EDU Core Research (ECR:Core)

PROGRAM SOLICITATION
NSF 21-588

REPLACES DOCUMENT(S):
NSF 19-508

National Science Foundation

Directorate for STEM Education
Division of Graduate Education
Division of Undergraduate Education
Division of Equity for Excellence in STEM
Research on Learning in Formal and Informal Settings

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

October 12, 2021

October 06, 2022

First Thursday in October, Annually Thereafter

IMPORTANT INFORMATION AND REVISION NOTES

Important Information

Innovating and migrating proposal preparation and submission capabilities from FastLane to Research.gov is part of the ongoing NSF information technology modernization efforts, as described in Important Notice No. 147. In support of these efforts, research proposals submitted in response to this program solicitation must be prepared and submitted via Research.gov or via Grants.gov, and may not be prepared or submitted via FastLane.

NSF is taking proactive steps to move the preparation and submission of all proposals from FastLane to Research.gov, however until capabilities are fully implemented, Conference proposals must be prepared and submitted via FastLane or Grants.gov in accordance with the applicable guidance contained in the PAPPG or the *NSF Grants.gov Application Guide*.

Revision Notes

The solicitation clarifies the types of **fundamental research** (curiosity-driven basic and use-inspired basic research) funded by the program.

New descriptions of the **three research areas** (STEM Learning and Learning Environments, Broadening Participation in STEM, and STEM Workforce Development) are detailed.

A list of **Research Topic Clusters** is added.

Pilot studies are added as a new proposal type at Level I.

The Project Summary should specify the Level, Research Area, Research Topic Cluster(s) and include a list of **five key words** that best describe the theory, research methodology, the population to be studied (e.g., age, grade level, gender), any specific STEM disciplinary content that is to be studied (e.g., algebra), or potential stakeholder communities, as appropriate.

The Project Description should include a **justification for project level and duration**. Proposals that request the highest level of funding are particularly expected to discuss the need for resources.

Any proposal submitted in response to this solicitation should be submitted in accordance with the revised *NSF Proposal & Award Policies & Procedures Guide* (PAPPG) (NSF 22-1), which is effective for proposals submitted, or due, on or after October 4, 2021.

SUMMARY OF PROGRAM REQUIREMENTS

General Information

Program Title:

EDU Core Research (ECR:Core)

Synopsis of Program:

The EDU Core Research (ECR) program offers this ECR:Core solicitation and invites proposals for fundamental research (curiosity-driven basic research and use-inspired basic research) that contributes to the general, explanatory knowledge that underlies STEM education in one or more of the three broadly conceived Research Areas: **Research on STEM Learning and Learning Environments**, **Research on Broadening Participation in STEM fields**, and **Research on STEM Workforce Development**. Within this framework, the ECR program supports a wide range of fundamental STEM education research activities, aimed at learners of all groups and ages in formal and informal settings.

Fundamental research generates knowledge and understanding with the potential for broad relevance. The potential implications of ECR fundamental research for improving STEM education practice may be indirect and long-term rather than direct and immediate. Moreover, whether they include basic or use-inspired basic research, all successful ECR:Core proposals focus on the advancement or refinement of foundational knowledge for STEM education.

The amount of funding and duration requested in proposals submitted to the ECR:Core solicitation should align with the maturity of the proposed work and the size and scope of the empirical effort. The solicitation has three levels of funding with a range of budget sizes, and proposals may request a duration of 3 to 5 years for any level: (1) **Level I proposals** may request up to $500,000; (2) **Level II proposals** may request up to $1,500,000; (3) **Level III proposals** may request up to $2,500,000. **All proposals should justify the level of funding and duration in the project description.**

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.

- Address questions to the program, telephone: (703)292-2333, email: ECR@nsf.gov

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

- 47.076 --- Education and Human Resources

Award Information

Anticipated Type of Award: Standard Grant or Continuing Grant

Estimated Number of Awards: 40

approximately 15 awards at level I; 12 awards at level II; 5 awards at level III, and 9 other awards.

