NSF-EHR Framework for Improving Science, Technology, Engineering and Mathematics Education R & D

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National Science Foundation
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Directorates

- Biological Sciences
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Directorate for Education and Human Resources

- Division of Undergraduate Education (IUSE; ATE; NOYCE; STEM-C)
- Division of Graduate Education (GRFP; IGERT; GK 12)
- Division of Human Resource Development (ADVANCE; AGEP; HBCU; TCUP)
- Division of Research on Learning in Informal and Formal Settings (CORE; ITEST; DR K 12; REAL; AISL; STEM-C)
Reflections on STEM R & D

- It is essential to have a coherent and deep scientific research base that informs/guides efforts to meet national STEM education and workforce development needs/priorities.

- Need CORE research projects that address broad, essential, enduring, and challenges of great importance and are designed to inform the transformation of STEM learning and education.

- Continue to support research projects that are potentially transformative and innovative.
Example of a Core Program

Environmental Sustainability

Education and the Economy

Public Safety

Health

Health and Education

**Foundations for Innovation**

In addition to participating in NSF-wide initiatives and special programs, the Division of Earth Sciences consists of core scientific programs that fund both larger- and small-scale projects. These core programs support cutting-edge research that advances scientific understanding, and help to address pressing global issues, including the provision of clean water, the prediction of natural disasters, understanding human impacts on our environment and resource management.

The core programs within the Division of Earth Sciences support innovative research that forms the pillars of the broader cross-cutting research encouraged by NSF-wide initiatives.

The core programs are devoted to supporting fundamental and focused science that is not driven by a specific mission or directive. This allows for free-flowing creativity that can lead to the innovation necessary for great advances. Furthermore, this core understanding is the key enabler of broader-scale interdisciplinary research. Core scientific knowledge fuels interdisciplinary advances.
NSF EHR CORE

STEM LEARNING

STEM LEARNING ENVIRONMENTS

STEM WORKFORCE DEVELOPMENT

BROADENING PARTICIPATION IN STEM
STEM Learning

- Learning of specific STEM disciplinary knowledge and practices across different groups of learners, contexts, and environments
- Learning includes cognitive, social and behavioral competencies
- Range of theoretical and methodological approaches, including the use of “big data”
- Focus on learning at the frontiers of STEM disciplines and interdisciplinarity
STEM Learning Environments

- Range of formal and informal learning environments across the K-16 landscape
- Develop an understanding of how characteristics of learning environments interact with or support multiple aspects of STEM learning
- Special focus on emerging learning environments and evidence-based approaches to undergraduate STEM instruction
- Multiple theoretical and methodological perspectives
STEM Workforce Development

- Preparation of a diverse, globally-prepared and highly-skilled STEM workforce - including teachers
- Focus on entire STEM workforce continuum, from Pre-K to postdoctoral training to career
- Emphasis on academic and non-academic STEM career pathways and transitions across changing contexts and climates
- Connecting workplace expectations to design of interventions
Broadening Participation in STEM

- Practices that broaden participation, retention, and success of individuals underrepresented in STEM
- Preparing students for successful transition to further education or training, or the STEM workplace
- Study of accessibility and the impacts of technology on diverse populations
- Measures, processes and metrics to assess impacts and outcomes of broadening participation and institutional capacity building (e.g. on STEM innovation/productivity)
NSF Merit Review Principles

- 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.
- 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.
NSF Review Criteria

All proposals are evaluated against the two NSB-approved review criteria:

- **Intellectual Merit**: criterion encompasses the potential to advance knowledge

- **Broader Impacts**: criterion encompasses the potential to benefit society and contribute to the achievement of specific, desired societal outcomes
NSF Suggested Questions for Intellectual Merit & Broader Impact

1. What is the potential for the proposed activity to:
   - **Advance knowledge** and understanding within its own field or across different fields (Intellectual Merit); and
   - **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?
Additional Proposal Considerations

- **Project evaluation**
  - Evaluation plan appropriate to project goals and descriptive of project assessment approach
  - Substantive external expert review mechanism

- **Project personnel and management**
  - Research and management roles of senior personnel
  - Roles and responsibilities of students and other trainees
  - Mentoring plan for postdoctoral researchers

- **Dissemination strategy**
Additional Proposal Considerations

- Letters of agreement to participate
  - All appropriate organizations
  - Members of advisory committees

- Research design and methodology
  - Appropriate and rigorous research methods
  - Well-documented usable, and replicable models, frameworks, data, literature, and measures
  - Well-justified methods, consonant with theory, and suited to the stated questions or hypotheses
Common Guidelines for Education Research and Development

U.S. National Science Foundation and U.S. Department of Education
What do we mean by “Common Guidelines?”

A cross-agency framework that describes:

- Broad types of research and development
- The expected *purposes, justifications, and contributions* of various types of research to knowledge generation about interventions and strategies for improving learning
Why do we need “Common Guidelines?”

