Published in final edited form as:

Int J Sci Soc. 2012 August 1; 3(3): 31–44.

Teaching Environmental Health Science for Informed Citizenship in the Science Classroom and Afterschool Clubs

Alla Keselman¹, Daniel M. Levin², Savreen Hundal³, Judy F. Kramer⁴, Karen Matzkin⁴, and Gale Dutcher¹

¹Division of Specialized Information Services, US National Library of Medicine, National Institutes of Health, Bethesda, MD, USA

²Science Teaching Center, Department of Teaching and Learning, Policy and Leadership, University of Maryland College of Education, College Park, MD, USA

³Center for Public Service Communications contractor to Division of Specialized Information Services, US National Library of Medicine, National Institutes of Health, Bethesda, MD, USA

⁴ICF International contractor to Division of Specialized Information Services, US National Library of Medicine, National Institutes of Health, Bethesda, MD, USA

Abstract

In the era of growing concerns about human-induced climate change and sustainable development, it is important for the schools to prepare students for meaningful engagement with environmental policies that will determine the future of our society. To do this, educators need to face a number of challenges. These include deciding on the science knowledge and skills needed for informed citizenship, identifying teaching practices for fostering such knowledge and skills, and finding ways to implement new practices into the tightly packed existing curriculum. This paper describes two collaborative efforts between the U.S. National Library of Medicine (NLM) and University of Maryland College of Education that attempt to meet these challenges. The focus of both projects is on helping students develop information seeking and evaluation and argumentation skills, and applying them to complex socio-scientific issues that have bearing on students' daily lives. The first effort involves co-designing an afterschool environmental health club curriculum with an interdisciplinary team of middle school teachers. The second effort is the development and implementation of a week-long school drinking water quality debate activity in a high school environmental science classroom. Both projects center on Tox Town, an NLM web resource that introduces students to environmental health issues in everyday environments. The paper describes successes and challenges of environmental health curriculum development, including teachers' and researchers' perception of contextual constraints in the club and classroom setting, tensions inherent in co-design, and students' experience with socio-scientific argumentation.

Keywords

Environmental Health; Science Education; Middle Schools; Informed Citizenship; Science for All; Socio-Scientific Issues

Why should the public understand environmental health?

As a global society, we are becoming increasingly concerned about human impact on the environment and the resulting impact of the environment on human health. Environmental

health issues entered public discourse in the late 1800s. Throughout the 20th century, the public became increasingly concerned about water and air quality, radiation, declining energy resources, disposal of toxic wastes and potentially dangerous chemicals in food and household products. Needs for environmentally sound policies and practices grew in urgency, as we came to realize human potential for contributing to irreversible negative changes to the Earth's environment. A 2009 Nature paper proposed an approach for "identifying and quantifying planetary boundaries that must not be transgressed." The authors also pointed out that two of the nine boundaries they identified three (climate change, loss of biodiversity and human interference with the nitrogen cycle) have already been overstepped, so immediate action is needed to return them to safe levels (Rockström et al., 2009).

These circumstances require efficient, effective changes in many areas, from research to policy-making, which, in turn, require citizens willing to support these changes and to advocate for them. However, while many people are generally aware that human impact on the environment has negative repercussions, their knowledge lacks depth and details. For example, a Pew Global Attitudes Survey (2009) found that while "majorities [of the populations] in 23 of 25 countries agree that protecting the environment should be given priority, even at the cost of slower economic growth and job losses," individuals' beliefs are not always consistent. In 11 of the 25 nations that participated in the survey, majorities disagree that "people should pay higher prices to deal with climate change." When it comes to global warming, majorities in only 10 of the 25 countries, including the US, do not consider it a "very serious" issue (cited in Keselman, Levin, Kramer, Matzkin, & Dutcher, 2011). Gaps and inconsistencies in the public's dedication to environmental health issues may be partly related to their lack of understanding about the particulars of the negative health impact of environmental carelessness. For example, while many individuals are aware of drastic reduction in plant and animal species, fewer realize that the resulting ecosystems may affect crop pollination and thus diminish human food supply.

