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Key Recommendations from Selected Recent Reports on Graduate Education (1995-2017)

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Context for *Key Recommendations from Selected Recent Reports on Graduate Education (1995-2017)*

The Committee on Revitalizing Graduate STEM Education for the 21st Century requested the following paper as a part of the execution of the landscape analysis described in the Statement of Task (below). Given the number of previous reports that have been issued on graduate education, both specific to STEM disciplines and broadly on issues affecting all fields, the committee sought a review of the previous reports to identify key themes in the reports' recommendation. The *Key Recommendations* document provides an overview and summary of the key themes and provides a list of the reports reviewed.

Statement of Task

An ad hoc committee, under the auspices of BHEW (Board on Higher Education and Workforce) and COSEPUP (Committee on Science, Engineering, and Public Policy), and liaising with GUIRR (Government-University-Industry Research Roundtable) and TAC (Teacher Advisory Council), will lead a study of STEM graduate-level education in the U.S., revisiting and updating a similar COSEPUP study completed 20 years ago.

Specific tasks will include:

- Conduct a systems analysis of graduate education, with the aim of identifying policies, programs and practices that could better meet the diverse education and career needs of graduate students in coming years (at both the master's and Ph.D. levels—understanding the commonalities and distinctions between the two levels), and also aimed at identifying deficiencies and gaps in the system that could improve graduate education programs.
- Identify strategies to improve the alignment of graduate education courses, curricula, labs and fellowship/traineeship experiences for students with the needs of prospective employers--and the reality of the workforce landscape--which include not only colleges and universities but also industry, government at all levels, non-profit organizations, and others. A key task will be to learn from employers how graduate education can continue to evolve to anticipate future workforce needs.
- Identify possible changes to federal and state programs and funding priorities and structures that would better reflect the research and training needs of graduate students.
- Identify policies and effective practices that provide students and faculty with information about career paths for graduates holding master's and Ph.D. degrees and provide ongoing and high quality counseling and mentoring for graduate students.
- Identify the implications of the increasingly international nature of graduate education and career pathways, reflecting both the numbers of foreign students who enroll in U.S. graduate schools and the increasing global migration of U.S. STEM graduates.
- Investigate the many new initiatives and models that are influencing graduate education, including MOOCs, other digital learning programs, increasing numbers of alternative providers of master's and Ph.D. degrees, and opportunities to secure credentials through multiple sources.
- Create a set of national goals for graduate STEM education that can be used by research universities, Congress, federal agencies, state governments and the private sector to guide graduate level programs, policies and investments over the next decade, and ensure that this "blueprint" for graduate education reform is revisited and updated on a periodic basis to reflect changing realities.

The products of this study will be an interim report and a final report that is widely disseminated for analysis and adoption of new programs, policies, and practices that enhance STEM graduate education. This may include dissemination activities on campuses, at professional society meetings and in other venues to share the report's findings and recommendations and to engage stakeholders in discussions around implementing new strategies, programs and models.

Key Recommendations from Selected Recent Reports on Graduate Education (1995-2017)

Prepared by Yasmeen Hussain – 05/2017

Many reports have been written on the subject of graduate education. The intent of this document is to examine the recommendations made by previous reports in order to inform the work of the *Revitalizing Graduate STEM Education for the 21st Century* study committee. This is a selected, not comprehensive, list of reports (see Appendix), focusing on documents released since the 1995 National Academies report *Reshaping the Graduate Education of Scientists and Engineers*. Throughout the twenty reports considered, we identified five broad themes of recommendations and 25 subthemes, outlined below with a summary description of the recommendations and their reasoning.

I. **<u>Student Infrastructure and Policies:</u>** These recommendations outline infrastructure and policies to support graduate students, from providing financial support to emphasizing diversity.

a. **Financial Support:** Stipulations on the mechanism and amount of financial support provided to graduate students or their host institutions. Suggestions include methods to provide support throughout graduate education, capitalize on business partnerships, ensure students have protected research time or professional development experiences, or increase participation of particular groups or in particular fields.

b. **Emphasize Diversity:** Suggestions for attracting students from underrepresented groups to graduate programs and ensuring their future success via methods like summer programs, early mentoring, providing financial and information resources, changing recruitment and admissions policies, or cultivating an inclusive departmental culture.

c. **Start Early:** Recommendations about recruiting future graduate students and leveraging the time early in graduate students' careers to facilitate success in the graduate program. These goals of these suggestions for interventions as far back as primary school are to increase interest in and preparation for graduate education in critical fields and retain graduate students, especially those from underrepresented groups.

d. **International Students:** Recommendations to recruit and retain international graduate students, as well facilitate their post-graduation plans while ensuring the sufficiency of resources for domestic students. Reasoning includes attracting the best graduate students regardless of national origin, ensuring that those who are in the US have access to needed resources, and benefiting from inclusion of educated individuals in the labor pool.

e. **Prioritize Student Needs:** Encouragement for institutions to center their decisions on the needs of graduate students, for example in admissions or in the design of funding structures. In particular, these recommendations point to ensuring that graduate students are receiving quality educational experiences.

II. **<u>Data:</u>** This category of recommendations emphasizes the need for data, collected by graduate education institutions and facilitated by federal agencies, and articulates the need to disseminate this data to the appropriate stakeholders.

a. **Departments Collect Data:** Suggestions that institutions collect data on their students' trajectories through graduate programs and post-graduation careers, in order to inform funding agencies, faculty, current and prospective students, and departments themselves.

b. **Agencies Collect Data:** Encouragement of federal agencies such as the National Science Foundation facilitating data collection and/or keeping national databases. The goals stated are for agencies to provide broad public access to information on graduate education and the science and engineering workforce, namely to encourage good decision-making by students, departments, and agencies themselves.

c. **Departments Provide Data:** Proposals that institutions openly share data on graduate students' trajectories through programs and post-graduation careers. In particular, recommendations stress the need to provide this data to prospective graduate students to improve transparency and good decision-making, but there are also suggestions to make faculty aware of student statistics and inform funding agencies of the current landscape.

III. **Careers and Competencies:** This group of recommendations focuses on the graduate education experiences that help students prepare for future careers, including professional development, internships, and restructuring of degree content.

a. **Diverse Career Preparation:** Suggestions on experiences integrated into graduate programs that can prepare students to enter a variety of careers, including in academia. These range from training in entrepreneurship to 'preparing future faculty' programs, but all stress the need for mechanisms to prepare graduate students for myriad potential careers.

b. **Professional Development:** Recommendations to develop structures to cultivate development of professional skills transferable to a variety of careers. Named professional skills include creativity, project management, ethics, communication, teamwork, safety, teaching, and others, and the responsibility is placed on institutions, departments, professional societies, potential employers, and funders.

c. **Internships:** Suggestions to provide work experiences to graduate students in order to expand their transferable and industry-specific skillsets and prepare them for a variety of potential careers via exposure to employment in different sectors.

d. **Career Assistance:** Mechanisms to assist graduate students in exploring career paths and obtaining jobs post-graduation. These include career counseling, alumni connections, application and interview preparation, and job placement assistance.

e. **Social Engagement:** Recommendations that graduate programs engage in the greater community, such as by encouraging students to apply their work to societal challenges, in order to make programs comprehensive and prepare students to work with diverse groups in all sectors.

f. **Interdisciplinarity:** Practices to facilitate cross-disciplinary research and graduate work via specific funding, departmental and interdepartmental policies, and through collaboration with businesses or agencies. The reasoning provided points to engaging graduate students in complex problem solving and a more robust intellectual experience.

IV. **Degree Experience:** These recommendations are focused on the process of attaining a graduate degree and point to particular supports that would improve this process.

a. **Support During Degree:** Suggestions of policies to ensure that students are supported, particularly in an advisory capacity, throughout their graduate careers. These include articulating degree expectations and benchmarks, actively advising students, and providing resources such as writing instruction throughout all stages of graduate education.

b. **Student Well-Being:** Suggestions on supporting graduate students' physical and mental health, ranging from improving safety to encouraging student cohesion to implementing family and medical leave policies.

c. **Mentoring:** Encouragement of structures to improve mentoring of graduate students, from educating faculty mentors to creating peer mentor networks, in order to improve graduate experiences and success, especially for students from underrepresented groups.

d. **Shorten Degree:** Recommendations on reducing graduate students' time to graduation through institutional policies, efficiency improvements, and support mechanisms. The reasoning provided is that this would attract graduate students and hasten their employment.

e. **Improve Completion:** Encouragement of institutions to reduce attrition of graduate students, including by using this as a metric of department success, to better attract talented students.

f. **Evaluate Programs:** Recommendations to assess graduate programs and practices via mechanisms such as surveys, analysis of student success data with appropriate metrics, evaluation of efficiency, and articulation of program goals. These recommendations emphasize that program modification and improvement should be paired with assessment.

V. **Buy-In**: This set of recommendations is built on the recognition that graduate education has diverse stakeholders with different incentives, and focuses on what these different stakeholders can bring to the table to improve graduate education.

a. **Student Involvement:** Encouragement of current students and alumni to participate in graduate education decisions and programs. These recommendations point towards institutions to involve current and former graduate students in discussions, as well as towards graduate students themselves to advocate for their needs and utilize resources.

b. **Employer Involvement:** Recommendations that employers support graduate education through tools such as funding, employment, or input. The goals range from alignment between employer needs and graduate education to better prepare students, to employer contribution to the funding of graduate education.

c. **Professional Societies:** Notes on the role of professional societies in disseminating information and providing resources to graduate students. All of these recommendations came from reports by the American Chemical Society, itself a professional society.

d. **Faculty Support:** Suggestions for faculty buy-in to graduate student education, such as culture change within faculty regarding mentoring, safety, diversity, and teaching. These suggestions also include providing opportunities for faculty to expand their own experiences in order to better support graduate students.

e. **Convene & Discuss:** Calls for conversations and consensus-building between stakeholders in graduate education, including federal and state governments, universities, employers in industry and other sectors, professional organizations, faculty, and graduate students and alumni. The goals of these conversations would be to coordinate efforts, align goals and information, and provide guidance on changes in graduate education.

