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Introductory Statistics Education and the National Science Foundation

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Abstract

This paper describes 27 National Science Foundation supported grant projects that have innovations designed to improve teaching and learning in introductory statistics courses. The characteristics of these projects are compared with the six recommendations given in the *Guidelines for Assessment and Instruction in Statistics Education (GAISE) College Report 2005* for teaching an introductory course in statistics. Through this analysis, we are able to see how NSF-supported introductory statistics education projects during the last decade achieve the GAISE ideals. Thus, materials developed from many of these projects provide resources for first steps in implementing GAISE recommendations.

1. Introduction

For many years, statistics educators have been concerned with reforming undergraduate education, especially the introductory course in statistics. Throughout this article, *introductory statistics* refers to Joan Garfield's definition: the "non-calculus based, often terminal, introductory applied statistics course" for students not majoring in the subject (Garfield 2000, p.2). The latest efforts to address this first course have evolved for some time and have resulted in the *Guidelines for Assessment and Instruction in Statistics Education (GAISE) College Report* (2005), which sets forth six recommendations for teaching the introductory course. Likewise, the National Science Foundation (NSF) has addressed undergraduate statistics education by funding many projects aligned with statistics education standards; George Cobb (1993) reviewed 12 such projects, lending inspiration to this report. Following Cobb's lead, this article reviews the GAISE recommendations and supporting literature, describes the NSF programs used to support this reform, and examines 27 NSF projects, funded from 1993 to 2004, which address the introductory statistics course. By comparing these projects with the GAISE recommendations, we are able to show how NSF has been supporting GAISE principles over the past decade.

2. Guidelines for the Introductory Statistics Course

2.1 Evolution of GAISE

As statistics has made its way into the undergraduate curriculum over the past century, the introductory course has undergone numerous changes. Always at the forefront of reform is the effort to improve teaching and student learning in this course (GAISE 2005). In the early 1990's, George Cobb organized a focus group to set up guidelines for teaching this course. This group produced a paper called "Teaching Statistics" that set forth three recommendations: 1) emphasize statistical thinking; 2) more data and concepts, less theory and fewer recipes; and 3) foster active learning (Cobb 1992). Toward the end of the decade, the launching of the Undergraduate Statistics Education Initiative (USEI) drew more attention to the introductory course through a paper calling for increased attention to statistical thinking. That article also reported that teachers of statistics were already increasing their use of technology and active learning in the classroom (Garfield, Hogg, Schau, Whittinghill 2002). These publications are just two examples of the work done in statistics education reform that has helped lead to the production of the *Guidelines for Assessment and Instruction in Statistics Education (GAISE) College Report* (2005).

2.2 GAISE Recommendations

The *GAISE College Report* (2005) was developed by a group of statisticians/statistics educators with funding from the American Statistical Association (ASA). On May 17, 2005, the ASA approved this document which provides six primary recommendations for teaching introductory statistics: emphasize statistical literacy and develop statistical thinking, use real data, stress conceptual understanding rather than mere knowledge of procedures, foster active learning in the classroom, use technology for developing conceptual understanding and analyzing data, and use assessments to improve and evaluate student learning.

2.2.1 Emphasize Statistical Literacy and Develop Statistical Thinking

The common thread throughout introductory statistics education reform efforts is the emphasis on statistical thinking and literacy (Cobb 1992, Snee 1993, Garfield et al 2002, MAA 2004). Instructors of introductory level courses want their students to understand statistical terms, symbols, graphs, and fundamental ideas, which the GAISE authors consider to be statistical literacy. Along with literacy, students in these courses should be able to think statistically, meaning they should understand the need for data, the importance of data production, the omnipresence of variability, and the quantification and explanation of variability (GAISE 2005). Rumsey (2002) adds to this definition the ability to make informed decisions, while Chance (2002) wants her students to see the big picture and think of statistics in terms of the whole process, rather than isolated techniques. Furthermore, since statistics are present everywhere in the media it is important for citizens to be able think critically about the information thrust upon them (Rumsey 2002; Sullivan 1993).

2.2.2 Use Real Data

Because statistics is about understanding data (Hakeem 2001), students should have access to and experience with real data. The use of real data in introductory statistics courses provides authenticity, helps address issues of data production and collection, gives real-life context to a problem, and can increase student interest in the course (GAISE 2005). There are three kinds of data which accomplish these goals, each with advantages and disadvantages. Class generated data can provide meaningful connections for students because they participated in its production; unfortunately, it can also be toy-like and shallow. Archival data gives students experience with real-world statistics and can be complex and rich in nature; however, students' excitement may be compromised since they were excluded from the production process, and variability can be hidden. Simulated data emphasizes variability well and allows the instructor more control, but it is not real (Cobb 1993). Regardless of the type, real data used in context can motivate and engage students in the statistical process without being burdensome thanks to technological advances (GAISE 2005).

2.2.3 Stress Conceptual Understanding Rather Than Mere Knowledge of Procedures

Like Cobb (1992), the GAISE authors believe that topical coverage can be sacrificed for conceptual understanding and suggest paring down the course syllabus. "If students don't understand the important concepts, there's little value in knowing a set of procedures," (GAISE 2005, p. 10). Experts in other disciplines, such as biology professors Udovic, Morris, Dickman, Postlethwait, and Wetherwax (2002), agree that deep understanding of fewer concepts is better than shallow understanding of many. This has been a principle part of the undergraduate statistics education reform movement, as more instructors are focusing on concepts in their courses (Garfield 2000). The Mathematical Association of America (2004) also endorsed this recommendation for statistics courses in their Committee on the Undergraduate Program in Mathematics 2004 Curriculum Guidelines.