What does this mean for K-12 education?

As educators, we believe that introducing environmental health in middle and high school is essential for producing informed citizens who are able to handle environmental health challenges of the 21st century. How should we think about instruction that will best prepare people to become informed citizens in this area? Research on conceptual change in science education identifies several core competencies critical for applying scientific knowledge to "real world" situations (for more details, see Keselman, Kaufman, & Patel, 2004). Of these, we focus on two: 1) conceptual understanding and 2) reasoning and argumentation skills (the ability to build and defend a coherent viewpoint on the basis of the evidence). Conceptual understanding – as opposed to knowledge of simple, disjointed facts - is knowledge that characterized by reasonably deep understanding of causal links that connect related concepts. For example, knowing *that* climate change or water pollution are bad for human health does not have to entail conceptual understanding. In contrast, knowing *how* urban sprawl contributes to industrial run off and water pollution, or *how* climate change may produce direct and indirect health effects (e.g., rising winter temperatures leading to longer survival of infection-carrying insects) suggests conceptual understanding. Conceptual understanding provides the basis for reasoning about complex socio-scientific issues. Conceptual knowledge alone, however, is not sufficient for preparing students for informed participation in socio-scientific discourse. Such participation also requires skills that involve locating and evaluating information, forming a position that is supported by available evidence, revising it in the light of the new evidence if necessary, and making a convincing case to others. This skill set aligns with practices of argumentation. There is consensus in the science education literature that argumentation is a central practice of science, and that

learning to participate in argumentation is fundamental to learning science (Berland & Reiser, 2009; Duschl, Schweingruber, & Shouse, 2007; Kuhn 2010).

Objectives of the K-12 Environmental Health Initiative at the National Library of Medicine

The rest of this paper describes a collaborative effort between two entities: 1) the K-12 Group at the Division of Specialized Information Services of the National Library of Medicine (K-12 Group) and 2) the Science Teaching Center at the University of Maryland College of Education. The Science Teaching Center at the University of Maryland is represented by a faculty member in science education with an expertise in science teaching and science teacher education, and ten years of prior science teaching experience at the middle and high school levels (DML). The K-12 Group is comprised of educational researchers (AK, SH), and developers and outreach specialists with background in education, public health, and library science (JFK, KM, GD). It is part of the National Library of Medicine (NLM), an Institute of the National Institutes of Health, dedicated to collecting, organizing, and disseminating biomedical information. The Group develops and promotes Web resources in environmental health (and other specialized health sciences topics) for K-12 students and teachers and conducts research informing this development. One of such resources is Tox Town (<http://toxtown.nlm.nih.gov>), a Web site for independent use by students in grades 9 and above, or by teacher-supported use by students in grades 6–8, that provides information about environmental health concerns in everyday environments (see Figure 1). The site is organized into interactive graphic neighborhoods, and presents information on everyday locations and health effects of over 40 potentially toxic chemicals. For other environmental health education resources from the National Library of Medicine, see Appendix A.

The specific objectives of the effort we describe here were to create an environmental health curriculum that uses Tox Town, in order to 1) support students' developing understanding of environmental health and 2) support the development of argumentation skills. The project also aimed to conduct an ethnographic investigation of teachers' and students' engagement with the curriculum. We expected that this ethnographic research will provide information about teachers' and students' knowledge, skills, and values, and inform improvements to the curriculum.

Context and evolution of the project

Several conceptual and logistical tensions had to be resolved in developing the project. Research suggests that argumentation skills develop through sustained practice, over a period of multiple lessons (Kuhn, 2010). However, implementing a multi-lesson environmental health argumentation curriculum in the classroom context is challenging, because environmental health as a content area is typically not taught in the US. While teachers view environmental health as important and highly relevant to making science-society connections, the busy curriculum and the need to teach to standards and indicators do not leave much room for introducing new topics. To resolve this issue, we (the NLM / university group)¹ initially decided to develop a Tox Town argumentation curriculum for a middle school afterschool environmental health club, believing that the club context would be free of the classroom constraints.