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(1) 1995. National Research Council. Reshaping the Graduate Education of Scientists and Engineers. National Academies Press, Washington, DC. (pgs. 3-9)

Report focusing on reshaping PhD graduate education and doctoral students' abilities to find appropriate careers.

1. To produce more versatile scientists and engineers, graduate programs should provide options that allow students to gain a wider variety of skills. On the academic level, discourage students from overspecializing. On the career skills level, gain skills such as communication and teamwork through experiences including off-campus internships. **[Diverse Career Preparation] [Internships]**

2. To foster versatility, government and other agents of financial assistance for graduate students should adjust their support mechanisms to include new education/training grants to institutions and departments. **[Financial Support]**

3. Graduate programs should change to promote versatility while maintaining local initiatives that build on institutional strengths and interests.

4. Graduate programs should maintain excellence in research by continuing to prepare students for careers in research while adding complementary steps to reflect employment opportunities in all sectors. Students should be prepared for continuous change rather than receiving narrow specialty training. **[Diverse Career Preparation]**

5. Time to degree should be controlled to shorten time to first employment, by ensuring that the primary objective of graduate education is the education of students. Institutions should set and enforce standards for time to degree and it should be a department's responsibility to advance students' progress. **[Shorten Degree]**

6. Graduate programs should attract women and minorities by deliberately addressing real and perceived barriers to full participation. **[Emphasize Diversity]**

7. Graduate scientists and engineers and their advisers should receive more up-to-date and accurate information to help them make informed decisions about professional careers. Departments should track information on their students, including career tracks, financial aid, time to degree, and placement. Broad electronic access to this information should be provided through a national database managed within the academic community and with federal participation coordinated by the NSF. **[Departments Collect Data] [Agencies Collect Data]**

8. Academic departments should provide the information from (7) to prospective and current students in a timely manner and should also provide career advice to graduate students. This career advice should be improved by departmental tracking of its graduates' employment paths. **[Departments Provide Data]**

9. At the point when they have met their qualifying requirements, students should be encouraged to consider three alternative pathways: (1) stop with a master's degree in light of a student's aspirations and projected employment demand, (2) proceed toward a PhD and a position in research, or (3) for a student interested in nontraditional fields, design a dissertation with high standards for originality but which would require less time than would preparation for a career in academic research. **[Diverse Career Preparation] [Prioritize Student Needs]**

10. The National Science Foundation should continue to improve the coverage, timeliness, and clarity of analysis of the data on the education and employment of scientists and engineers (including nonacademic employment) in order to support better national decision-making about human resources in science and technology. **[Agencies Collect Data]**

11. A national discussion group - including representatives of governments, universities, industries and professional organizations- should deliberately examine the goals, policies, conditions, and unresolved issues of graduate-level human resources. **[Convene & Discuss] [Evaluate Programs]**

12. A recommendation was not made on across-the-board limits on PhD enrollment because conditions differ by field and subfield, research experience provides valuable preparation for a wide variety of nontraditional careers, and limiting actions would have little immediate impact.

13. A recommendation was not made on limiting the number of foreign students because foreign PhDs who find employment in the United States make major contributions to the nation, the increase in the number of foreign-citizen graduate students was caused by political events that are unlikely to recur, and there is evidence that some foreign students are finding employment opportunities in their home countries.

(2) 1998. AAU Committee on Graduate Education. Report and Recommendations. (pgs. 3-5)

(http://www.aau.edu/workarea/downloadasset.aspx?id=6720)

Report and recommendations developed in response to criticisms of doctoral education, including "Reshaping the Graduate Education of Scientists and Engineers"

1. Admissions decisions should be made with the goal of maintaining and improving the quality of programs **[Prioritize Student Needs]**

2. Departmental recruitment and admissions policies should include provisions designed to increase the participation of talented students from groups underrepresented in their graduate programs. To make significant progress, universities will need to work with undergraduate institutions and K–12 schools to reach minority students as early as possible in their educational lives and encourage them to prepare for and pursue graduate study. **[Emphasize Diversity] [Start Early]**

3. Universities should encourage enrollment of exceptional foreign students while continuing efforts to develop the U.S. domestic talent pool. **[International Students]**

4. All admitted students should be given accurate information about the costs they will incur and realistic assessments of future prospects for financial support. **[Departments Provide Data]**

5. Financial support should be designed to assist students in their progress to a degree; financial support through work that draws students away from their graduate programs should be avoided. **[Financial Support] [Prioritize Student Needs]**

6. Institutions should evaluate the graduate curriculum to assure that it equips students with the knowledge and skills needed for a broad array of postdoctoral careers that they might wish to pursue. **[Diverse Career Preparation] [Professional Development]**

7. The graduate curriculum should balance breadth and depth with the need to minimize time-to-degree. **[Shorten Degree]**

8. Faculty mentors should confer with students frequently to assess students' progress, and should provide the department with periodic assessments on progress to the degree. **[Mentoring] [Support During Degree]**

9. Institutions and departments should clearly affirm the importance of faculty mentoring through policy guidelines and incentives. **[Mentoring]**

10. Institutions should maintain data on completion rates, time-to-degree, and placement to the first professional employment, as well as conduct exit surveys for all Ph.D. recipients. Institutions should provide such program performance data to student applicants. **[Departments Collect Data] [Departments Provide Data]**

11. Institutions should provide job placement assistance for students who request it. **[Career Assistance]**

12. Institutions should evaluate the quality of and justification for their doctoral programs through self-study, on-site evaluation by external reviewers, or both. **[Evaluate Programs]**

13. Institutions should terminate programs that cannot maintain the infrastructure and student financial support necessary for acceptable program quality. **[Evaluate Programs]**

14. Institutions should not begin new programs absent a regional or national need and sustainable support **[Evaluate Programs]**

15. Institutions should ask departments to provide descriptions of their goals and expectations for their graduate programs, and should periodically compare these against departmental program performance data. **[Evaluate Programs]**

16. The AAU should assist institutions in developing common definitions and reporting procedures that will permit cross-institutional comparisons of program performance. **[Evaluate Programs]**

(3) 2005. Woodrow Wilson National Fellowship Foundation. The Responsive PhD: Innovations in U.S. Doctoral Education. (pgs. 4-5, 8, 25)

(https://eric.ed.gov/?id=ED536859)

Report back from initiatives at 20 doctoral programs (including humanities) that were assessed and redirected into recommendations.

1. Graduate schools and graduate deans need to be strengthened with greater budgets and scope so that they can break down barriers between programs and sponsoring a more cosmopolitan intellectual experience for doctoral students (including interchange beyond academia). **[Interdisciplinarity]**

2. Changes in doctoral policy, as well as in the ultimate standards for the doctorate in each field, should emerge from a continuous dialogue among the faculty who teach doctoral students, the students themselves, and the representatives of diverse sectors that employ doctoral graduates. **[Convene & Discuss] [Student Involvement] [Prioritize Student Needs]**

3. Departments and graduate schools need to involve Ph.D. alumni more substantively in doctoral training. **[Mentoring] [Student Involvement]**

4. Doctoral students need both departmental and extra-departmental structures to give their concerns a strong and effective voice and to cultivate graduate student leadership as a component of graduate education and professional development. **[Student Involvement] [Prioritize Student Needs] [Professional Development]**

5. Information about doctoral education, program expectations, and career prospects must be more transparent to students from the moment they begin to consider a Ph.D. **[Departments Provide Data]**

6. Doctoral programs urgently need to expand their approaches to mentoring, such as through team mentoring, particularly for attracting and retaining a diverse cohort of students. **[Mentoring]**

7. Recommendations from the Woodrow Wilson Foundation report "Diversity and the Ph.D." were referenced, including fostering communication through an active consortium of organizations committed to greater doctoral diversity (including graduate schools), developing better data on interventions which work in recruiting and retaining Ph.D. candidates of color, allying doctoral education with K-12 reform efforts and community colleges, making the doctorate less insular and more socially engaged, providing practical mentoring and professionalizing experiences, treating race and need together to focus assistance where it is most needed, and working closely with federal agencies that call for inclusiveness. **[Emphasize Diversity] [Start Early] [Social Engagement] [Mentoring] [Professional Development]**

(4) 2005. National Research Council. Policy Implications of International Graduate Students and Postdoctoral Scholars in the United States. (pgs. 4-11)

Report on graduate student and postdoctoral scientists and engineers in the United States

1. The US must maintain or enhance its current quality and effectiveness in S&E with a principal objective being to attract the best graduate students and postdoctoral scholars regardless of national origin. The United States should make every effort to encourage domestic-student interest in S&E programs and careers. **[International Students]**

2. The overarching goal for universities and other research institutions should be to provide the highest-quality training and career development to both domestic and international graduate students and postdoctoral scholars of truly outstanding potential. The education of the next generation of researchers should have the highest priority among graduate admissions objectives. This educational process will include research and sometimes a teaching experience. **[Prioritize Student Needs]**

3. Admissions committees should keep in mind career and employment opportunities, in academe and elsewhere, when making admissions decisions. **[Prioritize Student Needs]**

4. Data concerning employment outcomes should be readily available to both students and faculty. **[Departments Provide Data]**

5. Universities should continue to encourage the enrollment of international students by offering fellowships and assistantships. **[International Students]**

6. Universities that have large international student and scholar populations should conduct surveys to evaluate existing services provided by the institutions. **[Evaluate Programs]**

7. Universities that do not already do so should offer orientation days for international students, train teaching assistants, update Web services, and provide professional development training for administrators staffing international student and scholar offices. **[International Students]**

