DRAFT

Creating a K-12 Learning Progression for Environmentally Literate Citizenship: Developing Frameworks for Exploring Relationships among Student' Identities, Understanding, and Reasoning about Issues

Blakely K. Tsurusaki, Beth Covitt, and Charles W. Anderson
Michigan State University

This research is supported in part by two grants from the National Science Foundation: the Center for Curriculum Materials in Science (ESI-0227557) and Long-term Ecological Research in Row-crop Agriculture (DEB 0423627. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Introduction

In today's world of complex science, complex society, and predictions of human-caused global change, what does it mean to be an environmentally literate citizen? Though this is not a simple question to address, we choose to explore it because of the important implications environmental citizenship has for how we will live our lives on Earth in the coming decades. We explore this question as part of a project seeking to develop a succinct and coherent framework for environmental science literacy that could be integrated into K-12 science education in the United States. One of the primary goals for our overall project is the development of K-12 learning progressions for environmental science literacy. These learning progressions outline both upper anchors (what students should know and be able to do by the time they graduate from high school) and lower anchors (grounded research about students' understanding, practices, and reasoning at various age levels). The carbon, biodiversity, and water strands of our project are developing learning progressions that emphasize students' abilities to tell and use scientific accounts. The citizenship strand is interested in developing a framework for how students apply their scientific knowledge to make decisions in their daily practices.

Because we focus on science education, our project has a clear emphasis on specific aspects of environmental literacy (e.g., understanding of environmental systems), and less emphasis on other aspects (e.g., understanding of social, economic and political systems). While we agree that both science and social science understandings and practices are essential to environmental literacy, we have narrowed our scope of study to what is still a large area to explore- understanding how people can use scientific understandings and practices as tools for effective citizenship. We define environmental science literacy as possessing the ability to recognize personal agency with respect to environmental issues, understand and evaluate arguments among experts, and reconcile actions or policies with one's values. We have identified three key practices that we believe encompass environmental science literacy. We suggest that individuals who have environmental science literacy can:

1. engage in *scientific inquiry* to develop and evaluate scientific arguments from evidence
2. use *scientific accounts* of the material world as tools to predict and explain
3. use scientific reasoning in *citizenship practices* of environmental decision making

This companion paper to the other environmental literacy project papers presented at the KSI addresses the citizenship strand. The citizenship strand is different from the others strands in that our work is complimentary to rather than parallel to the other strands. Whereas the other strands (including carbon cycling, biodiversity, and water) are exploring how students come to develop understanding and practices around scientific inquiry (practice 1), and using scientific accounts (practice 2), this strand focuses on how students apply, and develop the capacity to apply, their understanding of environmental systems to the decisions they make within the various citizenship roles that they play in their lives (practice 3).

Individuals play multiple roles in their lives which, whether they think about it or not, are related to the environment and environmental issues. They are learners, consumers, voters, workers, volunteers and advocates. For all of these roles that individuals play, we believe that K-12 science education can and should provide important preparatory experiences. Science education provides a unique opportunity to help students develop connected understandings

about how the world works and, importantly, about how our individual and societal actions impact the world as it works. In other words, school science can help prepare students to understand, navigate, and make decisions within coupled human and natural environmental systems; school science can help prepare environmentally literate citizens. This may sound like an obvious goal, yet in reality, few K-12 students engage in an extended sequence of science education that helps them develop the understandings and the capacity to engage in these practices. Instead, for instance, learning about ecology is often presented without the inclusion of human engineered systems. Thus, students do not learn about how human engineered and natural systems are connected and how humans impact the natural environment. Or students learn about the water cycle as a story or series of steps instead of as processes that move water and other materials through multiple systems. In other words, they do not develop model-based reasoning. While students may be able to tell the science textbook story of the water cycle, they cannot trace water and other substances that move with water through human engineered and natural systems.[1]

These are just two examples of how current practices in science education often fail to prepare students for the variety of environmental citizenship roles they play throughout their lives. For example, students do not recognize that the choices they make, including what house they live in and how they may take care of a lawn, impact the ability of the essential services of the water cycle to continue in a sustainable fashion. We believe that understandings about environmental systems, human impacts on environmental systems, environmental values (i.e., biodiversity), and environmental services (i.e., food, water, energy) should be central learning goals for K-12 science education.

