

Psychology as a Core Science, Technology, Engineering, and Mathematics (STEM) Discipline

Report of the American Psychological Association 2009 Presidential Task Force
On the Future of Psychology as a STEM Discipline

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Executive Summary

Psychological knowledge is essential to scientific and technological innovation. Technology requires the use of human operators, and understanding human capacities and limits is essential for implementing technological advances. Nevertheless, psychology is often excluded from the list of core disciplines responsible for scientific and technological progress – the STEM disciplines of science, *technology*, *engineering*, and *mathematics*.

The goal of this report is to review the current status of psychology as a STEM discipline, articulate the problem of inconsistent recognition of psychology as a core STEM discipline, provide a rationale for consistent recognition of psychology as a STEM discipline, and recommend specific actions to achieve this goal.

STEM initiatives in education and training enhance human capital by providing:

- Scientists and engineers who continue the research and development that is central to the economic growth of our country;
- Technologically proficient workers who are able to keep pace with rapidly developing scientific and engineering innovations; and
- Scientifically literate voters and citizens who make intelligent decisions about public policy and who understand the world around them.

Psychology is a core STEM discipline because of its direct scientific and technological innovations, as well as its indirect contributions to education and learning in science and technology. The achievements of psychological science include:

- Designing new technologies, including airplane cockpit displays, air traffic control digital communications systems, the computer mouse and other computer interfaces, anesthesiology displays, and redesigning everyday tools, such as the toothbrush, for greater effectiveness;
- Promoting public safety with innovations such as the centered high-mounted brake light, which has been mandated on all passenger cars made since 1985 due to its life-saving effects;
- Improving public health with basic and applied research leading to effective smoking cessation interventions, techniques for improving medication adherence, and activities to maintain cognitive vitality in aging;
- Introducing new statistical techniques that are widely used in other fields, contribute to applied mathematics, and advance understanding of complex social behavior and decision-making; and
- Developing educational techniques that facilitate students' mathematical and scientific learning and that help people address everyday problems by enhancing analytical skills, scientific literacy, and problem-solving strategies.

Technological solutions to large-scale problems routinely fail when they do not consider how people interact and behave in different contexts. The failures can be dramatic as with Three-Mile Island, Chernobyl, and the recent oil spill from the off-shore platform in the Gulf of

Mexico. Even when projects do not fail outright, quality, productivity, and efficiency can often be substantially improved by considering human capacities and behavior.

Nevertheless, psychology is not consistently recognized as a STEM discipline, and psychologists are often ineligible for STEM funding that provides support for education, training, and research. Consistent recognition of psychology as a core STEM discipline would:

- Include a critical component – the human being – within scientific and technological solutions to pressing questions of national interest;
- Acknowledge the past success of psychological science in providing important breakthroughs in critical problems of public health, public safety, education and learning, and national security; and
- Capitalize on a large and diverse source of human talent that can contribute directly to national technological and scientific achievements.

The Task Force offers specific recommendations for achieving consistent inclusion of psychology as a STEM discipline and also identifies specific initiatives the American Psychological Association can take to facilitate the recognition of psychology as a core STEM discipline. The underlying goals for all of the recommendations are to:

- Enhance psychology's prominence as a core STEM discipline.
- Improve public understanding of the scientific basis for psychology.
- Increase, through pedagogic collaboration and scholarly engagement, psychology's involvement with other STEM disciplines.
- Expand educational resources and opportunities in psychological science.
- Promote the applications of psychological science to daily living.

Without deep consideration of human abilities and behavior, the benefits of technology and science are compromised. Thus, consistent recognition of psychology as a core STEM discipline and inclusion in STEM funding and initiatives are essential for achieving the goals of STEM initiatives and for ensuring the scientific, technological, and economic leadership of the United States into the future.

Psychology as a Core Science, Technology, Engineering, and Mathematics (STEM) Discipline

Introduction

Scientific progress is essential to the growth of every nation's economy and security, as well as to the physical and mental health of its citizens. In the future, as in the past, the United States' global competitiveness has depended on, and will rely on, scientific and technological innovation. Since Sputnik, the nation's leaders have closely monitored America's global position in broad disciplines of science, technology, engineering, and mathematics – commonly called “STEM” disciplines. US policy-makers have acknowledged the importance of STEM education for improving America's ranking in international comparisons of students' performance on assessments of STEM knowledge, and ultimately for the sustainability of the nation's scientific, technological, and economic leadership. STEM education has become a national priority.

The goal of this report is to review the current status of psychology as a STEM discipline, articulate the problem of inconsistent recognition of psychology as a core STEM discipline, provide a rationale for consistent recognition of psychology as a STEM discipline, and recommend specific actions to achieve this goal.

