Conference Board of the Mathematical Sciences
One Hundred and Twenty-first Meeting of the Council
Friday, May 3, 2019

ASA Headquarters Building
732 North Washington Street
Alexandria VA 22314

8:30-9:00 **Coffee, Juice, and Breakfast Treats Available**

9:00-9:15 **Introductions and Overview of Meeting** – Diane Briars

9:15-10:00 **Business Meeting of the Council**

1. Secretary-Treasurer's Report – Charles Steinhorn
   - Approval of Minutes of the Meeting of December 6, 2018 (appendix A)
   - FY 2019 Half-Year Financial Report (appendix B)
   - Approval of FY2020 budget (appendix B)
2. Director's Report – David Bressoud (appendix C)
3. Draft of the MAA/CBMS statement to the House Education Committee relevant to the reauthorization of the Higher Education Act (Appendix D)
4. Nominating committee report and vote on Chair-Elect and Member-at-Large
5. Announcements
   - Rachel Levy on MSRI Critical Issues
   - Karen Saxe on DC update and issues raised in JPBM meeting

10:00–10:45 Hy Bass (Michigan) and Judit Moschkovich (UC Santa Cruz), authors of NAS English Language Learners report (Summary of report: Appendix E). Acknowledgment from Karen King.

10:45–11:00 **Break**

11:00–11:45 Billy Williams, VP for Ethics at the American Geophysical Union on the NAS Sexual Harassment report (Summary of report: Appendix F)

11:45–12:45 **Lunch**

12:45–1:30 Dan Heck (Horizon Research) NSSME+ report

1:30–2:30 NAEP update, Shandy Hauk

2:30–2:45 **Break**

2:45–3:45 Discussion led by NAS and ACM on Data Science, Andrea Danyluk (Williams) from ACM, Rebecca Nugent (CMU) author of NAS report (Summary of NAS report, Appendix G)

3:45–5:00 Discussion of responses to declining memberships

5:00–?? **Reception**

Invitees and Participants

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Appendix A

Minutes of the 120th Meeting of the Council of the Conference Board of the Mathematical Sciences Alexandria, VA December 7, 2018

The following were present for all or part of the meeting, held at the ASA Headquarters.

Executive Committee: Diane Briars, Chair, William (Brit) Kirwan, Past-Chair; Charles Steinhorn, Secretary-Treasurer; Christine Thomas, Member-at-Large; Deanna Haunsperger, Member-at-Large

Council Members: James Ham, AMATYC; Catherine Roberts (for Ken Ribet), AMS; Randolph Philipp, AMTE; Ron Wasserstein (for Lisa LaVange), ASA; Charles Steinhorn, ASL (for Ulrich Kohlenbach); Robin Hill (for Dewey Gottlieb), ASSM; Ami Radunskaya, AWM; Brea Ratliff, BBA; Jessica Utts, IMS; Deanna Haunsperger, MAA; Edray Goins, NAM; Connie Schrock, NCSM; Ken Krehbiel, NCTM (for Robert Berry); Kathleen Kavanaugh (for Nicholas Higham), SIAM; Eli Donkar, SOA; Diana Ceja, TODOS.

Additional society representatives: Anne Dudley, AMATYC; Karen Saxe, AMS; Mike Steele and Timothy Hendrix, AMTE; Karoline Pershell, AWM; Crystal Morton, BBA; Michael Pearson and Rachel Levy, MAA;

Invited Guests:
Lorraine Howard, WME; Ted Coe, ACHIEVE; Karen Marrongelle, Talitha Washington, and Catherine Paolucci, NSF; Kathie Bailey and Ana Ferreras, NAS; Kim Gattis, AIR; Bob Moses, Herb Clemens, and Catherine Belin, Algebra Project; Jane Tanner and Susie Hakansson, CBMS Forum; Katherine Leverenz, Mathematics Institute of Wisconsin; Uri Treisman, Doug Sovde, and Katey Arrington, Dana Center; John Staley, USNC-MI; Jeff Weld, OSTP; Lisa Stooksberry, US Dept of Ed; Ann Edwards and Shandy Hauk, WestEd; Ben Kallen, Lewis-Burke.

