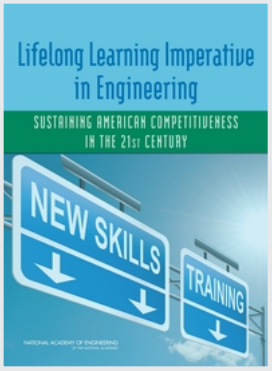

Lifelong Learning Imperative in Engineering: Sustaining American Competitiveness in the 21st Century

DETAILS

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Lifelong Learning Imperative in Engineering

SUSTAINING AMERICAN COMPETITIVENESS IN THE 21ST CENTURY

Debasish (Deba) Dutta and Lalit Patil
University of Illinois at Urbana-Champaign

and

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In cooperation with the
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of the National Academies
and the University of Illinois at Urbana-Champaign

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ABOUT THE PROJECT

The Lifelong Learning Imperative (LLI) project was initiated to assess current practices in lifelong learning for engineering professionals, reexamine the underlying assumptions behind those practices, and outline strategies for addressing unmet needs.

A project-framing workshop was organized by the University of Illinois at Urbana-Champaign (UIUC) in partnership with the National Academy of Engineering (NAE) in June 2009 to examine the issues relevant to lifelong learning in engineering. A UIUC research team then conducted a survey-based assessment of the issues identified in the 2009 workshop. Preliminary findings from the UIUC study were presented at a second workshop in October 2011 at which these issues were examined more fully. This monograph reflects the opinions of the authors based on the UIUC team's survey analysis and learning from the discussions at the 2011 workshop.

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Finally, the authors thank the members of the NAE organizing committee for the 2009 project-framing workshop, the NAE Lifelong Learning in Engineering project advisory committee, and the research team at the University of Illinois at Urbana-Champaign (UIUC) for their valuable contributions to the project.

This monograph has been subjected to a confidential review in draft form by individuals chosen for their diverse perspectives and technical expertise. The purpose of this independent review is to provide candid and critical comments to the authors to assist in making this publication as sound as possible. The review comments and draft manuscript remain confidential. We thank the following individuals for their review of this monograph:

Nicholas Donofrio (NAE), IBM Executive Vice President (retired), and Senior Fellow, Kauffman Foundation

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Although the reviewers listed above provided many constructive comments and suggestions, they were not asked to endorse the opinions or conclusions of the authors nor did they see the final draft of the publication before its release. Responsibility for its final content rests entirely with the authors.

FOREWORD

The Lifelong Learning Imperative (LLI) project brought together leaders of US industry, academia, government, and professional societies to assess the current state of lifelong learning of engineers; to examine the need for, and nature of, lifelong learning going forward; and to explore responsibilities and potential actions for the primary stakeholders.

The United States is facing a crisis in its engineering workforce just as global competition is becoming very intense. During the next several years there will be massive retirements of skilled and experienced engineers, and the United States has one of the lowest rates of graduation of bachelor level engineers in the world: only 4.5 percent of our university graduates are engineers. The issue is especially acute in the national security industry because of citizenship requirements. Perhaps even more critical, the pace of technological change continues to accelerate, making the specifics of engineering education and skill development obsolete in short order. A critical part of our corporate and national strategy to address this looming crisis should be to ramp up the quality and opportunity for lifelong learning for our engineering workforce. This would not only enhance the quality and competitiveness of our engineers, but also enrich the quality of their professional life, improve their capacity to innovate, and widen their fields of opportunity.

For too long the issue of lifelong learning for engineers has been on the back burner, even as American industry has heavily invested in MBA and executive business education. A plan for vigorous, continual intellectual renewal through broad-based commitment to lifelong learning could have a powerful role in ensuring that the United States remains competitive in the face of accelerating technological change and pressures on an aging US engineering workforce that is not being replenished sufficiently rapidly.

Charles M. Vest
President
National Academy of Engineering

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LIFELONG LEARNING AND TODAY'S ENGINEER

THE IMPORTANCE OF ENGINEERING

"*The key to our success—as it has always been—will be to compete by developing new products, by generating new industries, by maintaining our role as the world's engine of scientific discovery and technological innovation. It's absolutely essential to our future*." — President Barack Obama[1]

Eric Lander
President
Broad Institute of MIT and Harvard
and Co-Chair, PCAST

Learning can never cease – especially not for engineers, because the world around us keeps changing. The community has so many ways – facilities, equipment, teachers, mentors – to support engineers' thirst for lifelong learning.

Our innovative science, technology, engineering, and mathematics (STEM) workforce accounts for more than 50 percent of the nation's sustained economic growth.[2,3] Long-term strategies to maintain and increase US living standards, therefore, must include long-term plans to meet the educational needs of STEM professionals.

THE EDUCATIONAL NEEDS OF TODAY'S (AND TOMORROW'S) ENGINEER

Engineers today need at least a BS to be prepared for work in their field, and advanced degrees are increasingly necessary to advance professionally and remain competitive. But in a world of rapid scientific and technological advancement, the half-life of an engineer's vocation-specific knowledge is steadily decreasing. Even engineers with PhDs and extensive experience are vulnerable to being outdated. Moreover, new fields are constantly emerging (nanotechnology, biotechnology, information technology, and genetics are recent examples), and many problems require engineers to work—and therefore learn—across the standard boundaries of engineering disciplines.

The problem is that American engineering institutions and policies focus primarily on the traditional 18- to 24-year-old student, while, as noted by Tony Carnevale of Georgetown University, "Lifelong learning has become an applause line in everybody's stump speech but has yet to become a line item of any consequence in public budgets."[4]

Changing the postdegree learning culture among engineers in the United States is a tall order. But it's doable, and it's a lot easier than playing catch-up if the rest of the world passes us by. As Daniel Laughlin of NASA put it, we

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[1] Remarks by the President at the 2010 National Medal of Science and National Medal of Technology and Innovation Ceremony, November 17.
[2] Eleanor Babco. 2004. *Skills for the Innovation Economy: What the 21st Century Workforce Needs and How to Provide It.* Washington: Commission on Professionals in Science and Technology.
[3] Robert Solow. 1957. Technical change and the aggregate production function. *Review of Economics and Statistics* 39(3): 312–320.
[4] Anthony P. Carnevale. Postsecondary Education and Training As We Know It Is Not Enough: Why We Need to Leaven Postsecondary Strategy with More Attention to Employment Policy, Social Policy, and Career and Technical Education in High School. April 2010. Available online at *http://cew.georgetown.edu/uploadedfiles/412071_postsecondary_education.pdf*.

should be "preparing students for jobs that don't yet exist, using technologies that haven't been invented, in order to solve problems we don't even know are problems yet."[5]

The National Academy's report *The Engineer of 2020* calls for engineers to expand their learning over their lifetime.[6] Our nation's competitiveness and growth in a global economy hinge fundamentally on its ability to keep its STEM workforce at the technological forefront.

Despite many excellent degree programs and other educational opportunities for engineers in the United States, however, the current infrastructure for engineering education cannot meet the needs of the engineer of 2020.

LIFELONG LEARNING OUTSIDE THE UNITED STATES

The need to improve the lifelong learning infrastructure for engineers has been addressed outside the United States.

