Board Standing Committee on Planning

2016 Environment Scan – Key Trends – Revised February 16, 2016

Background: In early 2015, the Board Standing Committee on Planning prioritized key trends of the most importance to chemistry, chemists, and the ACS within the external strategic environment. During the spring 2015 meeting in Denver, CO, members of the Committee discussed these findings with ACS governance committees and other groups. The Planning Committee reviewed the trends during their February 9, 2016 virtual meeting and the Grassroots Dialog Working Group reviewed and revised the trends further during their conference call on February 16, 2016.

The list below represents a revised snapshot of the key trends. Ultimately the trends research is designed to raise awareness of external factors throughout the volunteer and staff leadership, as well as specifically informing the annual revision of the ACS strategic plan.

Social Trends

1. **Scientific enterprise globalization**
    a. More high technology inventions and commercialization originating outside the United States (often by non-U.S. citizens educated in the United States who have returned to their native countries to start businesses).
    b. More technology (and patent filings) coming into the United States originating elsewhere, looking for access to the country.
    c. U.S. patents that stem from foreign origin/invention recently passed the 50% mark for the first time in the history of U.S. patents.

2. **K-12 and higher education trends**
    a. Growing awareness of the mismatch between educational theory and practice. Research is available from cognitive science and science education researchers to support best practices in teaching and learning.
    b. Deepening cuts to U.S. public education – jeopardizing quality (and therefore U.S. competitiveness) for a generation of U.S. students.
    c. More two-year colleges are offering bachelor's degrees.
    d. Potential impact of proposals for free community college on four-year schools (and community colleges as well). What is the impact of constrained opportunities to serve as teaching assistant (TA) in graduate programs? Where are the costs for additional laboratories? Do students come to four-year schools with lab readiness?
    e. How will community colleges manage this change and additional workload?
    f. Funding pressures and change in all aspects of education
        i. Move to online textbooks
        ii. Reduced hands on laboratory experience, etc.
        iii. Increased use of adjunct and non-tenure track faculty

3. **Challenges in creating information, knowledge, and understanding**
    a. Replacement of factual knowledge with crowd source knowledge.
    b. Knowledge becoming redefined as electronic information access.

c. Data, information, knowledge, wisdom, and understanding have distinctions. We're looking for wisdom. The explosion of access to data skews the pyramid. Is wisdom the value proposition for scientific information and conferences? This also applies to local sections.
d. The changing nature of networking and community (e.g., at national and regional meetings and local sections).

4. **Shifting demographics in science and the broader U.S. population (and worldwide)**
    a. More women than men getting college degrees – current trend but continuing.
    b. Percent of women increasing in all science disciplines; not so for under-represented minorities, who are declining in some science disciplines.
    c. Growth of Hispanic, Asian population.
    d. Larger incoming generation X, Y, and millennial vs. baby boomers.
    e. Impact on leadership and governance processes.
    f. Generational dynamics apply worldwide in differing ways.
    g. An increase in the number of U.S. college students.
5. **Changing dynamics of membership organizations**
    a. Value proposition for membership organizations has been disrupted by social, economic and technological changes. This demands more targeted services, creative recruitment/retention strategies and evaluation of alternative membership models.
    b. Evolving conference and meeting models
        i. Maturation of virtual and hybrid conferences, flipped classrooms, and interactive and technology-enabled learning.
        ii. Broader use of virtual meetings by constituents (Local Sections, Technical Divisions, and Committees).
    c. General decline in association membership. Membership decisions are increasingly based more on personal return than support for the profession or greater good.
    d. Member desire for more targeted, mobile and video resources and messages.
    e. Constraints on volunteers warrant new tools to ease their jobs and grow their ranks.
    f. The integration of online technologies with onsite meetings and courses.