The other tension had to do with deciding who should design the curriculum. Our view on the role of argumentation in scientific thinking is grounded in academic educational

¹Here and throughout the paper, "we" represents the collaborating authors from the NLM/NIH and the University of Maryland.

research, and we would like the findings of this research to inform curriculum development. However, in order to be truly successful, the curriculum needs to be a good fit for the school setting: attractive to teachers and students and fitting within various school constraints of a club or a classroom. Individual lessons need to conform to the length of acceptable meeting periods and to link to existing classroom curricula. Professionals with the greatest level of knowledge about the classroom context are, of course, teachers. Studies also suggest that when teachers participate in curriculum design, they are likely to implement it in a “planful and reflective” manner (Reiser et al., 2000), which can serve as a professional development opportunity for further learning about their own teaching. Thus, we elected to “co-design” this curriculum with a group of teachers, both to tap into their expertise in classroom-level considerations, and to provide them with an opportunity to explore planning and teaching for informed environmental citizenship.

The rest of this paper describes two related but distinct projects. The first is co-design of a middle school afterschool environmental health club curriculum with an interdisciplinary team of teachers. The second is a researcher-led design and implementation of a week-long debate activity in a high school environmental science classroom. The high school classroom activity was developed once we realized that the middle school club curriculum evolved to deviate from the initial researchers-set goals. The main aim of this paper is to describe the process of designing an environmental health curriculum with an argumentation focus and to characterize its challenges and actual and potential successes. While this is not a traditional research paper, each of the two projects involved a research component, intended to inform curriculum development. Methods and findings of accompanying research studies are included in the paper.

Co-designing a middle school afterschool club curriculum with an interdisciplinary teacher team

This project involved co-design of a middle school afterschool environmental health club curriculum by the NLM/university group and an interdisciplinary team of four middle school teachers: two science teachers, one English teacher, and one social studies teacher. All teachers were from the same school, located in an affluent Maryland suburb of Washington, DC. All had many years of teaching experience at the middle school level. These teachers were chosen to facilitate an interdisciplinary approach to socio-scientific issues. We (the NLM/university group) contributed expertise in Tox Town, science learning and curricular design research. The teachers provided expertise in the knowledge of the middle school learning context and curriculum.

The development process involved weekly group meetings over a period of one year, with some preparatory work done by the teachers in the interim. Group meetings involved both the NLM/university group and the middle school team members. All project members also regularly communicated via email. During the first semester we (the NLM/university group) led discussions about the importance of argumentation and different curriculum development frameworks, and modeled strategies for supporting argumentation. Teachers also participated in a two-team debate activity, arguing for or against installing vending machines with bottled water in the school. After two hours of research and preparations, each team presented its position and delivered a rebuttal to the other team’s presentation and closing remarks. During the second semester, the teachers developed six units of the club curriculum. The units were as following: 1) Drinking water quality, 2) Air quality, 3) Chemicals in household products, 4) Food safety, 5) Runoff and impervious surfaces, and 6) Bottled water vs. tap water debate. Each unit followed the same format, starting with a lesson in which the teacher introduced the topic and asked the students to investigate it via Tox Town (e.g., research dangerous chemicals in the drinking water). This was followed by

one or two lab experiments lessons (e.g., testing water in the school fountains for presence of chlorine). The final lesson involved an activity during which students had to communicate their results persuasively to other groups or individuals (e.g., creating a school radio announcement). We reviewed the units and made suggestions for revision. The project did not involve implementing the activities with the students.

Engaging teachers in curriculum co-design with researchers is valuable for two reasons. On the one hand, it gives researchers the benefit of access to teachers' invaluable professional expertise and knowledge of the classroom context. On the other hand, it presents professional development opportunity for teachers. Despite mutual benefits, co-design projects are rare, particularly in the afterschool context. Conducting an ethnographic investigation into the co-design process between teachers, researchers, and developers was one of the objectives of this project. We hoped that this research would help us gain insight into benefits and pitfalls of co-design, informing future researcher-teacher collaborations.