In 2004, the European Commission proposed a Decision of the European Parliament and Council to establish an integrated action agenda called the Lifelong Learning Programme. The initiative supports lifelong learning through transnational learning mobility and cooperation projects aiming at modernizing education and training systems across the 31 participating European countries. In addition, as part of the Lisbon Strategy,[7] the European Union (EU) proposed an initiative aimed at improving workers' qualifications based on an analysis of labor market trends up to 2020. EU members fulfill the Programme's objectives in several ways. For example, in Finland, the Universities Act was enacted in 2009 mandating that lifelong learning be part of a university's mission. A 1971 French law set up the country's institutional training system, requiring employers to spend at least 1.6 percent of their wage bill on employee training or pay the equivalent in taxes. A follow-up law in 2004 establishes, in principle, an individual's right to training in the form of a 20-hour credit per year outside the workplace.[8]

In Asia, most wealthy countries promote lifelong learning for engineers.[9] South Korea and Japan, for example, have introduced explicit laws and legis-

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[5] National Aeronautics and Space Administration. Goddard's Innovative Partnerships Program Office; Accomplishments 2008. Available online at *http://ipp.gsfc.nasa.gov/downloads/accomp_reports/2008_ipp_accomp_report.pdf*.
[6] National Academy of Engineering. 2004. *The Engineer of 2020: Visions of Engineering in the New Century*. Washington: National Academies Press. Available online at *www.nap.edu/catalog/10999.html*.
[7] Put forward by the Lisbon Special European Council in March 2000; available online at *www.europarl.europa.eu/summits/lis1_en.htm*.
[8] Anni Weiler. Impact of training on people's employability. European Foundation for the Improvement of Living and Working Conditions, Ireland. 20 June 2005.
[9] Soonghee Han. 2001. Creating systems for lifelong learning in Asia. *Asia Pacific Education Review* 2(2): 90.

lation on lifelong learning. Korea's policy is based primarily on its Lifelong Education Law, promulgated in 1999. The Japanese Diet enacted the Lifelong Learning Promotion Law in 1990, administered by the Ministry of Education Science and Culture. Hong Kong and Singapore have developed policy models that focus on promoting lifelong learning through strategic banners such as "Manpower 21" (Singapore) and "Education Blueprint" (Hong Kong).

Needless to say, nothing similar exists in the United States, either formally or informally. This means that the American engineering community does not have access to a lifelong learning infrastructure that could help it remain competitive in the global marketplace.

Improving the lifelong learning infrastructure in the United States need not entail copying Asian and European models. Given the decentralization of American academic and governmental institutions, broad partnerships among leaders in industry and academia, federal and state-level policymakers, and engineering organizations could produce a US-based version of the infrastructure that's needed. Such partnerships, precisely because they are not necessarily tied to long-term, centralized efforts to formalize training, would be effectively responsive to the rapidly (and unpredictably) changing marketplace that the 21st century engineer will increasingly face. They could, in other words, enable the United States to position itself as a global engineering leader for many years to come.

THE LIFELONG LEARNING IMPERATIVE PROJECT: A BRIEF HISTORY

The Lifelong Learning Imperative (LLI) project is a joint initiative of the National Academy of Engineering (NAE) and the University of Illinois at Urbana-Champaign to assess current practices in lifelong learning for engineering professionals, reexamine underlying assumptions behind those practices, and explore strategies for addressing unmet needs.

In 2009, an NAE workshop organizing committee chaired by Linda Katehi, then Provost at the University of Illinois at Urbana-Champaign, was appointed to provide advice on the design of a project-framing workshop organized by NAE Scholar in Residence Debasish Dutta (Appendix A). The workshop, which resulted in a published summary, was aimed at identifying issues critical for restructuring ongoing education for engineering professionals in the 21st century knowledge-based economy.[10]

[10] National Academy of Engineering. 2010. *Lifelong Learning Imperative in Engineering: Summary of a Workshop*. Washington: National Academies Press. Available online at *www.nap.edu/openbook.php?record_id=12866&page=R1*.

Samuel J. Palmisano former President & CEO, IBM

By definition, a system of lifelong learning will require deep, long-term collaboration among all key players in science and engineering. In that, businesses of all sizes can and must play a lead role.

A research team, headed by Dr. Dutta, at the University of Illinois at Urbana-Champaign (UIUC) then conducted an assessment of the issues identified in the 2009 workshop. NAE appointed a project advisory committee chaired by James B. Porter, Jr., retired vice president, E. I. du Pont de Nemours and Company, to advise the work of the UIUC research team. The UIUC study included a survey of engineering professionals (targeted through professional societies, alumni associations, and corporations) and interviews with thought leaders; the questions focused on organizing and disseminating information about lifelong learning for engineers (Appendix B, C). This was followed by a workshop in the fall of 2011 to share initial findings and discuss next steps (Appendix D). This monograph, coauthored by Dutta, Porter, and Lalit Patil, is the result of that study and the two workshops.

THE LIFELONG LEARNING IMPERATIVE PROJECT: FINDINGS

The authors arrived at the following findings from their study and the conversations at the 2009 and 2011 workshops:

1. A rudimentary lifelong learning infrastructure exists in the United States. Bourne and colleagues (2005, p. 137) note two predominant educational models: "At one extreme, continuing education programs blend with traditional degree-based programs. For example, courses developed for on-campus degree seekers are often slightly modified and repurposed as a short course offered to industry professionals. At the other extreme, corporations contract with university faculty or for-profit vendors to develop continuing education content specific to their requirements."[11]

2. This rudimentary infrastructure is inadequate for today's (and tomorrow's) engineers. Evaluation in these courses is characterized by lack of standardization, and content is not uniform even within engineering subdisciplines. Very little is done to address the changing needs of learners, especially those who want to study and interact online. The most common approach (other than granting a postbaccalaureate degree) to recognize formal nondegree learning is by means of certificates.

3. Stimulating lifelong learning in the United States will improve the knowledge base of the country's engineers and our capacity for innovation and competition. In particular, a national vision and actionable strategy to overcome barriers for lifelong learning in the engineering profession are required.

[11] J. Bourne, D. A. Harris, and F. Mayadas. 2005. Online engineering education: Learning anywhere, anytime. *Journal of Engineering Education* 94(1): 131–146.

4. A well-coordinated effort between industry, academia, professional societies, and policymakers to develop a national framework for lifelong learning for engineers should begin as soon as possible. The *New York Times* reported that, based on a recent Battelle Memorial Institute study, Chinese spending on research and development will likely match US spending in 2022.[12] The article goes on to say that "if US government labs, university departments and corporate researchers aren't already on top of the next generation of breakthroughs, the country will very likely fall behind in 10 or 20 years when those innovations become marketable products." Such a scenario is possible but not likely if American engineers, who are motivated to maintain and upgrade their skills, find it straightforward to access lifelong learning.

[12] Adam Davidson. 2011. Will China Outsmart the US? *NY Times*, December 28. Available online at *www.nytimes.com/2012/01/01/magazine/adam-davidson-china-threat.html*.

RESEARCH RESULTS

The following data and analysis are based on detailed surveys of approximately 3,000 engineers across the United States and on interviews of thought leaders in the field. The online survey was conducted in collaboration with the Statistics division of Applied Technology for Learning in the Arts and Sciences (ATLAS) at University of Illinois. The respondents represented different engineering fields, managerial levels, and ethnicities (Appendix E).

MOTIVATION FOR LIFELONG LEARNING OPPORTUNITIES

Today's engineers are eager for lifelong learning opportunities and for recognition from their peers and employers for their learning. No one should doubt that there is a large and motivated population of engineers waiting to take advantage of an improved lifelong learning infrastructure.

The survey probed the engineers' motivations for lifelong learning.

The results (FIGURE 1) indicate that career growth is the major motivation for lifelong learning and that engineers are also interested in learning to satisfy their intellectual curiosity. Three additional findings are worth mentioning:

- The reason for enrolling in lifelong learning programs (or why they are considered important) varies across the managerial hierarchy. Nonmanagerial engineers and mid-level managers consider career growth at their current workplace the key reason to pursue lifelong learning, top-level engineers consider it important for satisfying intellectual curiosity.

