

Future of Computing Education Summit

June 25-26, 2009

Abstract

The Future of Computing Education Summit brought together 32 leaders of US-based organizations that have a stake in solving the current crisis in computing education, where declines in enrollment and diversity are making it difficult to meet industry's needs for employees that are skilled in computing. Breakout sessions were used to discuss challenges and strategies, and then a list of action items were defined, and attendees signed up as organizers or participants to work on the action items. Breakout sessions addressed issues such as increasing diversity, the role of programming in computing, messaging to improve the perception of computing, what measurement and research is required, and how partnerships and collaborations between K-12, academia and industry can be strengthened. A common theme was the desire for a new organization that would be the public voice for computing education and also provide a central repository of resources. Action items included the creation of the new entity, as well as actions to improve research and measurement, public relations, university-industry partnerships and changing the university.

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Executive Summary

Leaders from several computing organizations met for a day and a half in Arlington, VA, to discuss and strategize on how to solve the current crisis in computing education. Despite the increasing importance in computing in all elements of our economy and our culture, all computing disciplines—including computer science, computer engineering, information systems, information technology and software engineering—have been struggling with the lack of student interest and decreasing enrollments, as well as seeing a decrease in the diversity of students.

No keynote speaker was needed, because all the attendees had a good, basic understanding of the issues that needed to be addressed. Instead, the summit was used as a chance to break into smaller groups that first discussed challenges, then strategies, and finally created action items with owners and participants. A number of themes emerged from these discussions.

Diversity. Part of the current crisis is evidenced by the fact that the number of young women and under-represented minority students studying computing is at an all-time low. Diversity has been an issue for computing since the field's origin, and there are a number of efforts currently working on improving diversity. Diversity is strongly linked with the perception of computing: If the public perception of computing were better, then there would be more diversity, and if there were more diversity, then the perception of computing would improve. Measuring diversity requires some work, both in terms of defining computing and defining diversity. Increasing incentives, especially significant financial incentives, was identified as a strategy.

Computing is not programming. As technology's reach expands, computing has become very important in a larger variety of disciplines. Careers are now available for people who work with computing, but do not necessarily spend much time doing classic programming. There is controversy over the role of programming in computer science classes. Computer science classes often start with programming, which can turn off students who find programming difficult or uninteresting, but who would be very interested in working in areas such as information management, project management or system management.

Messaging. Messaging is critical to change the perception of computing. Currently, messaging is spread across several organizations with little coordination between those who are creating the messages. Message content should communicate that computing permeates all fields and has tremendous social impact. Different messages should be created for different audiences (K-12, undergraduate, academia, government etc.), but with a consistent message. A central repository could hold resources such as short messages (elevator speeches), talking points, presentation templates, posters and a database of speakers.

Measurement and Research. There is a clear need for measurement and social science research to understand retention, diversity and the effectiveness of incentives, schemes and programs. Research can help determine the effectiveness of non-traditional pedagogy and curricula. Studies need to go beyond traditional computer science academic institutions and look at schools that focus more on other aspects of computing, as well as two- and four-year schools. Research results need to be stored in a central repository for easy access.

Partnerships and Collaborations. Partnerships between K-12, academia and industry need to be strengthened. Since industry ultimately determines what skills are needed in the workforce, industry needs to help define what fundamental skills they use, and therefore what should be taught. Industry can be more closely involved in education, both at the K-12 and higher levels, and should be especially involved with overlooked institutions, such as community colleges and institutions that serve minorities. Various forms of collaborations between traditional computer science and other computing fields are also desirable, with sharing of resources. Many organizations could focus on one particular challenge each year (a “Global Challenge,” such as increasing diversity, establishing industry/academic collaboration or increasing education’s perceived value).