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

Anticipated Funding Amount: $35,000,000

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. Unaffiliated individuals are not eligible to submit proposals in response to this solicitation.

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 Research.gov: *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=pappg.
    - 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):

  October 12, 2021

  October 06, 2022

  First Thursday in October, Annually Thereafter

Proposal Review Information Criteria

Merit Review Criteria:

National Science Board approved criteria apply.

Award Administration Information

Award Conditions:

Standard NSF award conditions apply.

Reporting Requirements:

Standard NSF reporting requirements apply.

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I. INTRODUCTION

The nation faces extraordinary opportunities and challenges in aspiring to lead the world in science, technology, engineering, and mathematics (STEM). Diversity in human capital, rapid and exciting scientific advances leading to new approaches to solving critical societal problems, and a national emphasis on the importance of innovation all point to unparalleled opportunities for the future. At the same time, these rapid technological advancements and societal changes are challenges requiring the U.S. to continue to inspire the next generation of STEM workers, including the skilled technical workforce, for the nation to remain competitive, spur innovation, and grow the economy. [1]

The mission of the Directorate for STEM Education (EDU) is to achieve excellence in U.S. STEM education at all levels and in all settings (both formal and informal) to support the development of a diverse and well-prepared workforce of scientists, technicians, engineers, mathematicians and educators and a well-informed citizenry who have access to the ideas and tools of science and engineering. In fulfilling this mission, EDU seeks to support NSF's mission to enhance the quality of life of all citizens and the health, prosperity, welfare, and security of the nation.

The EDU Core research (ECR) program supports multiple solicitations under the ECR umbrella, including this ECR:Core solicitation and the ECR Building Capacity in STEM Education Research (ECR:BCSER) solicitation, NSF 20-521. This EDU Core research (ECR:Core) solicitation accepts fundamental research proposals in any one or more of the STEM disciplines that address Research Areas and Topic Clusters described in this solicitation. The ECR:BCSER solicitation requests proposals that build individuals' capacity to carry out high quality STEM education and broaden the pool of researchers who can conduct fundamental research.

There is a critical need to develop and accumulate knowledge based on fundamental research (whether curiosity-driven basic or use-inspired basic research [2] on STEM learning and learning environments, broadening participation in STEM, and STEM workforce development. Such foundational knowledge [3] in STEM education is essential to strategically guide the broader set of STEM education investments by the Federal government and other funding agencies and foundations, and to inform the activities of policymakers, researchers, and practitioners. This ECR:Core solicitation invites proposals to conduct fundamental research that advances knowledge across three Research Areas and several research Topic Clusters outlined below.

[1] Subcommittee of the Advisory Committee of the Education and Human Resources Directorate (2020). *STEM Education for the Future: A Visioning Report*. https://www.nsf.gov/ehr/Materials/STEM%20Education%20for%20the%20Future%20-%202020%20Visioning%20Report.pdf

[2] Stokes, Donald (1997). *Pasteur's quadrant – Basic Science and Technological Innovation*. Washington D.C.: Brookings Institution Press.

[3] *Common Guidelines for Education Research and Development* (2013). A Report from the Institute of Education Sciences US Department of Education, and the National Science Foundation, (https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf13126)

II. PROGRAM DESCRIPTION

ECR investments in fundamental research are designed to advance the discovery and testing of general, explanatory knowledge that supports STEM education. Moreover, the ECR program encourages projects that connect to any of the research strategic opportunities as outlined in the NSF Strategic Plan, Building the Future: Investing in Discovery and Innovation - NSF Strategic Plan for Fiscal Years (FY) 2018 - 2022.