2.2.4 Foster Active Learning in the Classroom

There are many advantages to incorporating active learning in the introductory statistics course. It allows students to discover concepts, engage in the statistical process, communicate in statistical language, and work in teams, as well as provides instructors informal methods of assessment (GAISE 2005). Active learning ideas can be traced back to Socrates and are found in the work of Dewey, Piaget, and Lewin (Zeichner, Litcher 1998). In a study of student learning styles in English, chemistry, mathematics, and psychology courses, August, Hurtado, Wimsatt, and Dey (2002) found that 91% of students felt they learned better from in-class activities and 85% found lecture-only classes boring. McConnell, Steer, and Owens (2003) found that active learning techniques in geology courses increase student participation and that students who have engaged in active learning perform better on exams and logical thinking tests than those in traditional settings. To foster active learning, activities should focus on conceptual understanding and discovery learning and can be group work, laboratory activities, or class discussions (GAISE 2005).

2.2.5 Use Technology for Developing Conceptual Understanding and Analyzing Data

Technology, a resource which has been transforming statistical research for many years, has also been a major component of statistics education reform (Moore, Cobb, Garfield, Meeker 1995, Garfield 2000). This remarkable tool can be used in the introductory statistics course to analyze data, simulate concepts, or provide alternative assessments, while motivating and exciting students (GAISE 2005, Schenone-Stevens 1999). However, there are some cautions teachers should heed when exploiting technology's benefits. When used for its own sake, technology has no redeeming educational value (Schenone-Stevens 1999); rather than replace human interaction, technology should enrich teaching styles and techniques (Moore, Cobb, Garfield, Meeker 1995). When used correctly, technology can greatly enhance student learning (GAISE 2005).

2.2.6 Use Assessments to Improve and Evaluate Student Learning

It is understood that students are concerned with how they are assessed; therefore, assessment techniques should place value on learning objectives and understanding key ideas (GAISE 2005). High quality assessments should be aligned with national standards, should measure what matters for improvement, and should be learning experiences themselves (Cobb 1993; Caudell 1996; Chance and Garfield 2002). Such instruments drive curriculum, reflect student learning, and have real-life context (Caudell 1996). Examples include formative evaluations, written reports, portfolios, experiments, essays, speeches, projects, and activities (Caudell 1996, McConnell, et al 2003, GAISE 2005).

2.2.7 Interconnection of the GAISE Recommendations

These recommendations made by the GAISE authors do not stand alone. Each can be met by materials or techniques intended to address another. For instance, a teacher may implement technology in order to convey a particular concept, an activity may involve student collection of data, or a group project may be used for assessment. Furthermore, all of these can move students toward being statistically literate or employing statistical thinking. In any case, statistics educators need not approach these guidelines as six separate techniques to master and implement, but as one complete way to help students become good statistical citizens in an information age.

2.3 GAISE in Other Disciplines

These approaches to teaching are not limited to introductory statistics or any statistics course. The ideas of scientific reasoning, active learning, conceptual understanding, use of technology, and appropriate assessments are present in biology, geology, business, engineering psychology, and other disciplines that depend on statistics (Rolker-Dolinsk, Qualters 1994; Craddock 1998; Bass, Rosenzwig 1999; Hakeem 2001; McConnell, et al 2003; McCormick, MacKinnon, Jones 1999; Udovic, et al 2002). Some National Science Foundation (NSF) projects described in this paper meet GAISE recommendations by addressing introductory level statistics through courses in these disciplines.

3. NSF Division of Undergraduate Education Programs

The NSF has supported undergraduate education since its inception in 1950. In order to take a more central role in reform efforts, NSF established the Division of Undergraduate Education (DUE) (NSF 1996). The following programs are or were supported by DUE and have had an impact on introductory statistics courses.

The Instrumentation and Laboratory Improvement (ILI) program of NSF DUE began in 1988 in order to encourage and support improvement in laboratory curricula for science, technology, engineering, and mathematics (STEM) education institutionally and nationwide. Projects funded through this program helped create and equip laboratory facilities, upgrade equipment for laboratory instruction, develop laboratory exercises that demonstrate basic principles, and stimulate interest in STEM courses by making them relevant and understandable. The program accepted its final proposals in fiscal year 1998 and transitioned into the Course, Curriculum, and Laboratory Improvement (CCLI) program (NSF 1998).

The main objectives of the Course and Curriculum Development (CCD) program, which ran from 1988 until 1998, were to improve undergraduate STEM teaching, increase student understanding of and attitudes toward STEM, and to place greater value on teaching and scholarship through the development and adaptation of courses, curriculum, and educational materials (Eiseman, Fairweather, Rosenblum, Britton 1998). Grants funded through this program often produced textbooks, manuals, or course materials or created courses or sequences of courses. Like ILI, CCD was finally assimilated into CCLI (NSF 1998).

Established in 1998, the Course, Curriculum and Laboratory Improvement (CCLI) program combined properties of CCD and ILI, funding proposals for curricular development and purchase of instructional laboratory equipment. The initial four tracks of CCLI were intended to stimulate creative teaching and pedagogical scholarship among faculty (NSF 1998). The Educational Materials Development (EMD) track aimed to encourage and support the development of quality instructional materials that enhance student learning in STEM, while the Adaptation and Implementation (AI) track assisted in integrating exemplary materials, laboratory experiences, and educational practices at other diverse universities (NSF 2003a, NSF 2003b). By sponsoring faculty development opportunities, the National Dissemination (ND) track of CCLI promoted the introduction of exemplary materials, practices, and techniques to large numbers of colleges and universities nationwide (2003a). Finally, the Assessment of Student Achievement (ASA) track developed effective assessment tools associated with student learning in STEM and supported the adaptation, implementation, and dissemination of such tools (NSF 2003c). These four tracks were phased out in 2006 to make room for a cyclical model of knowledge production and improvement with five supporting components: teaching and learning research, learning materials development, faculty enhancement, innovative materials implementation, and assessment of learning innovations (NSF 2005a).