- Engineers who considered their job secure ranked preparation for career growth beyond their current workplace as important as satisfying intellectual curiosity. Engineers who considered their job insecure, however, considered career growth beyond their current workplace more important than satisfying intellectual curiosity.

- Although both male and female engineers considered career growth at their current workplace the most important factor for enrolling in a lifelong learning program, they differed in terms of career growth beyond their current workplace. Female engineers considered it as important as satisfying intellectual curiosity, whereas male engineers considered it more important.

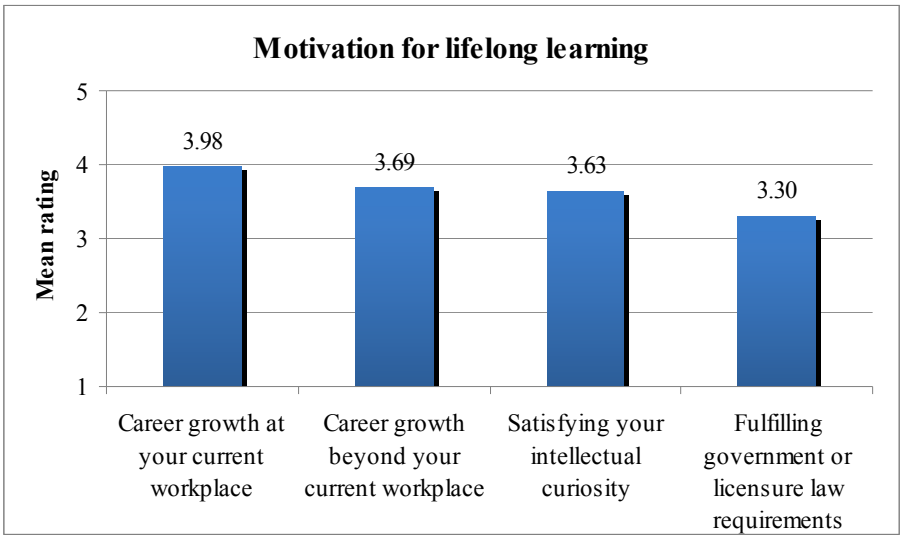

FIGURE 1 Graph showing engineers' motivation for lifelong learning based on 3,200 responses to the question: "In the future, how likely are you to enroll in a lifelong learning program for any of the following reasons?" (shown at the bottom of the figure). Respondents ranked each reason on a scale of 1 to 5, where 5 = would definitely enroll and 1 = definitely would not enroll.

BARRIERS TO LIFELONG LEARNING FOR INDIVIDUALS

When we asked engineers to rate the most common personal barriers to their participation in lifelong learning, we got the results shown in FIGURE 2.

The responses indicate that lack of time and finances are the primary obstacles for individuals considering lifelong learning, but it should be noted that lack of an appropriate program is also an important obstacle.

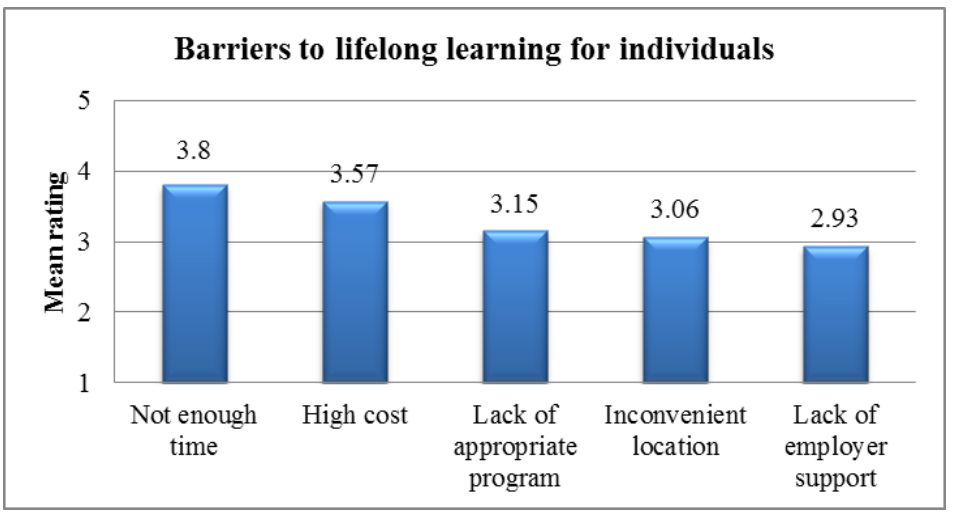

FIGURE 2 Respondents (2,800) rated personal barriers to lifelong learning, on a scale of 1 to 5, where 5 = the biggest obstacle and 1 = not an obstacle at all.

One other finding is worth noting:

- The order of importance was reversed for engineers from underrepresented racial/ethnic groups (African-American, Latino, Asian/Pacific Islander, American Indian/Alaska Native), who considered high cost the most important personal barrier and time the second most important.

We also studied the engineers' willingness to devote time for lifelong learning.

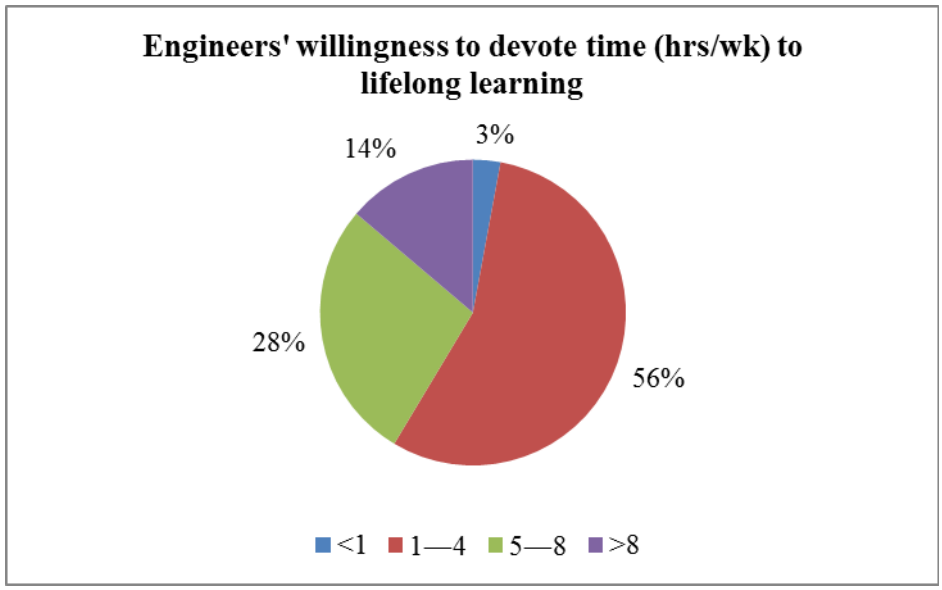

FIGURE 3 Graph showing the responses of 2,900 engineers to the question, "How many hours per week of your own time are you willing to devote to lifelong learning?"

The results (FIGURE 3) show that over half of the engineers surveyed would be willing to devote 1 to 4 hours per week for lifelong learning, and slightly less than a third expressed willingness to allocate 5 to 8 hours. We also discovered the following:

- Men expressed willingness to give somewhat more time (slightly more than 5 hours per week) to lifelong learning than women (just over 4 hours per week).

- Engineers with less than 10 years of experience are willing to allocate 5½ hours per week, while those with more than 10 years wish to give somewhat less time (approx. 4¾ hours per week).

- The willingness to devote time to lifelong learning is independent of the highest degree earned by the engineer.

- Engineers from underrepresented racial groups are, on average, willing to give 2 hours to lifelong learning per week than are white engineers: 7 hours per week for underrepresented groups and 5 for whites.

Barriers to Employer Support of Lifelong Learning Opportunities

We asked engineers about their perception of barriers that their employers face in regard to providing lifelong learning opportunities to their engineering employees.

