US House of Representatives
Science, Space and Technology Committee
Subcommittee on Research and Science Education
Hearing: *Oversight of the Networking and Information Technology Research and Development Program and Priorities for the Future*

Testimony of
Dr. Robert Schnabel
Dean, School of Informatics; Professor, Computer Science and Informatics, Indiana University
Chair, Education Policy Committee, Association for Computing Machinery

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On behalf of Indiana University, its School of Informatics, the Association for Computing Machinery, its Education Policy Committee, the members of the Computing in the Core Coalition and myself, thank you, Chairman Brooks, Ranking Member Lipinski, and Members of the Subcommittee, for the opportunity to share comments on the Networking and Information Technology Research and Development (NITRD) program with you.

I have been involved in computing and the computing community for nearly 40 years. Prior to assuming my current dean position in 2007, this includes 30 years at the University of Colorado at Boulder as a professor of computer science, and service as chair of Computer Science, associate dean for academic affairs in the College of Engineering and Applied Science, Vice Provost for Academic and Campus Technology and CIO, and founding director of the Alliance for Technology, Learning and Society (ATLAS) Institute. I also am a co-founder and executive team member of the National Center for Women & Information Technology.

Computing is transforming our world -- driving innovation in numerous fields, leading to entirely new multi-billion dollar industries creating thousands of new jobs, and transforming how we live, work, and socialize. Fueling this engine of innovation are the investments that various agencies have made in the computing research enterprise and the workforce that supports it. The Networking and Information Technology Research and Development program (NITRD) plays a key role in coordinating and focusing these federal programs.

Summary of Recommendations Concerning Education and Workforce

H.R. 2020, as passed the House in the 111th Congress, proposes enactment of the President's Council of Advisors for Science and Technology (PCAST) recommendations for assessment and strategic planning by the NITRD program. These elements will strengthen the overall NITRD program. We particularly appreciate and strongly support the committee's inclusion in H.R. 2020 that NITRD address both education and workforce issues, including the diversity of the IT student and workforce population, as part of its strategic planning process.

If we are to continue to discover and develop the innovations that have created new industries and transformed others, we need to ensure a healthy IT workforce that is skilled and large enough to meet the nation's growing IT needs, and reflects the gender and racial diversity of our nation. While university computing and IT education and research programs have done a good job of changing with the times to meet current needs, the education pipeline feeding our workforce is not producing enough graduates in IT fields to meet the growing needs of the computing industry, let alone the other industries that rely on computing and the public agencies that need computing professionals. In addition, women and many minority groups are greatly underrepresented among computing and IT students and in the IT workforce, depriving the nation both of potential skilled workers and of the innovation that results from diverse teams.

A key element of this pipeline is in crisis and is directly related to the insufficient number of students in university computing and IT programs: K-12 computer science education. If we do not address the issues in K-12 computer science education, students will have few opportunities to experience this critical discipline or its concepts before higher education and our computing pipeline will continue to suffer. NITRD and the National Coordinating Office (NCO) can play a key role in addressing obstacles standing in the way of strengthening K-12 computer science education. As the committee works toward considering a new NITRD reauthorization, we recommend Congress add additional provisions for NITRD programs to specifically address the systemic issues facing K-12 computer science education, namely:

- **NITRD programs should report to NCO what steps they are taking to address K-12 computer science education reform.**
- **Include the Department of Education in the NITRD program.**
- **Include and clearly define computer science in federal education programs.**
- **Create state planning and implementation grants for computer science K-12 curriculum and build national networks of support for K-12 computer science education.**
- **Create pre-service and professional development opportunities for K-12 computer science teachers.**

The remainder of this testimony expands upon the preceding points.

<u>NITRD's Important Role In Sustaining Innovation</u>

Information technology, driven by public and private research funding, has transformed our society and our economy. As amazing as the progress of the last twenty years is in this regard, the future can be even more amazing, if public and private players sustain our IT research ecosystem. Historically, the diversity of our NITRD agencies has been a major strength, fostering multiple approaches to complex problems. The Internet began as a Defense Advanced Research Projects Agency (DARPA) project, grew with National Science Foundation (NSF) support and blossomed with commercial funding. The Human Genome Project was a triumph of biomedicine and IT, building on National Institutes of Health, DARPA, NSF and Department of Energy research and birthing personalized medicine.