Another program that was integrated into CCLI was the Undergraduate Faculty Enhancement (UFE) program, which operated from 1988 to 1998. UFE sought to provide faculty with opportunities to experience new and exciting developments in undergraduate education such as new content, teaching methods, experimental techniques, and technology. Funded projects conducted workshops, short courses, seminars, and other such activities to promote these developments. The program supported more than 500 projects and over 750 workshops during its lifetime (Marder, McCullough, Perakis 2001). Another program for educators was the Collaboratives for Excellence in Teacher Preparation (CETP) program founded in 1993. The goal was to increase the number and quality of future pre-Kindergarten through 12th grade teachers, emphasizing subject area competence, effective pedagogical techniques, and national standards for math and science. This program was redesigned, and from 2003 to 2005 was the Teacher Professional Continuum (TPC) program (NSF 1999; Prival 2008b). Currently, components of this program are interwoven with the Discovery Research K-12 (DR-K12). (Prival 2008a)

The National Science, Technology, Engineering, and Mathematics Digital Library (NSDL) program supports the collection and organization of educational materials into a national online digital library through projects that develop and enhance collections as well as implement digital library services. Projects can support existing resource providers, maintain material currency and selection criteria, select existing materials for inclusion, or fund workshops promoting the library (NSF 2005b).

4. NSF Projects Meeting GAISE Recommendations

4.1 Overview

As noted above, any given educational technique, practice, or set of materials need not be isolated to one specific GAISE recommendation. Often, by setting out to meet one recommendation, educators end up meeting several at a time. By searching NSF's Award Search Webpage (www.nsf.gov), we were able to find 110 projects affecting introductory statistics funded between 1993 and 2004. Of these, 95% met at least one GAISE recommendation, while 65% met more than one. The NSF funded projects that follow are described in terms of one GAISE recommendation, but that does not mean they meet only that recommendation. Projects were selected to exemplify the qualities of a particular recommendation, even if they meet more than one, as many do. Furthermore, we do not claim that this list is exhaustive of NSF projects that meet GAISE guidelines. If you participated in an NSF project that fits the nature and scope of this article and is not discussed or listed in the Appendix, we extend our apologies for the omission.

4.2 Projects that Emphasize Statistical Literacy and Thinking

Projects that address the first guideline are targeted at helping students become statistically literate, critical thinkers, and informed statistical citizens. The Electronic Encyclopedia of Statistical Examples and Exercises (EESEE; http://www.whfreeman.com/eesee/eesee.html) and the Data and Story Library (DASL: http://lib.stat.cmu.edu/DASL/) are online resources full of real datasets, case studies, and other materials for use in statistics classes. In order to enhance these two resources, project investigators Paul Velleman, William Notz, Elizabeth Stasny, and Dennis Pearl led "Interactive Video Resources for Learning Statistics" (#9555073, #9555233). This project added video resources of current events found on the news and other television programs to help students think critically about statistical applications in real world events (Notz, Pearl, Stasny 1996).

Another project focused on current events that utilizes the EESEE and DASL, is "Change: Current Studies of Current Chance Issues, Phase II," (#9354592) by Laurie Snell. Chance is a quantitative literacy course designed to turn students into informed critical readers by basing the course on statistical concepts found in current events. Students read articles from *Chance Magazine* and other journals, critiquing the statistical methods used. Topics covered include probability concepts, descriptive statistics, design of experiments, sampling, correlation, and exploratory data analysis. Online and printed materials are available to help instructors teach such a course (Snell 1994, http://www.dartmouth.edu/~chance/). Additionally, a workshop called "Chance Workshop" (#9653416) was conducted to teach educators how to use current events to teach probability and statistics concepts (Snell 1997).

Other workshops have been conducted to help teachers with little or no statistical training learn better ways to teach statistical literacy. Two examples are George Cobb and Mary Parker’s "Statistical Thinking and Teaching Statistics"(#9255447) and its successor "STATS: Statistical Thinking with Active Teaching Strategies," (#9554621) led by Allan Rossman and Thomas Short. These projects supported numerous weeklong workshops emphasizing statistical thinking through real data, conceptual understanding, active learning, software, and assessments, thus touching all components of GAISE (Cobb and Parker 1998; Rossman and Short 1999).

Students in other disciplines also benefit from statistical literacy and thinking skills. To help biology students appreciate statistics and improve their quantitative reasoning skills, "IBASE: Integrating Biology and Statistics Education," (#0309751) by James Watrous, Deborah Lurie, and Denise Ratterman, created two courses, biology and statistics, to be taken simultaneously. In the biology course, students collected data from experiments completed in the lab and then analyzed the data in the statistics course. Thus the students were able to learn real-world applications in a relevant situation, reducing anxiety toward statistics and providing better understanding (Watrous, Lurie, Ratterman 2003).

