EXPANDING 21st CENTURY SCIENCE LEARNING TO ENCOMPASS CIVIC REASONING ON SCIENCE ISSUES

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ABSTRACT

21st century cyber infrastructures for distributed learning, communication, and knowledge sharing are unprecedented in the opportunities they provide for global citizens to come together to try to solve the great global crises of our time. Science and scientific research plays a critical role, yet to solve these crises requires a range of skills and understandings that include, yet go beyond science. Without such skills and understandings, the cyber infrastructures have the potential to become powerful destructive rather than constructive tools. This white paper proposes an interdisciplinary way of conceptualizing this pantheon of skills and understandings, which we refer to broadly as civic reasoning. We overview and illustrate the characteristics of civic reasoning. Then, we propose lines of research for identifying models of how distributed communities leverage cyber infrastructures in the pursuit of discourse and problem-solving around the critical issues of our day. Finally we propose research that channels that understanding into looking critically at how educational programs may need to change to make this broad vision a reality.

WHITE PAPER

Overview

The 21st century citizenry is beset by unprecedented global scientific challenges yet advantaged by unprecedented knowledge building and knowledge sharing opportunities. There is great potential for distributed 21st century cyber infrastructures to catalyze the human deliberations and innovations that will be needed to meet the unprecedented challenges. Media and technologies can provide citizen scholars with access to organized bodies of information, but also with supports and resources for discussion and social debate, opportunities for joining existing communities and for forming new ones organized around common interests in important problems.

Civic innovativeness and constructive discourse about science issues in the 21st century and beyond will emerge from activities that take place within *socio-technical environments,* contexts in which there is interaction among people and artifacts (e.g., tools, technologies, designs, represented ideas that embody knowledge from various constituent communities). These complexly intertwined organizations are not only psychologically, socially and technically diverse, but also physically and temporally distributed (Hutchins, 2001).

This scenario has significant implications for the education of scientific and technically literate citizens who must develop skills enabling participation in distributed socio-technical communities, where people with different knowledge and backgrounds tackle complex, socially-important problems through cycles of controversy, action and resource-sharing over long periods of time. Science is critical in this scenario because good 21st-century cyber-using citizens need to understand enough about scientific phenomena and scientific research methods to make optimal contributions to the societal debates about controversial issues in science. 21st century cyber structures have the capacity to empower such citizens to constructively deliberate, innovate, and act. Yet, without proper education, the structures can facilitate instead the types of toxic outcomes that result when the utilizations are grounded in ignorance of science, ignorance of the role that science plays in society, and inadequate skills in how to communicate constructively on difficult issues.

Substantial literature has been generated among science education researchers pondering different methods for improving science education for better 21st century scientists and science technicians. For example, Ford and Foreman (2006) have surveyed innovative science education practices against different models of professional scientific practice. Their findings can contribute to exploring how cyber infrastructures can be utilized for a 21st century science learning program that expands the focus on training future scientists into that of training 21st-century citizens. Such citizens would learn enough science to apply it to a broad range of civic reasoning tasks and uses of cyber infrastructures. This broader pantheon of understanding aligns the concept of citizenship to the concept of "place" and expands both to encompass the concept of geographically expanding communities and expanding citizenries with personal and collective stakes in those communities.

To make these connections between science and civic-mindedness, we need to explore interdisciplinary connections between discipline specific scientific knowledge and practice and the larger societal functions and structures within which science operates. In addition to its motivational and civic value, this interdisciplinary learning approach has the potential to improve student understanding of the discipline specific science itself by showing how it interacts with larger societal phenomena. It requires a broadening of the concept of "citizen science" to encompass more than its current usage as a characterizer of educational programs such as Global Learning and Observations to Benefit the Environment program (http://globe.gov/) in which ordinary citizens provide data about their local areas to professional scientists. While important and valuable, these citizenship efforts are for the most part limited to the act of contributing to the pool of technical knowledge rather than to the broader civic pursuits within which scientific research plays a critical yet not exclusive role.

The six phases of civic reasoning

The dimensions of civic reasoning and societal issues around which a new set of interdisciplinary learning goals could be directed needs further elaboration through the research agenda suggested later in the paper. For now, one can conceptualize an idealized model consisting of six interacting phases of civic reasoning that characterize the way a society takes action to solve identified problems that have science components. These six phases require the carrying out of needs assessment, knowledge gathering, negotiation, policy making, and evaluation. In parentheses below are examples of prerequisite skills and understandings that a citizen would need to exercise critical civic reasoning at each phase. Each set of skills in the six phases is capable of being addressed in educational settings.