ECR is a fundamental research program that supports both curiosity-driven basic and use-inspired basic research. As such, proposals submitted to this ECR:Core solicitation must have strong potential to make important contributions to general, explanatory knowledge (e.g., theories) pertaining to STEM learning and learning environments, broadening participation in STEM, or STEM workforce development. Fundamental research generates knowledge and understanding with the potential for broad relevance. By contrast, applied research, which ECR does not fund, aims to generate knowledge primarily or solely with specific relevance (e.g., to a particular curriculum or technology) with direct and immediate implications for practice. The potential implications of ECR fundamental research for improving STEM education practice may be indirect and long-term rather than direct and immediate. Indeed, the impact on practice might only be realized long after the end of a given project's funding period. ECR:Core projects may also influence other intermediate research domains and communities, both basic and applied, before affecting practice. Whether they include curiosity-driven basic or use-inspired basic research, all successful ECR:Core proposals will focus on the advancement or refinement of foundational knowledge for STEM education.

ECR supports and encourages multidisciplinary and interdisciplinary approaches to developing foundational knowledge for STEM education. The ECR program seeks to create a multidisciplinary portfolio and to fund projects from investigators representing a broad range of disciplinary backgrounds and approaches, including those from fields more typically associated with other NSF directorates and offices. The program encourages investigators to draw on all relevant disciplinary literatures, and to create teams that reach across disciplinary bounds when appropriate. This emphasis on multi- and inter-disciplinarity is consistent with the NSF Big Idea on Convergence: https://www.nsf.gov/news/special_reports/big_ideas/convergent.jsp. However, this ECR:Core solicitation does not require that individual proposals be multi- or interdisciplinary.

ECR supports theoretically, methodologically, and analytically thorough research. The research questions or issues to be addressed in ECR:Core proposals should drive the choice of research design. Research designs may be qualitative, quantitative, or mixed methods. The research design must be described in sufficient detail to allow evaluation of its appropriateness to address the research questions or hypotheses proposed. The research could involve the collection of new data, secondary analyses using extant datasets, or meta-analyses/meta-syntheses. In addition, this ECR:Core solicitation supports research to develop innovative research methods, measurement approaches, and conceptual models to assess existing and emerging phenomena, and to test theories that inform core scientific questions about STEM learning and learning environments, broadening participation in STEM, and STEM workforce development. The Institute of Education Sciences (IES)-NSF Common Guidelines for research may serve as a guide in this regard: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf13126.

ECR embraces fundamental research involving all people in all STEM learning environments, including STEM workplaces. Proposals to ECR:Core could study people who are members of diverse social groups (e.g., race, religion, ethnicity, gender, sexual orientation, language, socio-economic status, disability status, or geography), any age level (from infancy through the lifespan), any grade level (pre-K to graduate), or in any virtual, formal, or informal learning environment.

ECR:Core Research Areas

The ECR:Core portfolio spans three broad and overlapping Research Areas that map to the organizational structure of EDU investments: (1) Research on STEM Learning and Learning Environments, (2) Research on Broadening Participation in STEM fields, and (3) Research on STEM Workforce Development.

Research Area I – Research on STEM Learning and Learning Environments

This ECR:Core solicitation supports fundamental research projects that advance general, explanatory knowledge and understanding about STEM teaching and learning in the many environments and contexts in which such teaching and learning take place. Studies may inform or draw upon research from multiple disciplines that study learning at the level of the learner, the teacher, the learning environment, or the broader institutional or systemic context, as well as other organizations or individuals that may influence STEM learning.

Research Area II – Research on Broadening Participation in STEM

This ECR:Core solicitation supports fundamental research investigating issues related to broadening participation in STEM education and the STEM workforce. Broadening participation research may focus on the individual and/or the organizational factors that positively or negatively impact individuals from diverse groups in STEM. The phrase "diverse groups" refers to people of various races and ethnicities, genders, sexual orientations, and ability who are currently underrepresented in their participation in STEM education and the STEM workforce. In STEM education and workforce contexts, this includes, but is not limited to Blacks/African Americans, Latino/Hispanic Americans, American Indians, Alaska Natives, Native Hawaiians and Other Pacific Islanders, women and girls, and persons with disabilities. Other populations might include English-language learners, veterans, individuals from low-resourced areas, individuals that identify as members of the lesbian, gay, bisexual, transgender, queer (LGBTQ) community, and/or individuals facing challenging socio-economic circumstances. While race, ethnicity, gender, ability, and other identities are listed separately in the previous two sentences, ECR recognizes that these identities do not exist in isolation from each other. Depending on the research questions proposed, the intersection of one or more of these identities may be considered when developing research studies, collecting, and analyzing data, and drawing conclusions from research.