Data for the analysis of co-design came from two audio-recorded sources: 1) pre- and mid-project interviews with the teachers and 2) design meeting sessions. The interview questions focused on teachers' perspectives on environmental health, the roles of science in society and the goals of science education. The mid-study interview also focused on the perceived progress and success of the co-design process. All audio-recordings were transcribed for analysis. Transcripts were uploaded to NVivo qualitative analysis program. The coding scheme was developed in several discussion rounds, using a combination of research-objectives-driven and data-driven approaches. Sample coding categories include *goals of the club*; *argumentation*; *constraints*; and *beliefs about teaching*.

The analysis suggested that the most noteworthy aspect of the project was the degree to which the resulting curriculum deviated from the researchers' expectations. During the discussion of the first semester, we (researchers / developers) emphasized that building an effective argument is challenging for adolescents, because it requires such metacognitive skills as distinguishing between theory (what I believe) and evidence, selecting and interpreting evidence, and anticipating and pre-empting or rebutting an opponent's response. The development of strong argumentation skills requires sustained practice with many opportunities to review and revise an argument, and we anticipated a curriculum that would span a small number of content topics, but present multiple opportunities for examining and improving arguments. Instead, the actual curriculum was fast-paced, covering six separate topics. Although each unit included a lesson that required making a persuasive case, this was done as a culminating activity in the last lesson of the unit (e.g., writing a letter to parents or making a poster about the quality of school water) and did not involve evaluating and revising arguments.

Iterative analysis of the qualitative data provided a possible explanation for the shift in the course of the project. One way for researchers to understand tensions in the co-design process is by examining the deficits in teachers' knowledge and beliefs about science and student learning, as these knowledge deficits may limit teachers' ability to successfully collaborate with researchers. However, while teachers may have little background for thinking deeply about scientific argumentation, an explanation that focuses on individual deficits may be oversimplified and researcher-centric. A more complex and holistic understanding of these tensions can be understood through the theoretical lens of "framing."

Framing stems from a diverse history in cognitive science and sociolinguistics (Minsky, 1985; Tannen, 1993). Here, we define framing as an individual or collective sense of "What is going on here?" It involves an interaction between the contextual cues present in any given situation and the intellectual resources that various participants bring from prior

experience. Any particular community of practice (Wenger, 1998) includes shared ways of framing particular situations, or “professional vision” (Goodwin, 1994). We find that framing provides us with a useful theoretical framework for understanding the tensions inherent in curricular co-design that brings together stakeholders from different communities of practice, because it looks beyond individual beliefs and knowledge and considers the importance of context and shared understandings of practice.

Our analysis suggested that like many researchers, the teachers valued argumentation and saw it as a potentially powerful tool for helping students reason through problems and make informed choices. Teachers also valued the emotional intensity of argumentation, which helped sustain students’ interest in science. However, our analysis suggested that the teachers focused primarily on argumentation as a *kind of activity* that required sufficient preparation, rather than an integral component of any stage of science learning. This activity focus contributed to a superficial approach to the opportunities for argumentation—the teachers did not plan for opportunities to draw out or highlight the metacognitive and epistemological aspects of argumentation.

Teachers also differed from researchers in the objectives that they had for the club. The “official” objectives involved using Tox Town to support the development of argumentation skills in the context of environmental health education. While teachers agreed with the researchers-proposed objectives, they also had other objectives, which had to do with how they perceived the constraints of the club. As teachers were very much aware that participating in an afterschool club was optional for the students, one of their goals was making the curriculum highly engaging and “fun”. Thus they planned a curriculum that made much space for “hands-on” activities, minimizing the time for searching and discussing information, which they expected the students would find tedious. Although the club did not have to adhere to any particular content indicators, teachers wanted it to cover a broad range of content topics. Consequently, teachers were quite concerned about time constraints. With the perceived need to cover a broad range of topics, to make the club “fun” and to limit each lesson to the 45 minutes, teachers felt that they had little time to introduce argumentation activities once the “mandatory” hands-on laboratory exercises were completed. If we consider the teachers’ collective *framing* of the after-school club design context as an exercise in creating a “fun” curriculum that covered a lot of topics in a short time, we can understand why argumentation would get short shrift, even if teachers purported to value it.