8. A high priority should be placed on collecting and disseminating data on the demographics, working conditions, and career outcomes of scholars who earned their doctoral degrees outside the United States. Funds should be allocated for this purpose by Congress to the NSF or by nonprofit foundations to other organizations to combine this information with current data collected by the National Science Foundation (NSF) and professional societies to make a more complete picture of the US S&E workforce. **[Agencies Collect Data]**

9. So that students can make informed decisions about advanced training in S&E, career outcomes of recent graduates should be communicated to prospective students by university departments and faculty advisers. **[Departments Provide Data]**

10. In addition to intensive focused research work, graduate education and postdoctoral programs should encompass career preparation and the development of varied skills for successful careers in S&E. **[Diverse Career Preparation] [Professional Development]**

11. When it is appropriate, funding agencies should provide career-transition grants for early-career researchers.

12. Universities, industry, and funding agencies to discuss and explore how to expand graduate fellowships and encourage women and members of underrepresented minorities to consider education and training in S&E. **[Emphasize Diversity]**

13. The United States needs a new system of data collection to track student and postdoctoral flows so that it can understand the dynamics and effects of shifting sources of talent. Funds should be provided to the NSF or other institutions to collaborate internationally to create a data system similar to a balance-of-trade account to track degree production, student and postdoctoral movement between countries, push-pull factors affecting student choice at all degree levels, and employment outcomes. **[Agencies Collect Data]**

14. Visa and immigration policies should provide clear procedures that do not unnecessarily hinder the flow of international graduate students and postdoctoral scholars. New regulations should be carefully considered in light of national-security considerations and potential unintended consequences. Research institutions and the Departments of State (DOS) and Homeland Security (DHS) should continue their discussion on these matters. **[International Students]**

    a. We strongly encourage DOS and DHS to continue working toward extending the duration of Visas Mantis clearances for some students and scholars is a positive step and to consider applying those provisions to students and scholars from all countries.
    b. Means should be found to allow international graduate students and postdoctoral scholars who are attending or appointed at US institutions to attend scientific meetings that are outside the United States without being seriously delayed in reentering the United States to complete their studies and training.
    c. The Technology Alert List, used to manage the Visas Mantis program, should be reviewed regularly by scientists and engineers outside government. Scientifically trained personnel should be involved in the security-review process.
    d. New nonimmigrant-visa categories should be created for doctoral-level graduate students and postdoctoral scholars, whether they are coming to the United States for formal educational or training programs or for short-term research collaborations or scientific meetings. The categories should be exempted from the 214b provision whereby applicants must show that they have a residence in a foreign country that they have no intention of abandoning.
    e. Multiple-entry and multiple-year student visas should have high priority in reciprocity negotiations.
    f. Procedures for change of status should be clarified and streamlined.

(5) 2007. National Research Council. Rising Above the Gathering Storm. (pgs. 5-12)

Priorities to enhance the science and technology enterprise

1. Recruit 10,000 science and mathematics teachers annually with 4-year scholarships
2. Strengthen the skills of 250,000 teachers through training and education programs at summer institutes, master's programs, and AP and IB training programs.
3. Increase the number of students who pass AP and IB science and mathematics courses and expand statewide specialty high schools and inquiry-based learning.
4. Increase the federal investment in long-term basic research by 10% each year over the next 7 years
5. Provide new 5-year, $500,000 research grants to 200 of the nation's most outstanding early-career researchers.
6. Institute a National Coordination Office for Advanced Research Instrumentation and Facilities to manage a fund of $500 million in incremental funds per year over the next 5 years
7. Allocate at least 8% of budgets of federal research agencies to discretionary funding focused on high-risk, high-payoff research.
8. Create an Advanced Research Projects Agency-Energy (ARPA-E) as a DARPA-like entity in the Department of Energy
9. Institute a Presidential Innovation Award to stimulate scientific and engineering advances in the national interest.
10. Provide 25,000 new 4-year competitive undergraduate scholarships each year to US citizens attending US institutions with the intent to obtain bachelor's degrees in the physical sciences, life sciences, engineering, and mathematics.
11. Fund 5,000 new graduate fellowships each year for NSF to use to increase the number of US citizens pursuing graduate study in areas of national need. **[Financial Support]**
12. Provide a federal tax credit to encourage employers to make continuing education available to practicing scientists and engineers
13. Improve visa processing for international students and scholars.
14. Provide a 1-year automatic visa extension to international students who receive doctorates or the equivalent in science, technology, engineering, mathematics, or other fields of national need at qualified US institutions to remain in the United States to seek employment. If these students are offered jobs by US-based employers and pass a security screening test, they should be provided automatic work permits and expedited residence status. **[International Students]**
15. Institute a new skills-based preferential immigration option.
16. Reform the current system of "deemed exports"
17. Enhance intellectual property protection for the 21st-century global economy.

18. Enact a stronger research and development tax credit to encourage private investment in innovation.
19. Provide tax incentives for US-based innovation.
20. Ensure ubiquitous broadband internet access.

(6) 2009. National Research Council. A New Biology for the 21st Century. The National Academies Press, Washington, DC (pgs. 87-89)

> Examine the current state of biological research and recommend how best to capitalize on recent technological and scientific advances.

1. The committee recommends that the New Biology Initiative devote resources to programs that support the creation and implementation of interdisciplinary curricula, graduate training programs, and educator training needed to create and support New Biologists. **[Interdisciplinarity]**

(7) 2009. Council of Graduate Schools. Broadening Participation in Graduate Education. (pgs. 19-20)

Report focusing on increasing participation of underrepresented groups in STEM

1. Institutions of higher education should closely monitor completion and attrition rates of students from underrepresented groups and implement best practices to improve completion rates. **[Improve Completion] [Emphasize Diversity]**

2. Institutions of higher education should develop training programs for graduate student mentors who can help a diverse group of students navigate graduate school successfully. **[Mentoring]**

3. Institutions of higher education should experiment with programs that use technology, which attracts and appeals to today's students. **[Prioritize Student Needs]**

4. Institutions of higher education should identify strategies for recruiting a more diverse faculty by broadening faculty search criteria and by advertising positions as widely as possible.

5. Institutions of higher education should identify possible faculty members by establishing linkages with specialized targeted institutions, including HBCUs.

6. Institutions of higher education should encourage faculty to be ever vigilant of opportunities to promote a more inclusive environment for students as well as themselves. **[Faculty Support] [Emphasize Diversity]**

7. Institutions of higher education should encourage graduate deans, who are uniquely positioned in institutions of higher education to become leaders in inclusiveness by:
    a. Working to ensure that inclusiveness is a team effort in the institution, involving the student body, faculty, and the highest levels of administration.
    b. Supporting the development of a more inclusive curriculum with courses that appeal to a wide range of students.
    c. Using their understanding of the academic pipeline to assist in diversifying the faculty.

    [Emphasize Diversity] [Prioritize Student Needs] [Convene & Discuss]

8. Institutions of higher education should continue to foster partnerships with those in the business community who have made inclusiveness an essential part of their organizations. **[Employer Involvement] [Emphasize Diversity]**

9. Institutions of higher education should continue to develop strategies that are effective in helping to make graduate education responsive to the intellectual aspirations of all students. **[Prioritize Student Needs]**

10. Institutions of higher education should recognize that broadening participation is a dynamic process and that supporting diversity and inclusiveness is a priority. **[Emphasize Diversity]**

11. Federal and state governments should organize a national summit on investing in human capital and talent in the 21st century. **[Convene & Discuss]**

12. Government should create incentives for students, particularly students from underrepresented groups, to pursue graduate education in the STEM fields, social sciences, and humanities, through portable and competitive fellowships and traineeships, loan forgiveness, and other measures. **[Financial Support] [Emphasize Diversity]**

13. Government should create a program, funded by H-1B visa program revenues, to encourage U.S. domestic students, particularly students from underrepresented groups, to pursue graduate education in key areas of national need that are at the cutting edge of new markets. **[Financial Support] [Emphasize Diversity]**

14. Government should identify strategies and funding mechanisms that will encourage more women and underrepresented groups in STEM fields to advance to leadership positions. **[Emphasize Diversity] [Financial Support]**

15. Government should enact an NDEA for the 21st Century. **[Financial Support]**

16. Government should increase support for graduate fellowships at NIH and NSF as well as at the Departments of Energy and Education, and other appropriate federal and state agencies. **[Financial Support]**

17. Government should increase the awareness, particularly of students from underrepresented groups, of the breadth of career paths for those with graduate education by:
    a. Supporting innovative professional master's degrees in order to address pressing national needs in critical fields such as mathematics, science, engineering, social sciences, and humanities.
    b. Fashioning graduate support and research programs to reward creativity and inclusiveness as key components of a U.S. strategy on innovation.

    [Social Engagement] [Diverse Career Preparation]

(8) 2010. National Research Council. Rising Above the Gathering Storm Revisited. (pg. 30)

Reviewing changes since the original report

1. Action in response to Rising Above the Gathering Storm (Recommendation 11): About $640 million authorized and $475 million appropriated over FY 2009-2010 (including ARRA) to NSF for existing programs such as Graduate Research Fellowships, Integrative Graduate Education and Research Traineeships, and Protecting America's Competitive Edge Graduate Fellowships.

2. Action in response to Rising Above the Gathering Storm (Recommendation 14): By regulation, the Office of Citizenship and Immigration Services extended the optional practical training period for F-1 nonimmigrant students with STEM degrees from 12 to 29 months, and amended regulations to allow for automatic extensions of status and employment authorizations for F-1 students with pending H-1B applications.

(9) 2010. Council of Graduate Schools. PhD Completion and Attrition: Policies and Practices to Promote Student Success. (pgs. 2-5)

(http://www.phdcompletion.org/information/book4.asp)

> Promising intervention strategies and pilot projects at institutions to improve Ph.D. completion and reduce attrition (not necessarily recommendations).