Staff: David Bressoud, Kelly Chapman

Reports from the presenters are available at https://www.cbmsweb.org/2017/12/cbms-council-meeting-december-7-2018/

I. Opening Remarks

Chair Diane Briars welcomed those who were present and outlined the agenda.

II. Business Meeting

1. **Approval of Minutes**. The minutes of the May 2018 CBMS Council meeting were approved unanimously.

2. **Financial Report and Budget.** Charlie Steinhorn presented the end of year report on the FY2018 budget and the Unrestricted Net Assets.

3. **Dues Assessment.** Eli Donkar raised the issue of whether all societies were aware that membership only counts US members. This has been explicit in the annual request for membership numbers. The question was raised whether this includes institutional members. David Bressoud clarified that these are individual memberships. The following motion for determining dues assessment was passed unanimously:

   For the purpose of calculating dues, the membership number is the number of individual dues-paying members of any category who reside in the United States, beginning with FY 2019.

   The 2019 dues assessment was approved unanimously, subject to possible recalculation from adjustments to membership numbers.

4. **Director's Report.** David Bressoud reported on the status of funding for the CBMS Forum. Thirty-two states applied, and we have in place funding for 21 of them. In addition, the funding for the Regional Conference Series was awarded, with approval for CBMS to now handle its own grants.

5. **Announcements.**
   - John Staley reported on the activities of the US National Committee on Mathematics Instruction. CBMS nominated Rob Gould (UCLA), Julie Hanson (Clinton Community College), and April Ström (Chandler/Gilbert Community College).
   - Brit Kirwan reported on the activities of TPSE and invited the CBMS societies to send representatives to the TPSE meeting on April 1 in Miami, Florida. The point was raised that this conflicts with the annual meetings of ASSM, NCSM, and NCTM. It was suggested that CBMS maintain a master calendar of the main meetings of the member societies.
   - Jim Ham reported on AMATYC's IMPACT document.
   - Kathie Bailey reported on plans for the International Congress in 2026. France and Russia had bid for 2022. Russia won the bid. While it was expected that France would apply for 2026, the USNC decided to put in a bid for 2026.
   - Rachel Levy reported that on the new AAAS SEA (STEM Equity Achievement) institutional awards for work on diversity, equity, and inclusion.

III. Report from Karen Marrongelle on EHR

Karen Marrongelle, the new Assistant Director at EHR, reported on new initiatives connected with the NSF's Ten Big Ideas and the new White House five-year plan for STEM Education. One area of emphasis is internship opportunities for graduate students that give them experience outside of academia. Another is integration of disciplines to provide richer experiences for graduate students.

IV. Report on the White House Office of Science and Technology Policy on the new five-plan for STEM Education

Jeff Weld talked about the thinking that went into and expectations for the future in the recently released report, *Charting a Course for Success: America's Strategy for STEM Education*.

V. Report by Doug Sovde on the *Launch Years* project

Doug Sovde and Uri Treisman reported on the Dana Center's new *Launch Years* project, funded by the Gates Foundation to work at scale on the problems of coordinating mathematics education from grade 10 to the junior year of college.

VI. Update on the NAEP Framework

Shandy Hauk and Ann Edwards from WestEd and Lisa Stooksberry from the National Assessment Governing Board talked about the effort now underway to update the Framework for National Assessment of Education Progress, an undertaking that now occurs roughly every twenty years. The first draft of the new framework will be made available for the May CBMS council meeting for feedback.

VII. Report from Bob Moses on the new National Alliance

Herb Clemens introduced the National Alliance, Math Literacy for All Project, funded as part of the NSF INCLUDES original planning grants. Bob Moses talked about the importance for racial justice in the effort to provide equal educational opportunities to all students. Catherine Belin, a teacher at the Fannie Lou Hamer Freedom High School in the Bronx, explained what her school has been doing to meet the needs of its community and improve educational outcomes.