This report is primarily addressed to people who are engaged in leadership and advocacy for science and who are responsible for policies concerning scientific and technological development in the United States. This audience includes advocates for psychological science and STEM funding, program staff of federal and nonfederal funding agencies, and policy-makers, elected officials, and legislators who influence funding for STEM initiatives. The report also addresses issues relevant to educational institutions from elementary schools through graduate programs, and it describes for the public at large the important role of psychology as a STEM discipline. The Task Force offers specific recommendations for including psychology as a core contributor to STEM initiatives and also identifies specific initiatives the American Psychological Association can take to facilitate the recognition of psychology as a core STEM discipline among policy-makers.

The ultimate goal of STEM initiatives is to keep the United States' at the forefront of scientific and technological innovation. Human behavior is critical to the success of such endeavors, and psychology is the science of behavior and its perceptual, cognitive, emotional, and motivational underpinnings. Psychologists study issues of immediate practical consequence. A few examples of psychology's relevance to broad challenges of national health, safety, and productivity include the following:

- Every year millions of people fly in commercial and private aircraft. The safety of the passengers is enhanced because pilots stay competent and communicate using methods developed by psychological research in human factors. This research is critical to how pilots train and how the FAA designed its aviation safety and communication systems. In addition, air traffic control uses psychological research both in their system of flight planning and safety and for training air traffic controllers (Smolensky & Stein, 1998).
- Military success requires a good fit between personnel abilities and job requirements. Yet, until World War I, military personnel were assigned to duties based largely on senior officers' intuitions rather than on objective criteria. The Army Alpha test was developed

during World War I to measure abilities, such as screening military personnel for literacy. Both the Alpha and the nonverbal version (Beta) can be seen as early prototypes of modern ability testing, such as college entrance examinations and personnel selection tests for the military and the private sector. Although standardized testing has generated some controversy over the intervening years, modern tests have benefited substantially from conceptual, methodological, and statistical advances in psychology, and their validity exceeds that of alternative techniques, such as interviews (McDaniel, Whetzel, Schmidt, & Maurer, 1994; Reilly & Chao, 1982).

- The costs of healthcare are steadily rising, burdening governments and businesses and thereby reducing economic competitiveness. Human behavior is a major contributor to these rising costs: Diet, exercise, smoking and substance use contribute significantly to preventable chronic disease and acute trauma, including major killers such as cardiovascular disease, cancer, and physical trauma (e.g., gun violence and traffic fatalities). According to the American Medical Association, at least 25 cents of every health care dollar are spent on the treatment of diseases or disabilities that result from changeable behaviors (see also National Institutes of Health, 2009). Psychological science has been at the center of several successful efforts to improve public health, such as effective smoking cessation interventions (Lichtenstein & Hollis, 1992; Prochaska, DiClemente, Velicer, & Rossi, 1993), understanding medication adherence (Reyna, Nelson, Han, & Dieckmann, 2009), and maintaining cognitive vitality in aging (Willis et al., 2006).
- Significant medical advances have been made in extending the lives and improving the quality of life for people who are HIV-positive or living with AIDS. However, without the development of highly effective interventions to change behaviors that contribute to the spread of HIV/AIDS, the results of these medical advances could have been disastrous, actually promoting the spread of the virus: more HIV-infected people would be living longer and more actively, which could provide more opportunity to engage in unsafe sex practices. Instead, behavioral interventions, grounded in psychological science, for HIV-positive individuals and the population more generally have been extremely successful in limiting the transmission of HIV and helping individuals and families cope and adapt to HIV/AIDS (Fisher, Kohut, & Fisher, 2009; Pequegnat, 2009).

Moreover, ignoring the contribution offered by psychology can have tragic consequences. For example, when a metropolitan children's hospital implemented a newly developed computerized physician order entry system without sufficient training and consideration of the human operator, child mortality increased from 2.8% to 6.6%. Much of the increased mortality was attributed to lack of attention to human factors (Han et al., 2005). In contrast, when a similar system was introduced in a different hospital, but implementation involved training that attended to "psychological" aspects of using the system, there was a subsequent substantial *reduction* in infant mortality (Seattle Children's Hospital, 2006).

These examples illustrate that proper recognition, funding, and support for psychological science as a core STEM discipline would significantly improve the effectiveness and pace of scientific innovation and enhance its impact on challenges of national and global scope.

Statement of the Problem

The *American Psychological Association 2009 Presidential Task Force on the Future of Psychology as a STEM Discipline* was formed to articulate the rationale for consistent inclusion of psychology as a core STEM discipline. (See Appendix A for the charge to the Task Force). A central problem that the Task Force addressed was the inconsistent recognition of psychology as a STEM discipline. The failure to group psychology with other core STEM disciplines ignores a critical component – the human being – within scientific and technological approaches to pressing questions of national interest. The exclusion of psychology in STEM education and training programs overlooks the value of a large and diverse source of human capital that can contribute directly to national technological and scientific achievements. The past success of psychological science in providing important breakthroughs in public health, public safety, education, and national security provide a template for future success. When psychology is not recognized as a STEM discipline, psychologists are often not eligible for targeted funding for education, professional training, and research that could contribute substantially to achieving STEM goals. Current funding and support for this work does not match its promise.