Literature Review

Evidence suggests that most Americans are poorly equipped with the scientific understanding needed to make informed decisions about issues that include scientific components (National Science Board, 2004). And yet, individuals regularly do encounter these issues and make de facto decisions in their day to day lives. Socio-ecological issues confront us with a need to make *decisions associated with arguments from evidence* under circumstances where both the decision and the evidence are contested. The decisions can be either personal decisions (e.g., what products to buy, how to vote) or decisions made by others (e.g., judges, school boards, legislatures) in which we have a stake. The arguments come from more or less trustworthy sources and are based on more or less compelling evidence.

Citizens may recognize the importance of socioscientific issues, but find them perplexing (Kolstø, 2001). Our goal is to understand how individuals understand socioscientific issues and how they engage with these issues. Previous work provides a starting point for this research. For example, we know that individuals rely on different resources and strategies (epistemological stances) for developing their understanding of the world (e.g., Belenky, et al., 1986; Hofer & Pintrich, 1997; Perry, 1970). An individual's epistemological stance reflects how they answer questions such as what makes for a good source of knowledge, what counts as evidence, how do I decide what's true, how certain can anyone be about what is true? Scientists and non-scientists

[1] We define model-based reasoning as the ability to use patterns in observations of phenomena (i.e., laws) and models or theories to explain and make predictions.

often answer these and other epistemological questions in very different ways. It is possible to help individuals develop epistemological stances that are more in line with standard conceptions of scientific reasoning, but such processes require concerted, long term educational efforts, and are never quick or easy (Smith & Anderson, 1999).

We also know that people often make decisions about issues in ways that scientists would not consider to be purely rational or logical. Decision research suggests that people use two different kinds of processes as they reason and make decisions. One system is explicit and analytical; it is based on arguments about evidence, interests and values. The other system is tacit and experiential; it is based on individuals' identities, emotions and personal affiliations (Slovic, 2006). When relying on the experiential system, individuals often rely on psychological biases or heuristics in decision-making. For example, social norms (e.g., identities and affiliations) can play a large role in how people make decisions (Fleming, et al., 2004). In the experiential system, affect or emotion about an issue is also likely to outweigh logic as a factor in decision making (Arvai, 2004). Although all people use both systems under different circumstances, the analytical system is more often associated with scientific thinking, and the experiential system is more often associated with non-scientific or lay thinking and decision-making.

Thus, we know that scientists and non-scientists come to understand the world in different ways, use very different mental models to reason about the way the world functions, and consequently often make different decisions about what to do (Kempton, Boster, & Hartley, 1996). Mental models, "simplified representation[s] of the world that allow one to interpret observations, generate novel inferences, and solve problems," are generated over time, as individuals actively make sense of their world and their experiences (Kempton, et al., 1996, p. 10). Because individuals who share similar social groups, cultures, and environments often share similar experiences, they sometimes develop similar mental models for phenomena. When a similar mental model is shared within a group of people, it is referred to as a cultural model. Both scientists and non-scientists use mental models because they are a useful tool for navigating what could otherwise be an overwhelmingly complex world (Kempton, et al., 1996). Although scientific models and mental models are both useful tools, they are sometimes at odds with one another. Furthermore, these differences often arise within the context of important science in social issues (e.g., teaching evolution in schools). When people are confronted with information that does not fit into their mental map, a common response is to dismiss or reject the new information (Harmon-Jones & Mills, 1999). Unfortunately, this human tendency is in conflict with one important goal of science education, which is to help students integrate more scientific understanding into their mental models.

In the citizenship environmental literacy strand we are interested in exploring individuals' pre-existing knowledge, beliefs, attitudes, epistemological stances, etc. related to science in social issues; how they integrate new information and experiences (i.e., through classroom science) into their perspective about an issue; and how they make decisions about an issue. To this end, we explore three aspects of citizenship decision-making.

1. **Who do you trust? (Reasoning about SOURCES of information)** Citizens have access to multiple sources of information, making different and sometimes contradictory claims. How do students evaluate the credibility of different sources.

2. **What's the evidence? (Reasoning about ARGUMENTS or positions and supporting evidence)** Some sources of information give citizens access to scientific evidence in various forms and media and arguments based on that evidence. How do students use evidence to support their arguments?

3. **What should we do? (Reasoning about what course of action or POSITION to take)** Citizens have opportunities to explore different alternatives and to choose or identify their own course of action or position. How do they make sense of the different positions and possible consequences? How do they assess the desirability of different positions?