Research Area III – Research on STEM Workforce Development

This ECR:Core solicitation supports fundamental research on STEM workforce development and invites proposals that strengthen general, explanatory knowledge, and understanding about STEM workforce participation, skill-building approaches, workplace knowledge and competencies, learning in workplace contexts, and critical shifts in STEM workforce trends. ECR investments address basic questions concerning how best to prepare a STEM workforce that is ready to capitalize on the latest advances in technology and science, as well as to tackle current and future social and economic challenges. Of particular interest in this research area are frontier topics in the education and training of a workforce for the industries of tomorrow, pushing the boundaries of technology use in STEM workplace learning, and examining how learning will change for STEM workers because of advances in technology or changes in the working environment.

ECR:Core Research Topic Clusters

The ECR:Core solicitation invites proposals with a wide range of disciplinary perspectives and welcomes fundamental research proposals across the three research areas. Proposals submitted to ECR:Core often fall into one or more of the following research topic clusters. This list of research topic clusters is neither exhaustive nor mutually exclusive, and the program is open to other topic clusters that advance fundamental knowledge across the three research areas.

- Diversity, equity, access, and inclusion in STEM education and the workforce.
- Cognitive and neural underpinnings of STEM learning.
- Discipline-based education research in STEM fields.
- Factors at the institutional, structural, organizational, societal, and systemic levels that affect STEM teaching, learning, and participation in STEM education and the workforce.
- Factors at the cultural, affective, psychological, and demographic levels that affect STEM teaching, learning, and participation in STEM education and the workforce.
- Research on technology-enabled learning.
- Studies of the diffusion of knowledge and research on the translation and implementation of advances in STEM education and workforce development.
- Advances in methodology, measurement, and assessment in STEM education and workforce development research.
- Policy research and research that builds on and expands the theoretical foundations for evaluating STEM education and workforce development initiatives.
- Other topics that involve fundamental research in STEM learning and learning environments, broadening participation in STEM, and STEM workforce development.

ECR:Core Proposal Types

The amount of funding and duration requested in proposals submitted to this ECR:Core solicitation should align with the maturity of the proposed work and the size and scope of the empirical effort. The program has three levels of funding with a range of budget sizes, and proposals may request a duration of 3 to 5 years for any level: (1) **Level I proposals** may request up to $500,000; (2) **Level II proposals** may request up to $1,500,000; (3) **Level III proposals** may request up to $2,500,000. **All proposals should justify the level of funding and duration in the project description.**

ECR:Core also welcomes and supports pilot studies, synthesis projects, and conferences related to advancing fundamental knowledge in one or more of the three Research Areas.

Pilot Studies are small-scale, preliminary studies that investigate one or two components of a larger fundamental STEM education study that may be underdeveloped. Pilot studies should produce evidence or findings that help the research team make critical decisions about future work. Pilot study proposals may include high risk strategies or methods that need exploration (piloting) before further research is justified. Pilot studies are considered Level I proposals and should request less than $500,000 and up to a three-year grant period.

Synthesis Proposals combine fundamental knowledge and findings on a topic of critical importance to STEM learning, education, broadening participation, or workforce development. They should strive both to present the state of the knowledge on an area, across disciplines where appropriate, as well as highlight issues for future research. Synthesis proposals should explain and justify the methodological approach (e.g., meta-analysis or meta-synthesis) to be adopted, and should outline the steps for literature identification, decision points (e.g., identifying inclusion and exclusion criteria and outcome measures of interest), and systematic techniques to ensure all relevant research is included and that information is gathered accurately across studies. Proposals should place particular emphasis on the goals and outcomes of the synthesis and the dissemination plan. Synthesis proposals may be budgeted at Level I or Level II.