1. Recruitment: Offer pre-admission and pre-enrollment campus visits; use early research opportunities as a recruitment tool; improve efforts to recruit underrepresented students. **[Start Early] [Emphasize Diversity]**

2. Transparency: Improve department websites to ensure that each includes additional data, information, and resources necessary for prospective students to make informed decisions; increase transparency in the selection processes and clarify expectations for students in their doctoral programs, including assessment milestones. **[Departments Provide Data]**

3. Admissions: Develop workshops for admissions committees; select students based on "fit" to program; survey applicants to determine why admissions offers are accepted or declined. **[Departments Collect Data]**

4. Resources for students: Provide a comprehensive orientation to prepare students for graduate school; develop/revise graduate student handbooks; clearly articulate program expectations/academic milestones; develop/enhance online mechanisms so students and faculty can track progress and communicate with one another; implement online milestone tracking systems, "dissertation checklists," electronic portfolios, and annual progress report systems that integrate graduate school records, student input, and evaluative comments from faculty. **[Departments Provide Data] [Support During Degree] [Prioritize Student Needs]**

5. Regularity and uniformity of progress review: Implement regular advisor/advisee meetings and progress reports; encourage programs to set up annual student performance review systems. **[Support During Degree] [Mentoring]**

6. Early advising: Require each first-year student to have an advisor or advisory structure; conduct regular evaluations of progress; encourage women and minority students to participate in programs that offer mentorship outside the department; create ombud position to support first-year students. **[Mentoring] [Support During Degree]**

7. Resources for faculty: Offer workshops for faculty on mentoring; offer mini-grants to help faculty develop initiatives aimed at improving the quality of mentoring; recognize excellence in mentoring through faculty awards. **[Mentoring] [Faculty Support]**

8. Other mentors: Train peer mentors and ensure that all new students are assigned a trained peer mentor; provide students with external mentors. **[Mentoring]**

9. Increased student support: Increase stipend levels to be comparable to peers; increase the number of selective university fellowship awards; increase the number of summer research awards in the humanities and social sciences; provide health insurance premium coverage; explore higher stipends and more one quarter releases from teaching for dissertating students; change graduate assistantship allocation to a "Ph.D. preferred" model, whereby 80% of doctoral students and 20% of master's students will be funded; address potential IRS tax inequities within graduate student population. **[Financial Support] [Student Well-Being]**

10. Incentives to departments: Link departmental allocations and performance indicators of student completion. **[Improve Completion]**

11. Support networks and support services: Initiate campus-wide efforts to bring students together across disciplines and within the department for academic and social interaction; encourage graduate student

organizations in all programs/departments to explore community building activities; promote involvement of graduate students as members of campus-wide or department-wide committees; highlight achievements and accomplishments of graduate students through newsletters, dinners, or other venues; develop a network for support; outreach to and integration of fellows. **[Student Involvement] [Mentoring] [Student Well-Being]**

12. Family accommodation policies: Implement a parental accommodation policy and institution-wide policy on family and medical leave for graduate assistants. **[Student Well-Being]**

13. Pre-program research experiences: Identify top undergraduates and invite them to participate in a research institute late in their sophomore year to prepare and recruit these students to pursue doctoral studies; offer summer predoctoral institute for underrepresented students. **[Start Early]**

14. Early research experiences: Encourage lab rotations prior to choosing a mentor/research area; provide opportunities and funding for humanities and social sciences students to participate in research in the early stages of their programs and to attend professional meetings; provide students with a catalog of research opportunities and facilitate matching of research interests between advisors and students; streamline course requirements to allow students the opportunity to engage early in research. **[Start Early]**

15. Administrative/curricular processes and procedures: Create/enhance institutional database on students via a web-based system to track student aid; monitor and track all students who leave; introduce a continuous enrollment policy to serve as the impetus for students to stay on track; refine policies and practices for matriculation and track and report on Ph.D. student degree progress; revise program review process to examine quality of each graduate program in terms of quality inputs, outcomes, and operational practice; streamline the sequencing of courses. **[Departments Collect Data] [Support During Degree] [Evaluate Programs]**

16. Writing assistance for graduate students: Offer a writing assistance program for graduate students at all stages through trained writing coaches or writing consultants (senior-level graduate students trained in writing); offer writing assistance to groups of students from several disciplines so they can appreciate the commonality of writing difficulties. **[Support During Degree]**

17. Support During the Dissertation Phase: Offer a Dissertation Retreat/Dissertation Boot Camp/Dissertation House/Dissertation Writing Institute for students who are stalled in their progress that offers uninterrupted time to focus on the dissertation, writing strategies, receive feedback, and build peer support; establish a Doctoral Student Writing Room, where doctoral students could engage in project development, research and writing and collaborate with others; offer a summer Dissertation Writing Residency Fellowship for students who are not making progress (especially students from underrepresented groups). **[Support During Degree] [Emphasize Diversity]**

18. Professional Development of Graduate Students: Offer a safe, hospitable space in which graduate students engage in microteaching activities, videotape themselves teaching, and engage in the peer review of teaching to develop skills in constructive peer teaching review; offer a University Graduate Certification in College Teaching, requiring workshop experiences in five competency areas as well as a mentored teaching experience; offer a Graduate Teaching Fellowship Program to provide mentored teaching experiences for qualified students who might not normally have such an opportunity in their own discipline; offer enrichment events aimed at preparing students for job applications and interviews or preparing them for careers in other sectors. **[Diverse Career Preparation] [Financial Support] [Support During Degree] [Career Assistance] [Professional Development]**

(10) 2010. Council of Graduate Schools and the Educational Testing Service. The Path Forward: the Future of Graduate Education in the United States. (pgs. 41-54)

http://www.fgereport.org/

Study of the trends that impact participation in graduate education in all fields

1. Universities need to improve undergraduate and graduate completion rates, especially at the master's level **[Improve Completion]**

2. Graduate schools must provide appropriate training, mentoring, and information about career opportunities outside of academia, such as business, government, and the nonprofit sector. **[Diverse Career Preparation] [Mentoring] [Career Assistance]**

3. Universities need to prepare graduate students to be future faculty by continuing to develop and evolve strong "Preparing Future Faculty" programs which allow students to observe and experience faculty responsibilities, especially teaching, at a variety of academic institutions. **[Diverse Career Preparation] [Mentoring] [Career Assistance]**

4. U.S. graduate schools should provide professional development in their doctoral education, as master's education has. These professional development programs should: encourage development of creativity and entrepreneurship; improve personal effectiveness such as self-organization and career development skills; develop capacity for project management including finance, funding, and resource management; cultivate professional and research ethics; and encourage the development of skills that enhance research impact such as communication, teamwork, relating work to a broader context, and application of research to larger corporate or social purposes. **[Diverse Career Preparation] [Social Engagement] [Professional Development]**

5. Federal agencies could favor professional development programs in grant solicitations, specifying that programs should not extend time to degree. Professional development activities should be included in new doctoral traineeship programs. **[Diverse Career Preparation] [Financial Support] [Professional Development]**

6. Universities should establish and expand programs to identify talented undergraduate students who have the interest and potential to pursue graduate training and provide educational pathways for students (linking K-12, undergraduate, and graduate education) to enter fields that prepare them to address pressing challenges. **[Start Early]**

7. Employers should partner with individual universities to establish a "Graduate School Chair" for a graduate student. Tuition and fees for the graduate student would be covered for up to 5 years for doctoral students and 2 years for master's students. The sponsoring entity would also provide an internship opportunity for the chosen graduate student. A faculty member and/or other employee of the university could be eligible for a 1-month sabbatical to be spent at the internship site. Conversely, the industry representative could spend time in the academic environment. **[Financial Support] [Internships] [Employer Involvement]**

8. Employers in all sectors should consider creating employer-matched, portable individual accounts for purposes of financing employee education and training. Both employers and employees would contribute to the account, and the programs would provide a tax benefit for both employees and employers. **[Employer Involvement]**

9. All employers should be encouraged to provide tuition reimbursement programs for current employees who seek to further their education and pursue graduate degrees. **[Employer Involvement]**

10. Employers across all sectors should partner with universities and governments to develop programs designed to promote the participation of students from underrepresented groups in graduate programs. The National Consortium for Graduate Degrees for Minorities in Engineering and Science (GEM) provides a possible model for replication. **[Employer Involvement] [Financial Support] [Emphasize Diversity]**

11. Industry funding could be used to establish a parallel, industry-specific program in conjunction with current successful fellowship programs, including the NSF GRF program, the U.S. Department of Education GAANN Program, and the Office of Science Graduate Fellowships (SCGF) at the U.S. Department of Energy, among others. This program would enable industry funding for fellowship support in the broad disciplines of their interest. Award levels would entail approximately $125,000, to cover the stipend itself plus the associated cost of education for 3 years, not including any administrative fees to the program. Companies that sponsor fellows would be allowed to pool their donations and to provide pooled job-related opportunities for graduate fellows. There would be no commitment to hire on the part of an individual company and no commitment to a particular job. **[Employer Involvement] [Financial Support] [Internships]**

12. Small business owners, and national organizations that represent them, should pursue tax breaks for their firms or their employees to make graduate education more affordable and appealing. **[Employer Involvement] [Financial Support]**

13. All employers should communicate the educational skills needed for 21st century jobs in the global economy to universities and clarify entry points into careers. Additionally, they should make this information widely known from high school through graduate school. **[Employer Involvement] [Diverse Career Preparation] [Departments Provide Data]**

14. All sectors of the U.S. economy should seek ways to provide internships and work study opportunities for graduate students. For example, U.S. multinational corporations are in a position to create internship and work/study opportunities for graduate students to provide cutting-edge training and exposure to working in diverse cultures **[Internships]**

