gov. After proposers have received an e-mail notification from NSF, Research.gov should be used to check the status of an application.

VI. NSF PROPOSAL PROCESSING AND REVIEW PROCEDURES

Proposals received by NSF are assigned to the appropriate NSF program for acknowledgement and, if they meet NSF requirements, for review. All proposals are carefully reviewed by a scientist, engineer, or educator serving as an NSF Program Officer, and usually by three to ten other persons outside NSF either as *ad hoc* reviewers, panelists, or both, who are experts in the particular fields represented by the proposal. These reviewers are selected by Program Officers charged with oversight of the review process. Proposers are invited to suggest names of persons they believe are especially well qualified to review the proposal and/or persons they would prefer not review the proposal. These suggestions may serve as one source in the reviewer selection process at the Program Officer's discretion. Submission of such names, however, is optional. Care is taken to ensure that reviewers have no conflicts of interest with the proposal. In addition, Program Officers may obtain comments from site visits before recommending final action on proposals. Senior NSF staff further review recommendations for awards. A flowchart that depicts the entire NSF proposal and award process (and associated timeline) is included in PAPPG Exhibit III-1.

A comprehensive description of the Foundation's merit review process is available on the NSF website at: https://www.nsf.gov/bfa/dias/policy/merit_review/.

Proposers should also be aware of core strategies that are essential to the fulfillment of NSF's mission, as articulated in *Investing in Science, Engineering, and Education for the Nation's Future: NSF Strategic Plan for 2014-2018*. These strategies are integrated in the program planning and implementation process, of which proposal review is one part. NSF's mission is particularly well-implemented through the integration of research and education and broadening participation in NSF programs, projects, and activities.

One of the strategic objectives in support of NSF's mission is to foster integration of research and education through the programs, projects, and activities it supports at academic and research institutions. These institutions must recruit, train, and prepare a diverse STEM workforce to advance the frontiers of science and participate in the U.S. technology-based economy. NSF's contribution to the national innovation ecosystem is to provide cutting-edge research under the guidance of the Nation's most creative scientists and engineers. NSF also supports development of a strong science, technology, engineering, and mathematics (STEM) workforce by investing in building the knowledge that informs improvements in STEM teaching and learning.

NSF's mission calls for the broadening of opportunities and expanding participation of groups, institutions, and geographic regions that are underrepresented in STEM disciplines, which is essential to the health and vitality of science and engineering. NSF is committed to this principle of diversity and deems it central to the programs, projects, and activities it considers and supports.

A. Merit Review Principles and Criteria

The National Science Foundation strives to invest in a robust and diverse portfolio of projects that creates new knowledge and enables breakthroughs in understanding across all areas of science and engineering research and education. To identify which projects to support, NSF relies on a merit review process that incorporates consideration of both the technical aspects of a proposed project and its potential to contribute more broadly to advancing NSF's mission "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes." NSF makes every effort to conduct a fair, competitive, transparent merit review process for the selection of projects.

1. Merit Review Principles

These principles are to be given due diligence by PIs and organizations when preparing proposals and managing projects, by reviewers when reading and evaluating proposals, and by NSF program staff when determining whether or not to recommend proposals for funding and while overseeing awards. Given that NSF is the primary federal agency charged with nurturing and supporting excellence in basic research and education, the following three principles apply:

- All NSF projects should be of the highest quality and have the potential to advance, if not transform, the frontiers of knowledge.
- NSF projects, in the aggregate, should contribute more broadly to achieving societal goals. These "Broader Impacts" may be accomplished through the research itself, through activities that are directly related to specific research projects, or through activities that are supported by, but are complementary to, the project. The project activities may be based on previously established and/or innovative methods and approaches, but in either case must be well justified.
- Meaningful assessment and evaluation of NSF funded projects should be based on appropriate metrics, keeping in mind the likely correlation between the effect of broader impacts and the resources provided to implement projects. If the size of the activity is limited, evaluation of that activity in isolation is not likely to be meaningful. Thus, assessing the effectiveness of these activities may best be done at a higher, more aggregated, level than the individual project.

With respect to the third principle, even if assessment of Broader Impacts outcomes for particular projects is done at an aggregated level, PIs are expected to be accountable for carrying out the activities described in the funded project. Thus, individual projects should include clearly stated goals, specific descriptions of the activities that the PI intends to do, and a plan in place to document the outputs of those activities.

These three merit review principles provide the basis for the merit review criteria, as well as a context within which the users of the criteria can better understand their intent.

2. Merit Review Criteria

All NSF proposals are evaluated through use of the two National Science Board approved merit review criteria. In some instances, however, NSF will employ additional criteria as required to highlight the specific objectives of certain programs and activities.