In this report, the Task Force addresses the challenges of (a) inconsistent attitudes of federal funding agencies toward psychology as a STEM discipline; (b) lack of opportunities and incentives for interdisciplinary training and collaboration between psychological scientists and other STEM disciplines; and (c) a conception of the field, held by the public, the media, and sometimes psychologists themselves, that dilutes the connection between psychology and other STEM disciplines.

Definition of STEM and STEM Initiatives

The National Science Foundation (NSF) definition of STEM fields includes mathematics, natural sciences, engineering, computer and information sciences, and the social and behavioral sciences – psychology, economics, sociology, and political science (National Science Foundation, Division of Science Resources Statistics, 2009).

STEM education and training provides the United States with three kinds of intellectual capital (National Science Teachers Association, 2010):

- Scientists and engineers who continue the research and development that is central to the economic growth of our country;
- Technologically proficient workers who are able to keep pace with rapidly developing scientific and engineering innovations; and
- Scientifically literate voters and citizens who make intelligent decisions about public policy and who understand the world around them.

To achieve this expanded human capital, STEM initiatives are aimed at improving the educational experience from elementary school to graduate education, and thus prepare students to eventually solve not only current problems but also unimagined ones of the future.

The current goals of STEM education, as identified in the National Governors Association Report (2007; see also Morrison, 2006), “Innovation America: Building a Science, Technology, Engineering, and Math Agenda,” are to promote “literacy” of various kinds:

- *Scientific literacy*, which is the ability to use scientific knowledge and methods to understand the natural world and to participate in decisions that affect it.

- *Technological literacy*, which is the ability to use, manage, understand, and assess technology, as well as to know how to use new technologies, understand how new technologies are developed, and have skills to analyze how new technologies affect us, our nation, and the world.
- *Engineering literacy*, which is the understanding of how technologies are developed through engineering design processes and appreciation of the creative application of scientific and mathematic principles to practical ends, such as the design, manufacture, and operation of efficient and economical structures, machines, processes, and systems.
- *Mathematical literacy*, which is the ability of students to analyze, reason, and communicate ideas effectively as they pose, formulate, solve, and interpret solutions to mathematical problems in a variety of situations.
- *STEM literacy*, which bridges the four STEM areas of science, technology, engineering, and mathematics and involves integrative analysis and investigation of interrelated elements of problems and challenges.

Across funding sources, STEM initiatives support a range of activities that are intended to increase the number, diversity, and quality of students pursuing study or careers in STEM disciplines. However, the percentage of students entering STEM professions has remained relatively constant in the last decade: about 17% of all postsecondary degrees awarded are in STEM disciplines other than psychology (Kuenzi, 2008).

Psychology as a STEM Discipline

Psychology is the science of behavior and its underlying processes. Therefore, given the definition and goals of STEM initiatives, psychology should consistently qualify as a STEM discipline. In the following three sections, we provide a rationale for this inclusion, and we provide several examples of psychology's frequent exclusion from the community of STEM disciplines. Our discussion begins with an articulation of the basic science of psychology. We then discuss the application of psychological science to address major societal challenges and provide examples of psychology's critical role in enhancing the effectiveness of technology through an appreciation of human perceptual, cognitive, and performance systems. We also consider the critical role of psychology as an interdisciplinary bridge, which facilitates STEM literacy through its integration of all of the components of STEM, as well as psychology's ability to facilitate STEM learning. The following sections demonstrate that, like other STEM disciplines, psychological science is a core component of the national effort to prepare students, teachers, and professionals in STEM sciences, to promote innovation, and to enhance scientific and technological literacy and national competitiveness.

Psychology Is a Basic Science

Psychology is the basic science of behavior. Psychology uses the scientific method to conduct both laboratory and field experiments in order to test hypotheses that lead to creation of unique knowledge about human behavior. Psychological science has used state-of-the-art scientific instrumentation since its inception. The discipline currently employs diverse methodologies, such as fMRI, electromyographs, robots, virtual reality, psychophysical techniques, animal modeling, and behavioral analysis, to achieve empirical and theoretical advances. Psychology thus offers unique scientific insights into a range of phenomena:

- Psychological research on learning, memory, and emotion has transformed our understanding of the brain's fear system. Research with humans and laboratory animals has identified the brain areas and processes responsible for regulation of fear and initiation of responses to fearful stimuli. This work has led to a deeper understanding of mental disorders, such as post-traumatic stress disorder, and also to potential treatments, including interventions that interfere with the reconsolidation of fear memories, preventing the return of the fear response (Schiller et al., 2010).
- Basic psychological experiments in group processes, decision-making, emotion, motivation, and learning and memory have all informed new theories and interventions for changing health behaviors such as smoking, heavy drinking, exercise, and medication adherence. For example, psychological research revealed that people discount rewards (or costs), if the impact is delayed, according to a mathematical function that is based on the value of the reward and the length of the delay. This discovery has led to changes in the ways in which health behavior interventions are presented and timed, including an appreciation of individual differences in response (Simpson & Vuchinich, 2000). These changes have improved outcomes for addiction interventions (Prochaska, Delucchi, & Hall, 2004; Prochaska, DiClemente, & Norcross, 1992).
- A growing body of research shows that social experiences across the lifespan, including prenatal environmental exposures, mother–infant interactions, social interactions, and social stress can change the way in which genes are expressed in brain cells, which in turn changes behavior (Champagne, 2009). This work demonstrates the enormous plasticity of the brain, helps to explain how early life experiences continue to affect behavior throughout the lifespan, and provides a deeper understanding of the link between environmental stress, depressed mood, and social isolation.