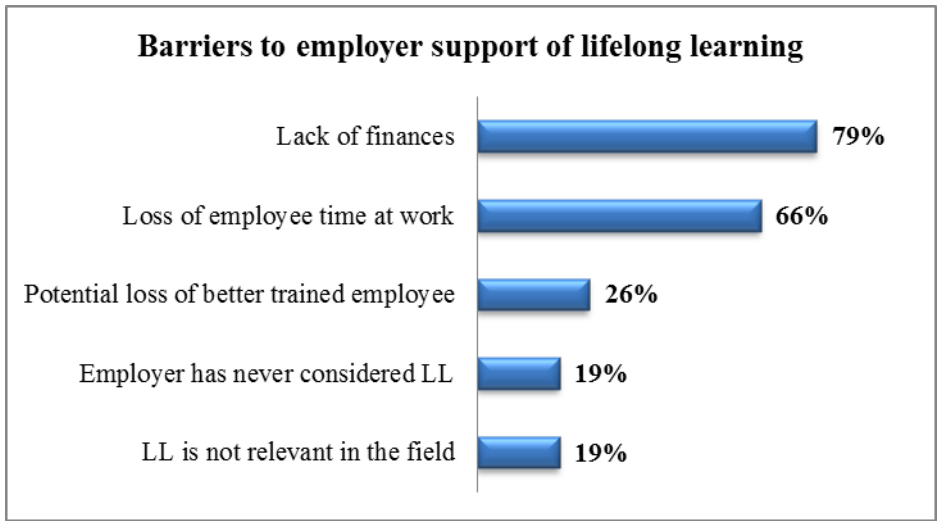

FIGURE 4 Engineers' perception of why their employers might not support their lifelong learning needs, based on approximately 2,300 responses to the question, "Why do you think your employer might not support employee lifelong learning?" LL = lifelong learning

The results (FIGURE 4) show that engineers perceive that the main reasons their employers do not support lifelong learning are lack of resources and loss of employee time at work. The potential loss of a better trained employee is not a significant barrier.

Responses to the question of funding responsibilities differed according to firm size. Engineers from smaller firms generally responded that individuals should take more responsibility than employers for financing lifelong learning, engineers from medium-sized firms thought that employees and employers should be equally responsible, and engineers from large firms, that employers should take more responsibility than individuals.

Indeed, small to medium enterprises (SMEs)—i.e., those with 500 or fewer employees—face particular difficulties when it comes to providing lifelong learning opportunities for their engineering employees. They tend not to have significant resources and to focus on short-term needs because of their vulnerability in the marketplace. Yet SMEs represent 98 percent of the businesses in the

United States, employing half of all private-sector employees[13] and 41 percent of the nation's high-tech workers (such as scientists, engineers, and computer technicians). They have generated 60 to 80 percent of net new jobs annually over the last decade and produced 14 times more patents per employee than large patent-producing firms.[14] Thus, any infrastructure development for lifelong learning for engineers should be made with SMEs and their employees in mind.

DRIVERS FOR DEVELOPMENT OF CONTENT FOR LIFELONG LEARNING

We asked employees what should drive the content for lifelong learning. The results (FIGURE 5) indicate that scientific and technological advances must drive the content of lifelong learning programs. This is particularly important in the context of the rapid development and depreciation of knowledge. We also note that engineers believe that changing global business practices must drive content —in other words, some lifelong learning programs in the United States must be directed at learning business practices in other countries.

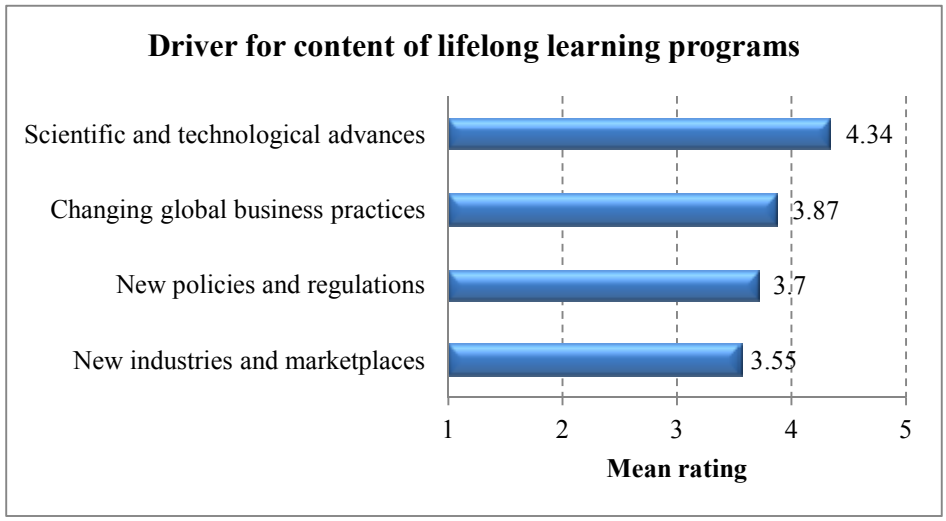

FIGURE 5 Engineers' views of what should drive the content of lifelong learning programs, based on 2,900 responses to the question: "How important should each of the following considerations be in driving the content of lifelong learning?" Respondents ranked each from 5 = extremely important to 1 = not important at all.

[13] Katherine Kobe. 2007. The Small Business Share of GDP, 1998-2004. Small Business Administration Office of Advocacy, April. Available online at *www.sba.gov/advo/research/rs299tot.pdf*.
[14] CHI Research. 2003. Small Serial Innovators: The Small Firm Contribution to Technical Change. Small Business Administration Office of Advocacy, February. Available online at *www.sba.gov/advo/research/rs225.pdf*.

THE ROLE OF VARIOUS STAKEHOLDERS

We asked engineers how much of a role they think the government, industry, universities, and professional societies should play in the development of a national lifelong learning infrastructure.

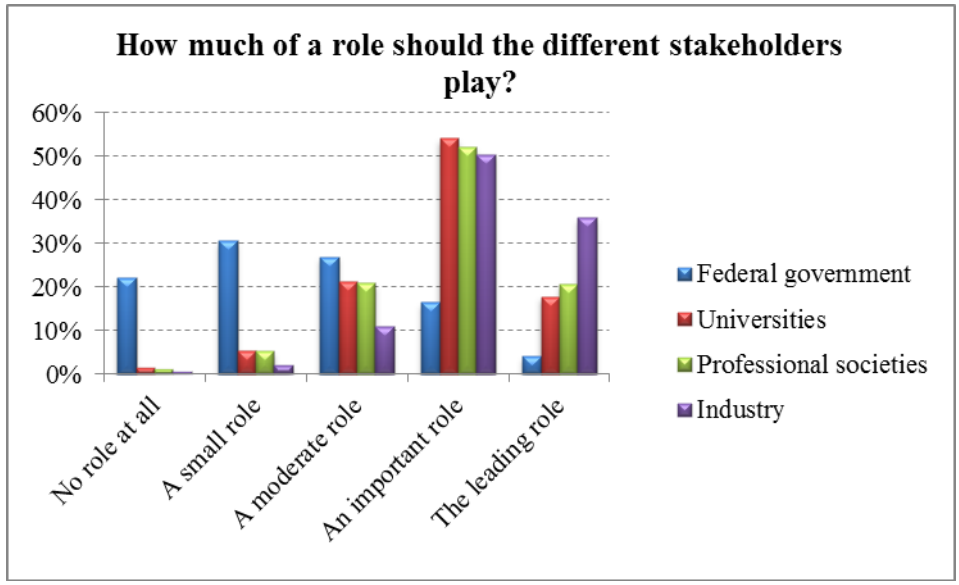

FIGURE 6 Engineers' beliefs about the role of different stakeholders in lifelong learning, based on 3,000 responses.