The two merit review criteria are listed below. **Both** criteria are to be given **full consideration** during the review and decision-making processes; each criterion is necessary but neither, by itself, is sufficient. Therefore, proposers must fully address both criteria. (PAPPG Chapter II.C.2.d(i). contains additional information for use by proposers in development of the Project Description section of the proposal). Reviewers are strongly encouraged to review the criteria, including PAPPG Chapter II.C.2.d(i), prior to the review of a proposal.

When evaluating NSF proposals, reviewers will be asked to consider what the proposers want to do, why they want to do it, how they plan to do it, how they will know if they succeed, and what benefits could accrue if the project is successful. These issues apply both to the technical aspects of the proposal and the way in which the project may make broader contributions. To that end, reviewers will be asked to evaluate all proposals against two criteria:

- **Intellectual Merit:** The Intellectual Merit criterion encompasses the potential to advance knowledge; and
- **Broader Impacts:** The Broader Impacts criterion encompasses the potential to benefit society and contribute to the achievement of specific, desired societal outcomes.

The following elements should be considered in the review for both criteria:

1. What is the potential for the proposed activity to
    a. Advance knowledge and understanding within its own field or across different fields (Intellectual Merit); and
    b. Benefit society or advance desired societal outcomes (Broader Impacts)?
2. To what extent do the proposed activities suggest and explore creative, original, or potentially transformative concepts?
3. Is the plan for carrying out the proposed activities well-reasoned, well-organized, and based on a sound rationale? Does the plan incorporate a mechanism to assess success?
4. How well qualified is the individual, team, or organization to conduct the proposed activities?
5. Are there adequate resources available to the PI (either at the home organization or through collaborations) to carry out the proposed activities?

Broader impacts may be accomplished through the research itself, through the activities that are directly related to specific research projects, or through activities that are supported by, but are complementary to, the project. NSF values the advancement of scientific knowledge and activities that contribute to achievement of societally relevant outcomes. Such outcomes include, but are not limited to: full participation of women, persons with disabilities, and underrepresented minorities in science, technology, engineering, and mathematics (STEM); improved STEM education and educator development at any level; increased public scientific literacy and public engagement with science and technology; improved well-being of individuals in society; development of a diverse, globally competitive STEM workforce; increased partnerships between academia, industry, and others; improved national security; increased economic competitiveness of the United States; and enhanced infrastructure for research and education.

Proposers are reminded that reviewers will also be asked to review the Data Management Plan and the Postdoctoral Researcher Mentoring Plan, as appropriate.

Additional Solicitation Specific Review Criteria

Proposed work must demonstrate research and development of interventions for teaching and/or learning that integrates computing in one or more STEM disciplines, and/or the integration of a STEM discipline in the applied teaching and learning of computer science.

B. Review and Selection Process

Proposals submitted in response to this program solicitation will be reviewed by Panel Review.

Reviewers will be asked to evaluate proposals using two National Science Board approved merit review criteria and, if applicable, additional program specific criteria. A summary rating and accompanying narrative will generally be completed and submitted by each reviewer and/or panel. The Program Officer assigned to manage the proposal's review will consider the advice of reviewers and will formulate a recommendation.

After scientific, technical and programmatic review and consideration of appropriate factors, the NSF Program Officer recommends to the cognizant Division Director whether the proposal should be declined or recommended for award. NSF strives to be able to tell applicants whether their proposals have been declined or recommended for funding within six months. Large or particularly complex proposals or proposals from new awardees may require additional review and processing time. The time interval begins on the deadline or target date, or receipt date, whichever is later. The interval ends when the Division Director acts upon the Program Officer's recommendation.

After programmatic approval has been obtained, the proposals recommended for funding will be forwarded to the Division of Grants and Agreements for review of business, financial, and policy implications. After an administrative review has occurred, Grants and Agreements Officers perform the processing and issuance of a grant or other agreement. Proposers are cautioned that only a Grants and Agreements Officer may make commitments, obligations or awards on behalf of NSF or authorize the expenditure of funds. No commitment on the part of NSF should be inferred from technical or budgetary discussions with a NSF Program Officer. A Principal Investigator or organization that makes financial or personnel commitments in the absence of a grant or cooperative agreement signed by the NSF Grants and Agreements Officer does so at their own risk.

Once an award or declination decision has been made, Principal Investigators are provided feedback about their proposals. In all cases, reviews are treated as confidential documents. Verbatim copies of reviews, excluding the names of the reviewers or any reviewer-identifying information, are sent to the Principal Investigator/Project Director by the Program Officer. In addition, the proposer will receive an explanation of the decision to award or decline funding.

VII. AWARD ADMINISTRATION INFORMATION

A. Notification of the Award

Notification of the award is made to *the submitting organization* by a Grants Officer in the Division of Grants and Agreements. Organizations whose proposals are declined will be advised as promptly as possible by the cognizant NSF Program administering the program. Verbatim copies of reviews, not including the identity of the reviewer, will be provided automatically to the Principal Investigator. (See Section VI.B. for additional information on the review process.)