1. Seeking common ground and consensus around what constitutes problems and needs (prerequisites: constructive discourse capabilities, knowledge about place−past and present, self and community awareness)
2. Leveraging power structures to fund and support important avenues of scientific research (prerequisites: negotiation, decision-making, and leadership skills)
3. Designing and carrying out scientific research (prerequisites: scientific knowledge, skills in the design, execution, and analysis of discipline- specific inquiry)
4. Peer critique in scientific communities of practice (prerequisites: communication, principled constructive criticism)
5. Using findings to set policy or take other forms of civic action (prerequisites: designing action strategies, negotiation, decision-making and leadership skills; abilities to weigh options against multiple competing priorities; ability to weigh costs against benefits)
6. Evaluation of policy effectiveness (prerequisites: skills in designing, conducting, and analyzing evaluation options in different technical areas)

National and state standards indicate that most skill-building in K-12 science falls in phases 3 and 4, which are about accumulating canonical scientific knowledge and designing and carrying out discipline-appropriate scientific research, with some attention also to persuasively communicating and critiquing scientific results. They provide a myopic look into the world of science when in fact scientists are merely sets of specialized citizens who are immersed with everyone else in the broad struggle that the entire citizenry engages in to improve the world. A transformational interdisciplinary focus on all six phases could increase student understanding of scientific, social, economic, and cultural aspects of issues, increase students' abilities to practice reflection and meta-cognition about them, engage in productive discourse about them, and ponder the methodological challenges of evaluating effects of policies and actions taken to address them.

Example of a direction that an expanded civic reasoning program could take

There is precedent for such an expanded interdisciplinary approach in post-secondary education. For example, Stanford University's Science, Technology, and Society (STE) program is built around the idea that key educational objectives are "Understanding the natures, causes, and social consequences of scientific and technological developments, how science and technology function in different societies, and how social forces attempt to shape and control these forces to serve diverse, often conflicting interests." (http://sts.stanford.edu/qa.html).

The STE emphasis on recognizing and negotiating among diverse, often conflicting interests is one direction that a K-12 multidisciplinary civic reasoning learning program could take for engaging students better in the first phase of civic reasoning (i.e., seeking common ground and consensus around what constitutes problems and needs). A possible direction that this focus could take has precedence in constructivist K-12 science activities that prompt students to try solving "ill-structured" problems about real-world phenomena that have multiple dimensions and solution possibilities. Students are encouraged in these contexts to ponder solution options critically yet rationally, under the assumption that the focal situation is accepted consensually as constituting a “problem”.

Though prompting students to solve ill-structured problems is a step in the right direction, it does not go far enough. The real world is messy not only because problems do not have unequivocal solutions. It is also messy because, with some unequivocal exceptions such as natural disasters, one person or one group’s attribution of what issues constitute problems may not be another’s. The identifying of what constitutes a problem in the real world is often not amenable to social consensus and may only be partly the result of rational reasoning. Rather, values, social pressure, and perceptions of individual or collective self-interest compete with rational reasoning in the pantheon of contributors to decision-making about what constitutes a problem in the subjective mind of the beholder.

In pursuit of our first phase of civic reasoning, instructional programs can be devised that get students to (1) recognize the varying amounts of controversies surrounding the issues that drive scientific research, (2) understand what arguments frame the controversies, (3) struggle with whether a particular issue being addressed by scientific research is truly, in the student’s view, a problem, or a greater problem than other problems, (4) exercise self-awareness of the origins of their own positions in factors such as sense of personal or collective-self-interest, religious or ethical principles, social pressure, cost and benefit analysis (5) build greater empathy for sources of others' views, and (6) channel that understanding into deeper appreciation for what societal stakes frame the scientific research about the issue.

Research needs

Several research phases can be undertaken to clarify the characteristics of 21st century cyber-enabled knowledge building and discourse and then leverage the findings for transformative educational practices that address the full civic reasoning pantheon. First, harnessing distributed intelligence in the service of solving critical world problems is a complex challenge that is not understood and research must address it. We need to ask:

- How do successful communities create shared knowledge and common ground to support mutual learning and collaborative problem solving and decision making related to important world issues?
- If intelligence is distributed among people and tools and emerges in the process of problem solving, how do we educate citizens to improve distributed, not just individual, intelligence? (Hutchins, 1995)
- Rather than just creating reflective practitioners, how do we educate to create reflective communities?
- How does management distributed within and across communities emerge to facilitate work and collaboration in successful communities and how do we train young citizens to understand and participate in distributed leadership?

This line of research should be followed by critical examination of how well current educational programs prepare young people to effectively use cyber infrastructures for collective knowledge building and civic engagement on tough issues with scientific import. We know that there are already innovative attempts to engage in distributed knowledge building around science issues such as the Web-based Inquiry Science Environment (http://wise.berkeley.edu/) as well as virtual communities in which leaders from different fields work with students, share knowledge, and model being open-minded, reflective and appropriately critical while trying to integrate scientific knowledge in the processes of problem framing and solving. Yet, the extent to which these innovative projects catalyze attention to the full pantheon of civic reasoning remains to be determined.

Lastly, research and development efforts can explore what curricular, instructional, and institutional designs will permit these full utilizations. Harnessing the intelligence that is distributed throughout these organizations in service of solving the significant problems of our world is a complex challenge that is not understood and research must address it.

Conclusion

Is it in our students' interests and in the interests of society at large to recognize that scientists are merely technically specialized citizens who like all citizens need to understand science within the broad parameters of civic reasoning and engagement? Will students interested in a science career become better scientists if they are able to see their technical scientific endeavors within the greater context of all forms of civic reasoning and, as citizens themselves, hence be capable of exercising the skills and capabilities necessary to appreciate the challenges of the other phases as well? Will we all be better off if we can prepare students educated in the interdisciplinary dimensions of civic reasoning to become adept at utilizing cyber infrastructures constructively? If the answer is yes to these questions, we would have to agree that this research deserves pursuit.

Citations

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