Relevant Prior Research

The research design will draw on and extend prior research with respect to each key question. In this section we summarize some of the prior research most compelling and relevant to the current study for each question.

1. Who do you trust? (Reasoning about SOURCES of information)

Some explanation of how people process information from different sources is provided in the Elaboration Likelihood Model (ELM) (Petty & Wegener, 1999). The ELM suggests that when people are forming attitudes about an issue, they may follow either a central or a peripheral route of processing information. When following a central processing route, they invest greater amounts of energy and thought in the development of their position. The two factors that most influence which route is followed are motivation and ability. If a student is interested in an issue (motivated), she/he is more likely to spend energy investigating the issue. If she/he has a greater ability to critically evaluate the presented information, she/he is better poised to develop her/his understanding of the issue. To the extent that a central route of processing is followed, people will tend to judge source credibility based on scrutinizing evidence rather than on extraneous characteristics such as source attractiveness. One additional relevant cue to which route people take is their perception of the credibility of the source itself. When sources are perceived as high in credibility, individuals are more likely to engage in critical consideration of the information presented (Eagly, Wood, & Chaiken, 1978).

2. What's the evidence? (Reasoning about ARGUMENTS and supporting evidence)

Arguments may be grounded in scientific data that were collected, analyzed and interpreted with respect to the scientific method or they may be grounded in non-scientific ways of knowing such as theological beliefs, social norms, or subterfuge. It is important for people to be able to distinguish between knowledge claims grounded in scientific evidence, and knowledge claims grounded in non-scientific ways of knowing, when engaged in decision-making with respect to socioscientific issues. An understanding of the nature of scientific knowledge is also an important component in one's evaluation of the authority of scientific evidence (Sadler, 2004).

Research on individuals' epistemological stances informs our understanding of how people adopt different perspectives when deciding what they believe. Studies by Perry (1970) and Belenky, et al., (1986) suggest some of these varied perspectives. For example, Perry, found that over time, male college students moved from seeing the world in absolutist terms, to acknowledging a diversity of perspectives, through identifying personal commitments among relativistic possibilities. Working with women, Belenky, et al., (1986) found perspectives

including silent obedience to authority, valuing personal intuitive understanding, and integration of personal understanding with knowledge gained from others. The stance that an individual adopts influences the way she/he interacts with arguments and evidence of a socioscientific issue. One educational goal is to help individuals understand their strategies or approaches for assessing evidence (their epistemological stance) and the epistemological strategies that communities of scientists use to develop shared understanding of the material world.

Other factors also impact individuals' ways of dealing with arguments and evidence. For example, whereas scientists place high value on arguments accompanied by statistical evidence, non-scientists are often more swayed by arguments accompanied by graphic or personalized information (Arvai, 2004; Slovic, 2006). Heuristic biases are human tendencies to rely on simplified versions of information to reduce the complexity of processing (Tversky & Kahneman, 2000). The reliance on heuristic biases is well documented in human information processing and decision-making. It is important to understand possible heuristic biases student use in their decision-making.

3. What should we do? (Reasoning about what course of action or POSITION to take)

Expectancy of success and the value placed on a task have been described as critical variables in mediating motivation to learn (Brophy, J., 1998). Since expectancy and value are multiplicative in Brophy's framework, if either of them equal zero, then motivation also equals zero. In a somewhat overlapping framework, Doyle (1993) describes meaningful and challenging work as involving risk (the risk of failure) and ambiguity (uncertainly related to the task). These two frameworks may be helpful in understanding how students assess alternatives, risks, values, and uncertainties associated with socioscientific positions.

The process of decision-making is always complicated by limited information; there are usually aspects of uncertainty involved in any decision. When consciously considering risk, probabilities of outcomes are known. When dealing with uncertainty, even probabilities are not known (Zeckhauser and Viscusi, 2000). Whether dealing with risk, uncertainty, or both, in the end few people consciously engage in the weighing of expectancy, value, risk or ambiguity as they decide what to do. Instead, people generally rely on simplified understanding constructed through the use of heuristic principles (Tversky & Kahneman, 2000). One example is availability bias, where people judge the probability of an event based on the ease with which such an event can be brought to mind. An instance of availability bias would be a person thinking that traffic accidents are more likely to occur for a time after driving past a car that is overturned on the side of the road (Tversky & Kahneman, 2000). Such biases can impact individuals' decision-making processes. For example, a person who drove by an accident might decide to buy an SUV because they perceive that accidents are common (expectancy of outcome) and that SUVs are safer for passengers in an accident (value of outcome).