A key element of the NITRD program involves fostering communication and coordination across thirteen federal agencies where IT is relevant. This creates a rich ecosystem for information technology research and development, spanning many programs. The legislation proposed in the 111th Congress strengthens the program by addressing several key recommendations forwarded in 2007 by the President's Council of Advisors on Science and Technology.

As the National Coordinating Office (NCO) begins to develop strategic plans for computing research, it also should consider how agencies are meeting the ongoing challenge of supporting the continual broadening of the field of computing and information technology. I am closely acquainted with this broadening as the Dean of the School of Informatics at Indiana University, which offers a variety of undergraduate and graduate degrees in both computer science and informatics to meet the growing needs of the NIT workforce. These programs include research ranging from the foundational aspects of computer science to a wide range of applications and human and societal implications of computing and IT. It is important that NITRD programs embrace this breadth of research areas, as well as the growing diversity of university departments and schools that are part of the computing and IT field.

One area of particularly great and increasing national importance in both research and education is health IT. The challenges that this area addresses range from assuring that the federal government and the country's health care system meets the needs of modernizing and standardizing health records, to providing powerful and easy-to-use information technology systems that support health care providers, to creating tools and systems that allow individuals to monitor and improve their own health independently. It is clear there are tremendous needs and opportunities in Health IT, and this area should be considered as a strategic focus for NITRD.

Addressing Our Workforce and Education Needs

While everyone is talking about jobs these days—where to find them, how to create them—the computing industry is clamoring for the talent it needs to fill thousands of vacancies. The U.S. Bureau of Labor Statistic projects that the computing sector will have 1.5 million job openings over the next 10 years, making this one of the fastest growing economic fields. There are many pathways into these jobs, but a deeper look at the fastest growing occupations within this field (such as computer software engineers or computer and network systems analysts) shows they either will require a computer science or related degree or greatly benefit from the knowledge and skills imparted by computer science courses. It is gratifying to see that the report "Networking and Information Technology: Workforce Study" presented to NITRD in May 2009 by SRI, corroborated these widely used workforce projections.

Further, CNN's *Money* and PayScale.com ranked the "Best Jobs in America", and the number one job is Software Architect. Other computer science career paths also were high on the list, including Database Administrator at number 7, Information Systems Security Engineer at 17, Software Engineer at 18, and at least 10 other computing careers ranking in the top 50. I commonly forward articles about the jobs that are most in demand to our school's career services office; computing and IT jobs are virtually always on these lists.

During the past several decades, computing and IT has grown to address these needs. We have moved from a field focused on the foundational systems that make computers run (e.g. operating systems, programming languages) and applications in scientific computing and business data processing, to also encompass a wide array of general purpose computer applications (e.g. databases, computer graphics, robotics, computer security, graphical user interfaces) and discipline-oriented applications (e.g. bioinformatics, health informatics). Higher education has adapted both by greatly broadening the scope of computer science at many universities to embrace this breadth and by adding new schools of computing, informatics and information that enlarge or complement them.

In general, the students that are being produced by university computing and IT programs are meeting the needs of the IT workforce well; there are just far too few of them. Despite the tremendous job opportunities that computer science knowledge offers:

- Participation in AP Computer Science has been flat for a decade[1];
- Interest in majoring in computer science among incoming freshman is at an all-time low[2]; and
- There is little ethnic and gender diversity among those who take computer science courses[3].

This relates to insufficient exposure to computer science in K-12. We regard this as a fundamental issue that federal, state and local governments need to address to achieve its workforce needs.

ACM has been on the forefront of efforts to strengthen K-12 computer science education for years. Last year it spearheaded the formation of the Computing in the Core coalition to raise the national profile of K-12 computer science education. The founding members of this coalition are major stakeholders in the field of computing ranging from industry—Microsoft, Google, and SAS—to non-profit organizations, including the Association for Computing Machinery, Computer Science Teachers Association, National Center for Women and Information Technology, Computing Research Association, and Anita Borg Institute. Recently, the Coalition has grown to include the College Board, the National Council of Teachers of Mathematics and the National Science Teachers Association. Computing in the Core is united in our commitment to improving computer science education, which we strongly believe is marginalized in K-12 classrooms nationwide today.