4.3 Projects that Use Real Data

Real data is often easiest to collect in other disciplines that use statistics on a regular basis. For example, the American Sociological Association, partnering with the University of Michigan, sponsored "Collaborative Project on Integrating Census Data Analysis into the Curriculum" (#0088715, #0089006) led by William Frey, Carla Howery and Felice Levine. This National Dissemination project attempted to revise the sociology curriculum at numerous schools by emphasizing the use of real data from the US Census Bureau. The project investigators called for proposals from other universities to take part in this project in order to have widespread impact (Frey 2001, American Sociological Association 2002). The natural sciences are another area with easy access to real data. "Service Learning in Chemistry: Lead in Soil from Vehicle Emissions" (#0410115) by Hal Van Ryswyk incorporated data analysis into introductory chemistry classes. Students sampled and tested soil for lead, analyzed their own data, and prepared written and oral presentations. The students in these courses also collaborated with students in probability and statistics courses as well as local elementary schools (Van Ryswyk 2004). For those educators without such easy access to real data, there are other ways to find it. For example, James Albert designed an introductory statistics course based entirely on baseball statistics through "Development of Sports Statistics Modules for Introductory Statistics Classes" (#0088703). Data came from baseball cards, the Internet, and simulation. Students were able to understand concepts and analyze real data in an interesting context (Albert 2002).

Analyzing data can be difficult without computer access and appropriate software. Robert Gould and Mahtash Esfandiari’s goal for "A Statistics Undergraduate Computing Laboratory" (#9981172), funded in 2000, was to establish a computer laboratory for statistics courses, where students could analyze real data, teaching the value of statistical thinking and deeper intuitive understanding of the entire data analysis process. The project investigators believe real datasets can help students confront important basic problems in statistics without the datasets being huge and messy (Gould, Esfandiari 2003).

4.4 Projects that Stress Conceptual Understanding over Knowledge of Procedures

In order to place a deliberate emphasis on conceptual understanding versus theoretical background, educators often employ real data, active learning, and technology. The "Rice Virtual Laboratory in Statistics" (#9751307) by David Lane, Joe Austin, David Scott, Keith Baggerly, and Miguel Quinones is a web-based resource for students and teachers of statistics. The site (http://onlinestatbook.com/rvls.html) houses the *Hyperstat Online* textbook, case studies, simulations, and some basic analysis tools. The intended progression is for users to explore a statistical concept demonstrated in a case study, which will link them to explanatory material from the online textbook, leading them to simulations of the concept through Java applets, ending with the users’ own experiments, providing the student or teacher with a thorough lesson and deeper conceptual understanding (Lane, Austin, Scott, Baggerly, Quinones 2000). Associated with the Rice Virtual Labs is "Online Statistics Education: An Interactive Multimedia Course of Study" (#0089435) by David Lane, David Scott, Rudy Guerra, Michelle Hebl, and Daniel Osherson. This online statistics course (http://onlinestatbook.com/) contains lecture materials, simulations, self-testing, and real data from case studies, and can be modified depending on audience level. To learn the concepts, students answer a series of questions, then conduct simulations to see if they were correct, and then answer the questions again (Lane, Scott, Guerra, Hebl, Osherson 2004). Beth Klingner and Nira Herrmann make use of Lane’s online course in their project, "Enhancing the Mathematical Foundation of Students through Online Course Modules" (#0311016). They adapted the materials into modules designed to teach quantitative and analytical skills in relevant contexts (Klingner, Herrmann 2003). For those with little or no computer access, "Laboratory Lessons for Discovery-Based Statistics" (#9650581) by Richard Scheaffer produced hands-on, student-directed lessons that teach fundamental concepts like randomness, sampling distributions, confidence, and significance, which can include, but do not require, computer use (Scheaffer, 1996).

4.5 Projects that Foster Active Learning

Many projects that involve active learning do so through computer laboratory modules, activities, or course-long projects. These activities are designed to help students practice the scientific process while gaining deeper conceptual understanding. Both "Fostering Conceptual Understanding Using a ‘Hands-On’ Approach in Undergraduate Statistics" (#9452320) by Danuta Bukatko and Patricia Kramer and "A Statistical Laboratory for Active Learning" (#9550891) by Richard Scheaffer created interactive, hands-on computer module activities that help students learn statistical concepts using graphing and analysis (Bukatko, Kramer 1994; Scheaffer 1995). "An Activity-Based

Statistics Course for Engineers" (#0126815) by Steven Butt, Bob White, and Tycho Fredericks gives students the opportunity to collect their own data and solve real-world problems in weekly labs and workshops, while "Development of an Inquiry-based Curriculum in Ecology" (#0088369) by Richard Tankersley and John Morris has integrated laboratory modules into a four semester sequence of ecology courses, where students sharpen their thinking skills through statistical technique exercises and self-designed investigations (Butt, White, Fredericks 2004; Tankersley, Morris 2005).

Another active learning project that spans courses is "Promoting Undergraduate Research through Development of Two Interdisciplinary Research Methods/Statistics Courses and Increased Support of Student Research," (#0126435) by Kathy Silgailis and Vishwa Bhat. Resulting from this project is a two-semester sequence of courses for science majors in which students complete a sequence-long project. In the first semester, students develop a research question and hypothesis while learning basic statistical procedures, and in the second semester, they refine the question, design and conduct data collection, and prepare written and oral presentations of their findings. This in-depth project also includes software training and laboratory activities (Silgailis, Bhat 2005).

4.6 Projects that Effectively Use Technology

It would be very tempting to say that any project that implements some type of technology meets the technology recommendation; however, technology for the sake of technology is not what this guideline recommends. Utilizing technology means providing access to hardware or software that enhances the learning of statistics, especially computational or simulation software. For instance, Roxy Peck and James Daly's "Studio Environment for Introductory Statistics" (#9750663) established a laboratory classroom so that students could complete lab activities, projects and simulations to help them learn statistics (Peck, Daly 1997).