Lay ways of making decisions are useful and necessary in everyday life. Without these decision-making shortcuts, we would get bogged down in information processing and have little time left for actually doing anything. Still, when dealing with socioscientific issues that have important policy implications (e.g., what level of climate change we may face in the future), there is a societal interest in helping people consider scientific, analytical decision-making processes as well.

Methods

Scenarios

We developed interviews to help us ascertain how students understand and engage in citizenship issues. The interviews focused mostly on issues that we defined in advance. We presented students with tasks or issues and investigated how the students reasoned about their choices.

Thinking and Making Decisions about Purchasing Strawberries (Strawberry Interview)

For this interview, the students were asked to complete two ordering tasks (see Appendix A). First they were asked to order various food products from what they deemed most nutritious to least nutritious. This task positioned students as consumers. It focused on the *environmental systems services* arrow of the Loop Diagram (see Figure 1). Next, they were asked to order the same food products from what they thought was most environmentally friendly to least environmentally friendly. While the first task focused on the environmental system services arrow, the second task focused on the *human actions with environmental impact* arrow. In both ordering tasks, they were asked to explain why they ordered each product as more or less nutritious/environmentally friendly than other products.

Thinking and Making Decisions about a Proposed Water Bottling Venture (Water Interview)

The water citizenship interviews had several parts (see Appendix B). First, the students were asked some general questions about how people use water, how they personally use water, preferences for drinking bottled versus tap water, and their understanding of environmental impacts of different uses of water. Next, the students were introduced to a true scenario about a company that would like to build a new well in Michigan to enlarge their water bottling business. After being introduced to the scenario the students were first asked some questions to find out how they understood the science around the scenario. Next, the students were asked some questions about how, as citizens, they would respond to the water bottling issue. In the course of the citizenship section of the interviews, the students were presented with some additional information from different stakeholders. The students could use the additional information to inform their positions and decisions with regard to the issue. Two interview protocols were used: a high school protocol and a middle school protocol in which the additional information was abridged.

Participants

We interviewed 6 students for the strawberry interview: 3 high school and 3 middle school students. For the water interview, we interviewed 19 students: 11 high school, 4 middle school, and 4 upper elementary school students.

Analysis

For this paper, we transcribed 6 strawberry interviews and 6 water interviews. We used the Loop Diagram for Environmental Science Literacy (Figure 1) and developed and used the Environmental Decision Making Process framework (Figure 2) to guide our analysis.

Frameworks for Environmental Science Literacy

In our analysis, we draw on two frameworks to help us explore how students understand and reason about environmental topics. The first framework is the loop diagram adapted from the LTER ISSE report (LTER Planning Committee, 2007). It helps us assess student understanding of the structure of coupled human and natural systems. For example, do students understand the processes of environmental systems (i.e., tracing water through multiple systems)? The second framework is the environmental decision-making process diagram that we have developed to describe the process of reasoning that students may go through as they make decisions about environmental topics.

The loop diagram for environmental science literacy (Figure 1) provides a framework for examining the structure of students' understanding of coupled human and natural environmental systems. This diagram focuses on four aspects: human communities, environmental systems, human actions with environmental impact, and environmental system services.