New Entity. Throughout the summit, a common desire was raised to have a new organization that would speak for computing education and serve as an umbrella over several efforts. One of the purposes of the entity would be to provide a single voice to government regarding policy and funding. Another would be to provide a central repository for resources that would help improve the perception of computing (such as talking points, presentations and lists of speakers), as well as curricula and case studies that could improve computing education. The entity could also help coordinate the many organizations that are involved in computing, providing annual “Grand Challenges” that all organizations could focus on for the year. It could also be a place where achievements are recognized and celebrated.

Action Items. The summit concluded by posting a number of action items on the conference room walls so people could sign up as conveners, organizers and participants. The action items were:

- Initiate a new entity for computing education
- Write a white paper on the top five research questions to advance computing education
- Identify, develop and centralize resources
- Identify audiences for greatest public relations impact and develop appropriate messages
- Develop mini-grants for teachers
- Develop a partnership to support state-level advocacy
- Urge funders to support university/industry collaborative ventures and partnerships
- Encourage academia to create incentives to promote industry participation in joint conferences
- Engage industry to collaborate in computing work with faculty and students

- Develop a study of what industry needs in computing-student preparation
- Initiate recognition of pedagogical achievement
- Disseminate good practice with respect to computing education
- Redefine faculty development to include pedagogy
- Gather data about experiences on dual track (research/teaching) tenure lines
- Survey non-major's computing courses and general education schemes regarding the inclusion of computing studies

Attendees

The Planning Committee consisted of Mark Guzdial, Jane Prey, Heikki Topi and Joe Urban, with Lillian “Boots” Cassel advising and providing some financial support, and the support of our ACM contact, David Schneider.

Organization	Web site	Attendees
ACM Ed Board	http://www.acm.org/education	Mark Guzdial, Jane Prey, Heikki Topi, Lillian (Boots) Cassel
ACM SIGCSE (Special Interest Group on Computer Science Education)	http://www.sigcse.org/	Barbara Boucher Owens
ACM SIGITE (Special Interest Group on Information Technology Education)	http://www.sigite.org/	Han Reichgelt
AIS (Association for Information Systems)	http://www.aisnet.org	Mary J. Granger
ASEE (American Society for Engineering Education)	http://www.asee.org/	Sarah Rajala, Dennis Silage
Bookey Consulting (Writing)	http://bookeyconsulting.com/	Peter Gruenbaum
CRA (Computing Research Association)	http://www.cra.org/	Andy Bernat, Andy Van Dam
CSTA (Computer Science Teachers Association)	http://www.csta.acm.org/	Gail Chapman, Setphanie Hoepfner
IEEE	http://iee.org/portal/site	Tom Hilburn, Alan Clements, Stephen B. Seidman
NCWIT (National Center for Women and Information Technology)	http://www.ncwit.org/	Lucy Sanders, Lecia Barker
NSF (National Science Foundation)	http://www.nsf.gov/	Harriet Taylor, Janice Cuny, Joan Peckham, Victor Piotrowski, Rajinder Khosla, Ty Znati, Amy Sharma
SIM (Society for Information Management)	http://www.simnet.org/	Debabroto “Dave” Chatterjee,
SRI International	http://www.sri.com/	Raymond McGhee
Texas Tech University	http://www.ttu.edu/	Joe Urban
The iSchools	http://www.ischools.org/	John Unsworth

Action Items

Several action items were identified at the end of the summit. Attendees agreed that their organizations would be willing to take on roles as either owners or participants, and one

individual was selected to be the convener to make sure that the owners and participants would continue to meet in order to keep the action item going.

Note that when Ensemble is mentioned, it refers to the digital library for computing education project: <http://www.computingportal.org/site/node/4>.

[Entity] for Computing Education

This action item involves the creation of a new entity (umbrella organization or center) to provide several functions to promote computing education:

- It speaks with a united front, especially with regard to policy and funding.
- It provides a clearinghouse or repository of ideas, policy recommendations, curricula, and other useful computing education information. A “Computing Education Act of 2012” would come from here.
- It declares the “Year of X” (that is, an annual “Grand Challenge”) that would be addressed by all participating organizations. Examples include diversity, perceived image of computing, industry/academia collaboration etc.
- It brings large and small organizations together.
- It is ultimately accountable for computing education.