The results (FIGURE 6) show that 4 out of 5 engineers expect businesses (industries) to play an important or leading role in developing the national lifelong learning infrastructure, from which one could conclude that they believe employers have or should have a responsibility to ensure continuous education for their engineers. An overwhelming majority (3 out of 4) felt that universities and professional societies also have a significant role to play.

One other finding is worth noting:

- Engineers who considered their job insecure believed that the government should play an important role, whereas engineers who were very secure in their job did not.

CONCLUSIONS

The future of US competitiveness and growth can be enhanced by a robust lifelong learning system for engineers. Such a system would likely have many moving parts involving universities, industry, professional societies, and others and could be facilitated by appropriate government policy. New lifelong learning content and structure should take account of the needs of a diverse workforce (i.e., managerial and nonmanagerial, ethnic minorities and whites, men and women).

At the 2011 workshop, more than 50 thought leaders from different engineering fields and stakeholder groups considered possible steps to advance the goal of creating a robust lifelong learning infrastructure. The feedback and our analysis indicate that individual engineers must accept lifelong learning in many different forms as a natural part of their professional life and personal advancement. But, given the importance of lifelong learning to America's future competitiveness, we also believe it is the responsibility of the leaders of the engineering world—in business, professional societies, higher education, and government—to begin the process of reshaping lifelong learning opportunities for engineers in the United States.

Based on our assessment of the survey results and the intense discussions at the workshop, we suggest the following recommendations and urgent action items (in italics) for key stakeholders—businesses, professional engineering societies, educational institutions, and policymakers—to begin improving the quantity and quality of lifelong learning for engineers in the United States.

FOR BUSINESSES

Develop a learning culture.

Engineers expect businesses (including SMEs) to play the leading role in developing a lifelong learning culture and providing lifelong learning opportunities. Therefore, businesses should *develop lifelong learning resources for engineering employees* and *incorporate lifelong learning metrics into employee performance reviews*. Companies should recognize and support lifelong learning activities offered by professional societies and universities, and professional societies can in turn give special recognition to businesses that support and promote lifelong learning for their employees.

Invest in lifelong learning for employees.

Engineers should be expected to pursue lifelong learning opportunities, and businesses should do everything they can to make such a pursuit possible. In

particular, businesses should *invest money and time in lifelong learning for their engineers as a regular expense*, and *partner with academic institutions and professional societies to develop lifelong learning programs for their engineers*. In addition, businesses should *promote Section 127 of the federal tax code*, which allows employees to deduct up to $5,250 of their income for educational purposes each year.

For Professional Engineering Societies

Emphasize the urgency of the need to change the culture of lifelong learning among engineers in the United States.

The National Academy of Engineering (NAE), in partnership with professional societies with broad national reach such as IEEE, ASCE, and ASME, should *instigate and support efforts to develop new lifelong learning paradigms and possibilities*. For example, they can provide forums for collaboration among businesses, educational institutions, and professional societies in identifying lifelong learning goals and best practices. Furthermore, because addressing lifelong learning is an important aspect of restructuring engineering education for the 21st century, *NAE needs to play a major leadership role in moving this agenda forward*.

Communicate the value of lifelong learning.

Professional societies should lead the effort to make a clear, concise, and compelling case for the value of lifelong learning. In particular, they should *develop a set of core messages that will form the basis of all communications about lifelong learning to engineers at all levels of education, experience, and expertise*. They should also *encourage all engineers to continually identify gaps in their skills and knowledge and devise personal educational plans*.

Develop cost-effective ways to disseminate lifelong learning programs.

Professional engineering societies should be thought leaders of and advocates for lifelong learning for engineers. To fulfill this role, they should *form local partnerships with businesses and educators to develop lifelong learning opportunities for local engineers*. Furthermore, as central organizations with large memberships, professional societies can help develop and deliver lifelong learning content that reflects the highest industry standards.

Develop means of evaluating lifelong learning programs.

As thought leaders of the profession, professional societies are well qualified to produce reliable evaluations of lifelong learning programs and should therefore *develop criteria for measuring the content and outcomes of lifelong learning*

programs. These criteria could then be used to guide the development and evaluation of all lifelong learning modules in a particular field. The Accreditation Board for Engineering and Technology (ABET) should expand its role and, in collaboration with education institutions and businesses, develop mechanisms to accredit lifelong learning programs.

. John Hennessey
President
Stanford University

Academic degrees should be only one part of engineering education. There should be dozens of ways to grow and increase one's engineering knowledge and skill.

For Educational Institutions

Teach engineers that learning is a lifelong endeavor that is not limited to the classroom.

Engineering professors must be at the forefront for setting the expectation that learning is not confined to courses related to obtaining a degree. They should *include messages about the importance and necessity of lifelong learning in every undergraduate and graduate engineering course*. To emphasize that formal learning can take place beyond what is taught in classes, they should *include a hands-on training component in every graduate and undergraduate engineering course*. ABET accreditation of engineering programs should include their contribution to lifelong learning experiences for practicing engineers.

Develop a variety of lifelong learning programs.

In addition to traditional degree-oriented courses, engineering departments at educational institutions must develop different kinds of classes, seminars, and workshops with different time demands and delivery methods. To achieve this goal, engineering deans should *create academic committees devoted to developing a variety of courses for practicing engineers*. Normal teaching responsibilities of engineering faculty should include such courses. Also, graduate deans and continuing education units should collaborate with engineering faculty to reimagine postbaccalaureate knowledge acquisition needs and opportunities.

For Policymakers

Enact policies that encourage financial support for lifelong learning.

High-level politicians in both political parties have stated their commitment to keeping the United States at the front of the global technology curve. The following actions can encourage engineers to engage in lifelong learning in support of that goal: (1) *Extend Section 127 of the federal tax code*, (2) *Grant tax credits to engineers to help cover the cost of memberships in professional societies,*[15] and (3) *Grant tax credits to businesses—especially SMEs—that sponsor lifelong learning for their engineering employees*.

[15] The current tax code allows these to be deducted only as a business expense.

Enact policies that provide regulatory support for lifelong learning.

Federal policymakers should encourage agencies such as NSF, the Department of Energy, and the Department of Defense to work together to create programs for the support of lifelong learning. State governments should consider policies that facilitate lifelong learning for practicing engineers and work with community colleges and universities to develop lifelong learning modules that are not tied to earning a degree.

ONE FINAL NOTE: It is not yet any organization's role to initiate cooperation and/or coordinate efforts among stakeholders to improve the lifelong learning infrastructure for engineers. But this is not a task to be put off in hopes that some other stakeholder will address it. We hope that the engineering societies, with the strong backing of the NAE, will take action to "get the ball rolling," because doing nothing could have serious consequences for the United States' capacity to stay at the forefront of innovation and remain globally competitive.

APPENDIX A

LIFELONG LEARNING IMPERATIVE IN ENGINEERING

ORGANIZING COMMITTEE FOR THE JUNE 17-18, 2009, WORKSHOP*

Linda Katehi (NAE), Chair, Provost, and Vice Chancellor for Academic Affairs, University of Illinois at Urbana-Champaign

John Seely Brown, Senior Fellow, Annenberg Center for Communication at University of Southern California, and Past Chief Scientist, Xerox Corporation

James J. Duderstadt (NAE), President Emeritus and University Professor of Science and Engineering, University of Michigan

Patrick J. Natale, Executive Director, American Society of Civil Engineers (ASCE)

James B. Porter, Jr. (NAE), Chief Engineer and Vice President (retired), Engineering and Operations, E. I. du Pont de Nemours and Company

Betty Shanahan, Executive Director and CEO, Society of Women Engineers (SWE)

Philip Woodrow, Executive Director of Science & Technology Development, Merck Manufacturing, Division of Merck & Co., Inc.