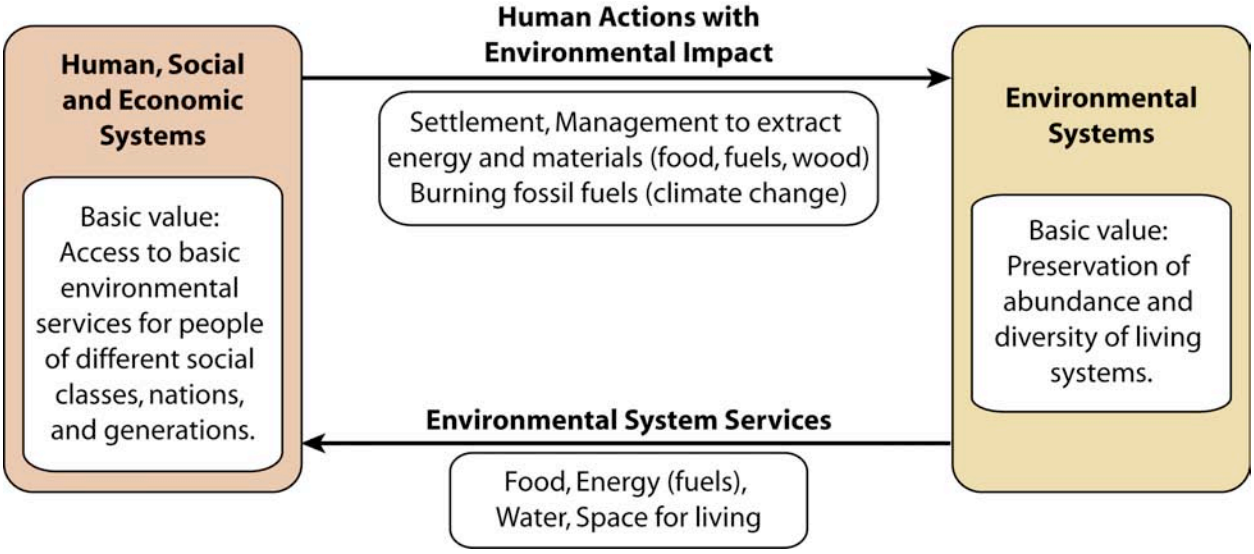

Figure 1: Loop Diagram for Environmental Science Literacy
(Structure of Understanding about Connected Human and
Natural Environmental Systems)

1. ***Human communities:*** Focus on students' awareness and understanding of social science issues such as economics, politics, and sociology as well as how students express anthropocentric types of values.

2. ***Human actions with environmental impacts:*** Focus on students' awareness and understanding of how human actions including settlement, management to extract energy and materials and the burning of fossil fuel impact the sustainable functioning of environmental systems.

3. ***Environmental systems:*** Focus on students' awareness and understanding of environmental systems science as well as how students express ecocentric types of values such as preservation of biodiversity.

4. ***Environmental systems services:*** Focus on students' awareness and understanding of essential services that environmental systems provide including food, energy, water and space for settlement.

We believe that students need to have understanding of all four aspects of this loop diagram and how they interact in order to be environmentally literate.

The environmental decision-making process diagram (figure 2) provides a framework for examining how students reason about environmental topics and issues. We are interested in how students draw on their understanding of coupled human and natural systems (Figure 1, loop diagram) in making decisions about environmental topics or issues. While the loop diagram (Figure 1) focuses on student understanding of coupled human and natural systems, this framework focuses on aspects that may influence decision-making.

- Global Perceptions of the World: What types of issues or practices do students perceive as environmental issues? For example, do students see the choices that they make at a supermarket (the food they choose to buy) as an environmental issue?

- Local Framing of Self and Situation: Two facets play a role in how students frame an issue: Who am I?; and their initial perception/framing of the situation. We view these facets as reflexive (e.g., student personal identity may influence how one frames an issue).
    - Who am I?: Individuals' perceptions of personal identity, roles and agency. For example, do students see themselves as individuals who are concerned about the environment? Smart? Do they identify with particular recreational activities or occupations with particular values? Do students think that they can actually make a difference? Which citizenship roles do students see themselves playing (i.e., consumer, voter, etc.)?
    - Initial perception/framing of situation: Students may frame issues based on cultural models. For example, do students see an issue as a human consumption issue? In other words, do students view an issue as simply one of which product to buy according to their values? Or do students frame an issue in terms of environmental impact? Do they consider how their decisions/actions impact the environment?

- Deciding About Issue and/or Action: Do students make immediate decisions based on their perception of a situation without considering environmental impacts of their decisions? Or do students make conscious decisions, reasoning through the three criteria of responsible

decision-making (who do I trust, what is the evidence, and what do I understand and what information do I need). We see these as two ends of a decision-making continuum. Students may use varying amounts of understanding and reasoning to make decisions depending on their prior knowledge, personal identity, etc.