The marginalization of K-12 computer science education is a result of numerous federal, state and local education policies that do not make room for K-12 computer science education, coupled with deep confusion about what computer science education is in elementary, middle and secondary schools. A recent study, *Running On Empty: The Failure to Teach K-12 Computer Science in the Digital Age*[4], revealed K-12 computer science education is currently focused on basic skills, which teach students how to consume technology, versus acquiring deeper knowledge and skills which teach them to create new technologies. Further, only nine states "count" computer science courses toward a core academic graduation credit. Finally, few states have robust teacher certification programs for K-12 computer science teachers.

The systemic absence of rigorous and engaging computer science in K-12 education starts at the local level, but there is a set of recurring policy issues that the Federal Government and the NITRD program can take strides to address:

- There are few states that have standards for computer science education and there are virtually no assessments for computer science education.

1 Growth in AP Computer Science tests taken has remain flat for the past decade while AP tests in other STEM fields has grown rapidly, see: http://www.acm.org/public-policy/AP.jpg

2 Source: UCLA Higher Education Research Institute Survey of Incoming Freshman

3 According to the National Center for Women and Information Technology, computer science education has significant equity barriers. In 2008, only 17 percent of Advanced Placement (AP) computer science test takers were women, and only 4 percent (784 students) were African American.

4 This study can be found at http://www.acm.org/runningonempty

- Professional development for computer science teachers is limited as resources are focused away from this area.
- Computer science courses typically do not count toward a student's core graduation credit requirements.

While decisions on these issues are often vested at the state and local level, NITRD and the NCO can address obstacles in federal STEM education and workforce-related programs computer science faces to help creating breathing room for state-led reforms of K-12 computer science education. We make the following specific recommendations for the committee to consider:

- **NITRD programs should report to the NCO what steps they are taking to address K-12 computer science education reform.**

  NITRD has a Program Component Area (PCA) that includes education activities and specifically mentions the 21st Century workforce and K-12 education as strategic priorities. However, there is little specific attention to these issues within the PCA or prioritization within the NITRD program in general. Most education funding within the NITRD program is from the National Science Foundation (NSF), while the Department of Education does not participate in the NITRD program at all. Of the NSF activities, there appears to be little to no involvement with some of the key programs within NSF's Education and Human Resources Directorate focused on strengthening K-12 science, technology, engineering and mathematics education, including the Math Science Partnership program. We encourage greater ties with these programs, particularly MSP.

  We note that the CE-21 program within the Computing and Information Science and Engineering Directorate at NSF is one program focused on addressing K-12 computer science education. It has invested in the development of a new *AP Computer Science: Principles*[5] course intended to be broadly engaging and appealing to students, as well as other initiatives focused on reviving K-12 computer science education. The effort also rightly focuses on inclusion—making sure that the AP test and the computer science discipline appeal to a population of students diverse in race, ethnicity, socio-economic status and gender. We support this program and point to it as model for addressing some of the key challenges in K-12 computer science education.

- **Include the Department of Education in the NITRD program**

  As previously mentioned, the Department of Education is not one of the agencies currently participating in the NITRD program. Considering the key linkage between education and workforce, it is difficult, if not impossible, to address the workforce needs and the K-12 education issues, without having the Department of Education at the table. We urge you to ask the agency to return to NITRD.

- **Include and clearly define computer science in federal education programs.**

5 See, http://www.collegeboard.com/html/computerscience/index.html

Computer science means the study of computers and algorithmic processes, including their principles, their hardware and software designs, their applications, and their impact on society. C*omputer science education* includes the following elements: design (both software and hardware), creation of digital artifacts, abstraction, logic, algorithm development and implementation, programming paradigms and languages, theoretical foundations, networks, graphics, databases and information retrieval, information security and privacy, artificial intelligence, the relationship between computing and mathematics, the limits of computation, applications in information technology and information systems, and social impacts of computing.[6]

As schools have increasingly stepped up the integration, use, and teaching of information technology as tools that support learning, distinctions between these areas that involve the use of computing and IT as learning tools, and genuine computer science education have blurred. Educators and policy makers consistently confuse the *use of technology* and *teaching of technology literacy* with teaching computer science as a core academic discipline within the STEM fields. PCAST recognized this issue in their 2010 report, *Prepare and Inspire: K-12 Education in Science, Technology, Engineering and Math (STEM) for America's Future*:

> "Computer-related courses should aim not just for technological literacy, which includes such utilitarian skills as keyboarding and the use of commercial software packages and the Internet, but for a deeper understanding of the essential concepts, methods and wide-ranging applications of computer science. Students should gain hands-on exposure to the process of algorithmic thinking and its realization in the form of a computer program, to the use of computational techniques for real-world problem solving, and to such pervasive computational themes as modeling and abstraction, modularity and reusability, computational efficiency, testing and debugging, and the management of complexity."