Psychological methods and insights have also had transforming effects on other fields. Behavioral economics uses psychological paradigms to study how social, cognitive, emotional, and motivational factors influence the ways people make economic decisions (Kahneman, 2003). Behavioral neuroscience research uses cognitive tasks to uncover the neural substrate for behavior, extending the fields of biology and neuroscience by considering how brain structures *function* to influence normal and abnormal behavior. Educational theory and practice have been significantly advanced by psychological findings illuminating the cognitive and neural bases of reading, mathematics (Rittle-Johnson & Koedinger, 2005; Rittle-Johnson, Siegler, & Alibali, 2001), and scientific reasoning (Klahr, 2000; Newcombe et al., 2009; Zimmerman, 2007).

In addition to the use of psychological experiments to gain basic knowledge about behavior and cognition, psychological researchers routinely use sophisticated mathematics, from statistical analyses to behavioral genetics modeling, computer simulations of complex phenomena, and predictive mathematical models (Anderson, Anderson, Ferris, Fincham, & Jung, 2009; Brainerd, Reyna, & Howe, 2009; Busemeyer & Diederich, 2002; Dilkina, McClelland, & Plaut, 2008; Kahneman, 2003). Psychological modeling requires an understanding of mathematics, technology, and scientific facts. Within social psychology, new techniques can disentangle how the behaviors of one person influences others in a group, how the group affects each individual, and how unique forces that develop through interaction over time shape the actions and coordination of each person in a group (Kashy & Kenny, 2000). Psychology, combined with statistics and quantitative modeling, also contributes directly to applied mathematics. For example, Structural Equation Modeling (SEM) was introduced by Karl

Joreskog (1971) in a psychology journal and is now widely used in engineering, sociology, and economics.

Psychology Supports the Translation and Application of Basic Science into Useable Technology, Teaching, and Interventions

Effective application of science and technology always includes some element of human interaction and behavior (Durso, DeLucia, & Jones, 2010). For example, modern aircraft that used to require three pilots can now be safely flown with two, and fighter jets that required two pilots require one. These efficiencies can be traced to new technologies and their effective integration with the human operators. The way that pilots train and stay competent is based on psychological research. Approaches to solving problems routinely fail when they do not consider how people interact and behave in different contexts. These failures can be dramatic as with Three-Mile Island, Chernobyl, and the recent oils spill in the Gulf of Mexico. Even when projects do not fail outright, quality, productivity, and efficiency are often substantially less than they could have been if knowledge about human behavior had been more fully integrated into the design and operation of these complex systems. Mine sweeping by human operators has been dramatically improved by designing better procedures for interaction with the modern, more plastic than metal, land mines. In fact, some branches of psychology, particularly engineering psychology, contribute directly to the design of a wide variety of new technologies and improve the effectiveness of existing technologies. Examples of these technologies include the airplane cockpit display, air traffic control digital communications systems, the computer mouse, anesthesiology displays, and the redesign of the toothbrush.

The practical value of psychological science – its implications and applications in everyday life – reflects, in essence, a form of engineering (Stokes, 1997). Indeed, many subdisciplines can be viewed as having an “engineering” relationship to basic psychological science, such as engineering psychology (human factors), industrial/organizational psychology, and clinical psychology. Human factors researchers combine their understanding of human perception and cognition with design principles to create “usable artifacts” ranging from cockpits, to reactor control panels, to cell phones. Industrial/organizational psychologists apply principles of judgment and decision-making, social influence, and motivation to improve the leadership and efficiency of organizations and the well-being of employees. Clinical psychologists generate and apply psychological knowledge (e.g., about perceptions of helplessness) to develop and deliver therapeutic interventions (e.g., to alleviate depression) and enhance personal productivity.

Furthermore, psychology is a discipline that spans micro- and macro-levels of analysis. For example, mathematical models of memory link genetics, neurobiology, and, naturally, mathematics. Thus, as a basic and applied science, psychology is a core member of interdisciplinary teams. With its focus on human behavior, learning, and interaction and coordination, psychologists can facilitate communication among members of multidisciplinary teams, address the most effective ways of disseminating scientific knowledge, and evaluate the impact and utilization of new scientific and technological interventions (Fisher et al., 2009).