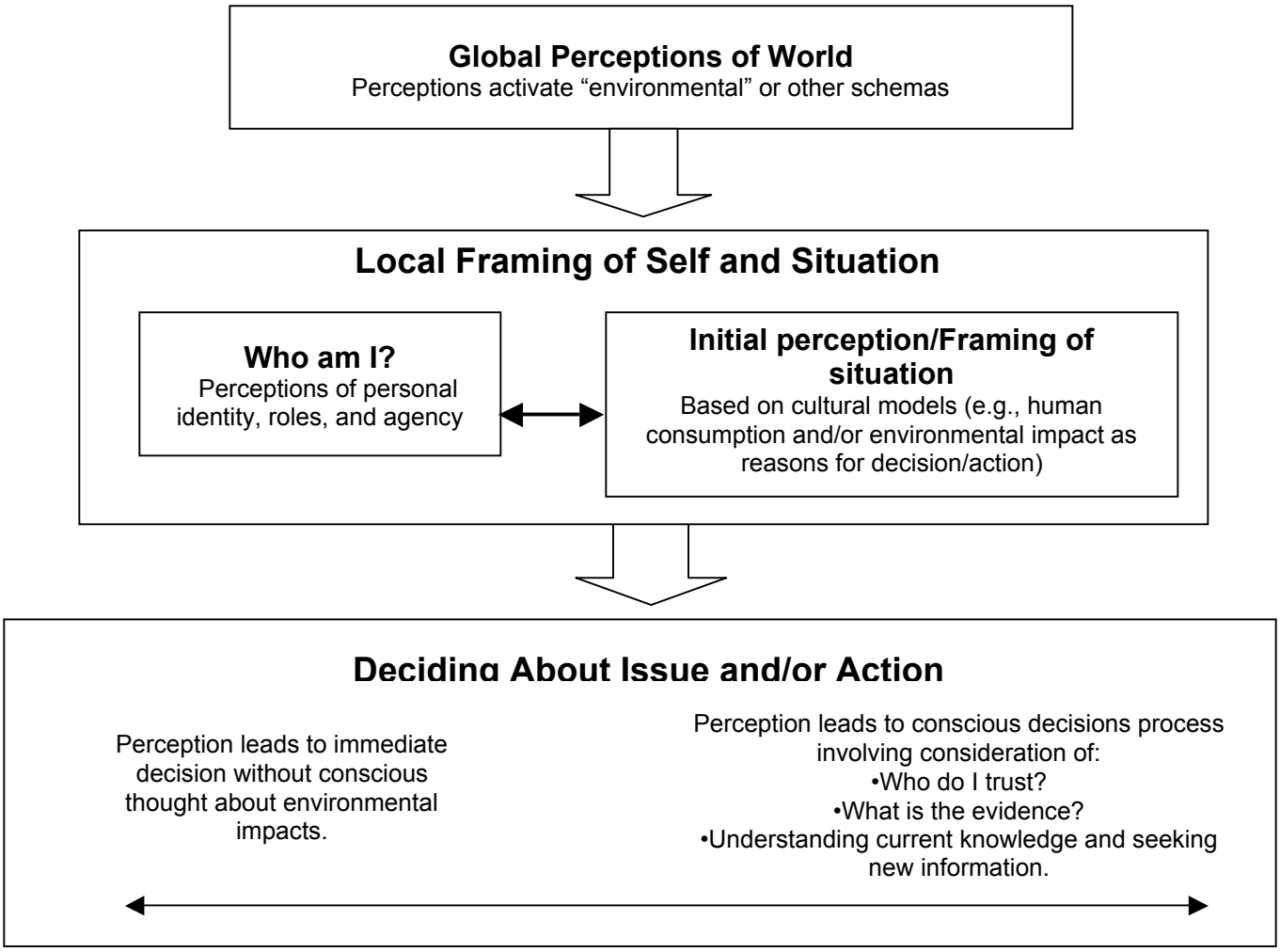

Figure 2: Environmental Decision Making Process (Reasoning about Decisions Involving Connected Human and Natural Environmental Systems)

We believe that understanding of the environmental structure (Figure 1) and processes for reasoning about environmental topics (Figure 2) combine to serve as our upper anchor of the learning progression for environmental science literacy citizenship. Our explorations of students' structures and processes for reasoning about topics are helping us to articulate the lower anchor.