VIII. Other Business

- Ana Ferraras talked about activities of the US National Commission on Mathematics Instruction, especially their binational workshops.
- Ami Radunskaya made a short presentation on the new National Academies report on Sexual Harassment. It will receive more extensive treatment at the May meeting.
- Diane Briars raised explained concerns about the work of *Ed Reports* in providing reviews of K-12 educational materials. NCTM and NCSM and other of our member societies have found serious flaws in the rubrics they use and raised issues about the quality of the reviews.
- Lorraine Howard presented the case for admitting Women and Mathematics Education as a member of CBMS. After her presentation, the motion to accept W&ME to membership was passed.
- David Bressoud and Katey Arrington provided an update on the status of the CBMS Forum on *High School to College Pathways—Preparing Students for the Future*. A motion was made to draw up to $10,000 from the CBMS reserves for video-taping the conference. This was moved and seconded and unanimously passed.

Appendix B – Budget

FY 2020 Budget: Oct 1, 2019 - Sep 30, 2020
FY 2018 Actual and FY 2019 Budget Shown for Comparison

Income					
	FY 2018 Actual	FY 2019 Budget	FY 2019 Status as of 3/31		FY 2020 Budget	
Dues	$ 67,675	$ 66,500	33,950		$ 66,500	
Interest	$ 24	$ -	158		$ 100	
Royalties	$ 601	$ 2,000	1,000		$ 1,000	
NSF Regional Research Conferences						
Salaries	$ 8,333	28,909	24,054	c	29,865	
Indirect Costs	$ 2,917	4313	3794	d	4487	
Total Income	$ 79,550	$ 101,722	$ 62,956		$ 101,952	
Expense						
Compensation						
Director	$ 45,000	$ 45,000	$22,500		$ 45,000	
Administrative Coordinator	$ 9,250	$ 15,000	$7,012		$ 16,500	
Telephone		$ -			$ -	
Supplies	$ 2,459	$ 2,000	$2,808		$ 3,000	
Website	$ 380	$ 260	$556		$ 600	
Postage and Shipping	$ 460	$ 300	$122		$ 500	
Council Meetings						
Travel	$ 5,002	$ 7,500	$3,035		$ 7,500	
Food and Other Expenses	$ 11,972	$ 12,000	$5,855		$ 12,000	
Staff Travel	$ 5,323	$ 7,000	$3,773		$ 7,000	
Dues and Subscriptions		$ 500				
Accounting Fees	$ 3,810	$ 4,000	$2,810		$ 4,000	
Auditing Fees		$ 2,250			$ 2,250	a
Insurance					$ 700	b
USAMO Contribution	$ 3,000	$ 3,000				
Non-budgeted Expenses						
Charitable contribution			$300			
Total Expense	$ 86,656	$ 98,810	$ 48,771		$ 99,050	
Operating Surplus or (Deficit)	$ (7,106)	$ 2,912	$ 14,185		$ 2,902	

Notes

a - These are paid every third year. Anticipating auditing fees of approximately $6750 in FY 2020.
b - We have added officers and directors liability insurance
c - $5516 of this is salary money from NSF that should have been charged for FY 2018, but because of the delay in funding was not charged until FY 2019
d - $552 of this is indirects from FY 2018

Investments

Vanguard Balance Mar 31, 2018	$	136,924
Vanguard Balance Sep 30, 2018	$	139,188
Vanguard Balance Mar 31, 2019	$	142,140
net gain	$	5,216

Change in unrestricted net assets, September 30, 2018 to March 31, 2019 $ 17,137

Appendix C

CBMS Director's Report
May 3, 2019
Submitted by David Bressoud

NSF-CBMS Regional Conference Series

In January we sent out the letters to all chairs of departments of mathematics in the United States describing the upcoming Regional Research Conferences and encouraging departments to apply to hold one of these conferences in 2020. Proposals are due April 26, 2019. Because CBMS is no longer involved in the vetting of proposals, we have no idea how many proposals are coming in.