Wm. A. Wulf (NAE), University AT&T Professor (retired), University of Virginia, and Past President, National Academy of Engineering

* Affiliations shown are those at the time of committee membership.

LIFELONG LEARNING IMPERATIVE IN ENGINEERING
WORKSHOP AGENDA, JUNE 17-18, 2009

June 17

6:30PM: WORKSHOP DINNER

Lifelong Learning in Medicine: What We Have Learned

Dr. Chris Cassel, President, American Board of Internal Medicine

June 18

Lifelong Learning Imperative in the Knowledge Age: Needs, Challenges, and Opportunities

8:00AM: *The LLI Project Background & Workshop Objectives*

Debasish Dutta, Program Chair

Linda Katehi, Organizing Committee Chair

8:15AM: *Learning and the 21st Century Workforce*

Charles M. Vest, President, National Academy of Engineering

8:45AM: *Two Score and More: A Lifetime of Learning for Keeping Engineers at the Fore*

Arden Bement, Director, National Science Foundation

9:15AM: *Lifelong Learning and Universities: Options and Opportunities*

Dan Mote, President (retired), University of Maryland

10:00AM: BREAK

10:10AM: *Federal Agency Panel*

Steve Koonin, Under Secretary, Department of Energy

Tom Kalil, Deputy Director (Policy), OSTP

Tom Peterson, Assistant Director of Engineering, NSF

11:10AM: *Lifelong Learning on a Smarter Planet*

Nick Donofrio, IBM Fellow and Executive Vice President I&T Alumnus

12:00PM: LUNCH

12:45PM: *Professional Society Panel*

Enrique Gomez, SHPE

Jerry Galloway, ASCE

Peter Finn, SWE

1:45PM: *Breakout sessions*

LLI Models and Program Structure

James Porter, Moderator (Organizing Committee)

Myles Boylan/NSF, Co-moderator (scribe)

LLI Content and Certification

Philip Woodrow, Moderator (Organizing Committee)

Anthony Walters/NSF, Co-moderator (scribe)

Cyberinfrastructure Support for LLI

Patrick Natale, Moderator (Organizing Committee)

Ping Ge/NSF, Co-moderator (scribe)

Organizational Model for LLI

Elizabeth Shanahan, Moderator (Organizing Committee)

Carol Stoel/NSF, Co-moderator (scribe)

3:15PM: BREAK

3:30PM: *Report-back Session (15 min each)*

James Porter: *LLI Models and Program Structure*

Philip Woodrow: *LLI Content and Certification*

Patrick Natale: *Cyberinfrastructure Support for LLI*

Elizabeth Shanahan: *Organizational Model for LLI*

4:30PM: *Next Steps & Adjourn*

Debasish Dutta, Program Chair

Linda Katehi, Organizing Committee Chair

APPENDIX B

LIFELONG LEARNING IN ENGINEERING
WEB-BASED INTERVIEW QUESTIONS

Note: The target respondents for the web-based interviews were thought leaders who represented key stakeholders and were individually identified by the organizing committee with input from the National Academy of Engineering.

INTRODUCTION

Dear <Name>:

The National Academy of Engineering (NAE) is conducting a study to understand the lifelong learning needs and experience of engineers and computers scientists.

We are referring to learning for the (engineering) professional, who is working and doing a good job, but is doing so in a rapidly changing world. The learning is dynamic and integrative and includes opportunities that are specifically intended to deepen and broaden the engineer's knowledge and skill sets. This is broader than the typical interpretation of "lifelong learning" which frequently includes adult learning and vocational courses that are offered for updating, certifying, or retraining the engineer in order to obtain or retain her employment.

As a part of this study, we are conducting web-based interviews with the goal of identifying and defining strategies to establish a strong national policy and framework for lifelong learning. This includes understanding the roles of different stakeholders and the importance of lifelong learning and its evaluation.

You have been selected as a thought leader representing key stakeholders in achieving and sustaining the right level of lifelong learning to give us your input on this important matter.

You do not have to complete this survey if you do not wish to do so. All interviews will be processed by the ATLAS unit at the University of Illinois at Urbana-Champaign. If you have questions about the interview, please contact Maryalice Wu (malice@illinois.edu; tel: 217-333-9776).

Your opinions are important and I hope you will participate in the interview. During the interview, you will be given the option of subscribing to receive a link to the final report that will be published in fall 2011.

Thank you for your help,

Charles M. Vest

President
National Academy of Engineering

QUESTIONS

We would like to use quotations from your responses in a report that will be available publicly in fall 2011. Do you give us permission to do so?

1. *Yes, you have my permission to use attributed quotations from my responses.*
2. *Yes, you have my permission, but only if they are attributed to "Anonymous."*
3. *No, you do not have my permission to use quotations from my responses in your report.*

Questions:

1. How much do the leaders and members of the engineering profession understand the need for continuous learning to remain effective in today's rapidly changing world? What could be done to bring about increased awareness?

2. What should be the objectives and focus of a national policy on lifelong learning for engineers?

3. Beyond ensuring grants and individual scholarship, how should the federal government be involved in lifelong learning?

4. What role should employers play in meeting the lifelong learning needs of their employed engineers?

5. Beyond ensuring licensure and/or certification, how should professional societies contribute to the lifelong learning of engineers?

6. How can educational institutions effectively contribute to the lifelong learning of engineers? What, if anything, should they be doing differently?

7. Are there any differences in the way that for-profit and nonprofit educational institutions can contribute to the lifelong learning of engineers? Are there things that nonprofit institutions can do better than for-profit institutions, and vice versa? Please explain.

8. What is the importance of evaluation in a lifelong learning program? What measures would you use to evaluate the success of a lifelong learning program in increasing the preparedness of the engineer?

APPENDIX C
LIFELONG LEARNING IN ENGINEERING ONLINE SURVEY INSTRUMENT

Note: The target respondents for the online surveys were professional engineers with characteristics described in Appendix D.

INTRODUCTION

The National Academy of Engineering (NAE) is conducting a study to understand the lifelong learning needs and experience of engineers and computers scientists. Our goal is to establish a strong national policy and framework for lifelong learning.

We are referring to learning for the (engineering) professional, who is working and doing a good job, but is doing so in a rapidly changing world. The learning is dynamic and integrative and includes opportunities that are specifically intended to deepen and broaden the engineer's knowledge and skill sets. This is broader than the typical interpretation of "lifelong learning" that includes adult learning and vocational courses that are offered for updating, certification, or for re-training the engineer in order to obtain or retain her employment.

You have been chosen, at random, from lists of professionals in your field, to be in the small group we are surveying. Answering this survey should take approximately 15 minutes. All responses will remain completely confidential. Your individual answers will not be shared with anyone, including your employer. The surveys will be processed by the ATLAS unit at the University of Illinois at Urbana-Champaign. If you have questions about the survey, please contact Maryalice Wu (Email: malice@illinois.edu, Tel: 217-333-9776).

You do not have to complete this survey if you do not wish to do so. Your opinions are important and your participation is crucial to the success of this effort; the accuracy of our results depends on obtaining a high response rate.

I hope you will participate in the survey. During the survey, you will be given the option of subscribing to receive a link to the final report that will be published in fall 2011.

Please click on "Next" button below to begin answering. If at any time you would like to save your responses and continue answering at a later time, click on the dark green stripe on the top of any page.

Thank you for your help,

Charles M. Vest

President
National Academy of Engineering

SURVEY QUESTIONS

We are interested in the opinions of both current and retired engineers and computer scientists. Some of the questions may seem geared only to currently working engineers. If you are retired, please answer the questions as you would have answered while you were still working.