Convener: Tom Hilburn of IEEE CS

Owners: IEEE CS, NCWIT, ACM Ed Board

Participants: Ensemble, SIGCSE, CSTA, CRA, ASEE, SIGITE

Research and Measurement

There are several research and measurement action items.

Organize a committee of organization representatives to write a white paper on the top five research questions to advance computing education.

Convener: John Unsworth of iSchools

Owners: iSchools, ACM Education Board

Participants: iSchools, ACM Education Board, Ensemble, SIGCSE, CRA, SIGITE, SIM

Identify, develop, and centralize resources.

- Develop a better way to archive findings on computing education research and to improve seeking and searching for these findings.
- Identify what resources, messages, research, etc. already exist.
- Develop resources and disseminate with funding development.
- Develop talking points resources to inform faculty about appropriate messages.
- Build a repository of resources, examples stories on message, templates, posters, links, and press releases.

Convener: AIS

Owners: NCWIT, ASEE, AIS

Participants: Ensemble, SIGCSE, SIGITE, NCWIT, ASEE, CSTA, iSchools, AIS

Notes: The resources should be on project. It's important to identify existing resources and then develop further. The existing [Ensemble](#) project and [BPC collections in Engineering Pathways](#) can be leveraged for this action item.

Public Relations

There are several public relations action items.

Identify audiences for greatest impact, develop appropriate messages (with requisite research) and gather funding for this.

Convener: None

Owners: None

Participants: NCWIT, ACM Education Board

Develop mini-grants for teachers (maybe for curriculum development) so local press has a reason to write about computing and bring positive attention to the school districts.

Convener: NCWIT

Owners: NCWIT, ASEEE

Participants: NCWIT, ASEEE

Note: NCWIT gives teacher aspiration awards.

Develop partnership with CSTA cohort leadership and university faculty to support state-level advocacy.

Convener: Mark Guzdial, with the goal of getting Cameron Wilson of ACM EPC to take over.

Owners: None

Participants: CSTA, IEEE-CS and ACM Ed Board (ACM Education Policy Council)

Note: ACM Education Policy Council maybe doing this already.

University-Industry Partnerships

There are several university-industry partnership action items.

Urge funders to support collaborative ventures and strategic partnerships.

Convener: Dave Chatterjee of SIM

Owners: SIM

Participants: CSTA, IEEE-CS and ACM Ed Board (ACM Education Policy Council)

Encourage academia to create incentives to promote industry-IHE participation in joint conferences.

Convener: None

Owners: None

Participants: SIM, iSchools

Engage industry to collaborate in computing work with faculty and students.

Convener: Dave Chatterjee of SIM
Owners: SIM
Participants: SIM, iSchools

Changing the University

There are several action items for changing universities.

Develop a study by a representative group in industry of what they need/want in computing student preparation:

- **What is the expected skill set?**
- **What does industry project for 10 years out? Characterize projected roles.**
- **Involve multiple groups from IT, software development, and research labs.**

Convener: Han Reichgelt of SIGITE

Owners: SIGITE

Participants: SIM, Ensemble, IEEE-CS, NCWIT, SIGITE

Note: We need to find out what already exists. Look at EU, BCS, and SIM.

Initiate recognition of pedagogical achievement, such as best paper, best education resources, etc.

Convener: ASEE

Owners: ASEE, IEEE-CS

Participants: ASEE, Ensemble, IEEE-CS, SIGCSE, SIGITE, AIS, iSchools

Note: We need to find out what already exists

Work with centers and institutes of teaching and learning to disseminate good practice with respect to computing education.

Convener: None

Owners: None

Participants: SIM, ASEE

Redefine faculty development to include pedagogy.

Convener: None

Owners: None

Participants: ASEE

Gather data about experiences on dual track tenure lines (research and teaching).