The Regional Conferences 2020 will be the first to be administered under the new guidelines recommended by CBMS and funded by NSF beginning in 2018. A description of the new guidelines was published in the January 2019 issue of the *Notices of the AMS*, "Fifty years of CBMS regional conferences," pp. 80–83.

Because the new grant governing these conferences will be paying for the posting of online materials and not the production of a monograph, monographs coming out of the 2019 regional conferences will be the last for which the author is paid an honorarium, instead receiving royalties. This means that CBMS will not be receiving royalties on the monographs produced in 2020 or later. That will decrease our income by about $2000 per year.

The years 2018–2019 have seen a great many new CBMS monographs, spurred on by the fact monographs that come in after 2019 will not receive the honorarium:

Semyon Aleskar, *Introduction to the Theory of Valuations*, AMS 126
Avner Friedman, *Mathematical Biology: Modeling and Analysis,* AMS 127
Palle E.T. Jorgensen, *Harmonic Analysis: Smooth and Non-smooth*, AMS 128
Wen-Ching Winnie Li, *Zeta and L-functions in Number Theory and Combinatorics*, AMS 129
Alice Guionnet, *Asymptotics of Random Matrices and Related Models: The Uses of Dyson-Schwinger Equations*, AMS 130
Nalini Joshi*, Discrete Painlevé Equations*, AMS 131
J.M. Landsberg, *Tensors and Their Uses in Approximation Theory, Quantum Information Theory, and Geometry*, AMS, in production
Daniel S. Freed, *Lectures on Field Theory and Topology*, AMS, in production
Donald G. Saari, *Mathematics Motivated by the Social and Behavioral Sciences*, SIAM 91
Yuji Kodama, *Solitons in Two-Dimensional Shallow Water*, SIAM 92
Douglas N. Arnold, *Finite Element Exterior Calculus*, SIAM 93
Qiang Du, *Nonlocal Modeling, Analysis, and Computation*, SIAM 94
Alain Miranville, *The Cahn-Hilliard Equation: Recent Advances and Applications,* SIAM, in production
Alan E. Gelfand and Erin M. Schliep, *Bayesian Inference and Computing for Spatial Point Patterns*, IMS/ASA 10

CBMS Forum on High School to College Pathways

Planning for the Forum to be held in Reston, VA, May 5–7 has continued. We did not learn of the last piece of our major funding, $100,000 from NSF, until February 20, after NSF had returned from the government shutdown. We have also received a contribution of $6000 from Pearson and $18,000 from Texas Instruments. The Forum was greatly oversubscribed with applications from 32 states plus a team from Germany. The final count has 22 states participating. In addition to the $10,000 that the Council approved for video-taping the Forum, I also obtained approval from the Executive Committee to draw up to an additional $16,000 from the CBMS reserves if needed to cover the full cost of the Forum. This as before the additional money arrived from Texas Instruments, so I am hopeful that we will not need to draw on it.

I heard from Uri Treisman and Ted Coe that at the last meeting of Council of Chief State School Officers (CCSSO) there was a great deal of enthusiasm about this effort and significant disappointment from the states that either applied and were turned down or were unable to apply within our time limit.

The first of the webinars with the state leadership tams was held on February 5. A list of the participating states, speakers, and full details of the program can be found at https://www.cbmsweb.org/cbms_forum_6/program-information/.

The follow-up Forum is now tentatively scheduled for a year from this coming fall, November 1–3, 2020.

Other business

I discovered in November that CBMS has not carried liability insurance for its officers and directors. That has now been corrected and is a new budget line for FY2020.

We are also now due for an audit, which is conducted every three years. I have been in touch with the firm that has done our audits in the past, Franklin & Franklin. They will be doing the audit for FYs 2017–2019.

Via Karen Saxe, we learned that the House Education Committee is looking for input as they address reauthorization of the Higher Education Act. I worked with Karen, Michael Pearson, Marilyn Carlson, and the CBMS Executive Committee to craft a joint statement of MAA and the CBMS Executive Committee to provide a statement to this House Committee. The draft of this statement as of 3/30/2019 is included as Appendix D.