A. General Lifelong Learning

First, we would like to get your opinions about **lifelong learning**.

Think about lifelong learning as being education or training for the engineering professional who is working and doing a good job, but is doing so in a rapidly changing world. It could mean that the engineer has to take responsibility to deepen and broaden her knowledge and skill sets to remain relevant.

A1. How important is lifelong learning for your professional career?

Scale poles flipped randomly low-high or high-low.

1. Extremely important
2. Very important
3. Moderately important
4. Slightly important
5. Not important at all.

A2. In the future, how likely are you to enroll in a lifelong learning program for any of the following reasons?

Row order randomized

Reason	Would definitely enroll	Very likely to enroll	Somewhat likely to enroll	Not very likely to enroll	Definitely would not enroll
To upgrade your skills for career growth at your current workplace					
To develop your skills for career growth *beyond* your current workplace					
To satisfy your intellectual curiosity					
To fulfill government or licensure law requirements					

A3. How would you rate the overall quality of lifelong learning programs from each of the following potential providers?

Row order randomized

Provider	Overall Quality					
	Very poor	Poor	Fair	Good	Excellent	I don't know
Your employer						
University						
Community college						
Professional society						
Vendor						

A4. How much of a role should each of the following play towards developing a national framework and policies for lifelong learning?

Row order randomized

Group	No role at all	A small role	A moderate role	An important role	The leading role
Federal government					
Universities					
Professional societies					
Industry					

B. Lifelong Learning Models and Program Structure

In some fields, a single organization coordinates the development and evaluation of lifelong learning programs. For example, the American Academy of Family Physicians coordinates all continuing medical education for family physicians in the United States.

In other fields, such as engineering, lifelong learning programs are developed and evaluated by a variety of corporate and professional organizations without a centralized coordinating body.

B1. Which of the following models would work better in your own field?

Choices 1 & 2 are presented in random order.

1. A single organization should coordinate lifelong learning programs.
2. Multiple organizations should develop their own lifelong learning programs independently.

B2. Which of the following structures is better for meeting your lifelong learning needs?

Choices 1 & 2 are presented in random order.

1. A well-structured program with multiple courses (like an M.B.A. program)
2. Single course on one specific topic
3. Both equally

B3. Which instructional method for teaching lifelong learning courses would you prefer?

Choices 1 & 2 are presented in random order.

1. Courses taught online
2. Courses taught in a classroom
3. Some combination of online and classroom teaching
4. Both – online and classroom – methods are about the same

B4. If you were taking a classroom-based lifelong learning program, where would you prefer it to be?

Choices 1 & 2 are presented in random order.

1. At my workplace
2. Outside my workplace
3. I have no preference

C. Lifelong Learning Content and Certification

C1. How important should each of the following considerations be in driving the content of lifelong learning?

Row order randomized

Group	Not important at all	Slightly important	Moderately important	Very important	Extremely important
Scientific or technological advances					
Changing global business practices in my field					
New policies and regulations					
Emergence of new industries and market places					

C2. How effective would each of the following methods be to evaluate the performance of a student in a lifelong learning program?

Row order randomized

Evaluation method	Not at all effective	Slightly effective	Moderately effective	Very effective	Extremely effective
Accredited certification					
Attendance alone					
Evaluation by provider using internal measures (e.g., grades, projects, tests)					
No evaluation					

D. Organizational Support for Lifelong Learning

D1. How would you rate the following personal barriers for your participation in lifelong learning?

Row order randomized

	Not an obstacle for me at all	A slight obstacle	Somewhat of an obstacle	A big obstacle	The biggest obstacle for me
High cost					
Inconvenient location					
Not enough personal time to devote					
Lack of employer support					
Lack of lifelong learning program that teaches topics I need to learn					
Lack of knowledge of what topics I need to learn					

*If **lack of employer support** is an obstacle:*

D2. Why do you think your employer might not support employee lifelong learning?

Choices 1 thru 5 are presented in random order.
1. Check all that apply.

1. Potential loss of employee to another employer, because she is now better trained
2. Lifelong learning is not relevant in employer's field/business
3. Lack of finances dedicated to lifelong learning
4. Cannot afford loss of employee time at work
5. Employer has never given any thought to lifelong learning
6. Some other reason (*Please explain:*)

_____

D3. Think about lifelong learning as education that is focused primarily on the individual who must ensure that she has the appropriate abilities to adapt to the rapidly changing world and remain relevant. How much should each of the following be responsible for funding lifelong learning?

	Not at all	**A little**	**To a moderate extent**	**Very much**	**To the greatest extent**
The individual					
The employer					
The government					
Other nongovernmental organizations					

D4. How many hours per week of your own time are you willing to devote to lifelong learning?

Please enter a whole number of hours per week. If less than one hour per week, enter 0 (zero). _____

In the remainder of the survey, we will be asking you some questions about employment. If you are retired or not currently employed, please answer according to your most recent job. If you are currently employed, but in more than one position, please answer regarding only the job you consider your main job.

E. Labor Force Status

E1. What is your current employment status?

1. Employed (except self-employed)
2. Self-employed
3. Retired
4. Not currently employed for some other reason
5. Have never been employed

2. If 5, skip to E7. (Never employed)
3. All others, continue to E2.

E2. What is the main industry sector of your employer in your current or most recent job?

Choices 1 through 3 are presented in random order.

4. Energy Research, Manufacturing, Generation, or Distribution
5. Pharmaceutical Research or Manufacturing
6. Information Technology (IT)
7. Construction industries not listed above
8. Manufacturing industries not listed above
9. Another industry *(Please specify:)* _____

E3. Approximately how many employees work for your most recent employer across all sites and branches?

1. 1 to 4 employees
2. 5 to 99 employees
3. 100 to 499 employees
4. 500 to 4,999 employees
5. 5,000 or more employees

E4. Where does your current or most recent position fall within the management hierarchy of your company?

1. Top level or senior management, CEO, CFO, COO, owner, president, vice-president, etc.
2. Middle level management, plant manager, regional manager, program leader, etc.
3. First level management, supervisor, team leader, first-line manager, etc.
4. Nonmanagerial
5. None of the above *(Please explain)* _____

E5. What engineering field or discipline best describes most recent or current job?

Examples might be: civil engineering, electrical engineering, mechanical engineering, medical software development, or many others.

_____

E6. How secure do you feel in your current position for the next 3 to 5 years?

Scale poles flipped randomly low-high, or high-low.

1. Very secure
2. Reasonably secure
3. Somewhat insecure
4. Very insecure
5. I don't wish to answer

E7. Are you actively looking for a job right now?

Choices 1 and 2 are presented in random order.

1. Yes
2. No
3. I don't wish to answer

E8. How helpful would lifelong learning opportunities be in increasing your job security or finding a new job?

Scale poles flipped randomly low-high, or high-low.

1. Extremely helpful
2. Very helpful
3. Moderately helpful
4. Slightly helpful
5. Not at all helpful
6. I do not know how helpful it would be

F. Training History

F1. Since obtaining your degree, have you attended any kind of training program designed to keep you current in your field?

Choices 1 and 2 are presented in random order.

By "training program", we mean anything from short seminars and lectures to longer workshops, courses, and certification or licensure programs. It could be sponsored by your employer, by a vendor, by a college, or by some other organization. It could be instructor-led, self-paced, online, or hands-on.

1. Yes
2. No

F2. Are you required to receive continuing education, training, or certification to retain your position?