Convener: SIGSCE

Owners: SIGSCE

Participants: SIGSCE, AIS, iSchools

Survey non-major's computing courses, get reviews and find exemplars; survey general education schemes for including computing.

Convener: SIGSCE

Owners: SIGSCE

Participants: SIGSCE, IEEE-CS, NCWIT, CSTA, CRE

Summary of Breakout Sessions

Challenges

Revising the Curriculum

Challenges in revising the curriculum include:

1. Attraction and retention in undergraduate computing programs, especially women and minorities. This involves changing the perception of computer science and information technology as disciplines and careers. One of the issues of perception is that computing is perceived as being the same as programming. Mathematics skills may be an inhibitor, and the current mathematics that is required is not necessary for all computing disciplines. We need good data on retention, and we need consensus on what employers expect, which is often difficult.
2. Modernization of undergraduate computing curricula on an ongoing basis so that they remain relevant in the context of the limited space in the university curriculum. We need to figure out how to integrate computing curricular topics with application areas. We need to resolve the dynamic tension between teaching job skills and more long-lasting skills. How do we teach students to learn, including lifelong learning, unguided learning, exploratory learning etc.? What is the core knowledge needed by someone graduating with a degree in computer science? What role does mathematics play in this core knowledge? How can we teach abstraction in a systematic and useful way across the curriculum?
3. A computer scientist is no longer able to know the entire discipline.
4. Most people in the computing profession are no longer primarily tool builders, but rather sophisticated tool users, and the curriculum needs to reflect this.

Strategies include:

1. Define the expected outcomes of a computer science curriculum. To design a curriculum, we need to understand what students need to know.
2. Possibly organize the Master's curricula in computing.
3. Reduce redundancy in the curriculum and reorganize it, potentially teaching non-programming aspects earlier in the courses.
4. Learn from successful efforts in computing education, such as the secondary-school computer-science education efforts in Israel.

Diversity

Challenges:

1. First, we need to define diversity, and this brings up who and what we count. Whether someone is counted as being in computing will vary depending on if they are counted by looking at discipline, major, courses etc. We should be aware that since computing is involved in a large range of technical fields, we can't count just computer science majors. Diversity should include gender, race, veterans and people with disabilities.

2. It's important to focus beyond "silos of need" and the symptoms in order to focus on the causes. How do we get various groups working for diversity working together? We need to deal with the myth of a "meritocracy" which suggests no action needs to be taken. We also need to address issues of quantity vs. quality, making sure that we are providing effective education to a diverse group and not simply achieving statistics that show high numbers of students. We also need to be aware that these programs take time, and increasing middle school students interested in computing will not be visible for 10 or 20 years. How do we address diversity fatigue and lack of acknowledgement?

Strategies:

1. Once a few big ideas and solutions are identified, we should create action items and talking points for that will work for a variety of audiences, including industry, government, K-12 programs and academia.
2. We need more incentives, but they should be more than just plaques; they should ideally include money. Sticks and carrots should be identified, and we need to be inclusive to many strategies.

A question was raised: why isn't the U.S. Department of Education at this meeting?

Finally, citation crawling was suggested as a way to follow good ideas and to define the boundaries of the field of computing by looking at literature citations.

Professional Development and Lifelong Learning

Three critical challenges were identified:

1. Train more K-12 teachers, with a goal of 10,000 teachers by 2015, as well as support their professional development in regard to lifelong learning.
2. Provide more professional development for computing faculty so they can learn new paradigms, and provide more professional development for practitioners (CIOs, undergraduates etc.) to encourage lifelong learning. ASEE has ongoing efforts to develop practitioners, but there is very little for computing faculty at either the K-12 or university level. How do you keep up with the latest paradigms? How do you increase diversity?
3. Help everybody in all related fields learn computational thinking.