B. Award Conditions

An NSF award consists of: (1) the award notice, which includes any special provisions applicable to the award and any numbered amendments thereto; (2) the budget, which indicates the amounts, by categories of expense, on which NSF has based its support (or otherwise communicates any specific approvals or disapprovals of proposed expenditures); (3) the proposal referenced in the award notice; (4) the applicable award conditions, such as Grant General Conditions (GC-1)*; or Research Terms and Conditions* and (5) any announcement or other NSF issuance that may be incorporated by reference in the award notice. Cooperative agreements also are administered in accordance with NSF Cooperative Agreement Financial and Administrative Terms and Conditions (CA-FATC) and the applicable Programmatic Terms and Conditions. NSF awards are electronically signed by an NSF Grants and Agreements Officer and transmitted electronically to the organization via e-mail.

*These documents may be accessed electronically on NSF's Website at https://www.nsf.gov/awards/managing/award_conditions.jsp?org=NSF. Paper copies may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-7827 or by e-mail from nsfpubs@nsf.gov.

More comprehensive information on NSF Award Conditions and other important information on the administration of NSF awards is contained in the NSF *Proposal & Award Policies & Procedures Guide* (PAPPG) Chapter VII, available electronically on the NSF Website at https://www.nsf.gov/publications/pub_summ.jsp?ods_key=papp.

C. Reporting Requirements

For all multi-year grants (including both standard and continuing grants), the Principal Investigator must submit an annual project report to the cognizant Program Officer no later than 90 days prior to the end of the current budget period. (Some programs or awards require submission of more frequent project reports). No later than 120 days following expiration of a grant, the PI also is required to submit a final project report, and a project outcomes report for the general public.

Failure to provide the required annual or final project reports, or the project outcomes report, will delay NSF review and processing of any future funding increments as well as any pending proposals for all identified PIs and co-PIs on a given award. PIs should examine the formats of the required reports in advance to assure availability of required data.

PIs are required to use NSF's electronic project-reporting system, available through Research.gov, for preparation and submission of annual and final project reports. Such reports provide information on accomplishments, project participants (individual and organizational), publications, and other specific products and impacts of the project. Submission of the report via Research.gov constitutes certification by the PI that the contents of the report are accurate and complete. The project outcomes report also must be prepared and submitted using Research.gov. This report serves as a brief summary, prepared specifically for the public, of the nature and outcomes of the project. This report will be posted on the NSF website exactly as it is submitted by the PI.

More comprehensive information on NSF Reporting Requirements and other important information on the administration of NSF awards is contained in the NSF *Award & Administration Guide* (AAG) Chapter II, available electronically on the NSF Website at https://www.nsf.gov/publications/pub_summ.jsp?ods_key=aag.

VIII. AGENCY CONTACTS

Please note that the program contact information is current at the time of publishing. See program website for any updates to the points of contact.

General inquiries regarding this program should be made to:

- Arlene M. de Strulle, EHR/DRL, telephone: (703) 292-5117, email: adestrul@nsf.gov

- Michael Ford, EHR/DRL, telephone: (703) 292-5153, email: miford@nsf.gov

- Amy Baylor, EHR/DRL, telephone: (703) 292-5126, email: abaylor@nsf.gov

- Janice Cuny, CISE/CNS, telephone: (703) 292-8900, email: jcuny@nsf.gov

- Catherine Eberbach, EHR/DRL, telephone: (703) 292-4960, email: ceberbac@nsf.gov

- David L. Haury, EHR/DRL, telephone: (703) 292-8614, email: dhaury@nsf.gov

- Margret Hjalmarson, EHR/DRL, telephone: (703) 292-4313, email: mhjalmar@nsf.gov

- Paul W. Jennings, EHR/DRL, telephone: (703) 292-5307, email: pjenning@nsf.gov

- Rebecca Kruse, EHR/DRL, telephone: (703) 292-4211, email: rkruse@nsf.gov

- Julio E. Lopez-Ferrao, EHR/DRL, telephone: (703)292-5183, email: jlopezfe@nsf.gov

- Chia Shen, EHR/DRL, telephone: (703) 292-8447, email: cshen@nsf.gov

For questions related to the use of FastLane, contact:

- FastLane Help Desk, telephone: 1-800-673-6188; e-mail: fastlane@nsf.gov.

For questions relating to Grants.gov contact:

- Grants.gov Contact Center: If the Authorized Organizational Representatives (AOR) has not received a confirmation message from Grants.gov within 48 hours of submission of application, please contact via telephone: 1-800-518-4726; e-mail: support@grants.gov.