Conference Proposals plan for well-focused meetings related to the ECR goals to advance fundamental research in STEM learning, education, broadening participation, or workforce development. Budgets should be commensurate with the duration of the event and the number of participants. Proposals should include a conceptual framework for the conference, draft agenda, categories of possible participants, the outcomes or products that will result, and how these products serve the fundamental research goals of the ECR program. Investigators are encouraged to contact a cognizant ECR Program Officer prior to submission. Typical costs are $25,000 to $99,000. Further information about what to include in conference proposals may be found in the NSF Proposal and Award Policy and Procedures Guide. Conference proposals must be prepared and submitted via FastLane or Grants.gov. If using FastLane, proposals must be submitted to the current version of the PAPPG.

III. AWARD INFORMATION

Anticipated Type of Award: Continuing Grant or Standard Grant

Estimated Number of Awards: 40

approximately 15 awards at level I; 12 awards at level II; 5 awards at level III; and 9 other awards.

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

Anticipated Funding Amount: $35,000,000

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. Unaffiliated individuals are not eligible to submit proposals in response to this solicitation.

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 Research.gov or Grants.gov.

- Full Proposals submitted via Research.gov: Proposals submitted in response to this program solicitation should be prepared and submitted in accordance with the general guidelines contained in the *NSF Proposal and Award Policies and Procedures Guide* (PAPPG). The complete text of the PAPPG is available electronically on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg. Paper copies of the PAPPG may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-8134 or by e-mail from nsfpubs@nsf.gov. The Prepare New Proposal setup will prompt you for the program solicitation number.
- 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) 292-8134 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 Research.gov. PAPPG Chapter II.D.3 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.

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

Cover Sheet.

- Select the **ECR:Core solicitation number**.
- **The box for Human Subjects must be checked**; this box should not be left blank. The Human Subjects box should be marked as pending if an Institutional Review Board (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. If human subjects activities are exempt from IRB review, enter appropriate exemption number in the space provided.
- To avoid delays in processing award recommendations, **it is strongly recommended that PIs begin the process of obtaining appropriate IRB approvals or exemptions** as needed for projects involving human subjects. No awards will be made without such approvals or exemptions.

Project Summary. The Project Summary should specify the proposal level (I, II, or III), Research Area of interest (i.e., STEM Learning and Learning Environments, Broadening Participation in STEM, or STEM Workforce Development), and Research Topic Cluster if appropriate. More than one Area and Cluster may be specified. If the proposal is a pilot, conference, or synthesis, that also should be noted in the Project Summary. In addition, the Project Summary should indicate **five key words** that best describe the theory, research methodology, the population to be studied (e.g., age, grade level, gender), any specific STEM disciplinary content that is to be studied (e.g., algebra), or potential stakeholder communities, as appropriate.

Project Description. The Project Description is limited to 15 pages and must comply with all formatting requirements of the PAPPG in effect at the time of submission. Proposals funded under this solicitation must focus on fundamental research questions or hypotheses related to one or more of the three Research Areas described above.

Elements of ECR:Core Proposals: Proposals are strongly encouraged to address the following elements in the 15-page Project Description:

- **Logical connections to an established research base:** All fundamental research proposals should be grounded in and build upon relevant disciplinary literatures. The proposal should make the case for how the established research base and its theoretical underpinnings justify new investment in the proposed line of inquiry, and how the project and its findings are likely to build upon and refine relevant theory.
- **A comprehensive research plan:** Successful ECR:Core proposals include well-focused research questions or testable hypotheses that reflect the current state of knowledge in the area and the theory or conceptual framework being used. The proposal should discuss in detail the methods used to answer the research questions or test the hypotheses posed, along with the types of data to be collected. Proposals should clearly describe the measures, instruments, and procedures to be used in the data collection process and the technical adequacy of the measures, if available. The research plan should also include specific plans for how the collected data will be analyzed to answer the research questions. Studies should be described in sufficient detail so that other researchers can replicate the research as discussed in the *Companion Guidelines on Replication and Reproducibility in Education Research (https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf19022)*. Methods should directly link to the theory or theories being used. The proposal should describe the participant sample, along with the rationale for sample selection, and the investigator's access to the sample. Proposers should clearly define the study participants, and address whether the design is premised on the needs and interests of participants. Such needs may be premised on individual and group characteristics, such as educational level, gender, race, ethnicity, economic status, or disability. When theoretically and methodologically appropriate, proposals would discuss how data might be disaggregated for multiple characteristics.
- **A plan to assess success of the project:** Plans for carrying out proposed activities should be well-reasoned, well-organized, based on a sound rationale, and incorporate a mechanism to assess success. Projects are expected to document, and report progress toward the accomplishment or trustworthiness of intellectual merit and broader impact goals, objectives, and outcomes defined in the proposal, including any anticipated impacts on potential stakeholder communities. Proposals should include plans for soliciting and addressing external feedback (e.g., through an advisory board, evaluation plan, or other evaluative mechanisms).
- **A plan for sharing the research and results:** Proposals should include a strategy for dissemination and transparency of the research, and for reaching a broad audience with the findings of the project. Transparency and dissemination activities may include preregistration, providing data or code, and increasing the availability of published research. Reaching a broader audience may include, where appropriate, using various media to communicate findings to practitioners, policy makers, and public audiences and stakeholder communities. The potential results of the proposed research are expected to be of sufficient significance to merit peer-review and broader publication. (For additional information on communicating research results see the resources available from the American Association for the Advancement of Science's Center for Public Engagement with Science & Technology.)
- **A justification for project level and duration:** ECR:Core expects all proposals to provide a strong rationale for the duration and level of funding requested, with more detailed elaboration in the budget justification. Proposals that request the highest level of funding are particularly expected to discuss the need for resources.

Other Required Sections: Per guidance in the PAPPG, the Project Description must contain, as a separate section within the narrative, a section labeled **Broader Impacts** that includes a discussion of specific broader impacts goals and outcomes and a plan and resources allocated to achieve them (more information about Broader Impacts may be found in the NSF PAPPG and on the NSF website). Proposers may decide where to include this section within the Project Description. The proposal must also describe **Results of Prior NSF Support** for related projects in which the PI or co-PI have been involved, as outlined in the NSF PAPPG.

Budget and Budget Justification. Budgets should be in NSF format and include up to five pages of budget justification. The budget justification should be in narrative form and include detailed explanations for each line item with budget resources listed in the budget. Information about what may or may not be included in the budget or budget justification is outlined in the NSF PAPPG or NSF *Grants.gov Application Guide*. For proposals with subawards, each subaward must include a separate budget and budget justification of no more than five pages.

Funds should be budgeted for the principal investigator or a project member to attend a two-day grantees' meeting in the Washington, D.C. area every other award year.

Supplementary Documentation.

Supplementary documents should include **Letters of Collaboration** from project partners, the **Postdoctoral Mentoring Plan** *(if applicable*), the **Data Management Plan (DMP)** as described in the NSF PAPPG, and a **List of Project Personnel** described below. Letters of support from persons endorsing the project but not making a substantial commitment to the project are not allowed. Inclusion of any other information in the supplementary documents or as an appendix will result in the proposal being returned without review.