Simulation software is useful technology for teaching statistics. Sampling SIM, software developed by Joan Garfield, Robert delMas, and Beth Chance through "Tools for Teaching and Assessing Statistical Inference" (#9752523), helps students with conceptual understanding by allowing them to make and test predictions. The simulation software provides instructional materials and is available freely over the web at http://www.tc.umn.edu/~delma001/stat_tools/ (Garfield, delMas 2000).

A larger software program focused on data analysis was developed through "A Data Analysis Exercise Server for Introductory Statistics Courses" (#9980973) by Todd Ogden and Webster West and "DoStat.com: A Web Site for Educational Data Analysis and Assessment" (#0226097) by Webster West and James Lynch. "StatCrunch," initially called "WebStat," is low-cost online computational software found at http://www.statcrunch.com. This Excel compatible software allows students to upload their own data and perform descriptive statistics, hypothesis testing, confidence intervals, regression, ANOVA, categorical or quantitative graphing, and more (West, Wu, Heydt 2004). A project utilizing StatCrunch is "Visualizing Statistics – A Online Introductory Course" (#9950671) by Alexander Kugushev and CyberGnostics, Inc. This online course offers explanatory text, applets, real data, testing, and "StatCrunch" analytical software (CyberGnostics 2005).

4.7 Projects on Assessment

Determining if you are meeting your instructional goals for your students is difficult without proper assessment instruments. Two projects have been funded which provide access to statistical assessments. The "Web-based ARTIST Project" (#0206571) by Joan Garfield, Beth Chance, and Robert delMas consists of an assessment builder of over 1,000 items varying by format, level, and statistical topic as well as project ideas, article critiques, group work options, and scoring guidelines. References of works published on assessment topics are also available on the site, https://app.gen.umn.edu/artist/ (Garfield, Chance 2004). "Statistical Concepts Inventory (SCI): A Cognitive Achievement Tool in Engineering Statistics" (#0206977) by Teri Rhoads, Teri Murphy, and Robert Terry is a multiple choice exam intended to measure the ability of engineering students to apply statistical concepts to real-world situations. This assessment tool includes questions related to statistical topics important in engineering such as designing and conducting experiments and analyzing and interpreting data. It is available at http://onlinestatbook.com/rvls.html/ (Rhoads, Murphy 2005).

4.8 Projects that Address All Recommendations

Many of the projects previously described meet more than one recommendation. However, few projects meet all GAISE recommendations. One such project that reaches across the discipline of statistics to touch students and teachers at all levels is "CAUSEweb: A Digital Library of Undergraduate Statistics Education" (#0333672) led by Dennis Pearl and supported by the Consortium for the Advancement of Undergraduate Statistics Education (CAUSE). This digital library, found at http://causeweb.org/, includes a resource section which provides descriptions and/or reviews for statistics education materials. Students and teachers can search for resources by material type, audience level, math level, application area, or statistical topic (Green, McDaniel, Rowell 2005).

5. Conclusion

The *GAISE College Report* recommendations are the result that evolved from many years of work by the statistics education community to determine the best standards for teaching and learning introductory statistics. With so many NSF-funded projects achieving the ideals described in GAISE, it is apparent that the NSF supports the implementation of these recommendations. NSF-supported resources described in this paper provide a good starting place for introductory statistics teachers to find ideas to help them implement one or more of the GAISE recommendations. The Appendix includes additional "information" on over 100 NSF-supported projects in introductory-level statistics education. Additional information about these projects can be found by using the NSF Awards Search webpage (http://www.nsf.gov/awardsearch/) and entering the award number in the "Search Award for" dialog box.

Appendix: NSF Projects

Award Number	Title	PI	Start Date	NSF Program	Award Amount	Institution
9950494	Computer Enhanced Mathematics Instruction	Addison Frey	June 1, 1999	AI	$25,429	Alfred University
9950161	An Interactive Learning Environment in Statistics: Integrating Multimedia Laboratory Exercises and Courseware into the Statistics Curriculum	Deborah A. Nolan	July 1, 1999	AI	$99,238	U. California Berkeley
9950509	High-Tech., Project-Based Beginning Algebra and Statistics Course for Two-Year Colleges	Sue E. Stokley	August 1, 1999	AI	$32,847	Spartanburg Tech. Coll.
9950628	Beyond Mapping and Reporting: Improving Students' Skills in Science and Analysis for Geography, Environmental Studies, and Ecology	Robert Werner	August 1, 1999	AI	$42,200	Univ. of St. Thomas
9972494	Integrated Statistics and Computer Application Courses	Melinda A. Holt	August 1, 1999	AI	$87,577	Texas Women's Univ.
9950229	Quantitative Reasoning and Informed Citizenship: Implementing an Activity-based Laboratory Course	Kay Somers	September 1, 1999	AI	$79,412	Moravian College
9950856	New Laboratory and Integrated Course Materials to Improve the Psychology Curriculum	Scott Ottaway	September 1, 1999	AI	$86,276	West. Washington U.
9980995	Using the LaCEPT Model to Reform an Elementary Statistics Course	Frank Neubrander	January 1, 2000	AI	$74,063	LSU, A&M Coll.
9952620	Development of Laboratory and Field Experience Based Course in Asphalt Technology for Civil Engineering Undergraduate Students	Rajib Mallick	February 1, 2000	AI	$31,479	Worcester Poly. Inst.
9981172	A Statistics Undergraduate Computing Laboratory	Robert L. Gould	March 1, 2000	AI	$69,181	UCLA
0087680	A Multifunctional Technology Classroom for the Teaching of Data-Intensive Statistics	Steven C. Patch	January 1, 2001	AI	$49,450	UNC, Asheville
0088369	Development of an Integrated Inquiry-based Curriculum in Ecology	Richard Tankersley	February 1, 2001	AI	$201,134	Florida Inst. Of Tech.
0088377	Political Analysis in an Experiential/ Collaborative Setting	Allan McBride	March 15, 2001	AI	$45,642	Univ. Southern Miss.
0088422	Adaptation and Implementation of Computer Technology into the Mathematical Science Curriculum	T. Len Miller	July 1, 2001	AI	$93,011	MSU
0126815	An Activity-Based Statistics Course for Engineers	Steven E. Butt	January 23, 2002	AI	$52,139	Western Michigan U.
0126914	Integrating Mathematics and Statistics into the Biology Curriculum	Eric Marland	March 1, 2002	AI	$159,583	Appalachian S.U.