1. Yes, the government or licensure law requires it
2. Yes, my employer requires it
3. No, I am not required to receive continuing education or certification.
4. I am not sure

G. Education

G1. Please tell us about your completed bachelor's degree(s). *If you do not have a bachelor's degree, just skip this section.*

	Major field	Institution	Graduation year
Bachelor's degree 1			
Bachelor's degree 2			

G2. Please tell us about any advanced degrees you have completed beyond the bachelor's degree (master's, MBA, PhD, MD, etc.). *If you do not have any advanced degrees, just skip this section.*

	Degree (e.g., master's, PhD, MBA)	Major field	Institution	Graduation year
Advanced degree 1				
Advanced degree 2				
Advanced degree 3				

H. Demographics

H1. Thinking about all the jobs you have ever had including your current position, for how many total years have you worked as an engineer or computer scientist?

Please round your answer to a whole number of years you have worked as an engineer or computer professional. If the answer is 6 months or less, please enter 0 (zero). If you have never worked as an engineer or computer scientist, please enter "N/A". _____

H2. What is your gender?

Choices 1 & 2 are presented in random order.

1. Male
2. Female

H3. How old are you?

_____

H4. What racial or ethnic group do you identify with?

Choices 1 through 5 are presented in random order.
Choose all that apply

1. White
2. Black or African American
3. Hispanic or Latino
4. Asian, Native Hawaiian, or Pacific Islander
5. American Indian or Alaska Native
6. Other (please specify:_____)

H5. What is the zip code of the place where you live?

I. Final Comments

I1. What do you feel are the greatest challenges facing engineers or computer scientists in your industry? Are there ways that lifelong learning can help overcome these challenges?

J. Request Report

J1. The results from this survey will be published in a report in fall 2011. Would you like to receive a link to the final copy of our report when it is finished?

We will use your e-mail address for no other purpose than to send you a link to the report.

1. No, thank you
2. Yes, my e-mail address is : _____

Closer

Thank you so much for your participation in this important survey. If you are interested in lifelong learning for engineers and computer scientists, more information can be found at our website: www.llproject.org/. You may close your browser window now.

APPENDIX D

LIFELONG LEARNING IMPERATIVE FOR ENGINEERING

SEPTEMBER 11-12, 2011 WORKSHOP AGENDA

Sunday, September 11

7:30PM:	Dinner speaker: Charles O. Holliday, Jr., Chairman, Bank of America; former Chairman & CEO, DuPont

Monday, September 12

7:30AM:	Breakfast
8:15AM:	Deba Dutta *LLI project background*
8:25AM:	James Porter *Workshop goals*
8:30AM:	Charles Vest *LLI and national competitiveness*
8:45AM:	Anthony P. Carnevale, Director, Center on Education and the Workforce, Georgetown University, *Lifelong Learning: More Important Than Ever for STEM Workers*
9:30AM:	BREAK
9:45AM:	Breakout sessions – I *(four 90-min sessions in parallel)*
11:15AM:	**Reconvene to plenary room**
	Report back from session leaders (7-8 min each)
12 noon:	LUNCH (Buffet)
1:00PM:	Breakout sessions – II *(four 90-min sessions in parallel)*
2:30PM:	BREAK
2:45PM:	**Reconvene to plenary room** Report back (10 min each)
3:30PM:	Deba Dutta and James Porter Closing remarks

APPENDIX E

2011 LIFELONG IMPERATIVE SURVEY RESPONDENT POOL CHARACTERISTICS

The responses for this project were categorized into two components:

1. Random Component: We selected respondents via true random sampling with a known probability of selection wherever possible. Response rates[16] from our random component range from 5.8% to 13.1% dependent upon the sampled group (various professional engineering societies and University of Illinois alumni). The overall response rate was 9.4%.
   The sampling frame for professional societies was all active, nonstudent members with a US mailing address. The sampling frame for Illinois alumni was everyone who graduated with any degree in engineering (bachelor's and above) between 1985 and 2005 and had a US mailing address.
2. Nonrandom component: Sometimes, due to privacy concerns or restrictions on email lists, it was not possible to draw a random sample of respondents. In those cases, we relied upon the organizations to invite members to take our survey in whatever way they thought was best. This formed the nonrandom component of the surveys.

Overall, 19.7% of the responses came from the random component, and 80.3% from the nonrandom component.

Following is the breakdown of survey respondents by demographic and employment characteristics:

Gender

84.9% Male
15.1% Female

Race

83.4% White
16.6% Nonwhite

Sector

70.2% Manufacturing
12.5% IT
4.8% Pharma
3.1% Academia
2.0% Energy/Mining
1.7% Civil
1.6% Defense
4.1% Other

Discipline

41.9% Mechanical
27.4% Electrical
16.2% Interdisciplinary
7.3% Chemical
2.7% Civil
3.5% Other

Management Level

51.8% Nonmanagerial
32.4% First level
11.6% Mid-level
4.2% Top level

[16] American Association for Public Opinion Research, standard definition for response rate #2 (*www.aapor.org/Standard_Definitions2.htm*).

Member of a Professional Society

58.8% Not a member
41.2% Member of at least one

Region of the US

69.8% Midwest
12.0% South
10.3% Northeast
8.0% West

APPENDIX F

AUTHOR BIOGRAPHIES

Debasish Dutta

Debasish (Deba) Dutta is Dean of the Graduate College and Associate Provost at the University of Illinois at Urbana Champaign, and a Scholar-in-Residence at the National Academy of Engineering. During 2004-07 he served at the National Science Foundation as Acting Director of the Division of Graduate Education, Integrative Graduate Education and Research Traineeship (IGERT) Program Director and as Advisor in the Office of Assistant Director, Education and Human Resources. He chaired the Learning and Workforce Development sub-committee during the development of NSF's Cyberinfrastructure Strategy (Vision for 21st Century Discovery).

At Illinois, Deba is Edward William and Jane Marr Gutgsell Professor of Mechanical Science and Engineering. Prior to this he was on the faculty of mechanical engineering at the University of Michigan, Ann Arbor. A Fellow of AAAS and ASME, Deba Dutta has received several awards including the ASME Design Automation award and the NSF Director's Award for Collaborative Excellence. He is a member of ASEE and SME.

Lalit Patil

Lalit Patil is a postdoctoral research fellow with the Mechanical Science and Engineering Department at the University of Illinois at Urbana-Champaign and manages research at the Product Lifecycle Management (PLM) Lab. Prior to this he was a senior research fellow and lecturer at the University of Michigan, Ann Arbor.

James B. Porter, Jr.

James B. Porter, Jr. was chief engineer and vice president of Engineering and Operations for DuPont until his retirement in September 2008. Jim joined the company in 1966 as a chemical engineer in the engineering service division (ESD) field program at the Engineering Test Center in Newark, Delaware. He left the same year for a tour in the United States Army and returned in April 1968 as a technical services engineer at DuPont's Chattanooga, Tennessee, fibers plant. He was named vice president of Engineering on November 1, 1996, and became vice president of Safety, Health & Environment and Engineering on February 1, 2004. He assumed the position of Chief Engineer and Vice President of DuPont Engineering and Operations on July 1, 2006.

Jim has served as chair for the Construction Industry Institute (CII) and he was the 2004 recipient of CII's Carroll H. Dunn Award of Excellence. In 2005 he

received the Engineering and Construction Contracting Association Achievement Award and in 2007 he was honored with the Society of Women Engineers Rodney D. Chipp Memorial Award. In 2008 he was the inaugural recipient of FIATECH's "James B. Porter, Jr. Award for Technology Leadership." He is a member of several boards of directors and is on the Argonne National Laboratory Board of Governors.

Jim is the founder and President of Sustainable Operations Solutions, LLC, which provides consulting services to help companies make significant and sustainable improvements in workplace safety, process safety management, capital effectiveness, and operations productivity.

Born in Knoxville, Tennessee, he received a bachelor of science degree in chemical engineering from the University of Tennessee in 1965.