Data Management Plans: All data collected for ECR:Core projects must accord with the revised EDU Data Management Guidance, which may be found here: https://www.nsf.gov/bfa/dias/policy/dmpdocs/ehr.pdf. DMPs will be reviewed by panelists and program directors and should be written with sufficient clarity and detail to support proposal processing and the merit review process. Generic DMPs should be avoided. Each DMP should describe the data, metadata, samples, software, curricula, documentation, publications, and other materials to be generated during the proposed research. DMPs should reflect the best practices and standards for the proposed research and types of data being generated, whether experimental, computational, text-based, media or physical materials. ECR expects its awardees to describe how data and related materials are generated to allow others to reproduce the research study. Further the DMP should support the sharing of data, products, and methods in such a way that others can understand, validate, replicate, and build upon the research findings. For more information, please consult the recently released Companion Guidelines on Replication and Reproducibility in Education Research.

List of All Project Personnel: In addition to guidance provided in the PAPPG on required Special Information and Supplementary Documents, provide a list of

all project personnel in the Supplementary Document section. Include 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, postdoctoral researchers (if known), 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:

1. Ebony Johnson-Smith; XYZ University; PI
2. John Garcia; University of PQR; Senior Personnel

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

Single Copy Documents.

Collaborators and Other Affiliations Information: Collaborators & Other Affiliations (COA) information specified in the PAPPG should be submitted using the instructions and spreadsheet template found at https://nsf.gov/bfa/dias/policy/coa.jsp.

B. Budgetary Information

Cost Sharing:

Inclusion of voluntary committed cost sharing is prohibited.

C. Due Dates

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

  October 12, 2021

  October 06, 2022

  First Thursday in October, Annually Thereafter

D. Research.gov/Grants.gov Requirements

For Proposals Submitted Via Research.gov:

To prepare and submit a proposal via Research.gov, see detailed technical instructions available at: https://www.research.gov/research-portal/appmanager/base/desktop?_nfpb=true&_pageLabel=research_node_display&_nodePath=/researchGov/Service/Desktop/ProposalPreparationandSubmission.html. For Research.gov user support, call the Research.gov Help Desk at 1-800-673-6188 or e-mail rgov@nsf.gov. The Research.gov Help Desk answers general technical questions related to the use of the Research.gov 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: https://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 Research.gov may use Research.gov 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 *Building the Future: Investing in Discovery and Innovation - NSF Strategic Plan for Fiscal Years (FY) 2018 – 2022*. 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 other underrepresented groups 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.

B. Review and Selection Process

Proposals submitted in response to this program solicitation will be reviewed by Ad hoc Review and/or 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) 292-8134 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=pappg.

Administrative and National Policy Requirements

Build America, Buy America

As expressed in Executive Order 14005, Ensuring the Future is Made in All of America by All of America's Workers (86 FR 7475), it is the policy of the executive branch to use terms and conditions of Federal financial assistance awards to maximize, consistent with law, the use of goods, products, and materials produced in, and services offered in, the United States. Consistent with the requirements of the Build America, Buy America Act (Pub. L. 117-58, Division

Consistent with the requirements of the Build America, Buy America Act (Pub. L. 117-58, Division G, Title IX, Subtitle A, November 15, 2021), no funding made available through this funding opportunity may be obligated for an award unless all iron, steel, manufactured products, and construction materials used in the project are produced in the United States. For additional information, visit NSF's Build America, Buy America webpage.

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 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=pappg.

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:

- Address questions to the program, telephone: (703)292-2333, email: ECR@nsf.gov

For questions related to the use of FastLane or Research.gov, contact:

- FastLane and Research.gov Help Desk: 1-800-673-6188
- FastLane Help Desk e-mail: fastlane@nsf.gov
- Research.gov Help Desk e-mail: rgov@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 https://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:** 2415 Eisenhower Avenue, Alexandria, VA 22314
- **For General Information** (NSF Information Center)**:** (703) 292-5111
- **TDD (for the hearing-impaired):** (703) 292-5090
- **To Order Publications or Forms:**

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

  or telephone: (703) 292-8134
- **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 System of Record Notices, NSF-50, "Principal Investigator/Proposal File and Associated Records," and NSF-51, "Reviewer/Proposal File and Associated Records." 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
Policy Office, Division of Institution and Award Support
Office of Budget, Finance, and Award Management
National Science Foundation
Alexandria, VA 22314