15. Policymakers should authorize a new federal program, called the COMPETES doctoral traineeship program, to support doctoral education associated with areas of national need. The program would cover direct student support of $30,000 stipends plus tuition and fees, other costs of education, and ancillary fringe costs, for a total of $80,000 per student per year. Students would be eligible for up to 5 years of support. The authorization would be for 6 years to ramp up the program, beginning with $2 billion in FY 2011 to accommodate approximately 25,000 students and building up to $10 billion in FY 2016 to accommodate approximately 125,000 students as the program reaches its steady state. Universities submitting proposals would be required to provide data, including enrollments, completion rates, and job placement information to the funding agency. 20% of the funding could support international students. **[Financial Support] [Departments Provide Data]**

16. The federal government should authorize a new federal competitive grant program to inspire innovation in master's degree programs and responsiveness to workforce needs. Each program would be required to demonstrate maintenance of enrollment, completion rates, and job placement outcomes, as well as ongoing involvement by employers. Programs should be required to secure 2/3 of their funding from non-federal-government sources. When fully implemented, this program would support development of 1,000 new or reinvented master's programs, including professional master's programs. Each institution would be eligible for a one-time $500,000 5-year grant, and the authorization would be for 200 grants per year for a total federal investment of $500 million over 5 years. **[Financial Support] [Evaluate Programs]**

17. In addition to creating programs for doctoral and master's education to address challenges in particular key areas, the federal government should increase the cost of education allowance for existing

traineeships and portable graduate student fellowships for doctoral students. Federal agencies should adopt a common standard for determining the amount and criteria for allocating this cost of education. Increases should come in established programs including the NSF-IGERT, NSFGRF, Department of Education Graduate Assistance in Areas of National Need (GAANN), the Jacob K. Javits Fellowship Program, the Department of Defense SMART program, NIH NRSA graduate fellowship and training grant programs, and the newly established Department of Energy Office of Science Graduate Fellowship program. **[Financial Support]**

18. The federal government should expand the number of fields in which it permits loan forgiveness to students who complete their graduate degree, in return for a certain period of employment in their chosen fields in the public or nonprofit service sector. Policymakers should consult with graduate education leaders to determine these critical fields. **[Financial Support] [Convene & Discuss]**

19. The federal tax code should be amended again to language similar to the pre-1986 version to include: "Non-taxable graduate education scholarships and fellowships are an amount paid or allowed to, or for the benefit of, a student at an educational institution in a graduate degree-seeking program. This includes scholarships, fellowships, and grants at the institution. A graduate degree is defined as a post baccalaureate, masters, doctorate, or professional degree. The maximum non-taxable amount will be limited to the projected cost of attendance reported annually by the student's institutions." **[Financial Support]**

20. The federal government should encourage and adopt policies, practices, and strategies designed to achieve increased alignment and coordination of federal grant programs that support graduate education and state programs that have the same or similar goals. State grant programs that support graduate education could be better aligned with some of the federal programs at NSF, the U.S. Department of Education, and elsewhere. Federal agencies should encourage alignment of state programs with federal ones as part of their grant solicitation processes. **[Financial Support] [Convene & Discuss]**

21. The US must adopt policies that welcome those international students who desire to pursue graduate education as well as future employment in our country. The federal government should: Continue to improve the visa process to make the pathway for international students and scholars in high-priority fields more efficient; As part of any future immigration reform, create a new visa category for international students who receive a doctorate in a STEM field from a U.S. institution of higher education that establishes a clear pathway to permanent residency; Encourage federal funding agencies to support collaborative graduate degree programs with universities abroad in an effort to develop sustainable pathways to ensure that an ongoing supply of the world's most talented students flows into U.S. graduate schools and that there are strong educational opportunities for U.S. graduate students abroad; Encourage and support more U.S. graduate students to engage in international experiences, such as the Fulbright or study abroad programs. **[International Students]**

22. The U.S. Department of Education should implement a Fund for the Improvement of Postsecondary Education (FIPSE) competition that would allow graduate students to apply their talents to issues of national importance at the local, state, national, and international levels. Universities would be encouraged to assemble interdisciplinary teams to identify and address pressing issues or problems and would provide a national presentation of the results of their work. **[Interdisciplinarity] [Social Engagement] [Financial Support]**

23. The federal government should support studies about: understanding aspirations and creating career pathways for students; careers in the 21st century and pathways that lead to them; and humanities in the 21st century economy and the role of graduate education. **[Agencies Collect Data]**

(11) 2012. National Research Council. Research Universities and the Future of America. (pgs. 7-19)

Identifying top ten actions to assure the ability of the American research university to maintain excellence in research and doctoral education.

1. The federal government should adopt stable and effective policies, practices, and funding for university-performed R&D and graduate education. **[Financial Support]**

2. Provide greater autonomy for public research universities so that these institutions may leverage local and regional strengths to compete strategically and respond with agility to new opportunities.

3. Restore state appropriations for higher education, including graduate education and research, to levels that allow public research universities to operate at world-class levels. **[Financial Support]**

4. Strengthen the business role in the research partnership to facilitate transfer of knowledge, ideas, and technology to society. **[Employer Involvement]**

5. Increase university cost-effectiveness and productivity in order to provide a greater return on investment for taxpayers, philanthropists, corporations, foundations, and other research sponsors. **[Evaluate Programs]**

6. Create a "Strategic Investment Program" that funds initiatives at research universities critical to advancing education and research in areas of key national priority. **[Financial Support]**

7. The federal government and other research sponsors should strive to cover the full costs of research projects and other activities they procure from research universities in a consistent and transparent manner.

8. Reduce or eliminate regulations that increase administrative costs, impede research productivity, and deflect creative energy without substantially improving the research environment.

9. Improve the capacity of graduate programs to attract talented students by addressing issues such as attrition rates, time to degree, funding, and alignment with both student career opportunities and national interests. **[Shorten Degree] [Financial Support] [Diverse Career Preparation] [Improve Completion]**

10. Secure for the United States the full benefits of education for all Americans, including women and underrepresented minorities, in science, mathematics, engineering, and technology. **[Emphasize Diversity]**

11. Ensure that the United States will continue to benefit strongly from the participation of international students and scholars in our research enterprise. **[International Students]**

(12) 2012. American Chemical Society. Advancing Graduate Education in the Chemical Sciences. Summary Report of an ACS Presidential Commission. (pgs. 12-18)

(http://www.acs.org/content/dam/acsorg/about/governance/acs-commission-on-graduate-education-summary-report.pdf)

> Changes in graduate education in the chemical sciences to keep pace with changes in the economic, social, and political environment, including technological change

1. The Commission encourages departments to undertake greater oversight over the progress and opportunities of individual graduate students. **[Support During Degree]**

2. Graduate programs should be more active in diagnosing and remediating deficiencies in the preparation of first-year students. **[Start Early] [Support During Degree]**

3. Faculty overseeing doctoral programs need to offer specific activities that would enhance students' ability to: communicate complex topics to both technical and nontechnical audiences and to effectively influence decisions; learn new science and technology outside prior academic training; collaborate on global teams and/or with global partners and clients; effectively define, drive, and manage technical work toward a practical, significant result; and clearly understand the ethical conduct of research. Significantly enhance interdisciplinary collaboration among students to address this. **[Diverse Career Preparation] [Social Engagement] [Interdisciplinarity]**

4. Four years should be the target for completion of the Ph.D., with the departmental median time less than five years. Degree times greater than five years should be strongly discouraged through enforced institutional policies. Increase the efficiency of graduate education with better program design, superior monitoring of student progress, use of the summer before the first year of graduate study, and fuller use of short courses and online classes. **[Shorten Degree] [Support During Degree]**

5. Every department should constitute a doctoral committee for each student composed of several faculty who will be intimately involved in the student's graduate education. Graduate programs should see that the doctoral committee is involved more closely and more frequently in graduate student mentoring than is currently the norm in Ph.D. student advising. This should include, at a minimum, annual meetings, and opportunities for the student to address matters such as possible conflicts with the advisor. **[Support during Degree] [Mentoring]**

6. Graduate programs should make an Individual Development Plan (IDP) a standard part of every doctoral student experience. The structure and elements of the IDP should be developed in a tailored way at each institution. **[Diverse Career Preparation] [Mentoring]**

7. Faculty should encourage students to engage in projects requiring collaboration that broadens the student's field of study. In particular, faculty should encourage collaboration across disciplines as much as possible. **[Interdisciplinarity]**

8. Departments should require at least two original research proposals, one with a focus outside the student's immediate field of study. **[Interdisciplinarity]**

9. Departments in the chemical sciences are encouraged to set up structures that enable and facilitate an interdisciplinary and multidisciplinary team approach to complex problem solving. **[Interdisciplinarity]**

10. Students interested in entrepreneurship should have access to a curricular option providing an introduction to relevant topics, including the protection and management of intellectual property (IP), the basic economics of IP-based businesses, the financing of start-up enterprises, and selected legal concepts. The ACS might provide useful short courses for delivery on campuses or via the Internet. **[Diverse Career Preparation]**

11. The ACS should develop one or more formal courses for the more explicit preparation of students who intend to seek academic employment. The first should be focused on undergraduate curriculum development, teaching standards, and teaching methods. It should be provided on campus through specifically trained faculty or perhaps online, in part, or in whole. Academic institutions should strongly encourage all applicants for teaching positions to have résumés noting successful completion of this course or a suitable alternative. **[Diverse Career Preparation]**

12. The ACS should develop a course to cover the mentoring of graduate students, grantsmanship, interactions with program officers, and other related topics. **[Diverse Career Preparation]**

13. The ACS is encouraged to survey representative graduate programs at selected major universities to ascertain requirements and expectations and organizational structure that best facilitate the educational goals of the Commission. **[Convene & Discuss]**

14. The ACS should assure that the Commission's recommendations on best educational practices are reflected in the work of the ACS Education Division, the ACS Graduate Education Advisory Board, and the ACS Committee on Economic and Professional Affairs. **[Professional Societies]**