We now have a Google Calendar for major events of the member societies on our website at https://www.cbmsweb.org/about-cbms/. Please send this information to Kelly <kchapma1@macalester.edu>.

Appendix D

Improving Student Outcomes in Higher Education Mathematics

Joint statement from the Mathematical Association of America and the Conference Board of the Mathematical Sciences

The mathematical sciences community has implemented and studied new placement schemes and introductory curricula, together with student support systems, that are showing success at improving student success in postsecondary mathematics. Fully scaling such efforts in ways that expand this success will require further study to understand their critical components, as well as investments in support structures and faculty professional development. We believe that investments in such efforts, through the re-authorization of the HEA, will further the shared goal of improving student outcomes for our diverse student population.

Mathematics plays a central role in shaping student outcomes in higher education. Until the 1970s, most students did not take a math course unless their major required it. In the 1960s, only a few math department chairs at major public universities believed that mathematics should be part of a graduation requirement.[1] This changed over the ensuing decades. By 2010, most U.S. universities had a mathematics or quantitative reasoning requirement for graduation.[2]

As explained in the remainder of this document, the changing needs of our society with respect to mathematics education have created significant problems for higher education. At the same time, we know what needs to be done in terms of improved curricular options and better pedagogies to meet these challenges. Their uptake is accelerating, but is still slow. Faculty are reluctant to change the practices that worked for them even when these traditional approaches no longer meet the needs of the students they are supposed to serve. Math departments are often inadequately prepared and sustained for successful implementation of new curricula, pedagogies, and support structures.

The colleges and universities that have been at the forefront of these improvements have usually had discipline-based education specialists within the departments who led, studied, and adapted local interventions. Training and embedding specialists responsible for: i) implementing, studying, and adapting local innovations; ii) adapting assessments and curriculum to be more conceptually focused, and iii) supporting faculty to implement more engaging instruction constitute one of the most significant steps that could be undertaken with additional resources.[3]

We have a very small number of education specialists who are trained both in the mathematical sciences and in the research in undergraduate mathematics education. Expanding this corps and encouraging all departments to embrace their expertise would greatly facilitate the improvement of the mathematical experience for all students.

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[1] 15% according to Burdman et al (2018)

[2] 87% according to Schield (2010)

[3] See Chasteen and Code (2018) for details on the preparation and use of discipline-based education specialists.

Statement of the challenge

The National Assessment of Educational Progress (NAEP) reports that only about one-quarter of high school seniors are proficient in mathematics,[4] in line with ACT's assessment that only 40% of students who take the ACT demonstrate readiness for college mathematics.[5] The need for remediation in mathematics before taking any college-credit-bearing math course is widespread. Of students at public 2-year colleges, over half, 59%, take a remedial course in mathematics. Of the students who enter a remedial course in mathematics, only 21% will earn a degree within six years. The situation is better for students who are accepted into a public 4-year college, but it is still a third who enroll in remedial mathematics. Of these students, less than a third go on to earn a Bachelor's degree.[6]

Combined with other attrition, the six-year graduation rate of those who matriculate at a 2-year college (Associate or Bachelor's degree) is 48%, at 4-year colleges (Bachelor's degree) it is 59%. And the situation is worse for Black and Hispanic students where the six-year graduation rates are, respectively, 20% and 26% at 2-year colleges and 39% and 51% at 4-year colleges.[7] Our country cannot afford to lose all of this talent.

College completion is not the whole story. Mathematics is also the gateway to engineering and most scientific and technical careers. Even for those who arrive in college with mathematical proficiency, calculus is often a stumbling block. Nationally, over a quarter of those who enroll in the first mainstream calculus course will fail to earn a satisfactory grade. Another quarter will earn a C, a grade adequate for credit but a strong signal that further progress will be difficult. This is despite the fact that roughly 70% of those who enroll in calculus in college have already taken and passed it in high school.[8] It has been broadly reported[9] that even high performing calculus students complete calculus with weak understandings of fundamental ideas. Addressing this problem would enable more students to complete calculus with an A or B; concurrently enabling even the highest performing calculus students to acquire stronger mathematical conceptions and connections.