- The American education system needs stronger evidence provided at a faster pace
- More constrained federal resources demand that NSF and ED purposefully build on each other’s research and development portfolios
- A cross-agency vocabulary and set of research expectations is critical for effective communication
Implications of the NSF/IES Common Guidelines

- Guidelines can help stakeholders develop a better understanding of what different stages of education research should address and might be expected to produce
  - Helps stakeholders understand what to expect from different types of research findings
  - Supports more informed decisions based on the level of evidence
  - Provides a shared sense of what is needed as stakeholders engage with research to improve educational practices
Knowledge Development in Education

- Is not strictly linear, but multi-directional. Investigations can sometimes move directly from development of core knowledge to Scale-up.
- Requires efforts of researchers and practitioners representing a range of disciplines and methodological expertise.
- May require more studies for basic exploration and design than for testing the effectiveness of a fully-developed intervention or strategy.
- Requires assessment of implementation—not just estimation of impacts.
- Includes attention to learning in multiple settings (formal and informal).
CORE KNOWLEDGE

- Foundational Research
- Exploratory/Early Stage Research
Foundational Research

Fundamental knowledge that may contribute to improved learning & other education outcomes

Studies of this type:

◦ Test, develop or refine theories of teaching or learning
◦ May develop innovations in methodologies and/or technologies that influence & inform research & development in different contexts
Early-Stage or Exploratory Research

- Examines relationships among important constructs in education and learning
- Goal is to establish logical connections that may form the basis for future interventions or strategies intended to improve education outcomes
- Connections are usually correlational rather than causal
Design and Development Research
Design and Development Research

- Draws on existing theory & evidence to design and iteratively develop interventions or strategies
  - Includes testing individual components to provide feedback in the development process
- Could lead to additional work to better understand the foundational theory behind the results
- Could indicate that the intervention or strategy is sufficiently promising to warrant more advanced testing
STUDIES OF IMPACT

- Efficacy Research
- Effectiveness Research
- Scale-Up Research
Studies of Impact generate reliable estimates of the ability of a fully-developed intervention or strategy to achieve its intended outcomes.

Efficacy Research tests/examines whether an intervention or strategy can improve outcomes under what are sometimes called “ideal” conditions.

Effectiveness Research tests/estimates the impacts of an intervention or strategy when implemented under conditions of routine practice.

Scale-Up Research examines/estimates the impacts of an intervention or strategy under conditions of routine practice and across a broad spectrum of populations and settings.
Another Way of Thinking About Different Impact Studies (Dearing)

- Internal validity research is about **efficacy**
- External validity research is about **effectiveness**
- Dissemination research is about **efficiency**
- Implementation research is about **compatibility**
### Important Features of Each Type of Research

<table>
<thead>
<tr>
<th>Purpose</th>
<th>How does this type of research contribute to the evidence base?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Justification</td>
<td>How should policy and practical significance be demonstrated?</td>
</tr>
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</table>
## Important Features of Each Type of Research

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Generally speaking, what types of outcomes (theory and empirical evidence) should the project produce?</th>
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<tbody>
<tr>
<td></td>
<td>What are the key features of a research design for this type of study?</td>
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</table>

Comparison, in brief: JUSTIFICATION

- A clear description of the *practical education problem* and a compelling case that the proposed research will inform the development, improvement, or evaluation of education programs, policies, or practices
- A strong *theoretical and empirical rationale* for the project, ideally with citations to evidence
Comparison, in brief: JUSTIFICATION

<table>
<thead>
<tr>
<th>Design and Development Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>▶ A clear description of the <em>practical problem</em> and the initial concept for the planned investigation, including a well-explicated <em>logic model</em></td>
</tr>
<tr>
<td>▶ In the logic model, identification of <em>key components of the approach</em>, a description of the relationships among components, and <em>theoretical and/or empirical support</em></td>
</tr>
<tr>
<td>▶ Explanation of how the approach is different from current practice and why it has the potential to improve learning</td>
</tr>
</tbody>
</table>
Comparison, in brief: JUSTIFICATION

- Clear description of the intervention/strategy and the *practical problem* it addresses; how intervention differs from others; and connection to learning
- *Empirical evidence of promise* from a Design and Development pilot study, or support for each link in the logic model from Exploratory/Early Stage research, or *evidence of wide use*
- Justification for examining impact under ideal circumstances, rather than under routine practice conditions
Comparison, in brief: OUTCOMES

<table>
<thead>
<tr>
<th>Exploratory/Early Stage</th>
<th>Empirical evidence regarding associations between malleable factors and education or learning outcomes</th>
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<tr>
<td></td>
<td>A conceptual framework supporting a theoretical explanation for the malleable factors’ link with the education or learning outcomes</td>
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<tr>
<td></td>
<td>A determination, based on the empirical evidence and conceptual framework, of whether Design and Development research or an Efficacy study is warranted, or whether further Foundational or Exploratory/Early-Stage research is needed</td>
</tr>
</tbody>
</table>
## Comparison, in brief: OUTCOMES

<table>
<thead>
<tr>
<th>Design and Development Research</th>
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</thead>
<tbody>
<tr>
<td>▶ A <em>fully-developed version</em> of the intervention or strategy</td>
</tr>
<tr>
<td>▶ A well-specified <em>logic model</em></td>
</tr>
<tr>
<td>▶ Descriptions of the <em>major design iterations</em>, resulting evidence, and adjustments to logic model</td>
</tr>
<tr>
<td>▶ Measures and data demonstrating project’s <em>implementation success</em></td>
</tr>
<tr>
<td>▶ <em>Pilot data on the intervention’s promise</em> for generating the intended outcomes</td>
</tr>
</tbody>
</table>
Comparison, in brief: OUTCOMES

- **Detailed descriptions** of the study goals, design and implementation, data collection and quality, and analysis and findings

- **Implementation documented** in sufficient detail to judge applicability of the study findings; when possible, relate these factors descriptively to the impact findings

- **Discussion of the implications** of the findings for the logic model and, where warranted, make suggestions for adjusting the logic model to reflect the study findings
Project Narrative

- **Project Outcomes**
  - Detailed descriptions of the study goals, design and implementation, data collection and quality, and analysis and findings

- **Research Plan**
  - Study design used to estimate causal impact of the intervention on the outcomes of interest
  - Key outcomes of interest for the impact study and the minimum impact that would have policy or practical relevance
  - Study setting(s) and target population(s)
  - The sample
  - The data collection plan
  - The analysis and reporting plan
Thank You!!!