<u>Technology Trends</u>

1. **3-D printing**
    a. Additive manufacturing (3-D printing, etc.)
    b. 3D printing/synthesis replacing more traditional approaches.
    c. Growing number of makerspaces which offers broader access to technology.
2. **Social, mobile, and cloud affecting information-sharing**
    a. Increasing use of social media, especially in younger scientists.
    b. New consumer information-sharing platforms = constant access to information.
    c. Mobile devices are influencing our life, work, play, and associations.
    d. Demand for immediacy and a personalization of information and resources.
    e. Global connectivity.
3. **Increasing cyber-security threats**
    a. Cyber-security threats to the collection, distribution, and protection of information are increasing.
    b. Cyber-security threats put privacy at risk.
4. **Evolving online and other education tools**
    a. Move to all online textbooks.
    b. MOOCs (Massive Open On-line Course) are becoming less popular; support for them is struggling.

c. Access to micro-courses and relevant topic availability through (for instance) university continuing education.
   i. e-learning, MOOCs (second generation), new credentialing, redefinition of qualifications/education, virtual-focused universities, online competency-based learning providers, decline of courses & credit hours, micro-credentials, and micro-certification.
d. Inability to predict what approaches are going to be accepted and have staying power.
e. Competency-based education fostered by federal government and accrediting agencies. Blurring of the difference between education and simple training. Care needed to achieve desired outcomes of education.
f. Changing role of internship and cooperative education programs.
g. Recognition of the importance of active learning and involvement.

5. **Big data**
   a. Huge databases impact publications and scientific information.
   b. Massive computational resources and big data are used in science, particularly in the design of new materials and drugs.
   c. Increased use of data and analytics to better serve stakeholders.
   d. Predictive / AI (Artificial Intelligence) technology and ontologies are emerging and evolving in the scientific information research space. For example, IBM Watson is changing how artificial intelligence is applied to real-world problems.
   e. The number and scope of open access mandates by research funders is growing as are attempts to coordinate between different groups.
   f. Chemistry-related information sources, including free resources, are increasing. The expectation of more personalized offerings from organizations is growing, along with the technology which enables them.

<u>Economic Trends</u>

1. **Decreasing oil prices and demand**
   a. Change the mix for industry profitability due to energy costs and feedstock prices.
   b. Gasoline prices are declining drastically; the *trend* is actually fluctuations/unpredictability with respect to oil prices/demand.
   c. Saudi Arabia announcement that they were going to drop oil prices.
   d. Even though the United States is riding high now with self-sufficient energy, alternative energy investment may grow.
2. **Urgent world challenges**
   a. Chemical sciences are increasingly central to development of solutions to the global challenges of energy, environment, water, health, and food.
   b. As the world's population increases, resources are under pressure.
   c. Effect of environmental concerns on world economies and competition.
   d. Waste will become a resource: how to mine landfills or the "island of plastic in the ocean."
   e. Particularly relevant to younger chemists—will likely be resolved using a multidisciplinary approach.
3. **Changing dynamics of the global economy**
   a. Global economic and government budget constraints impact research output and demand.
   b. Currency fluctuations, market volatility.
4. **Changing career pathways**
   a. Employers of chemists are increasingly diverse, smaller, and more service-oriented**.**
   b. The mismatch between the current training of new graduates and the jobs available.
   c. More temporary and contract chemistry jobs.

d. Switch to non-traditional roles for chemists.
e. Growth in the number of those who don't call themselves chemists as their primary professional identity.
f. Chemistry shifting from being a respected, defined, and well-resourced discipline to competing with hot new interdisciplinary fields in academia and research.
g. Training remains focused on traditional chemical specialties and not aligned with cross-functional expertise needs.
h. Shifting to a series of mini-careers, as opposed to one extended professional career: multiple shifts in job and career focus.
i. Aging traditional chemistry workforce being replaced with a young, interdisciplinary, and more entrepreneurial work force.
j. The bar is raised with respect to expectations in the work place; some work that used to be done by PhD chemists is now done by technologists, due to improved instrumentation and computerization.
k. Shifting away from:
    i. highly-skilled and in-demand professions to automation and the appificationof technical expertise;
    ii. internal career pathways and job tenure to multiple careers and career pathway;.
    iii. sufficient employment opportunities for entering professionals to searching for scarce and more creative ways to apply education and expertise; and
    iv. pure research in dedicated research institutions to applied and translational research engaging practitioners, clinicians, and supply chain partners. Emerging platforms for collaborative research discovery, content sharing, and funding.
l. Low wages.
m. Potential impact on research and educational quality.
n. Impact on career progression and career opportunities.
o. Increasing use of adjunct and non-tenure track faculty

