Identifying and Developing Talent in Science, Technology, Engineering, and Mathematics (STEM): An Agenda for Research, Policy, and Practice

The recent National Academies publication, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (NRC, 2006), identifies highly educated and innovative scientists, engineers, and technologists as precious resources to secure a bright economic future for the United States. Members of Congress have responded to this important report with bills designed to strengthen science and mathematics education and increase the number of college graduates with STEM degrees. The President has proposed similar efforts in the name of "American Competitiveness." State legislators have followed suit, and many states are now considering new initiatives and policies such as increasing secondary mathematics and science course requirements in order to prepare students for the 21st century and to build capacity for innovation. Among these and other efforts to improve STEM education, one critical but often overlooked need is seeding the next generation of leaders in science and technology by identifying youth possessing exceptional talent in STEM and helping to ensure the quality of their educational experiences and their interest in STEM careers.

In response to this need, a STEM Talent Development Organizing Committee comprised of representatives from the *American Psychological Association*, the *National Commission on Teaching and America's Future*, the *National Institutes of Health*, the *National Science Foundation*, and the *U.S. Department of Education* commissioned the *Center for Education (CFE) of the National Academies* to hold an invitational forum in September of 2006 on the topic of identifying and developing exceptional talent in the STEM disciplines. While attention to issues of STEM talent identification and development are relevant throughout the years of schooling, this effort focused on the middle and high school years because of the prevalence of special STEM talents programs for such students and the fact that these are particularly critical years in shaping students' long-term interests and career trajectories. Forum participants included representatives from current STEM talent development initiatives and from scientific and technical societies; prominent researchers on expertise, creativity, and eminence in scientific domains; and federal and state education officials.

The knowledge base that formed the background for the forum draws heavily on recent research from cognitive science on how people learn. Among the most critical findings from this work are that successful learning depends on: (1) engaging students' prior understandings in the learning environment; (2) supplying students with both factual knowledge and a conceptual framework on which to hang that knowledge; and (3) successfully instructing students on how to monitor their own learning (NRC, 1999). Further, it is increasingly agreed upon that successful learning is domain specific (NRC, 2005a, 2005b, 2007). In science, such learning involves both content knowledge and understandings of how scientists develop ideas about the natural world, or the processes of science. This means that in the scientific disciplines, models, theories, and hypotheses are valued to the extent that they make testable precise predictions for as yet unmeasured or unobserved effects; provide a coherent conceptual framework that is consistent with a body of facts that is known; and offer suggestions of new paths for further study (NRC, 2007). Recent evidence-based concepts of student "proficiency" in mathematics or science are based on students knowing more than discrete pieces of content, but rather having the ability to

link deeper conceptual understanding specific to their discipline with such content knowledge (NRC 2001, 2007). These ideas should undergird STEM teaching and learning for all students, and are of critical value to the education of talented students, who, with appropriate instruction, can be expected to exceed proficiency standards.

The forum sought to bring together evidence on learning with research on talent and the wisdom accrued from talent development programs. Invited speakers at the forum included those who have investigated the concept of talent, who have managed current approaches for identifying and developing STEM talent in middle school and high school, and who have considered how to evaluate the success of STEM talent development programs. The participants sought to address the available evidence and implications for research, policy, and practice in response to the following questions:

1) How is "talent" conceptualized in STEM? Is talent domain specific, and is it amenable to development through appropriate program initiatives?

2) Which outcome measures are most appropriate for assessing the effectiveness of STEM talent development efforts in middle and high school (e.g., completing an undergraduate STEM major in undergraduate education, entering a STEM career, becoming a leading scientist or innovator)?

3) How is STEM talent currently identified? Is this the best way to continue? How might STEM talent be identified in ways that would expand and diversify the talent pool?

4) What evidence is available to assess the impact and effectiveness of current STEM talent development programs both for traditional and underrepresented populations? What research evidence might inform the design of new program models?

An audio file of this event as well as commissioned papers prepared for the meeting can be found at
http://www7.nationalacademies.org/cfe/STEM%20Talent%20Dev%20Agenda%209-26-06.html

Based on the reaction and response to the presentations and facilitated group discussion, the assembled experts identified a number of critical issues in STEM talent development and suggested specific initiatives for research, policy, and practice. They focused their attention on meeting the needs of two distinct groups:

- Students with "developed" talent as reflected in significant accomplishments, intense curiosity, and motivation;
- Students with interest and potential STEM talent but who have not had access to opportunities allowing the talent to be adequately identified or developed.