Given the dismal record of student performance in postsecondary mathematics, it is no wonder that in 2012 the President's Council of Advisors on Science and Technology castigated the mathematics community for the apparent lack of attention to this problem.[10] In fact, there had been and continues to be a great deal of attention paid to addressing these problems, but progress is slow and difficult when addressing the flaws in a system that was created over fifty years ago, has had its own noticeable successes, and has grown generations of adherents.

Beginning in the 1960s and accelerating through succeeding decades, the primary concern for departments of mathematics was to identify those students who were best prepared for careers in engineering, science, or the mathematical sciences and to focus their attention on this select group. This is no longer sufficient. The demands of the 21st century have changed the

[4] NCES (2015)
[5] ACT (2018)
[6] Chen (2016)
[7] Chen et al (2019)
[8] Bressoud et al (2015)
[9] Carlson and Rasmussen (2008)
[10] PCAST (2012)

requirements of our society. All Americans now need basic quantitative literacy to understand the issues facing us and to fully participate in civic society.

Alternate pathways and co-requisite models

Most students who require remediation are better served by taking a college class in statistics or quantitative reasoning. For over two decades, the Mathematical Association of America (MAA) has promoted quantitative reasoning as an alternative to college algebra.[11] The American Statistical Association has developed guidelines for statistical literacy for all students.[12]

Over the past decade, there has been a great deal of work on alternate pathways for students who enter college requiring remedial support. This was the subject of the recent National Academies workshop on *Increasing Student Success in Developmental Mathematics.*[13] Both the Carnegie Foundation for the Advancement of Teaching and the Charles A. Dana Center at the University of Texas, Austin have built pathways programs that focus on actual student needs. They have moved rates for successful completion of math requirements from less than one in five to over half.[14]

Another successful strategy is the use of co-requisites. This is just-in-time instruction and support for students who previously would have been placed into remediation. Co-requisite programs have been shown to equalize or even increase the odds of succeeding compared to the students who are normally admitted to the course. It has the added benefit that students do not increase the time to graduation. One example of the successful implementation of the co-requisite model is in the University System of Georgia where passing rates of 10–15% were increased to 60–70%.[15]

The importance of active-learning pedagogies

Those who think seriously about the needs of mathematics education for all students recognize that this requires embracing and supporting multiple pathways through mathematics, both diverging and frequently reconnecting, opening routes into scientific or technical careers for non-traditional students. More careers than ever before presuppose a degree of mathematical competence, and this competence is now recognized as encompassing a far broader landscape. Statistics, data science, operations research, and computational science multiply the directions in which students might pursue mathematics. In addition, we can no longer afford to focus exclusively on conventional sources of engineers and scientists. To maintain the needed numbers, we must pay attention to how we support and encourage all students, and we must devise new interventions for attracting more women and students from traditionally underrepresented groups.

Since the 1980s, the mathematical community has recognized that needed changes require more than new curricular paths. They require a new mindset for how we teach. Traditional lecture methods have been adequate for an elite group of students who arrive in college equipped to build a personal understanding of the mathematics they study. These are mostly the children of

[11] Steen (2001)
[12] Franklin et al (2007)
[13] See https://sites.nationalacademies.org/DBASSE/BOSE/Developmental_Math/index.htm
[14] Huang (2018)
[15] Denley (2019)

college-educated parents and the students who have attended our best high schools. Traditional methods of instruction have further separated the haves from the have-nots. A student who enrolls in a public 4-year undergraduate program and whose parents have not gone beyond high school has only a 38% chance of earning a Bachelor's degree. If either parent has completed a Bachelor's degree, the likelihood of graduation almost doubles to 74%.[16] We have become very good at giving an excellent education to our most privileged students.