Strategies include:

1. Define "Computational Thinking" so that it includes Computer Science, Information Systems and Engineering, and create branding around these definitions. Branding should be across disciplines.
2. Set standards so that high school computing education can be effectively taught in all states.
3. Commit to teaching computing in K-12. This includes improving how states deal with computing education. Computer science in high school doesn't count toward graduating except in two states (Georgia and Texas). Certification for K-12 teachers would be valuable.
4. Get undergraduates into K-12 classrooms to assist teachers.

5. Change the universities to value teaching more. This means a shift away from being solely focused on computing research.
6. Put more emphasis how computing is used across many areas, in particular across STEM.

Pedagogy

For pedagogy, the challenges are:

1. Engagement of students in the discipline through active learning. This includes the use of case studies that provide realistic, meaningful scenarios and collaborative work. Collaborative experiences are important, and include team projects and pair programming. Students should also get direct experiences with industry. Both active learning pedagogy and industry interaction should be used early and throughout the curricula.
2. Preparation of the faculty for new pedagogy. This means an acceptance of team and collaborative approaches. We need to communicate to teachers that collaboration is not cheating, but a more realistic reflection of how work occurs in industry. Faculty needs to be willing and able to change from a lecture style to more interpersonal approaches. They also need to understand how to frame material so that students understand how it relates to their future careers.
3. Sharing of pedagogical resources, especially those that don't start by handling bits. These resources need to be adaptable and easy to integrate into a variety of courses using instructional design. They should be tagged as to how they fit into computing careers, and they should identify prerequisite knowledge.

Some resources are available, but it's not clear how well they work. Case studies are available in many fields, but very little in Computer Science. People are using digital libraries, but studies have shown this is not very effective. You can't just put them a digital library online; you need to build community first, and keep it up online. Instead of just creating resources and watching to see who uses them, we may need to learn from corporations, who make sure that people see the resources over and over again. Although there is no hard evidence for what pedagogies are effective, there are some case studies in other disciplines, and there are studies on pair programming.

Defining Computing

1. The following challenges were identified for defining computing:
2. The lack of joint definition is a sign of lack of joint identity among computing fields.
3. Various subdisciplines in computing do not share a core specification.
4. The Computer Science discipline dominates the terminology.
5. The perception of the public (including students and prospective students) is ultimately more important than the definition. Computing is perceived to be difficult, require long attention spans and long-term focus, and not provide immediate payoffs. Unfortunately, changing broad perceptions very slow and expensive.

6. The dynamic nature and continual evolution of computing makes it difficult and potentially misleading to create definitions.
7. There are many applications that use computing in a variety of domains, and a small number of core technologies, forming an inverted pyramid. Definitions will depend on where you are in that pyramid, but we need skilled people in all areas of the pyramid.

The important elements of computing are:

- Algorithmic thinking and modeling
- Structuring data and information
- Problem solving
- People skills (i.e., soft skills)

Understanding domains is also an important element. Students can often be motivated if domain relevance is incorporated into the teaching.

In order to teach computing, many capabilities must be integrated. A massive range of capabilities is often needed in a single project. This requires collaboration and a need to have individuals capable of crossing boundaries.

The fact that many disciplines now use computing can be described as “Computing + X”. This brings up the idea that computing adds value to nearly everything. For example, “computational biology” has a number of different combinations of computing and biology, including using computers to control biological experiments, analyze biological data, create biological simulations etc.

The definition may be less important to young people than the perception; computers are currently being blamed for all kinds of problems in society. However, definitions are important in making decisions about what curricula will cover for various disciplines.

Strategies include:

- Broad-based efforts that are associated more with perceptions than specific definitions. Project-based active learning can help change the perception of computing, showing how it requires a variety of skills and teamwork. There is a need for a professional approach and significant resources.
- Continued collaboration with representatives from the broad range of computing disciplines. Within the broader discipline, various levels of evolving specification of the field will be needed.
- Communication of the role of computing as a critical enabler of social structures.

Promoting Computing

The group working on promoting computing concluded that computing was not being promoted very well. Different and new messages are needed in order to increase the number of computing graduates to meet demand, as well as to increase diversity in the field.