Results

Strawberry Case - Adam

Nutrition ordering

This first task positioned students as consumers of food. We were interested in which products they thought were nutritious and why. Adam thought that food grown in Michigan was not very nutritious. He believed that the environmental and economic conditions under which crops are grown was important to the nutrition of food; he framed the ordering task in terms of his perceptions of the growing conditions of the strawberry products (framing of the situation, see Figure 2). He immediately said, "Local stuff's not that good" and moved it to the end where he placed the products that he thought were least nutritious. When asked why local products were not good, he replied, "Cause, um, Michigan's kinda glum," implying that the weather in Michigan was not good for growing strawberries. Later, he placed the products that were grown and produced in California at the end with more nutritious products. He said that things from California were more nutritious because he believed it did not snow there. Therefore, it was a better place to grow things. He also talked about how "The economy's going to hell and I don't like Michigan," further expressing why he thought local produce was not as nutritious as produce grown in California. Adam drew on his knowledge of environmental systems and the basic needs for growing plants. He also drew on a part of his identity – his dislike of Michigan – to frame his ideas about Michigan's ability to produce nutritious food.

In addition, Adam was not very concerned about the nutrition of the food he eats in his every day life. He said he picks food products based on what he feels like (e.g., feels like something sweet like a Snickers). This was consistent with other responses throughout the interview. After completing the nutrition sorting task, the interviewer asked Adam if he thought it was important to know where his food comes from. He said, "Not really. Unless you're actually trying to get nutrition stuff out." Again, nutrition did not play a large role in his consumer decisions. When probed further, he said that he was a little bit concerned about how food was produced "because it can make you sick if they do it wrong." When asked if he cared about whether a product was naturally grown or had a lot of artificial products in it, neither seemed to be an important factor in his decision making.

> Adam: If it tastes the same, doesn't hurt, cause harm, then no.
> Interviewer: Do you think it does cause harm?
> Adam: If they use a lot of chemicals, yeah, I would think so.

First, Adam said that as long as it tastes the same, it didn't matter. He added, "doesn't cause harm." When probed about this response, Adam reconsidered and stated that if they used chemicals, it is probably important to consider where food comes from and how it is made.

Interestingly, for the nutrition ordering task, Adam applied his understanding of pesticides differently than all of the other students interviewed. He thought that products that were grown *without* the use of pesticides were less nutritious. He said, "And no pesticides. It doesn't kill bugs so bugs could have gotten inside (referring to the strawberries)." All other students thought that food grown *with* the use of pesticides was less nutritious.

Environmentally friendly ordering

While Adam thought that food grown using pesticides was more nutritious than food grown without the use of pesticides, he believed "pesticides, I would think it's harmful to the environment because it kills bugs and shit." He ordered those products that used pesticides as less environmentally friendly than those grown without the use of pesticides. Another criteria he used to sort the products was transportation. Adam placed products from California as the worse for the environment because they are packed far away and semi-trucks had to transport them to Michigan. The transportation of the products produced carbon dioxide. Thus yogurt products from New York, which was closer to Michigan than California, were not as harmful to the environment as the products from California. Adam later reiterated that transportation was his most important consideration when he ordered the products in terms of being more or less environmentally friendly.

Adam talked about the importance of environmental systems in terms of its value to humans. He said that humans live and depend on "a good environment, stable environment for us to live," indicating both the intrinsic value (environmental systems box of Figure 1) and the environmental system services (bottom arrow of Figure 1) that natural environments provide for humans. He went on to talk about the importance of the ozone layer, which protects us from dangerous sunrays.

> The ozone layer. It's keeping dangerous sunrays or whatever from killing us. And then we need stable weather. Not storms all the time or dryness so we can't grow food. Cause once we can't grow food, grasses die and animals start to die. We lose our source of meat for food.

Adam mentioned connections between environmental systems and environmental systems services. He described how stable weather is necessary for us to grow food. He made connections between growing conditions, plants, and animals (i.e., food web). If we can not grow food, then plants and animals die and we lose our source of meat. Furthermore, he recognized the impact humans have on the environment through transportation (see top human actions arrow, Figure 1). When asked how humans affect the environment, he mentioned that semi-trucks, cars, and packaging products produce pollution. He attributed these as causes of the unstable weather and holes in ozone layer. He also talked about how nuclear testing and atomic bombs negatively affect the environment because they kill the ozone that protects our environment. These ideas about the interaction between naturals systems and human actions were consistent with the criteria Adam used to order the products from most environmentally friendly to least environmentally friendly. Transportation was the most important factor; products that had to travel further had a larger negative impact on the environment. Thus, his understanding of environmental systems and how human actions impact the environment informed his decision about which products were most or least environmentally friendly. When probed, Adam reasons through connections between human actions with environmental impact (top arrow on Figure 1), environmental systems (right-hand box), and environmental systems services (bottom arrow).