IX. OTHER INFORMATION

The NSF website provides the most comprehensive source of information on NSF Directorates (including contact information), programs and funding opportunities. Use of this website by potential proposers is strongly encouraged. In addition, "NSF Update" is an information-delivery system designed to keep potential proposers and other interested parties apprised of new NSF funding opportunities and publications, important changes in proposal and award policies and procedures, and upcoming NSF Grants Conferences. Subscribers are informed through e-mail or the user's Web browser each time new publications are issued that match their identified interests. "NSF Update" also is available on NSF's website.

Grants.gov provides an additional electronic capability to search for Federal government-wide grant opportunities. NSF funding opportunities may be accessed via this mechanism. Further information on Grants.gov may be obtained at http://www.grants.gov.

ABOUT THE NATIONAL SCIENCE FOUNDATION

The National Science Foundation (NSF) is an independent Federal agency created by the National Science Foundation Act of 1950, as amended (42 USC 1861-75). The Act states the purpose of the NSF is "to promote the progress of science; [and] to advance the national health, prosperity, and welfare by supporting research and education in all fields of science and engineering."

NSF funds research and education in most fields of science and engineering. It does this through grants and cooperative agreements to more than 2,000 colleges, universities, K-12 school systems, businesses, informal science organizations and other research organizations throughout the US. The Foundation accounts for about one-fourth of Federal support to academic institutions for basic research.

NSF receives approximately 55,000 proposals each year for research, education and training projects, of which approximately 11,000 are funded. In addition, the Foundation receives several thousand applications for graduate and postdoctoral fellowships. The agency operates no laboratories itself but does support National Research Centers, user facilities, certain oceanographic vessels and Arctic and Antarctic research stations. The Foundation also supports cooperative research between universities and industry, US participation in international scientific and engineering efforts, and educational activities at every academic level.

Facilitation Awards for Scientists and Engineers with Disabilities (FASED) provide funding for special assistance or equipment to enable persons with disabilities to work on NSF-supported projects. See the *NSF Proposal & Award Policies & Procedures Guide* Chapter II.E.6 for instructions regarding preparation of these types of proposals.

The National Science Foundation has Telephonic Device for the Deaf (TDD) and Federal Information Relay Service (FIRS) capabilities that enable individuals with hearing impairments to communicate with the Foundation about NSF programs, employment or general information. TDD may be accessed at (703) 292-5090 and (800) 281-8749, FIRS at (800) 877-8339.

The National Science Foundation Information Center may be reached at (703) 292-5111.

The National Science Foundation promotes and advances scientific progress in the United States by competitively awarding grants and cooperative agreements for research and education in the sciences, mathematics, and engineering.

To get the latest information about program deadlines, to download copies of NSF publications, and to access abstracts of awards, visit the NSF Website at https://www.nsf.gov

- **Location:**   4201 Wilson Blvd. Arlington, VA 22230

- **For General Information**   (703) 292-5111
  (NSF Information Center)**:**

- **TDD (for the hearing-impaired):**   (703) 292-5090

- **To Order Publications or Forms:**

     Send an e-mail to: nsfpubs@nsf.gov

     or telephone: (703) 292-7827

- **To Locate NSF Employees:**   (703) 292-5111

PRIVACY ACT AND PUBLIC BURDEN STATEMENTS

The information requested on proposal forms and project reports is solicited under the authority of the National Science Foundation Act of 1950, as amended. The information on proposal forms will be used in connection with the selection of qualified proposals; and project reports submitted by awardees will be used for program evaluation and reporting within the Executive Branch and to Congress. The information requested may be disclosed to qualified reviewers and staff assistants as part of the proposal review process; to proposer institutions/grantees to provide or obtain data regarding the proposal review process, award decisions, or the administration of awards; to government contractors, experts, volunteers and researchers and educators as necessary to complete assigned work; to other government agencies or other entities needing information regarding applicants or nominees as part of a joint application review process, or in order to coordinate programs or policy; and to another Federal agency, court, or party in a court or Federal administrative proceeding if the government is a party. Information about Principal Investigators may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records," 69 Federal Register 26410 (May 12, 2004), and NSF-51, "Reviewer/Proposal File and Associated Records," 69 Federal Register 26410 (May 12, 2004). Submission of the information is voluntary. Failure to provide full and complete information, however, may reduce the possibility of receiving an award.

An agency may not conduct or sponsor, and a person is not required to respond to, an information collection unless it displays a valid Office of Management and Budget (OMB) control number. The OMB control number for this collection is 3145-0058. Public reporting burden for this collection of information is estimated to average 120 hours per response, including the time for reviewing instructions. Send comments regarding the burden estimate and any other aspect of this collection of information, including suggestions for reducing this burden, to:

Suzanne H. Plimpton
Reports Clearance Officer
Office of the General Counsel
National Science Foundation
Arlington, VA 22230

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