Federal programs exacerbate this confusion with vague terminology, as well as simply including "STEM" as eligible subjects. This often does not translate into computer science programs being included in the scope of the programs when they are implemented at the state and local levels. Relying on "STEM" as the foundational definition can inadvertently set up barriers for computer science. For example, NSF's Math and Science Partnership program specifically states that it is open to all "STEM" proposals; however, a closer review shows that grants must focus on improving "math and science" scores. Any proposal focused on computer science must show gains in math and science, not actually on computer science.

For these reasons, it is crucially important that federal STEM workforce and education programs explicitly state that they include computer science. This recommendation is consistent with a recent report on PCAST that said computer science must be part of STEM education programs. As a coordinating body, NITRD should work with participating agencies to explicit include computer science as an eligible discipline within STEM education programs.

6 ACM and CSTA have a four-part, grade appropriate framework describing the standards for computer science education in K-12, see: http://www.csta.acm.org/Curriculum/sub/ACMK12CSModel.html

- **Create state planning and implementation grants for computer science K-12 curriculum and build national networks of support for K-12 computer science education**

  States should be developing specific, thorough plans to improve computer science education. Few states are deliberately integrating computer science into their K-12 offerings at elementary schools or ensuring its place in the high school curriculum. A broader capacity initiative focused on improving curriculum, outreach and evaluation would build support for the goals and efforts of state planning and implementation of grants.

  As we previously recommended, bringing the Department of Education back into the NITRD program could create additional resources for such plans, but other NITRD agencies (such as the Department of Defense, NSF and the Department of Energy, which all house formal and informal education programs) should work directly with states to ensure state workforce and education needs are met. Establishing these plans or pilots for reforms within the states is a step toward addressing the deeper policy issues in K-12 computer science education.

- **Create pre-service and professional development opportunities for K-12 computer science teachers**

  Very few schools of education are focused on preparing computer science teachers, and because of a focus on "core" courses, there is limited professional development funding for computer science teachers. Federal agencies have numerous professional development and pre-service programs, however, we have consistently found little support for K-12 computer science education teachers within them. As course offerings in computer science grow, particularly with the new Advanced Placement Computer Science Principles course being introduced into schools, a program that specifically addresses the shortage of certified computer science teachers at the K-12 level is imperative, as are investments in professional development for those already teaching. Again, NITRD can play a role in raising this issue within agencies that have STEM or general education professional development or pre-service teacher programs.

The Computer Science Education Act

Provisions of the No Child Left Behind Act (NCLB) have also contributed to computer science's marginalization. Because of NCLB's accountability provisions and its definition of "core" disciplines, states have put resources toward investments in curriculum, pedagogy and professional development related to "core" courses. Furthermore, high school graduation requirements are tied to core courses. There are countless stories of teachers being pulled out of computer science courses to support the mathematics proficiency goals of NCLB. While you and your colleagues consider the future of NITRD, the House Education and the Workforce Committee is considering reauthorization of the Elementary and Secondary Education Act. Computing in the Core is working to ensure that a revised education law accommodates computer science in its provisions related to STEM education and ensures that computer science educators have access to the professional development and supports their colleagues do. The Computer Science Education Act from the 111th

Congress represents our priorities related to programs administered by the Department of Education.

Conclusion

The NITRD program plays a crucial role in the development and health of the country's networking and information technology capabilities, and we strongly support the program. To meet the large and growing needs of this industry, the nation will require a much larger and more diverse array of computer science and IT professionals than it currently is producing. We welcome and applaud the inclusion of workforce, education and diversity issues in the NITRD program. We particularly encourage the NITRD program to play an active role in strengthening K-12 computer science education, as this is the foundational issue that needs to be address to bolster the population of students focusing on computing and IT at the university level, and entering the IT workforce.

Thank you again for the opportunity to appear before the Subcommittee today and for your attention. The groups I represent today stand ready to work with the committee to address our recommendations as NITRD reauthorization moves forward in this Congress. I'll be pleased to address any questions you have.