15. Federal and state funding agencies, private funders, and universities should take steps toward decoupling more student-support funds from specific research projects, in the interest of providing students the opportunity for better balance between training in research and training in other career skills, without significantly impacting the research productivity of faculty. **[Financial Support] [Prioritize Student Needs]**

16. In particular, federal agencies and private funders should experiment with a new strategy for "graduate program grants" to support graduate students. Analogous to training grants, but with perhaps greater support for innovation in the educational program, graduate program grants should be made available to departments on a competitive basis. They could be used to: provide students with semesters of support free of extensive service as teaching assistants; provide funding for students to begin graduate work in the summer after the bachelor's degree; or reward all programs at all levels for developing curricula to serve the overall education needs of students. **[Financial Support] [Prioritize Student Needs]**

17. The U.S. Department of Education should make the GAANN (Graduate Assistance in Areas of National Needs) Program more generally useful by making it generally applicable. **[Financial Support]**

18. Faculty members should view work by graduate students as teaching assistants much more strategically as an opportunity—and an obligation of the program—to enhance the professional development of the student. The experience should be deliberately complementary to research. However, teaching assistantships should not be the major basis of support throughout one's graduate career. **[Faculty Support] [Diverse Career Preparation] [Prioritize Student Needs] [Professional Development]**

19. Government sources should rebalance fellowship programs to make more awards available to students in the second year of graduate school and beyond (i.e., application made after the student has begun graduate school), rather than primarily in the first year. **[Financial Support] [Support During Degree]**

20. Departments and programs should place increased emphasis on international students being supported by their home countries. **[International Students]**

21. The Commission recommends the following structure for most students in most doctoral programs in chemistry departments:
    a. Summer before the start of courses: Support for all students for two months should be provided by departmental funds, including graduate program grants.

b. First year: Nearly all students should be supported on teaching assistantships or, where available, graduate program grants.
c. Second year: Most students should be supported by the department on individual fellowships or graduate program grants. Federal fellowships would also be available to some students. Teaching assistantships should be used, as needed, but should be at an advanced level (more responsibility, more training in pedagogy)
d. Third year: Research assistantships tied to the principal investigator's specific project, graduate program grants, individual fellowships, or teaching assistantships.
e. Fourth and fifth year: Research assistantships and individual fellowships. If teaching assistantships are used, they should include a major component of pedagogical training and should require a reduced time commitment compared to earlier years.
[Financial Support] [Support During Degree] [Prioritize Student Needs]

22. Safety as a culture must be consistently led by example in all graduate programs in the chemical sciences. **[Student Well-Being]**

23. Establish a safety performance partnership between industry and academic institutions, whereby corporations share best practices with students and faculty on a regular basis. The ACS should play a lead role facilitating training and sharing of best practices and should sponsor the development of a comprehensive safety curriculum based on best practices. **[Employer Involvement] [Professional Societies] [Professional Development]**

24. All universities and colleges should see that widespread and in-depth attention is given to the report, titled *Creating Safety Cultures in Academic Institutions: A Report of the Safety Culture Task Force of the ACS Committee on Chemical Safety*. Specific programs to implement the recommendations of this report should be established in all academic chemical science and engineering departments. Faculty members in the chemical sciences can and should take the lead toward best practices, and should advocate for support at the highest institutional levels. **[Student Well-Being] [Faculty Support]**

25. The Commission urges departments to adjust program sizes in the light of truly attractive opportunities for graduates. It further recommends that this consideration be paramount in determining the scale and balance of any program. A large undergraduate teaching need is not a sufficient justification for a large graduate program. Teaching needs that remain uncovered by graduate students in a healthy program should be addressed by faculty or other professionals hired and supervised by the department. **[Evaluate Programs] [Prioritize Student Needs]**

26. Faculty members and other academic leaders in every graduate program—whether at the master's or doctoral level—are urged to reassess and to focus the program distinctively toward its competitive advantages **[Evaluate Programs]**

27. The Commission recommends that the ACS collect and publish aggregated, privacy-protected data, organized by graduate program, on post-degree outcomes for all graduates, including time-to-degree, types of job placements, salaries, and overall student satisfaction with the graduate experience and employment outcome to provide prospective students with relevant information toward an informed decision in choosing a graduate school. **[Professional Societies] [Departments Collect Data] [Departments Provide Data] [Prioritize Student Needs]**

28. Programs should build the domestic fraction of their graduate enrollments as a high priority. **[International Students]**

29. Graduate programs must place an emphasis on attracting and empowering students from underrepresented groups. **[Emphasize Diversity]**

30. Communications to undergraduates should point out that not only is graduate education in the chemical sciences free to them, but that they will receive a stipend, as well. **[Start Early]**

31. Institutions and departments, as well as faculty mentors, should take greater responsibility for ensuring that postdoctoral associates develop professionally. Important steps toward achieving this goal include the use of individual development plans, regular access to multiple mentors, and the opportunity to present research at scientific meetings and departmental seminars. Institutions should appoint officers with responsibility for the wellbeing of postdoctoral associates.

32. All funding agencies should require general mentoring plans of applicants seeking support for postdoctoral associates. To help provide a professional path forward for postdoctoral associates, funding agencies should also be more receptive to requests for support of more senior research associates who are regular employees of research institutions.

33. Foundations and other funding agencies should re-explore programs for "teaching postdoctoral associates," so that trained professional instructors become an alternative to the current reliance on doctoral students for so much of the teaching responsibility. **[Prioritize Student Needs]**

34. The Commission urges integrated thinking at the program level regarding numbers of postdocs and doctoral graduates emerging together into employment markets. **[Evaluate Programs] [Prioritize Student Needs]**

(13) 2012. National Institutes of Health. Biomedical Research Workforce Working Group Draft Report. June 14, 2012. (pgs. 3-4)

(http://acd.od.nih.gov/bmw_report.pdf)

Working group of the NIH Advisory Committee to the Director report to develop a model for a sustainable and diverse US biomedical research workforce

1. NIH should create a program to supplement training grants through competitive review to allow institutions to provide additional training and career development experiences to equip students for various career options, and test ways to shorten the PhD training period. **[Financial Support] [Shorten Degree] [Diverse Career Preparation]**

2. Institutions should provide diverse types of training (e.g. project management and business entrepreneurship skills needed in the pharmaceutical and biotechnology industries, or teaching experiences needed for a successful faculty position in liberal arts colleges) **[Diverse Career Preparation] [Professional Development]**

3. NIH and the institutions should explore ways to involve relevant employers in the public and private sector in designing training paths for those students who seek employment in that sector. **[Internships] [Employer Involvement]**

4. Institutions could be encouraged to develop other degree programs (e.g. master's degrees designed for specific science-oriented career outcomes, such as industry or public policy) as stand-alone programs or sound exit pathways for PhD students who do not wish to continue on the research career track. The definition of "success" in the evaluation of NIH training grants would also need to change. **[Diverse Career Preparation] [Prioritize Student Needs]**

5. To encourage timely completion of graduate degrees, NIH should cap the number of years a graduate student can be supported by NIH funds (any combination of training grants, fellowships, and research project grants), with an institutional average of 5 years and no one individual allowed to receive support for more than 6 years. **[Shorten Degree]**

6. NIH should continue to assess the pre-doctoral stipend level annually. **[Financial Support]**

7. NIH should increase the proportion of graduate students supported by training grants and fellowships compared to those supported by research project grants, without increasing the overall number of graduate student positions. **[Financial Support] [Prioritize Student Needs]**

8. NIH should revise the peer review criteria for training grants to include consideration of outcomes of all students in the relevant PhD programs at those institutions, not only those supported by the training grant. Study sections reviewing graduate training programs should be educated to value a range of career outcomes. All NIH Institutes and Centers should offer comparable training programs and fellowships and their requirements should be harmonized. **[Diverse Career Preparation]**

(14) 2012. Council of Graduate Schools and the Educational Testing Service. Pathways Through Graduate School and into Careers. (pgs. 31-26)

(http://www.pathwaysreport.org/)

Overview of the trends, challenges, and vulnerabilities in the U.S. graduate education system

1. Universities should make early connections with students, building relationships between K–12, community colleges, four-year colleges, and graduate education systems so that students understand routes of progression. **[Start Early]**

2. Universities should make career counseling services available to graduate students to acquaint them with information about the full spectrum of careers available to them along with resources and strategies for preparing for a career. Career counseling services should provide graduate students at the master's and doctoral levels with professional skills development, resources, and guidance in preparing for a variety of career pathways. **[Diverse Career Preparation] [Career Assistance] [Professional Development]**

3. Universities should track career outcomes and job placement information for graduate students over a period of time that is long enough to capture information beyond the first or second job. University leaders, including graduate deans, need to work at all levels to establish specific responsibility for collecting and using student outcomes data by program. This information needs to be provided to graduate faculty so that they understand, value, and communicate to students about the full spectrum of career pathways, and to new graduate students at the time they are making the decision about which graduate program and career to pursue. **[Departments Collect Data] [Departments Provide Data]**

4. Universities should connect graduate students with graduate alumni to highlight career possibilities for graduate students while simultaneously connecting them with a potential employer. Graduate schools should collaborate with their alumni offices to create or utilize existing networks of alumni in different fields/areas and facilitate structured opportunities for interaction with graduate students. **[Career Assistance] [Student Involvement] [Mentoring]**

5. Universities should broaden the focus of graduate education to include development of professional skills such as communications, teamwork, creativity, presentation skills, oral communication, writing skills, analysis and synthesis of data, and planning and organization for graduate students, particularly doctoral students. **[Diverse Career Preparation] [Professional Development]**

6. Universities should emphasize and support innovative master's degrees.

7. Universities should provide opportunities for graduate school faculty to engage with industry, government, and other sectors. Universities should consider providing sabbaticals and/or research opportunities for faculty to gain experience and understanding in other sectors including business, government, and nonprofit organizations. **[Employer Involvement] [Faculty Support]**