Barriers to promoting computing include:

- Lack of incentives for promotion
- Poor coordination and communication
- Lack of expertise to share messages
- Lack of understanding of the issues
- The perception that computing is the same as computer science

Strategies include:

- Focus excitement in computing by using new techniques, such as viral marketing.
- Perform new research and distill existing research to understand the issues around the paucity of interest in computing. How are issues in computing similar to or different from other technical fields?
- Craft short, concise, and consistent messages.
- Work with partners, such as public relations firms, communication firms and K-12 after-school programs, to leverage existing infrastructure and expertise. Examples include. This should use both bottom-up and top-down approaches to get the message out.

Some questions were raised. How is computing the same as or different from other STEM disciplines in this area? Is this a United States problem, or more broad? It is not an issue in Asia. Since this is an NSF-funded meeting, we are focusing on solving the United States issues.

Strategies

Measurement and Research

Measurement and research can be applied to these audiences and participants:

1. Classes with non-traditional pedagogy or curricula
2. Non-PhD institutions
3. Schools that focus more on information than computer science (IS/IT/CS/SE/CE/iSchools)
4. Comparisons of rural and urban schools
5. Comparisons of two-year schools, 4-year schools and universities
6. Comparisons on-line and off-line education
7. Multinational, multicultural studies
8. Examinations of employees and alumni
9. Examinations of faculty and student perceptions of computing

These questions and issues can be studied:

1. Retention
2. Effectiveness of incentives, schemes and programs
3. Return on investment
4. Diversity
5. Use of pedagogy

6. Cultural issues, both national and community
7. Learning effectiveness
8. Standards for curriculum and accreditation
9. Employability
10. Development models (i.e., models for how students learn computing)

Research methods to be used:

1. Social science methods, like those used in education and psychology research
2. Citations analysis (i.e., bibliometrics, data mining of citations to learn how disciplines are linked through computing)
3. Quantitative and qualitative results
4. Academic genealogy (i.e., studying what students—and students of students—are doing as a way of tracking effectiveness)

“Meta-questions”:

1. How do we prioritize research questions? What research will be most useful in addressing known challenges? Known challenges include diversity, policy, attractive pedagogy, revising curriculum and promoting computing.
2. Is there anything unique to computing? In other words, where are the places where interdisciplinary collaboration will add significant research value, and where is computing unique and requiring its own approaches?
3. What is computing? Can it be better defined by a data-mining approach than by having experts come to an agreement?

University/Industry Partnerships

Strategies include:

1. Address the disconnection between universities and industry.
2. Improve placement of graduates in industry.
3. Increase research collaboration.
4. Enlist industry people to help define what fundamental skills they use, and therefore should be taught.
5. Improve ranking systems, which are quite problematic, because they leave out the smaller schools.
6. Work to transfer good research from academia to industry.

Actions include:

1. Professional societies should use collective clout to develop a new ranking system for schools. This should take into account skills development, experiences, projects, placement etc.
2. NSF and other government institutions should fund more collaborative ventures and assist with broad dissemination of opportunities.
3. Create incentives to promote industry and academia participation in joint conferences.
4. Engage industry in close collaboration and work with faculty and students. Guidance would be provided by industry, by a faculty/industry team-teaching

approach to courses. Collaboration between STEM and business school departments would be encouraged.

5. Invite overlooked institutions, such as community colleges and minority-serving institutions, to discuss partnership opportunities.

Some successful models of industry/academia partnerships include:

1. Boeing offers a program by which Boeing suggests research projects, academic institutions apply, and the winners work at Boeing.
2. Academics contact industry about best-practices research (this is a model that SIM uses).
3. Students wrote résumés describing their future goals, and industry members helped them determine the skills they'd need to get there.

Cross-Computing Engagements and Collaboration

Cross-computing engagement should include computing organizations/societies, universities, other higher education schools, K-12 schools and industry. Perspectives from subdisciplines and different organizations need to be taken into account and joint actions need to be specified.