Psychology is an Applied Science that Addresses Grand Challenges and Increases National Competitiveness

Psychological theory and research addresses large-scale, pressing issues that are the focus of STEM initiatives. *Grand challenges* in science and engineering require an understanding of

human capacities and behavior. For example, solutions to problems of climate change fundamentally involve human – that is, psychological – elements. As noted by the American Psychological Association Task Force on the Interface between Psychology and Global Climate Change (2009), “the recent and accelerating warming of the earth’s climate is largely attributable to human activity, and its impacts are mediated by psychological and social processes and can be limited primarily by human activity” (p. 13). Successfully meeting the challenges of long-term climate change requires knowing how people view the risks imposed by climate change, how people adapt to and cope with perceived threat and unfolding impacts of climate change, and how people can alter their behavior to limit climate change and its adverse consequences. In addition to climate change, other grand challenges are influenced by human behavior and thus require that scientific and technical solutions be intricately integrated with the science of human behavior (Kazdin, 2009).

Approximately 40,000 people die in traffic accidents each year in the United States. The number would be much higher were it not for widely known engineering advances, ranging from material and structural changes in automobile design to airbags. Traffic accidents have also been reduced by research based on human factors. Psychological science played a critical role in the adoption of the centered high-mounted brake light (Malone, 1986; Malone, Kirkpatrick, Kohl, & Baker, 1978), which has been mandated on all passenger cars made since 1985. The initial research on brake light placement involved 2100 taxicabs driven 60 million vehicle miles over 12 months. This research, built on an extensive body of literature in psychology, revealed that adding a centered high-mounted brake light to the traditional two lower-mounted lights significantly reduced – by over 50% – rear-end collisions. The conceptualization, design, implementation, analysis, and interpretation of this study illustrate clearly the integral role of psychology for scientific and technological solutions to pressing national challenges. More recently, using a similar systematic approach, psychological research demonstrated that the color yellow was more visible at night and more easily detected during the day than red, the traditional color of fire trucks (Dewar, Olson, Alexander, & Caird, 2002).

Psychological science has enormous potential for contributing directly to STEM objectives both directly, through its effectiveness in addressing relevant problems scientifically, but also indirectly, through better understanding of cognitive and motivational factors related to learning across disciplines. Indeed, historically, the nation has called upon psychology to help improve science education broadly (Newcombe et al., 2009). In the face of challenges to American scientific and technological leadership in the late 1950s, new initiatives fostered collaborative, interdisciplinary research teams that included psychologists, such as those developed by the Social Science Research Council (Morrisett & Vinsonhaler, 1965).

More recently, the National Mathematics Advisory Panel (2008) cited specific, empirically supported learning processes and techniques that were developed by psychologists and “that could be put to work in the classroom today to improve children’s mathematical knowledge” (p. 18). In addition, the Institute of Education Sciences introduced the Cognition and Student Learning Program to translate psychological science into scientifically grounded educational practice. Psychologists have demonstrated the effectiveness of programs for improving analytical skills, developing scientific literacy, and enhancing problem-solving strategies among young girls, children of color, and children from disadvantaged backgrounds (Ceci & Williams, 2003; Williams, Papierno, Makel, & Ceci, 2004a,b). Thus, psychological science plays a unique and comprehensive role in improving the educational processes involved

in preparing students for STEM careers, as well as a scientifically informed citizenry (Mestre, 2006; Newcombe et al., 2009).

Psychology plays an important role in enhancing the diversity of STEM professionals engaged in activities both directly, through the contributions of psychologists to scientific and technological innovation, and indirectly, through the field's contributions to education in science and technology. In 2008, 70% of new Ph.D.s in psychology were women, and 13% were African American or Latino/a (Center for Workforce Studies, American Psychological Association, 2009). Although, the percentages were smaller in areas of psychology outside of clinical fields (such as quantitative psychology, human factors, and cognitive psychology) – 47% for women and 12% for African Americans and Latino/as – these non-clinical sub-disciplines of psychology are much more demographically diverse than other STEM fields such as mathematics, chemistry, physics, and engineering (National Science Foundation, Division of Science Resources Statistics, 2009).

Why Psychology Is Inconsistently Recognized as a Core STEM Discipline

Although many federal agencies and organizations recognize psychology as a science, psychologists are often excluded from opportunities for STEM-related funding for education and research programs (Kuenzi, 2008; National Governors Association, 2007). For example, the National Science Foundation recently provided over \$30 million per year to support psychological research, including graduate study in psychology. However, the 2008 NSF Congressional Research Report for Congress explicitly lists psychology as a non-STEM discipline (p. 13) in its analysis of degrees awarded (<http://www.nsf.gov/pubs/2009/nsf09567/nsf09567.htm>). In addition, psychologists are excluded from NSF's program for Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) program and currently do not qualify for NSF's Research Experiences for Teachers program.

The inconsistent recognition of psychology as a STEM discipline occurs across other major federal agencies that provide funding for training and research of scientists to solve grand challenges and maintain national competitiveness. The National Institutes of Health supports a wide portfolio of health-related topics in which psychological science is a core discipline, and the Institute for Education Sciences, provides \$400 million annually to advance our knowledge of education-related topics, most of which can only be investigated by scientists with strong training in psychological theories, accumulated knowledge, and research paradigms. However, failure to include psychology as a STEM discipline has significant effects on eligibility for new or emerging programs to enhance STEM science. For example, the Department of Energy, which provides funding for a variety of STEM education initiatives at the middle school through graduate levels, does not support training in psychology and behavioral sciences relevant to energy use and climate change.