8. Universities should enhance collaboration with industry and government similar to the European University Association DOC-Careers project. Universities should strengthen and enhance opportunities for graduate students to engage in research or internships in the corporate or government sectors. University leaders should devote special attention to addressing the challenges faced by students from underrepresented groups and the need to enhance efforts to illuminate pathways into careers for these students. **[Employer Involvement] [Internships] [Emphasize Diversity]**

9. Universities should create advisory committees of employers to provide input and expertise in designing or modifying existing graduate education to provide a framework for developing the skills needed for success in a career, similar to most PSM programs. **[Employer Involvement] [Diverse Career Preparation] [Professional Development]**

10. Employers should reach out to universities in their state and region to develop and formalize relationships to provide internship and research opportunities for graduate students, post-doctorates, and faculty. **[Employer Involvement] [Internships]**

11. Employers should provide feedback to graduate institutions and programs on the training and performance of students and recent graduates to help improve the education and training of graduate students in preparing them for 21st century careers. **[Employer Involvement] [Diverse Career Preparation]**

12. Employers should make strategic investments in graduate education programs that align closely with their future workforce needs. **[Employer Involvement] [Financial Support]**

13. Employers should provide internship and research opportunities for graduate students. **[Employer Involvement] [Internships]**

14. Employers should provide sabbatical and research opportunities for graduate faculty. Universities and graduate schools need to support and reward faculty who are willing to take on opportunities in industry. **[Employer Involvement] [Faculty Support]**

15. Employers should provide support for employees to pursue graduate studies while employed. Employers should provide financial support and encouragement to their employees to pursue and complete their graduate studies. **[Financial Support] [Employer Involvement]**

16. Policymakers should create an advisory commission of leaders in business and graduate education to support workforce priorities, led by appropriate officials of the executive branch of the federal government. The blue ribbon commission should develop strategies and plans for clarifying career pathways for graduate students in key areas of national priority including energy independence, biomedical advances, climate change, financial industry reforms, and healthcare reforms, among others. Further, this commission should provide guidance on 21st century careers, the workforce needs, and the associated knowledge and training and career prospects for graduate degree holders. **[Convene & Discuss]**

17. Policymakers should establish a Professional Plus Program for graduate students on research assistantships to develop the full range of professional skills that will prepare them for the variety of career options open to them. A Professional Plus Program would supply funding that would support the graduate school or an appropriate university office in providing and maintaining professional development programs for all graduate students engaged in research projects with faculty. **[Financial Support] [Diverse Career Preparation] [Professional Development]**

18. Policymakers should implement a COMPETES doctoral traineeship program. **[Financial Support]**

19. Policymakers should support a new Integrative Graduate Humanities Education and Research Training (IGHERT) program to implement or expand master's and doctoral level humanities education to emphasize preparation for diverse careers and develop essential skills in critical thinking and problem solving.

20. Policymakers should give funding priority to proposals from collaborations between business and universities that support graduate students and their career pathways. **[Employer Involvement] [Interdisciplinarity] [Diverse Career Preparation]**

21. Policymakers should adopt progressive visa policies designed to retain international talent in the United States, particularly to retain talented international scholars who receive graduate training in the United States. **[International Students]**

22. Policymakers should implement tax policies that encourage employer-provided assistance for graduate study. **[Financial Support]**

23. Policymakers should provide federal support for studies that help us understand the journey through graduate school and into careers. Efforts, such as NSF's Survey of Doctorate Recipients and the Scientists & Engineers Statistical Data System (SESTAT), should be continued and expanded to include efforts that look at other fields (humanities, etc.) as well as master's students. **[Agencies Collect Data]**

(15) 2013. American Chemical Society. ACS Graduate Student Survey. Washington, DC. (pgs. 26-29)

(http://www.acs.org/content/dam/acsorg/education/educators/reports/2013-ACS-Graduate-Student-Survey-Report.pdf).

Report of data gathered through ACS survey of chemistry graduate students and opportunities to enhance the graduate student experience.

1. More comprehensive and integrated career resources should be developed at the department, institution, and/or professional society level. Chemistry departments should partner with their campus career centers to develop a comprehensive suite of career resources targeted to the needs of graduate students in the chemical sciences. Conferences and meetings could offer more career-focused programming specifically targeted toward graduate students. The American Chemical Society should develop more formal career-focused programming specifically for graduate students and their advisors at its national and regional meetings and play a role in better informing graduate students about job prospects in a particular field. **[Diverse Career Preparation] [Career Assistance] [Professional Societies]**

2. We support the *Beyond Bias and Barriers* report recommendation that deans, department chairs, and their tenured faculty should develop and implement programs that educate all faculty members and students in their departments on unexamined bias and effective evaluation. **[Emphasize Diversity]**

3. The American Chemical Society or other professional societies, and the National Science Foundation, National Institutes of Health, or other funding agencies should assist graduate students in developing needed oral and written communication skills via proposal-writing workshops and webinars, and foster professional relationships with structured networking events. **[Diverse Career Preparation] [Professional Societies] [Professional Development]**

4. We support the *At Cross Purposes* report recommendation that graduate faculty conduct a thorough annual evaluation of each advisee, discuss students' timely progress through the program, and work to ensure that their experiences prepare them for the careers they plan to enter. We suggest that graduate programs formalize an annual review process to ensure that graduate students receive timely feedback on progress toward degree and appropriate guidance in preparing for their careers, either from advisors or advisory/doctoral committees. One approach may be creating an Individual Development Plan (IDP) for every graduate student. **[Support During Degree] [Mentoring]**

5. Chemistry departments should balance graduate student support between research and teaching assistantships to ensure that students have adequate time for research while gaining the valuable skills acquired through experience as a teaching assistant. **[Financial Support] [Prioritize Student Needs]**

6. Future studies should consider examining the sources of funding for URM students to better understand disparities in student loan burden. **[Emphasize Diversity]**

7. Graduate programs could do a more thorough job of educating students about the benefits available to them. **[Departments Provide Data] [Student Well-Being]**

(16) 2013. National Science and Technology Council. Federal Science, Technology, Engineering, and Mathematics (STEM) Education 5-Year Strategic Plan.

https://www.whitehouse.gov/sites/whitehouse.gov/files/ostp/Federal_STEM_Strategic_Plan.pdf

OSTP Committee on STEM Education (CoSTEM) strategic plan involving K-12, undergraduate, and graduate STEM education

1. Provide graduate-trained STEM professionals with basic and applied research expertise, options to acquire specialized skills in areas of national importance, mission-critical workforce needs for CoSTEM agencies, and ancillary skills needed for success in a broad range of careers. **[Diverse Career Preparation] [Professional Development]**

2. CoSTEM agencies should coordinate to provide access to and efficacy of government-funded graduate fellowships. **[Financial Support] [Evaluate Programs]**

(17) 2014. National Research Council. The Postdoctoral Experience Revisited. National Academies Press, Washington, DC. (pgs. 4-9)

Report about postdoctoral researchers in the United States

1. Host institutions and mentors should, beginning at the first year of graduate school, make graduate students aware of the wide variety of career paths available for Ph.D. recipients, and explain that postdoctoral positions are intended only for those seeking advanced research training. Career guidance should include, where feasible, the provision of internships and other practical experiences. The postdoctoral position should not be viewed by graduate students or principal investigators as the default step after the completion of doctoral training. **[Departments Provide Data] [Internships] [Career Assistance]**

2. Host institutions, especially those with graduate student populations, should provide multiple engagement activities to help students explore all avenues of career development. Funding agencies should help to support these efforts. **[Diverse Career Preparation] [Career Assistance]**

3. Professional societies should gather and disseminate information about the full range of career paths within their discipline. Useful activities could include collecting statistics about job openings and salaries, identifying individuals in various sectors who can provide career advice, and organizing career fairs at professional meetings. **[Departments Collect Data] [Career Assistance]**

4. Mentors, in addition to providing guidance based on their own experience, should become familiar with and disseminate information about all forms of career development opportunities available either at the host institution or through their professional society. **[Mentoring] [Career Assistance]**

5. Postdoctoral researchers and graduate students have a responsibility to participate in the career development opportunities provided by their institutions, to explore other sources of information such as professional societies, and to use available career-development tools. **[Student Involvement]**

(18) 2015. Council of Graduate Schools. Doctoral Initiative on Minority Attrition and Completion. (pgs. 64- 66)

http://cgsnet.org/ckfinder/userfiles/files/Doctoral_Initiative_on_Minority_Attrition_and_Completion_2015.pdf

Recommendations to improve completion and attrition among URM STEM doctoral students

1. Conduct interventions throughout the doctoral process. This includes pre-exposing students to the doctoral experience through programs like summer research opportunities for undergraduates and incoming doctoral students. This also includes advisors and faculty meeting with incoming URM STEM doctoral students early in the doctoral programs. Interventions should extend beyond the first year of the doctoral program: for example, resources explaining each stage of the doctoral experience. **[Start Early] [Support Throughout Degree] [Emphasize Diversity]**

2. Provide enhanced academic support through academic supports such as writing classes and mathematics and statistics supplements. Possibly involve peers and peer mentors, and programs intended to help faculty advisors be better dissertation supervisors should be considered as well. **[Mentoring] [Support Throughout Degree]**

3. Monitor and evaluate programs and interventions. Assessment should be built into the design of programs, rather than post-facto analyses. **[Evaluate Programs]**

4. Cultivate a culture of diversity and inclusion. One example is faculty members attending minority-focused recruitment/ graduate fairs, serving on campus diversity committees, or helping URM students apply for minority fellowships. The implementation of diversity/cultural sensitivity training for administrators, faculty, and students as well as providing incentives to mentors and champions who take it upon themselves to support URM STEM doctoral student success would help to promote a culture of diversity and inclusion. Diversity and inclusion must be seen as a part of the excellence agenda, rather than be juxtaposed to it. **[Emphasize Diversity] [Faculty Support]**