Strategies include:

1. of common, global issues. Many of these are being discussed at this meeting, and include curriculum, accreditation, diversity and assessment.
2. Creation and sharing of resources, including ideas, events, media and other publicity. There could be joint public relations efforts.
3. Celebration of success toward a specific goal. (Computer scientists often do not do well at celebrating accomplishments.) This can involve public recognition of achievements.
4. Creation of an umbrella organization focused on computing education. This is described in more detail below.

An umbrella organization would:

1. Enhance collaboration. Currently, we don't always have collaboration within an organization.
2. Have a central web-based resource. This should be a sustained effort with support for crosscutting collaboration. Start-up funding from NSF would be helpful, including sufficient resources for two to three years for building it and then some years to evaluate it, and an annual evaluation meeting.
3. Possibly result in a Center for Computing Education.

Efforts could be focused by introducing the concept of Grand Challenges. Grand Challenges would provide an annual focus on one issue for all organizations. Some examples of challenges are:

1. Increasing the perceived value of education activities within universities
2. Industry-university collaboration
3. Diversity

Changing the University

Universities are difficult to change. Strategies include:

1. Offer models, preferably ones with proven track records, for how change can happen. A “one size fits all” approach won’t work; we need multiple models for multiple types of colleges and universities. Example: Georgia Tech Threads.
2. Offer accreditation to universities; they respond to this strategy when applied carefully (programs can be shut down if universities decide accreditation would be too difficult to achieve).
3. Create change by actions. Identify “change points”, such as requirements. For example, increase pressure to create a serious computing general education requirement. All students need computers for this approach; inexpensive notebook computers would make this more feasible. A course for everyone on computational thinking could be required, but it would require the university to have the means to implement it. Is it necessary for informed citizenship in the 21st century?
4. Get NSF or another national organization to recommend making changes, which would make the changes more likely to happen. This may require studies across several organizations.
5. Emphasize the value of teaching. Some universities, such as CMU, Stanford and the University of California, have two tracks—a research track and an education track—with tenure possible in either. Measurement and research in education are needed to see if this is effective.
6. Improve pedagogy by establishing connections between curriculum and pedagogy. We need more and better computing technology in computing education. Continuing professional development should include learning about new pedagogies. We must get faculty off the lecture-and-lab model and more involved in other ways in which students learn, such as learning communities and learning ecologies. Currently, pedagogies are still similar to those in the 19th century. Few faculty members are brave enough to experiment, and there are few incentives for experimentation. Make teaching more visible and give it weight by providing funding. Programs such as Science of Learning and CPATH are good, but not enough.
7. Brand computing as something that everyone needs, rather than just Computer Science for those in that specialization.
8. Action items:
 - a. CRA-E: Write a white paper on curriculum changes needed and actions that address those changes. Describe what the math piece should look like, show how to deconstruct the requirements of most computer science degrees, explain the need for computing the natural sciences, and give successful examples, such as Threads at Georgia Tech.
 - b. AIS: Curriculum work. A pedagogy link on the AIS site could include syllabi, cases, databases and ideas of pedagogical approaches. Hold conferences on the subject. Note that journals and proceedings from last 10 years will be in the AIS library.
 - c. ASEE: Work to change of university attitude toward teaching. This can be done through accreditation.

- d. Government: Activities related to accountability and to the importance of teaching. Provide funding.
- e. IEEE-CS: Address this issue through curriculum, masters, professional development and standards. Collaborate more closely with the CS Education Activities Board.

Note: SEMATECH is an example where the US military gave out grants in the semiconductor industry to help make the industry competitive. A similar approach could be effective with computing.

Public Relations

Overall strategy consists of:

1. Crafting, controlling, managing and disseminating the message and image of computing to key audiences with useful resources.
2. The message will be consistent with each audience's goals and values. It will overcome misconceptions and avoid planting negative or untruthful claims.