The larger scientific community also reflects this inconsistent orientation toward Psychology as a STEM discipline. For example, the program for the 2010 meeting of the American Association for the Advancement of Science, a premier professional organization for the sciences, includes more than 120 papers with the words *cognitive*, *behavior*, *psychological*, *cognition*, *thinking*, or *creativity* in their titles. In this organization, psychology is recognized as a science among peers. However, the broader community of practitioners, educators, and policy-makers frequently excludes psychology as a STEM discipline in their policy-making and in

documents emphasizing the importance of strengthening America's STEM education and workforce (Kuenzi, 2008). These inconsistencies may interfere with students looking to psychological science as a STEM career choice, thus contributing to a shortage of scientists capable of dealing with the behavioral aspects of societal problems of the future. For example:

- The Optional Practical Training extension is provided to academic foreign trainees with F-1 visa status so that they may work in the US for 12 months following the completion of their undergraduate or graduate degree to obtain further training and skills. If the trainee has obtained a STEM discipline degree, the OPT period is extended from 12 to 29 months. However, psychology is not listed as a STEM discipline under this program, thus denying foreign psychological science trainees sufficient time to complete post-baccalaureate or post-doctoral studies in the US prior to obtaining jobs.
- The US Department of Education, which provides additional funds to undergraduate students with Pell Grants through the National Science & Mathematics Access to Retain Talent Grant (National SMART Grant), does not include psychology among the eligible majors for the program. In contrast, the Department of Education, through the Institute of Education Sciences, also supports a rich array of pre-doctoral and post-doctoral training programs in education research, and a substantial proportion of that support is directed toward psychologists.
- Within O*Net (the Occupational Information Network, which is being developed under the sponsorship of the US Department of Labor/Employment and Training Administration), no occupations with the word “psychologist” qualify as a STEM occupation.
- The Oklahoma Department of Technology and Career Education has prepared an attractive brochure outlining its view of STEM careers (www.okcareertech.org/stem/images/STEM_fldr.pdf). It includes a list of approximately 150 different STEM occupations. “Psychologist” does not appear (although “anthropologist” and “economist” do).

Part of the problem may also reside in perception of the general public, perhaps because of widespread media exposure that not only emphasizes the therapeutic activity of mental health professionals but also conveys an easily accessible and seemingly intuitive basis for practitioners’ advice (i.e., “straight-talk”; Dembling & Guitierrez, 2003), that limits understanding of psychology as a science. As Kazdin (2009) noted, “The public as well as policymakers do not consistently recognize our science. The challenge for public recognition is illustrated by the dominance of nonscientific depictions of psychology in everyday life” (pp. 340). Whereas 80% of the respondents to a representative survey, conducted in 2009 for APA by Penn, Schoen, and Berland Associates, believed that a “strong foundation in scientific methods and techniques” was important for physicians and engineers, only 60% thought it was important for psychologists. Moreover, when asked how psychology “attempts to understand the way people behave,” only 30% of the respondents agreed with the statement that it does so “through scientific research,” whereas 52% agreed with the statement that it does so “by talking to them and asking them why they do what they do.”

The nature of the focus of research in psychology--human behavior--can also lead people to question the scientific foundation of psychology. Most people already believe that they are experts in human behavior. When students learn basic principles of human behavior, they are

rarely surprised, even when confronted with contradictory claims (e.g., people with high self-esteem are more or are less susceptible to flattery; Bolt, 2001). The tendency for people to view the discipline of psychology as intuitive and “nonscientific” makes it easier for policy-makers not to consider the training of psychologists as part of a STEM enhancement agenda.

Psychologists themselves and their representative organizations also contribute to the current inconsistent recognition of psychology as a STEM discipline by permitting, and sometimes promoting, the fractionation of the field along science-practitioner lines. Nevertheless, science remains the foundation of teaching, research, and practice in psychology.

In summary, despite psychology’s foundation in science and its standing as the science of human behavior, it is not fully accepted as a science by the general public. Moreover, even among professional organizations and agencies that acknowledge psychology as a science, psychology is often – too often – excluded from STEM-related funding and activities. This oversight, in perception and in access to resources for STEM activities, fails to capitalize on the expertise of psychologists to achieve the objectives of STEM programs and restricts the contributions of a large and diverse pool of talented students and professionals in psychology to scientific and technological innovation in the US well into the future.

Conclusion

Psychological science examines human behavior and its underlying bases through the scientific method and the accrual of basic scientific knowledge. Psychological research advances theoretical understanding of human behavior, offering practical solutions to complex problems. Psychological science addresses important and timely issues, such as patient compliance with medication regimens, consumer engagement in recycling and energy use, and chronic disease management. In addition, psychological knowledge is essential to scientific and technological innovation. Technology requires the use of human operators, and thus understanding human capacities and limits is essential to implementing technological advances.