5. Mergers & Acquisitions

a. Global chemical mergers and acquisitions (M&A) activity is expected to remain buoyant, with continued portfolio realignment and consolidation plays in various segments.
b. Companies have an increased focus on developing their core strengths and are looking to acquisitions to deliver growth and greater shareholder value.
c. Key chemical segments of fertilizers and agriculture chemicals, diversified, and industrial gases are all likely to experience an uptick in M&A transactions.
d. The spin-off momentum is likely to continue, given the often low tax basis in legacy businesses, resulting in tax-free spins delivering greater shareholder value than straight dispositions.
e. Digital design and Advanced Manufacturing open up new frontiers for materials innovation and potentially threaten historical volumes in some commodities.

<u>Political Trends</u>

1. Growing global terrorism

a. Reduced or restricted mobility due to terrorism.
b. Radical extremists' threat.
c. Rogue nations and failed states pose greater threats.
d. Radical Islamic, eco-terrorism, animal lab (PETA), and other groups.
e. Increasing costs of higher security related to restricting building access, extensive background checks, and cyber-security.
f. Additional restrictions/regulations on chemical industry.

2. **Shifting perception of science**
    a. Reliance on deep held feelings/beliefs instead of scientific knowledge on science-related issues.
    b. Peer review is not used as it should be for popular science disagreements.
    c. Recent Pew/AAAS study points to difference in perceptions of science held by scientists vs. public.
    d. The public often fails to understand chemistry's positive impact on people's lives and accepts inaccurate sound bites as fact.
    e. Accelerating trend toward being scientifically illiterate (e.g., politicians, media, public anti-vaccine movement, etc.)
    f. Some people in the United States:
        i. take pride in being scientifically illiterate, and
        ii. see science/facts in direct competition with faith/religion and belief systems.
    g. Politicization of the news industry makes getting the message out about chemistry difficult.
    h. Differences in demographics of politicians/legislators in the United States vs. other countries (e.g., number of scientists/engineers in China's leadership vs. U.S. Congress)
    i. Science is becoming less valued in the United States.
3. **Changing R&D funding levels**
    a. R&D Ecosystem changes—changes in how/where R&D is done; changing funding levels in academe, industry and government.
    b. Decreasing budgets for universities.
    c. Emerging declines in state funding.
    d. Steady decline in U.S. research funding. From a steady source of government and industry research grants to more constrained government finances.
    e. Funding outside the United States for academic research is increasing, and some U.S. scientists are moving their labs abroad in response to incentives offered by non-U.S. countries.
    f. STEM initiatives increase but chemistry realizes an increasingly smaller share.
    g. Greater need to market the chemistry value proposition to help justify continued funding.
    h. Increasing politicization of science/technology/engineering/mathematics (STEM) education funding in the United States.
    i. Chemistry degree programs are abandoned in favor of service teaching due to high costs.
    j. Decreasing support for investment in R&D to sustain US technology competitiveness.
4. **Increasing politicization of science education**
    a. Quality of K-12 education -– particularly, the inclusion of non-scientific explanations in the science curriculum. Portraying non-scientific content as science in the curriculum misrepresents the nature and process of science and poses a threat to the future scientific, technological, and economic competitiveness of the nation.
    b. Legislators exerting increased influence and some people consider this micromanaging.
5. **Implementation of safety standards**
    a. Safety in academic and industrial laboratories is a global as well as an US issue.
    b. Lack of reliable source of safety information, easily available, accurate, precise, and understandable.