Note that for K-12, audiences include teachers, school boards, relevant teachers' associations, parents, state departments of education and undergraduate educators.

Specific strategies include:

1. Look at the National Academy of Engineering's effort "Changing the Conversation," which focused on messaging.
2. Create a central repository for resources. This would encourage reuse of existing resources. The repository would include elevator speeches, talking points, presentation templates, posters, a database of speakers etc. It should be customizable.
3. Establish a messaging strategy that involves using media with repeated and consistent messages.
4. Use word of mouth (i.e., elevator speech), local press and local groups to get the message out.
5. Enhance partnerships between K-12 education, industry, community colleges and academia.

Message content should get across these ideas:

1. Computing permeates all fields. (Adding a "C" to STEM.)
2. There are many surprising uses for computers.
3. Computing contributes to a "whole" life.
4. Computing has tremendous social impact.
5. Many majors use computing.
6. Computing is not the same as programming.
7. Avoid the use of the term "computer scientist."

Changing Policy

Consistent policy and collaboration between groups would assist in the creation of a true computing community. Any disagreements between groups should be kept private, with a united front presented to the public.

Strategies include:

1. Get universities to value teaching more. This includes outreach, K-12, professional development and lifelong learning. This will require communication and mandates, and should be performed with practitioner input.
2. Define and brand computing in relation to career and technical education, with practitioner input and inclusion of the many types of institutions and organizations that are involved in computing. It should be accomplished by a large, esteemed group through meetings. A defined brand can be redefined later; but it is preferable to have a working model.
3. Develop and endorse state-by-state efforts for computing to count. This includes certification for teachers.
4. Develop leaders for the community. Provide professional leadership training.
5. Putting the “C” back in STEM. (Okay, there’s no “C” in “STEM”, but you know what we mean.)
6. Creating 10,000 K-12 computer science teachers.

Action Items

Changing the University

The following action items were identified:

1. Focus on what will have impact
2. Initiate a survey of non-CS courses that use computing.
3. Initiate a survey of requirements for non-CS majors
4. Redefine faculty requirements for pedagogy.
5. Create dual tenure tracks for teaching and research.
6. Recognize pedagogical achievements with smaller, more frequent awards.
7. Develop a study by a representative industry group of what is needed and/or desired in computing student preparation.

University/Industry Partnerships

The following action items were identified:

1. Create a new ranking system for schools.
2. Create legacy with more communication and sharing about existing programs.
3. Create incentives for partnerships. Universities should be rewarded, not punished, for working with practitioners.
4. Identify different ways of collaborating beyond recruiting. For example, use team teaching with academia and industry.

Public Relations

The following action items were identified:

1. Choose who should get the message first.
2. Develop talking-point cards, videos and other forms of targeted messaging.
3. Create a repository of content.
4. Develop messages that undergraduates would read and would inform them.
5. Award mini-grants for teachers. These provide more opportunities for publicity in the press.
6. Encourage partnerships between university faculty and K-12, since this can get states' attention.

Research

The following action items were identified:

1. Write a white paper on the top 5 challenges.
2. Identify, develop and centralize resources.

References and Links

[BPC collections in Engineering Pathways](#)

[Changing the Conversation](#) by the National Academy of Engineering

[Computational Thinking](#) by Jeannette Wing

[Computing Unplugged](#) by Tim Bell

[Ensemble](#) (Digital library for computing education)

[Georgia Tech Threads program.](#)

[Her Story: A Timeline of the Women Who Changed America](#) by Charlotte S. Waisman and Jill S. Tietjen

[Image of Computing](#)

[Learning Federation](#)

[New Image for Computing](#) by ACM and WGBH

[Outliers](#) by Malcolm Gladwell

[Rising Above a Gathering Storm](#)

[Taulbee survey](#)

[Why Choose Computer Science and Engineering by the University of Washington](#)

[Women's Underrepresentation in Science: Sociocultural and Biological Considerations](#)