The year we spent working with middle school teachers resulted in a unique curriculum that combines Web information-seeking and hands-on laboratory activities and prompts students to use their knowledge to engage in the social discourse about environmental health. It also introduces students to many important environmental health topics. As such, the effort should be considered a success. On the other hand, while teachers’ expertise brought unanticipated strengths to the curriculum, this curriculum did not meet the objective of supporting the development of argumentation skills. As researchers, we came to appreciate the power of framings that different stakeholders bring to the co-design process. Perhaps, to maintain argumentation focus in future collaborations with teachers we need to spend more time on specific modeling of metacognitive and epistemological aspects of argumentation. Since we as researchers are ultimately accountable for the outcome of our curriculum development work, we may also have to maintain the final decision-making and veto power, working with teachers as advisors. Finally, we need to recognize that teachers’ framing is valid, and deserves consideration. An afterschool club, with its pervasive emphasis on entertainment, may not be the ideal place for supporting the development of argumentation skills. These conclusions lead to another curriculum development project, which involved a

science teacher as an advisor rather than a co-designer. The project is discussed in the next section.

The School water use and safety legislative hearing in a high school environmental science classroom

This activity was developed by our research team, as an extension of the debate activity that we used to model an argumentation-based science activity for middle school teachers in the previous project. In order to accommodate a public school class-size group, we transformed the two-team debate into a mock state legislative hearing (DeGasperis, 1998). The premise of the activity is that a legislative committee needs to develop a policy governing school drinking water safety. In particular, the following questions need to be addressed:

- Should the committee suggest the legislature pass a law to require schools to sell bottled water?
- How often should the committee recommend that drinking water be tested? Who should test it?
- What kind of labeling should be required of bottled water sold in school?
- Should the legislature regulate or subsidize bottled water sold in schools?

In order to reach a decision, the committee is taking testimony from various interest groups. The groups represent stakeholders who would have different perspectives on these issues, such as bottled water associations, environmental groups, and water treatment plants. Students in the class are assigned either to the legislative committee, or to one of the interest groups. The task of the committee is to use Tox Town to develop questions and the procedure for the hearing. The committee then conducts the hearing, deliberates, and produces a policy decision. Interest groups are tasked with preparing a position statement that reflects their group's perspective, delivering an initial presentation, revising it to address questions and presentations from the other groups, and conducting the final presentation and closing remarks (for a detailed description, see Levin, Kramer, Keselman, & Whitlock, in press).

The curriculum was pilot-tested in a Washington, DC charter high school, serving a primarily minority, low SES community, in a combined 11th and 12th grade environmental science class, in a sequence of six lessons. Nineteen students participated. The environmental science teacher, who was in her sixth year of high school teaching, reviewed the curriculum and supported the project by scaffolding students' discussion as needed, along with the researchers. During the first lesson, we introduced the activity, explained the hearing procedure and assigned roles to the students. The second lesson involved becoming familiar with Tox Town's structure and resources. This was followed by two lessons (lessons 3 and 4) during which students searched Tox Town and prepared their presentation for the hearing. The initial hearing took place during lesson 5. Lesson 6 involved preparing and delivering rebuttal speeches and closing remarks and the committee making its decision.

As mentioned previously, the development of strong argumentation skills requires sustained practice. While not expecting to see a dramatic improvement in the students' scientific argumentation as a result of this pilot, we were nevertheless interested in their emergent skills and appreciation of argumentation in science. The project involved different types of assessment. The first was informal continuous formative assessment (e.g., Black & Wiliam, 1998) which occurred throughout the curriculum sequence, as three researchers and the classroom teacher moved from group to group, listening to students' ideas and arguments, and asking questions and making comments that encouraged students to reflect on the

strengths and weaknesses of their argument. Classroom sessions were video-recorded and transcribed for analysis. In addition to this continuous assessment, we asked students to complete pre- and posttest questionnaires, producing written arguments about two environmental health-related issues that were not discussed in class (climate change and carbon emissions). Both the informal formative assessment and the pre- posttest questionnaire analysis focused on noting whether students a) drew on evidence to support their positions, b) anticipated counter-arguments and gathered evidence to refute them and c) rebutted challenges to their arguments. Finally, at the time of the posttest we also asked students to write about their *personal* opinion on the issue raised in the hearing and about their opinion of the hearing as a science classroom activity.