0126682	A Multi-stage, Technology-intensive Approach to Statistics Instruction	Jeff Knisley	May 1, 2002	AI	$124,996	ETSU
0126435	Promoting Undergraduate Research through the Development of Two Interdisciplinary Research Methods/ Statistics Courses and Increased Support of Student Research	Kathy Silgailis	July 1, 2002	AI	$197,975	Will. Patterson Univ.
0309751	IBASE: Integrating Biology and Statistics Education	James J. Watrous	July 1, 2003	AI	$89,188	St. Joseph's University
0311016	Enhancing the Mathematical Foundation of Students through Online Course Modules	Beth Klingner	August 15, 2003	AI	$164,985	Pace University, NY
0310932	Implementing Activity-based Cooperative Learning and Technology (ACT Curriculum) in Statistics Courses for Non-majors and K-12 Preservice Teachers	Carl M. Lee	September 1, 2003	AI	$177,052	Central Michigan Univ.
0311579	Collaborative Research: Adapting and Evaluating Online Materials for Undergraduate Statistics using LON-CAPA Technology	Deborah A. Kashy	September 15, 2003	AI	$35,078	Michigan State Univ.
0311695	Collaborative Research: Adapting and Evaluating Online Materials for Undergraduate Statistics using LON-CAPA Technology	Jennifer G. Boldry	September 15, 2003	AI	$47,125	Montana State Univ.
0410115	Service-Learning in Chemistry: Lead in Soil from Vehicle Emissions	Hal Van Ryswyk	September 1, 2004	AI	$41,227	Harvey Mudd College
0411041	Integrating Data Analysis into the Curriculum: Responding to the Scientific Literacy Gap Among Undergraduate Students in the Social Sciences	Esther Wilder	September 1, 2004	AI	$175,000	CUNY, Herbert Lehman
0206571	The Web-based ARTIST Project	Joan Garfield	August 15, 2002	ASA	$551,094	UMN, Twin Cities
0206977	The Statistical Concepts Inventory (SCI): A Cognitive Achievement Tool in Engineering Statistics	Teri R. Rhoads	September 1, 2002	ASA	$499,999	University of Oklahoma
9254087	A Modular Laboratory and Project-Based Statistics Curriculum	Joseph D. Petruccelli	January 1, 1993	CCD	$165,000	Worcester Poly. Inst.
9254182	Realizing the Power of Computers in Business Statistics Instruction: A Next Step	Ronald Tracy	February 1, 1993	CCD	$60,029	Oakland University
9354506	Developing Statistical Understanding through Interactive Computing/Graphics	Leo Breiman	March 1, 1994	CCD	$166,637	U. California Berkeley
9354419	Constructing Knowledge of Statistical Concepts through Modern Technology	Dennis D. Wackerly	May 1, 1994	CCD	$99,992	University of Florida
9354592	Change: Current Studies of Current Chance Issues, Phase II	J. Laurie Snell	July 1, 1994	CCD	$209,914	Dartmouth College
9455393	New Engineering Course with a Virtual Computer Laboratory	Norma F. Hubele	February 1, 1995	CCD	$100,600	Arizona State Univ.
9455300	New Geology Laboratories: Interactive Data Acquisition, Analysis, and Multimedia Modules of Geologic Phenomena, Part II	Dennis Hodge	May 1, 1995	CCD	$75,000	SUNY, Buffalo
9455601	Coupling Mathematics and Life Science Courses	Marlene Wilson	June 1, 1995	CCD	$51,293	Univ. of Portland
9455578	Revitalizing Introductory Statistics for Engineering by Capitalizing on Interdisciplinary Cooperation and State-of-the-Art Technology	Panickos N. Palettas	August 1, 1995	CCD	$57,866	Virginia Tech
9696174	Revitalizing Introductory Statistics for Engineering by Capitalizing on Interdisciplinary Cooperation and State-of-the-Art Technology	Panickos N. Palettas	January 1, 1996	CCD	$140,975	Ohio State University
9555073	Interactive Video Resources for Learning Statistics	William I. Notz	March 1, 1996	CCD	$103,701	Ohio State University
9554805	Synergistic Learning in Biology and Statistics (SLIBS)	Robert V. Blystone	June 1, 1996	CCD	$246,336	Trinity University
9555233	Interactive Video Resources for Learning Statistics	Paul F. Velleman	June 1, 1996	CCD	$51,598	Cornell University
9653153	Earth Math Phase 3; Calculus and Statistics for a New World	Nancy Zumoff	January 1, 1997	CCD	$22,800	Kennesaw S.U.
9653267	Revitalizing the Study of Probability through Applications, Technology, and Collaborative Learning	Michael Bean	September 1, 1997	CCD	$180,001	University of Michigan
9752428	A Probability/Activity Approach for Teaching Introductory Statistics	James Albert	January 1, 1998	CCD	$50,000	Bowling Green Univ.
9752559	Probability and Surprise: Animations and Simulations	Susan P. Holmes	January 1, 1998	CCD	$99,970	Cornell University