The forum highlighted how efforts to address the needs of each of these groups are often stymied by poor alignment between current policies/practices for identifying and developing STEM talent and what high quality research, preliminary policy analysis, and the judgment of expert practitioners suggest is needed. Among the critical disjunctions noted were:

- A significant shortfall in the supply of STEM talent development opportunities relative to the number of students who could potentially benefit from such opportunities

- A lack of clearly articulated goals for a significant number of existing STEM talent development initiatives

- A lack of attention to student motivation and engagement as both factors in identifying STEM talent and as objectives for talent development programs

- Inadequate exposure to the nature of the scientific enterprise and the full complement of knowledge, skills, and dispositions that are associated with successful careers in different parts of this enterprise

- The absence of a sound knowledge base for determining which initiatives and strategies are most likely to prove effective in meeting particular program objectives

- Inadequate mechanisms for identifying and selecting students for STEM talent programs relative to what we know from the best research in cognitive science about the critical characteristics that define STEM talent

An Agenda for Research, Policy, and Practice

The outcomes of the forum suggested a series of high priority agenda items for research, and policy/practice. The following framework for implementing research and policy initiatives is intended to lead to the creation and spread of new models and programs holding real promise for substantially improving both the quantity and quality of talent in STEM. Initiatives should be developed, funded, and carried out in ways that allow current practitioners the opportunity to improve their efforts based on the best available evidence while also accumulating new knowledge to support future improvements in policy and practice

The agenda items identified reflect two strands of work, (1) information gathering and dissemination and (2) new knowledge accumulation, which when pursued in tandem will channel appropriate information to the development of more effective STEM talent policies and programs.

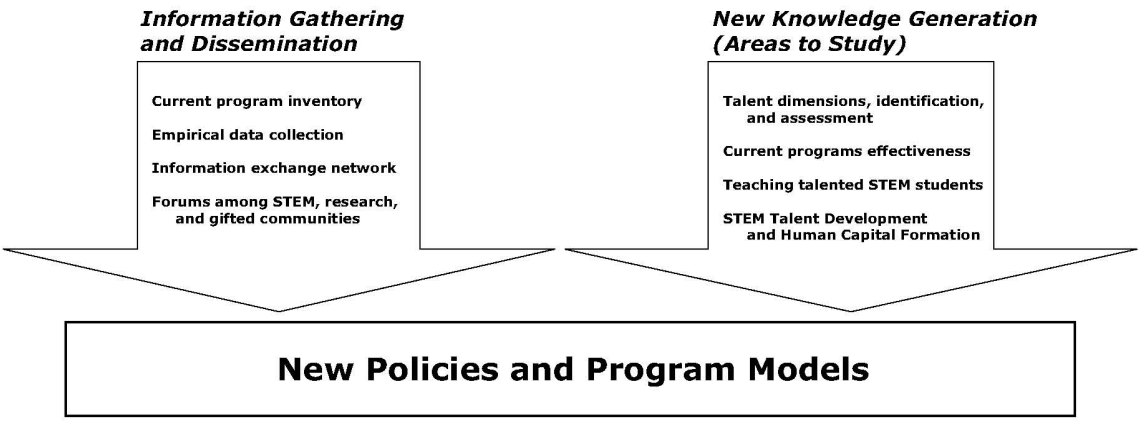

Figure 1: Two proposed strands of work -- information gathering and dissemination and new knowledge generation

Information Gathering/Dissemination

- Creating a comprehensive inventory of STEM talent opportunities, key characteristics, and availability – i.e. a consumer guide to STEM talent opportunities.

- Collecting empirical national data to demonstrate the need and shortage of opportunities such as the numbers of talented applicants that are turned away from development programs

- Establishing a STEM talent information exchange network consisting of resource listings, people to contact with particular expertise, updates on relevant research, best practice models etc.

- Developing a forum or forums among STEM, social and behavioral science research, and gifted communities to discuss definitions of STEM success, expansion of the talent base, the interaction of in-school and out-of-school talent development, or the resolution of conflicting positions around identification and development of talent.

New Knowledge Generation

- Conceptualizing the critical **dimensions** of STEM talent -- those specific to sub-disciplines and those that transcend them and those specific to different types of talent (e.g. initiators of ideas, developers of ideas, appliers of ideas) – and understanding the cognitive abilities (e.g., verbal, spatial, and mathematical intelligence) and dispositional factors (e.g., motivation, curiosity, and perseverance) that are associated with different STEM talent dimensions. Then studying the **identification and assessment** of talent in STEM that would be framed around the robust

conceptualization of talent dimensions but would also consider the strengths and limitations of current procedures based on what we know from cognitive science and related fields (including measurement/psychometrics).

- Analyzing current models of STEM talent development and evidence of their effectiveness including how first world countries are developing STEM talent in the pre-university years.

- Understanding the approaches used by expert teachers to identify and serve STEM talented students.

- Testing the premise that greater investments in STEM education, particularly those efforts to develop talent, are, in the long run, cost effective because they benefit economic growth and development.

New Polices and Program Models

- Undertaking a campaign to raise the status of STEM careers with a plan that is sustainable for the long-term. This campaign would need to addresses negative public associations, such as charges of elitism, and stress the continuous and ongoing national need for talent identification and development in the academic domains, particularly in STEM.

- Developing and promulgating real-world program models and government/foundation cost sharing models for meeting the unmet demand for STEM talent development opportunities in local school systems.

- Developing policies based on outcomes of research initiatives -- such as piloting research-based identification schemes; adopting ideas from other countries; combining the best aspects of various in- and out-of-school programs into a new evidence based model to be piloted; and embedding into teacher education and professional development best practices that have been shown to enable identification and development of talent.

Such effective new policies and programs for identification and development of talent in STEM can be developed as a direct outgrowth of the aforementioned investments in information gathering/dissemination and new knowledge generation. The forum has set the stage for exploring specific ways to launch and sustain this critical national agenda with leaders in the public, foundation, and corporate sectors.

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