STEM initiatives are investments in the global scientific and technological competitiveness of the United States. The success of these national efforts requires the contributions of psychological science to interdisciplinary and integrative scientific inquiry; to the effective engineering and use of technology for achieving optimal results; for attracting members of groups traditionally underrepresented in science and engineering to STEM activities; and for educating and training students, technicians, and professionals in psychology and in content areas in STEM disciplines beyond psychological science. Without deep consideration of human abilities and behavior, the benefits of technology and science are compromised. Thus, consistent recognition of psychology as a core STEM discipline and inclusion in STEM funding and initiatives are essential for achieving the goals of STEM and for ensuring the leadership of the United States scientifically, technologically, economically, and socially into the future.

In the next section, the Task Force presents two types of recommendations: (a) *external* recommendations, which are directed to policy-makers, and (b) *internal* recommendations, which are directed to APA and others within the field of psychology to facilitate STEM-related training, activities, and recognition for psychology.

Recommendations

STEM programs and incentives should be directed at fostering collaborations among scientists from relevant disciplines to solve modern problems on the grand and local scale. When STEM initiatives focus on solving real world challenges to our society, the science of behavior will always have a central role in effective solutions. Furthermore, many education programs in STEM are successful because they take advantage of expertise in psychology and its evidence-based pedagogic and evaluative practices. The recommendations we propose should increase recognition by the general public and policy-makers of psychologists as scientists and psychology as a science. While advocacy for these recommendations will largely be generated from within groups of psychological scientists such as APA, the targets of these recommendations are policy-makers, funding agencies, and other non-APA organizations that wish to enhance the effectiveness of STEM initiatives. The underlying goals for all of the recommendations are to:

- Enhance psychology's prominence as a core STEM discipline.
- Improve public understanding of the scientific basis for psychology.
- Increase, through pedagogic collaboration and scholarly engagement, psychology's involvement with other STEM disciplines.
- Expand educational resources and opportunities in psychological science.
- Promote the applications of psychological science to daily living.

Collectively these recommendations reinforce key objectives identified in APA's Strategic Plan (American Psychological Association, 2009).

External Recommendations

The Task Force's external recommendations for promoting psychological science's contribution to solving national and local challenges are to:

1. Create and fund interdisciplinary research centers that focus on specific problems, such as health disparities, counter-terrorism, or global climate change.
2. Increase the number of psychological scientists in STEM agencies (e.g., Department of Energy, Department of Transportation) on boards, review panels, and among senior staff, as well as on scientific advisory boards and commissions (such as the President's Council of Advisors on Science and Technology, the Office of Science and Technology Policy, and the upper rungs of management at federal research agencies, such as NSF, NIH, and NASA).
3. Increase recognition of psychological scientists with appointments to major scientific panels and inclusion in honorary scientific societies. In 2009 there were more members of the anthropology section of the National Academy of Science (NAS) than of the psychology section, despite the fact that there are substantially more psychologists than anthropologists. We should double the number of psychologists in the NAS over the next five years to reflect the growing importance of psychological science to our nation's economic success and health of our population.

4. Increase support from funding agencies, including federal, foundation, corporate, community, and university sources, for training graduate students and early career professionals for STEM-related activities in psychological science and other relevant disciplines. There are multiple existing recommendations for this activity contained within existing initiatives and reports, such as OppNet (<http://oppnet.nih.gov/>) and the Science of Behavior Change Report (NIH, 2009).
5. Consistently include psychologists and psychological science as eligible recipients of STEM funding.

The Task Force's external recommendations for promoting psychological science's contribution to education and training in STEM are to:

1. Increase resources for the teaching of psychology as a laboratory science at the high school, community college, and college level (see, for example, the 2004 Report to the National Science Foundation by Levine, Abler, and Rosich, *Education and Training in the Social, Behavioral, and Economic Sciences: A Plan of Action*).
2. Include psychological science courses among those required for general STEM education at high school, undergraduate, and post-graduate levels. These courses may emphasize the critical role of psychology within interdisciplinary science, such as behavioral neuroscience, behavioral genetics, or behavioral economics.
3. Acknowledge critical contributions of psychological science to teaching, learning and assessment of content and skills in other STEM disciplines.
4. Include psychology among the STEM disciplines that receive an extended training period (17 months instead of the usual 12 months) for visitors on an F-1 visa.
5. With support from funding agencies, increase the proportions of women and minorities obtaining advanced degrees in fields of psychological science in which they are currently underrepresented, such as statistics and measurement, cognitive psychology, neuropsychology, and industrial/organizational psychology.
6. Include instructors of psychological science in initiatives to expand the number of well-trained STEM teachers and enhance teacher knowledge and training (e.g., through teaching institutes) in STEM-related areas.

Internal Recommendations for APA

The Task Force calls for increased allocation of resources and prioritization of activities within the APA that strengthen the current perception of psychology as a core STEM discipline but also ensure psychology's position as a STEM discipline through its scientific contributions and training. The Task Force strongly recommends that the APA governance groups and APA staff who are tasked with implementation of these recommendations include clear outcomes and a plan for timely evaluation of these outcomes.