9752523	Tools for Teaching and Assessing Statistical Inference	Joan B. Garfield	February 1, 1998	CCD	$100,021	UMN, Twin Cities
9752645	Intersection of Population Biology and Mathematics	Jane Gallagher	June 1, 1998	CCD	$150,000	CUNY
9850035	Science Education for Tomorrow	Elizabeth Boylan	September 1, 1998	CCD	$196,152	Barnard College
9996235	Probability and Surprise: Animations and Simulations	Susan P. Holmes	January 1, 1999	CCD	$62,048	Stanford University
9653224	Revitalizing Classroom Teaching and Learning: A Beginning for Two-Year College Mathematics	Elizabeth Higgins	February 1, 1997	CCD/ATE	$99,799	Greenville Tech. Coll.
9752185	Integrating Pedagogical and Curriculum Theory with Teaching Practice Throughout all Mathematics and Science Courses in the College of Arts & Sciences and Evaluating ...	Edward Dubinsky	March 1, 1998	CCD/CETP	$100,000	Georgia State Univ.
9354529	Informed Statistical Reasoning in an Uncertain World: Situated Simulations for Undergraduates	Sharon Derry	June 1, 1994	CETP	$202,316	UW-Madison
9950671	Visualizing Statistics - An On-Line Introductory Course	Alexander Kugushev	October 1, 1999	EMD	$260,484	CyberGnostics Inc.
9980796	Development of an Interactive Tutorial on Statistical Design and Analysis of Experiments	John O'Haver	February 1, 2000	EMD	$79,898	University of Miss.
9980973	A Data Analysis Exercise Server for Introductory Statistics Courses	R. Todd Ogden	May 1, 2000	EMD	$75,000	USC, Columbia
0088703	Development of Sports Statistics Modules for Introductory Statistics Classes	James H. Albert	January 1, 2001	EMD	$67,258	Bowling Green Univ.
0089435	Online Statistics Education: An Interactive Multimedia Course of Study	David M. Lane	February 1, 2001	EMD	$401,990	Will. Marsh Rice Univ.
0126855	Case-Based Reasoning for Engineering Statistics	George C. Runger	December 1, 2001	EMD	$74,622	Arizona State Univ.
0126433	Teaching Psychological Research Methods with Online Examples	William Maki	April 15, 2002	EMD	$102,147	Texas Tech. University
0226097	DoStat.com: A Web Site for Educational Data Analysis and Assessment	R. Webster West	June 15, 2002	EMD	$130,002	USC, Columbia
0230803	Stem and Tendril: Vertically Integrated Statistics Laboratories	Andrew Poje	January 15, 2003	EMD	$74,836	CUNY Staten Island
0341210	Improving the Quality of and Access to Undergraduate Statistics Education	Fred Speed	January 1, 2004	EMD	$74,826	Texas A&M Univ.
0341529	An Audio-Tactile Curriculum to Support Visually Impaired Statistics Students	Karen Gourgey	February 15, 2004	EMD	$30,032	CUNY, Baruch
9752705	UFE: Teaching Computer-Intensive Resampling Techniques	Amer. Stat. Assoc.	February 15, 1998	EMD/UFE	$60,000	Amer. Stat. Assoc.
9250330	Behavioral Sciences Computer Laboratory	James Raymondo	July 1, 1992	ILI	$25,280	Union College
9351126	Data Analysis Laboratory	Loren Haskins	April 1, 1993	ILI	$32,355	Carleton College
9351926	Elementary Statistics Computer Laboratory	Louis M. Friedler	April 1, 1993	ILI	$19,259	Beaver College
9352131	An Interdisciplinary Laboratory for Data Acquisition, Analysis, and Modeling	Dwight Krehbiel	April 1, 1993	ILI	$49,560	Bethel College
9351035	Discovering Statistics: A Laboratory Approach	Richard L. Scheaffer	June 1, 1993	ILI	$25,000	University of Florida
9351493	Computational Classroom Facility for Biometry Courses	Charles McCulloch	June 1, 1993	ILI	$40,000	Cornell University
9352076	Technology for: Improvements of Mathematical Concepts and Initiation to Professional Tools	Karla Foss	June 1, 1993	ILI	$35,000	Pellissippi STCC
9352110	Instrumentation for Novel Laboratory Instruction in Undergraduate Statistics Curricula	Walter R. Pirie	June 1, 1993	ILI	$52,646	Virginia Tech
9350746	A Computer Lab for Biological Statistics	Daniel E. Wujek	July 1, 1993	ILI	$26,887	Central Michigan Univ.
9352312	Novel Laboratory Instruction in Undergraduate Statistics Curricula	Panickos N. Palettas	August 1, 1993	ILI	$90,221	Virginia Tech
9451814	Multidisciplinary Statistics Curriculum and Computing Laboratory	Chris Noble	June 1, 1994	ILI	$38,560	Lawrence University
9452229	Interactive Computerized Statistics Classroom	Louise Hainline	June 1, 1994	ILI	$70,072	CUNY, Brooklyn
9451972	In-Class Experimental Learning in Four Fundamental Courses	John Stone	July 1, 1994	ILI	$70,000	Grinnell College
9452622	Developing a Computer Lab for the Technology Enhanced Teaching of Undergraduate Statistics	Judith Treas	August 1, 1994	ILI	$55,000	U. California, Irvine
		Joseph D.				