Student participants in the project needed support in order to develop arguments and counter-arguments. Statements and written responses made by the students illustrate why anticipating an opponent's position is both challenging and valuable. For example, one student said during the introductory lesson, *"It's hard to think about what [the other side] would say because I've got my own ideas."* During the post-questionnaire, another student illustrated the value of "trying on" a position that is different from one's own, *"Supporting something that you don't agree with really makes you see from a different perspective."* Overall, students were engaged and enthusiastic throughout the lessons, and commented during the posttest that they found the activity interesting and valuable (in some cases, despite their initial skepticism). While initial hearing testimonies sounded stilted as students read them from their power point slides, subsequent discussions and rebuttals became animated and much more fluid. Students were able to challenge each other's position and respond by providing additional information. At the same time, one week of argumentation training was, of course, not sufficient to produce deep learning that would transfer to other domains, and posttest arguments about carbon emissions and global warming were not much different from the pretest. Moreover, despite our frequent reminders that the hearing was about developing a policy, it was hard for students to overcome the view of argumentation as competition. Upon returning to the room after deliberations, the committee pointed at the one of the groups and announced, "They win!"

Conclusions and future directions

Our experience with middle and high school teachers and with high school students suggests that both students and teachers are concerned about environmental health issues and find this area of study valuable and relevant to their lives. This makes environmental health a promising area for teaching science in a socially engaging way and for helping students combine scientific knowledge with the ability to argue and communicate. In addition, our high school project provides some evidence that preparing and revising socio-scientific arguments on a single topic can sustain students' interest over a course of several lessons, though more data is needed to confirm this.

At the same time, our efforts suggest that introducing argumentation about environmental health topics into schools is a challenge. While students may find argumentation engaging, they have little experience arguing about socio-scientific issues. Developing solid argumentation skills requires overcoming a number of epistemological and metacognitive barriers (e.g., understanding the importance of anticipating and pre-empting the opposition), which is not likely to happen in a week's time. Effective interventions need to be long and focused, evoking the tension between the need for in-depth sustained engagement and the pressure to cover large amount of content. To conduct successful school intervention, researchers and developers may need to advocate for their approach with school administrators. They may also need to look for creative interdisciplinary approaches of situating their curriculum across a range of school subjects.

While teachers are concerned about environmental health and value argumentation in the classroom, their view of argumentation often differs from researchers'. In addition, contextual priorities may take precedence over argumentation. This reality may call for the need to rethink the process and the nature of co-design. One possibility is spending more time explaining argumentation challenges and modeling argumentation activities. Another is testing different division of tasks and responsibilities among team members. For example, in our middle school curriculum development process, researchers developed overarching objectives, presented a theoretical framework to justify them, modeled activities, and provided feedback. Teachers took the lead in designing activities. Another approach would be for researchers to go beyond providing teachers with the framework / objectives, developing detailed specifications for the activities. Yet another possibility is to ask teachers to provide detailed feedback on the researcher-developed lessons.

Our team intends to continue working on curriculum development, creating modules in several areas of environmental health to integrate argumentation, content, and socio-scientific issues. We hope that when taught as a semester-long or a year-long sequence, these lessons will not only engage the students and make them see issues from a point of view different from their own, but will also enable them to develop solid arguments on novel topics that require information research. We encourage other science education researchers and practitioners to develop curriculum using Tox Town and other authoritative resources to engage students in socio-scientific argumentation.

Acknowledgments

The authors are very grateful to the student participants, and to the teachers who contributed their time, experience, and creativity to this initiative. This work was supported in part by the intramural research program of the National Library of Medicine.