What we have long suspected and have verified in recent years is that moving to a student-centered, active-learning pedagogy can greatly improve the success of our weakest students while enhancing the learning and mathematical experiences of the strongest.[17] The evidence is now so clear that the presidents of the professional societies in the mathematical sciences have all signed onto a joint statement requesting the investment of "time and resources to ensure that effective active learning is incorporated into postsecondary mathematics classrooms."[18]

This approach helps all students. Active-learning pedagogies are especially important in the preparation of preservice teachers. They help to ensure that these prospective teachers have strong understandings of foundational ideas of the mathematics they will need to draw upon in their teaching. They also equip these teachers to engage their own students in the development of mathematical ways of thinking, thus dramatically improving student preparation for postsecondary mathematics.

The leadership role of the professional societies in the mathematical sciences

Over the past decade MAA has continued its leadership role in identifying and supporting the implementation of best practices in undergraduate mathematics education. It led the creation of the joint report, *A Common Vision for Undergraduate Mathematical Sciences Programs in 2025*,[19] describing the need for updated curricula, well-articulated pathways, evidence-based pedagogical methods, the removal of barriers at critical transition points, and strong connections with other disciplines. The MAA's national studies of calculus instruction[20] have provided insight into best practices with respect to placement, student support services, construction of engaging curricula, coordination of instruction, training of graduate teaching assistants, use of data to guide curricular and structural modifications, as well as the use of active-learning strategies. Through its *Instructional Practices Guide*,[21] MAA has publicized practical steps to improving classroom practices, assessment, and course design. Its *Curriculum Guide*[22] provides recommendations on what is taught as well as dealing with recruitment, retention, articulation, placement, and preparation for graduate study.

Many of the professional societies in the mathematical sciences have recently released reports that describe best practices. The American Statistical Association's *Guidelines for Assessment and Instruction in Statistics Education College Report*[23] provides guidance into what should be

[16] Chen et al (2019)
[17] Laursen et al, (2014) and (2016). Freeman et al (2014)
[18] CBMS (2016)
[19] Saxe and Braddy (2015)
[20] Characteristics of Successful Programs in College Calculus, NSF #0910240, and Progress through Calculus, NSF #1430540
[21] MAA (2017)
[22] Zorn (2015)
[23] GAISE College Report ASA Revision Committee (2019)

taught in college-level statistics and how it should be taught. *Guidelines for Assessment and Instruction in Mathematical Modeling Education*[24] explains how to educate students at both K-12 and postsecondary levels in the aspect of mathematics that is most frequently needed both in the workplace and in society in general, the ability to understand, create, and analyze mathematical models. The American Mathematical Association of Two-Year Colleges has published its recommendations for effective instruction in two-year colleges, *Improving Mathematical Prowess and College Teaching*.[25] *Standards for Preparing Teachers of Mathematics*[26] is a product of the Association of Mathematics Teacher Educators, laying out expectations for high-quality teacher preparation.

Research and the experiences of implementation have demonstrated what works to strengthen the preparation of our scientific and technical workforce while equalizing opportunities for all of our students. There is now an abundance of evidence that all students would benefit from experiencing more meaningful and coherent instruction from the students' perspective—that is, mathematics curriculum and instruction that is more engaging and focused on developing students' mathematical understandings and practices. The professional societies in the mathematical sciences, supported by college and university consortia, are working toward the wide adoption of these best practices.

About the Mathematical Association of America: The mission of the MAA, founded in 1915, is to advance the understanding of mathematics and its impact on our world. The MAA has long been a leader in providing guidelines for the undergraduate program in mathematics, as well as professional development for improvement of all aspects of postsecondary mathematics.

About the Conference Board of the Mathematical Sciences: CBMS is an umbrella organization consisting of eighteen professional societies all of which have as one of their primary objectives the increase or diffusion of knowledge in one or more of the mathematical sciences. Its purpose is to promote understanding and cooperation among these national organizations so that they work together and support each other in their efforts.

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