The Task Force's internal recommendations for increasing recognition of psychology as a science and a STEM discipline are for APA to:

1. Create and launch a public education campaign, with integrated outcome measures, to increase the public recognition of psychology as a science and to communicate more effectively the critical role of psychological science in solving society's problems.
2. Be more vigilant, nimble, and proactive in its response to news events that may provide major opportunities to educate the public and lawmakers on how psychological science can illuminate and help provide solutions to the most important issues facing humankind.
3. Increase the staff and resources within APA to advocate effectively for psychology to be recognized consistently as a STEM discipline.
4. Facilitate academic exchanges between psychologists and other STEM disciplines through mechanisms such as funding, conferences, and new journal initiatives.
5. Increase the involvement and leadership of psychologists with STEM-related training and experience in APA in order to enrich the implementation of the recommendations of this report, provide continuity and balance throughout all aspects of APA governance, and to provide a model of service for students and early career psychologists pursuing psychological science.
6. Increase advocacy efforts to expand funding for psychology's participation in interdisciplinary STEM training programs.
7. Expand the capacity of APA to serve as a leader to advocate for STEM funding for psychologists (e.g., increase the number of agencies and organizations with which APA communicates about STEM related issues, such as Friends of NSF and AAAS).

The Task Force's internal recommendations for enhancing STEM-related training in psychological science are to:

1. Organize sustained interaction between APA's Science and Education Directorates, all of the APA divisions, other relevant organizations (e.g., Council of Graduate Departments of Psychology [COGDOP], Council of University Directors of Clinical Psychology [CUDCP], Teachers of Psychology in Secondary Schools [TOPSS], Psychology Teachers at the Community College [PT@CC]), and other constituents in order to develop and maintain a science-based, interdisciplinary curriculum in all of the sub-disciplines of psychology that emphasize the translation of basic psychological science to applied settings.
2. Partnerships should support and expand the experiences of students in introductory-level psychology courses, including those for university non-majors, community college students, and high school students, which impart a solid understanding of psychology as a science.
3. Expand continuing education programs offered or sponsored by APA, as well as programming at the APA convention, that increase psychologists' capacity to engage in STEM activities and develop interdisciplinary collaborations with researchers in other STEM disciplines.
4. Increase the scope of training in doctoral programs in psychological science to produce graduates with basic and applied knowledge and skills, and especially the capability of carrying out multidisciplinary team science.

5. Increase participation of women and minorities in STEM-related activities in psychological science as well as other STEM disciplines.
6. Develop a general model to guide the development of new undergraduate psychology programs to prepare students for STEM careers and for advanced training in STEM areas.
7. While psychological science enhances the teaching of other STEM sciences, the use of our empirically proven models of improving scientific literacy can be applied more widely to teaching psychological science to psychology majors and graduate students. Thus we recommend that the sustained interaction between the APA Science and Education Directorates include development of clear standards for STEM literacy within psychology training and sharing of effective models for increasing STEM literacy among psychologists.

These recommendations are consistent with the APA Strategic Plan to increase the recognition of psychology as a science and to promote psychological science to improve the health and wellness of individuals, organizations and communities. Implementation of these recommendations will help transform psychological science in the 21st century and lead to more effective application of our knowledge to benefit the public.

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Appendix A

Task Force Charge, Composition, and Process

The Charge to the Task Force

The original charge of *The American Psychological Association 2009 Presidential Task Force on the Future of Psychology as a STEM Discipline* was to:

- Articulate the rationale for why psychology is a core STEM discipline.
- Develop strategies for re-defining psychology as a STEM discipline.
- Determine what resources were needed to advocate effectively for psychology as a STEM discipline to science policy makers and elected officials.
- Identify barriers and needed resources to implement these changes and ways to address those barriers.
- Develop key partnerships for implementing APA's advocacy efforts.

Constitution and Work Process of the Task Force

The *American Psychological Association Presidential Task Force on the Future of Psychology as a STEM Discipline* was convened by James H. Bray, 2009 APA President, as one of his presidential initiatives. The Task Force was chaired by John F. Dovidio and included members Francis T. Durso, David J. Francis, David Klahr, Jennifer J. Manly and Valerie F. Reyna. The task force was jointly staffed by the Science Directorate (Steven J. Breckler and Howard S. Kurtzman) and Education Directorate (Cynthia D. Belar and Rena F. Subotnik).

The Task Force conducted its work at two in-person meetings and a series of conference calls. At a discussion session held at the 2009 APA Convention in Toronto, scientists, educators and administrators shared observations and ideas that helped to shape the Task Force report. An earlier draft of the report was reviewed by members of the APA Board of Scientific Affairs and Board of Educational Affairs, by APA staff, and by six additional outside reviewers who have a wide range of scientific, administrative, and advocacy experience. The Task Force members appreciate all the suggestions that they have received in the course of developing the report.