(19) 2016. Mellon Foundation. Reforming Doctoral Education, 1990 to 2015 Recent Initiatives and Future Prospects. (pgs. vi-vii)

(https://mellon.org/media/filer_public/35/32/3532f16c-20c4-4213-805d-356f85251a98/report-on-doctoral-education-reform_june-2016.pdf)

Summary of efforts to improve Ph.D. education in the U.S., seems to focus on humanities

1. Promote a cultural change in the definition of the Ph.D. degree, as providing disciplinary expertise applicable to all social sectors. Provide advising, training, and internships that allow for a range of academic and extra-academic career options, keeping in mind the changes in the professoriate: for example, teaching-centered faculty positions at two-year colleges, branch campuses, small colleges, and (off the tenure ladder) even at research institutions. Seek program efficiencies that allow for a more versatile training without lengthening time to degree. **[Social Engagement] [Diverse Career Preparation] [Career Assistance] [Internships] [Shorten Degree]**

2. Empower the Graduate Dean and the Graduate School with a budget that will allow implementation of student-centered practices of programs, innovations in admissions, advising, efficient student progress, and training for diverse career options in and beyond academia. At institutions where no graduate dean position exists, create a locus of responsibility for student-centered excellence in doctoral education. Further, allocate modest funds for the Graduate School or the central administration to maintain a database for each program encompassing admissions, program practices, and student outcomes. **[Financial Support] [Prioritize Student Needs] [Diverse Career Preparation] [Departments Collect Data]**

3. Design a national system that rates (not ranks) programs and graduate schools on the basis of student-centered practices and make these results available online on a regularly-updated website. The intent is to provide a counterweight to reputational surveys. Checkpoints could include, for example, reasonable attrition rates (under one third), responsible time to degree (6.5 years or under), a diverse student cohort, developmental training in pedagogy, training for expanded career opportunities, appropriate student financial and benefit support, and interdisciplinary and collaborative opportunities. **[Prioritize Student Needs] [Agencies Collect Data] [Departments Provide Data]**

4. Make diversity comprehensive and coherent, and more than a matter of cohort demographics, including curriculum, program culture, support and the financial aspects of time to degree, along with engagement with social challenges. **[Emphasize Diversity] [Social Engagement] [Financial Support]**

5. Coordinate efforts by organizations seeking to improve Ph.D. opportunities for students from under-represented groups by bringing funders together in a diversity collaboration. Consider inclusion of groups that focus on recruiting students from under-represented groups at the undergraduate level for their ability to forward the possibility of study beyond the B.A. **[Emphasize Diversity] [Start Early] [Convene & Discuss]**

6. Direct national funding by foundations and government agencies at these same student-centered practices. Funding proposals should include plans for permanence beyond current personnel. When selected programs are funded that implement innovation, they should include plans for disseminating the practices to other institutions, an effort which the funder can facilitate through convenings. Funders not only should require institutional cost-sharing but could also establish a preliminary review panel to determine cost effectiveness, thus allowing institutions to determine the viability of their proposals at an early date. Assessment should be continuous, with conditional funding dependent on demonstrated program improvement. National funders should communicate with each other to coordinate activities and learn from collective experience, and maintain a website to keep a record of reform efforts. Funds ideally should flow through the graduate dean to ensure that there is sufficient local oversight and to center

responsibility on the quality of doctoral education. **[Prioritize Student Needs] [Financial Support] [Evaluate Programs]**

(20) 2017. Council of Graduate Schools. Professional Development: Shaping Effective Programs for STEM Graduate Students. (pg. 11)

http://cgsnet.org/professional-development-shaping-effective-programs-stem-graduate-students-0

Examination of professional development of graduate students in preparation for multiple careers in the STEM workforce

1. Greater coordination and research among graduate schools, graduate programs, employers, alumni, and federal funding agencies is needed to meet the professional development needs of graduate students seeking careers in STEM. **[Diverse Career Preparation] [Prioritize Student Needs] [Professional Development]**

2. There should be more evidence and more accessible information about the effectiveness of different models for delivering engaging and relevant professional development programs to graduate students. Culture change should be promoted broadly and from a variety of sources. The graduate school, graduate fields, student organizations, and others should engage employer representatives, content experts and alumni, and should employ established and/or research best practices. **[Evaluate Programs] [Diverse Career Preparation] [Convene & Discuss] [Professional Development]**

3. There should be greater alignment among employers and universities to ensure that the professional development experiences provided to advanced STEM graduate students are relevant and where possible tailored to employer needs. **[Employer Involvement] [Diverse Career Preparation] [Professional Development]**

4. Professional development should be designed to strengthen and complement academic rigor. The integration of professional skills into graduate programs should not occur by sacrificing the excellent preparation in academic research skills received by today's master's and PhDs. **[Diverse Career Preparation] [Professional Development]**

5. Assessment of professional development must evolve beyond student participant satisfaction to include evaluation of the effectiveness of training in participants' subsequent non-academic and academic careers. Best practices are also needed in the use of these data to inform graduate degree programs and professional development programs. **[Evaluate Programs] [Diverse Career Preparation] [Professional Development]**

Reports focused on undergraduates

1. 2009. AAAS & NSF. Vision and Change in Undergraduate Biology Education: A Call to Action.
   Shared vision of undergraduate biology education and the changes needed to achieve that vision.
2. 2012. President's Council of Advisors on Science and Technology (PCAST). 2012. Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering and Mathematics. Washington, DC.
   Recruiting, retaining, and graduating undergraduates in STEM
3. Overview of Geoscience Employers Workshop Outcomes
   http://www.jsg.utexas.edu/events/files/Overview-Outcomes_2016.pdf
   The list of concepts/skills/competencies that came out of a Geosciences employers workshop
4. 2015. Mathematical Association of America. A Common Vision for Undergraduate Mathematical Sciences Programs in 2025.
5. 2016. Joint Task Force on Undergraduate Physics Programs. Phys21: Preparing Physics Students for 21st-Century Careers. American Physical Society, NSF, and American Association of Physics Teachers.
   http://www.compadre.org/JTUPP/report.cfm
6. 2016. National Research Council. Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Students' Diverse Pathways.

Data and Other Resources

1. 2005. National Research Council. Bridges to Independence.
   Recommendations on fostering the transition of biomedical researchers to independent positions
2. 2006. The Carnegie Foundation for the Advancement of Teaching. Envisioning the Future of Doctoral Education: Preparing Stewards of the Discipline. (book)
   Essays on structuring doctoral education to prepare scholars in the disciplinary and ethical sense
3. 2006. Michael Nettles and Catherine Millett. Three Magic Letters: Getting to PhD. (book)
   Findings from a survey of 9,000 doctoral students about the graduate experience
4. 2008. Van Hartesveldt, C., & Giordan, J. Impact of Transformative Interdisciplinary Research and Graduate Education on Academic Institutions. (http://eric.ed.gov/?id=ED530821)
   Report from a workshop, has recommendations on supporting interdisciplinary research
5. 2008. Council of Graduate Schools. Graduate Education and the Public Good.
   Report outlining how graduate education has provided benefits to the public
6. 2010. Council of Graduate Schools. The Role and Status of the Master's Degree in STEM. (http://cgsnet.org/masters-completion-project)
   Monograph providing data on the role of the master's degree in STEM education
7. 2013. National Science Foundation. Innovation in Graduate Education Challenge. (https://www.nsf.gov/news/special_reports/gradchallenge/)
   Challenge for STEM graduate students to submit ideas about graduate education & preparation
8. 2013. Council of Graduate Schools. Completion and Attrition in STEM Master's Programs. (http://cgsnet.org/masters-completion-project)
   A study of the completion and attrition in master's programs in mainly STEM fields, as well as promising practices
9. 2014. American Institutes for Research. The Nonacademic Careers of STEM PhD Holders. Washington, DC.
   (http://www.air.org/sites/default/files/downloads/report/STEM%20nonacademic%20careers%20April14.pdf)
   Data about nonacademic employment of STEM PhD holders
10. 2014. American Mathematical Society. Annual Survey of the Mathematical Sciences. AMS, Providence, RI. (http://www.ams.org/profession/data/annual-survey/2014Survey-SREC.pdf)
    Statistical profiles of doctoral degrees awarded at mathematical sciences departments
11. 2014. National Research Council. The Arc of the Academic Research Career.
    Summary of a workshop on faculty careers

12. 2014. National Research Council. Convergence: Facilitating Transdisciplinary Integration of Life Sciences, Physical Sciences, Engineering, and Beyond. The National Academies Press, Washington, DC
Convergence approaches to biomedical research and other fields
13. 2015. National Science Board. Revisiting the STEM Workforce. National Science Foundation, Arlington, VA.
Summary accompanying Science and Engineering Indicators data
14. 2014. Council of Graduate Schools, Understanding PhD Career Pathways for Program Improvement. (http://cgsnet.org/understanding-career-pathways).
Summary of findings of feasibility study about better understanding career pathways of PhD holders
15. 2016. National Academies of Sciences, Engineering, and Medicine. Developing a National STEM Workforce Strategy. A workshop summary. National Academies Press, Washington, DC.
Workshop summary – no recommendations
16. 2016. Council of Graduate Schools. The Future of the Dissertation. (http://cgsnet.org/sites/default/files/DissFwd_Print%20All%20Papers.pdf, http://cgsnet.org/future-doctoral-dissertation)
17. 2016. National Science Foundation. Strategic Framework for Investments in Graduate Education. (https://www.nsf.gov/pubs/2016/nsf16074/nsf16074.pdf)
NSF outline of intended changes to funding graduate education
18. 2016. Council of Graduate Schools. Holistic Review in Graduate Admissions. (http://cgsnet.org/innovation-graduate-admissions-through-holistic-review)
Practices and priorities in using holistic review for graduate admissions