9451398	A Computer Classroom for Introductory Statistics	Petruccelli	August 15, 1994	ILI	$53,348	Worcester Poly. Inst.
9452156	Enhancement of Statistics, Research Methods and Experimental Psychology Laboratories	Virginia A. Diehl	September 1, 1994	ILI	$33,659	West. Illinois Univ.
9452320	Fostering Conceptual Understanding Using a "Hands-On" Approach	Danuta Bukatko	September 1, 1994	ILI	$17,640	Holy Cross College
9550891	A Statistical Laboratory for Active Learning	Richard L. Scheaffer	May 1, 1995	ILI	$14,940	University of Florida
9551850	Computer Classroom for Statistical Instruction	Ronald L. Tracy	August 1, 1995	ILI	$65,000	Oakland University
9551275	Computer Stat Lab	Patricia R. Wilkinson	September 1, 1995	ILI	$29,391	CUNY, BMCC
9551460	From Descriptive to Adaptive Understanding: Using Interactive Computer Simulation in Quantitative Biology and Statistics Labs	David G. Huffman	September 1, 1995	ILI	$62,320	Southwest Texas S.U.
9552311	Fostering Creativity, Teamwork, and Scientific Thinking in Introductory Statistics through Computer-Based Laboratories	Peter G. Jessup	September 1, 1995	ILI	$24,333	Ursinus College
9650048	Interactive Undergraduate Statistical Computing Laboratory	John I. Marden	May 1, 1996	ILI	$38,070	UI, Urbana-Champaign
9650871	Computer Laboratories in Calculus & Statistics	Bruce Torrence	June 1, 1996	ILI	$41,597	Randolph-Macon Coll.
9696158	Novel Laboratory Instruction in Undergraduate Statistics Curricula	Panickos N. Palettas	June 1, 1996	ILI	$47,651	Ohio State University
9650645	Mathematics and Statistics Computer Classroom	I-Lok Chang	July 1, 1996	ILI	$23,680	American University
9651186	Mathematics Multimedia Presentation Classroom	Kevin McDonald	July 1, 1996	ILI	$60,000	Mt. San Antonio Coll.
9650032	A Microcomputer Laboratory for Experimental Psychology	Sarah Ransdell	August 1, 1996	ILI	$22,000	Florida Atlantic Univ.
9650581	Laboratory Lessons for Discovery-Based Statistics	Richard L. Scheaffer	August 1, 1996	ILI	$46,620	University of Florida
9650659	Department of Economics Computer Center	Byron David	August 1, 1996	ILI	$19,900	CUNY, City College
9651271	Computer Assisted Interdisciplinary Problem Solving in Mathematics and Science	Samantha Prashanta	September 1, 1996	ILI	$31,830	Finger Lakes CC
9750663	Studio Environment for Introductory Statistics	Roxy Peck	June 1, 1997	ILI	$61,429	Cal Poly State Univ.
9751571	Data-Driven Statistics Courses in an Interactive Teaching Computer Laboratory	Andre M. Lubecke	June 1, 1997	ILI	$54,969	Lander University
9751307	The Rice Virtual Lab in Statistics	David M. Lane	July 1, 1997	ILI	$200,000	Will. Marsh Rice Univ.
9851421	STATLAB - An Interactive Classroom and Laboratory for Introductory Statistics	David C. Carothers	June 1, 1998	ILI	$59,936	James Madison Univ.
9851146	Equipping the Statistical Toolkit: An Intranet-Based Approach to Introductory Statistics	Gavin M. Cross	July 1, 1998	ILI	$40,953	Coe College
9851321	Computers for an Introductory Interdisciplinary Data Analysis Course	Laura P. Eisen	July 1, 1998	ILI	$16,780	Trinity College
9851559	Computing-Enhanced Experiential Learning in the Introductory Statistics Course	Ann R. Cannon	July 1, 1998	ILI	$21,090	Cornell College
0089005	MAA Comprehensive Professional Development Program For Mathematics Faculty	J Michael Person	April 1, 2001	ND	$966,291	MAA
0088715	Collaborative Project on Integrating Census Data Analysis into the Curriculum	William H. Frey	May 15, 2001	ND	$522,205	University of Michigan
0089006	Collaborative Project on Integrating Census Data Analysis into the Curriculum	Felice J. Levine	May 15, 2001	ND	$417,241	Amer. Soc. Assoc.
0341481	PRofessional Enhancement Program (PREP)	J Michael Pearson	February 1, 2004	ND/NSDL	$462,690	MAA
0333672	CAUSEweb: A Digital Library of Undergraduate Statistics Education	Dennis Pearl	October 1, 2003	NSDL	$824,945	Ohio State University
9255447	Statistical Thinking and Teaching Statistics	George W. Cobb	March 1, 1993	UFE	$450,068	MAA
9554621	STATS: Statistical Thinking with Active Teaching Strategies	Allan J. Rossman	January 1, 1996	UFE	$202,844	MAA
9653416	Chance Workshop	J. Laurie Snell	January 1, 1997	UFE	$87,660	Dartmouth College
9653442	Elementary Statistics Laboratory Workshop	John D. Spurrier	March 1, 1997	UFE	$67,845	USC, Columbia

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