References

- Berland L, Reiser B. Making sense of argumentation and explanation. *Science Education*. 2009; 93(1): 26–55.
- Black PJ, Wiliam D. Inside the black box: Raising standards through classroom assessment. *Phi Delta Kappan*. 1998; 80(2):139–148.
- DeGasperi S. Activity description of "Animal Welfare Hearing". 1998 from <http://www.accessexcellence.org/AE/ATG/data/released/0228-ScottDeGasperi/description.php>.
- Duschl, RA.; Schweingruber, HA.; Shouse, AW., editors. Taking science to school: Learning and teaching science in grades K-8. Washington, DC: Committee on Science Learning, Kindergarten through Eighth Grade; 2007.
- Goodwin C. Professional vision. *American Anthropologist*. 1994; 96(3):606–633.
- Keselman A, Kaufman DR, Patel VL. "You can exercise your way out of HIV" and other stories: The role of biological knowledge in adolescents' evaluation of myths. *Science Education*. 2004; 88(4): 548–573.
- Keselman A, Levin DM, Kramer JF, Matzkin K, Dutcher G. Educating young people about environmental health for informed social action. *Umwelt und Gesundheit Online (Environment and Health Online)*. 2011 from <http://www.electronic-health-journal.com/documents/U&G%20Keselman%20et%20al.%202011.pdf>.
- Kuhn D. Teaching and learning science as argument. *Science Education*. 2010; 94(5):810–824.
- Levin DM, Kramer JF, Keselman A, Whitlock B. Integrating environmental health issues and argumentation through Tox Town: The school water use and safety legislative hearing. *Science Teacher*. (in press).
- Minsky, M. *The Society of Mind*. New York City, NY: Simon and Schuster; 1985.

- Pew Global Attitudes Project. Global Warming Seen as a Major Problem Around the World. Pew Research Center Publications. 2009 from <http://pewresearch.org/pubs/1427/global-warming-major-problem-around-world-americans-less-concerned>.
- Reiser, B.; Spillane, J.; Steinmuller, F.; Sorsa, D.; Carney, K.; Kyza, E. Investigating the mutual adaptation process in teachers' design of technology-infused curricula; Paper presented at the Fourth International Conference of the Learning Sciences; 2000.
- Rockström J, Steffen W, Noone K, Persson Å, Chapin FS III, Lambin EF, Lenton TM, Scheffer M, Folke C, Schellnhuber HJ, Nykvist B, de Wit CA, Hughes T, van der Leeuw S, Rodhe H, Sörlin S, Snyder PK, Costanza R, Svedin U, Falkenmark M, Karlberg L, Corell RW, Fabry VJ, Hansen J, Walker B, Liverman D, Richardson K, Crutzen P, Foley JA. A safe operating space for humanity. *Nature*. 2009; 461:472–475. [PubMed: 19779433]
- Tannen, D. *Framing in Discourse*. New York: Oxford University Press; 1993.
- Wenger, E. *Communities of Practice: Learning, Meaning, and Identity*. Cambridge, MA: Harvard University Press; 1998.

Appendix A. Selected environmental health education resources from the National Library of Medicine

ToxMystery (<http://toxmystery.nlm.nih.gov/>) is an interactive Web game designed to help teach children ages 6–10 about hazardous substances commonly found in the home.

Environmental Health Student Portal (<http://kidsenvirohealth.nlm.nih.gov/>) targets students in grades 6–8 and include sections on *Air Pollution*, *Chemicals*, *Climate Change*, and *Water Pollution*.

Household Products Database (<http://hpd.nlm.nih.gov/>) provides information about potential health effects, safety and handling of over 10,000 brands of household products.

TOXMAP (<http://toxmap.nlm.nih.gov/toxmap/main/index.jsp/>) uses maps of the United States to help users visually explore data from the US Environmental Protection Agency (EPA)'s Toxics Release Inventory (TRI) and Superfund Program.

Figure 1.
Tox Town (<http://toxtown.nlm.nih.gov>)