Who does Adam trust?

Adam did not mention any aspect of health or nutrition in his everyday decisions about what food products to buy (4 of the 6 students interviewed mentioned health as a criteria, and the

other student who didn't mention is in the baseline questions mentioned it as a large factor in his nutrition ordering). He also did not talk about sugar or calories as other did when completing the nutrition ordering task. Instead, he used pesticides and location (i.e., Michigan, California) as criteria for determining what was nutritious. Adam said that he buys food products based on what he feels like eating. "Well, I think about if I'm tired, then I need a real energy jolt, so maybe Mountain Dew or Volt. Then if I feel like something sweet, I get a Snickers or a Pop Tart." If faced with a decision about which product to buy if there is more than one similar choice, he said that he chooses based on "whatever looks better." He said he decides based on the color of the package, media and brand. He also mentioned that his family is picky about brands and will tell him what company made a product and he has to buy that particular brand. Similarly, when asked about who he would trust if presented with different information about a product on multiple websites, he said he would trust, "Whatever one looks like the put more money in the website." In other words, he would trust that website that looked better.

When prompted, Adam activated and connected three parts of the loop diagram (Figure 1): human actions with environmental impact, environmental systems and environmental system services. He applied his understanding of the growing conditions of various places and the use of pesticides to his decisions about which food was most or least nutritious. In the environmentally friendly ordering task, he used his knowledge of pesticides and transportation and their impact on environmental systems to order the products. While Adam used his knowledge of various parts of the loop diagram during the ordering tasks, he said he does not draw on this knowledge in his everyday decision making about what food to buy. He focused more on taste. Parts of his identity, such as a lack of concern for nutrition, appeared to play a larger role in his everyday decision making.

Water Case - Michael

Introductory Questions about Water

In the introductory questions about water, Michael does not bring up human impacts on environmental systems until he is prompted to do so, but when prompted, he has strong ideas about these impacts. For example, Michael talks about drinking bottled water, why he likes to drink bottled water, and where he thinks the bottled water he drinks comes from (glacial streams) without mentioning potential environmental impacts of bottled water. However, when asked about potential impacts he replies that, "taking water from one place and bringing it to another can make one spot run out of water." Michael is the only student in the water interviews who independently raises the redistribution of water by humans as an action that could have adverse environmental effects. This response signals knowledge and reasoning about water that is more than superficial; he acknowledges how connections between human engineered and natural environmental systems could impact our ability to continue to rely on environmental services like fresh water.

In the introductory questions, we also begin to get a sense of the family influence on Michael's personal identity. When asked if he does anything to protect water, Michael replies:

> Michael: Well, we don't use the laundry detergent with, my Dad told me about it, it had like some chemical in it which you're not supposed to use because it can pollute the water.
> Interviewer: Phosphates?

> Michael: Yeah I think so.
> Interviewer: Your Dad told you that?
> Michael: Yeah. And we don't, like some people if they don't have enough money or something they just dump their oil in yards and stuff, but we don't do that, we take it to recycling center.

In this statement, we see both that Michael is getting information about the environment from his Dad, and, that through the use of the pronoun "we" he indicates that the environmentally-friendly behaviors he engages in are family endeavors.

Water Scenario Science

In questions about the water science related to the Nestle water bottling plant scenario, we begin to see more of the structure of Michael's understanding of environmental systems (right-hand box of Figure 1). When asked if he thinks that Nestle's well could affect trout living in a nearby stream, Michael tells a long school science narrative story explaining how this could happen.

> It depends on how much water is going in but it could if they took too much and maybe the water wouldn't flow fast enough to make ripples that cause oxygen in the water and they might not be able to live there. And, it could draw the rivers in and then the trees wouldn't be able to drop leaves in and then bacteria wouldn't eat that which, the fish eat, and then they could end up losing different food sources. … Yeah, if nobody lived on this river, and the water level went down and the trees were on the side of the river and they were dropping leaves in, it would cause the bacteria to come in to eat the leaves. If the leaves drop and they don't go into the river the bacteria wouldn't eat the leaves and break them down. And then the zooplankton wouldn't eat the fish and then the fish wouldn't be able to eat the zooplankton. The leaves went in and they break down things and bacteria and they eat that – the zooplankton.

This long narrative shows that Michael has elaborated ideas about how environmental systems work and connections between organisms in systems. He actively tries to reason out, using his understanding, what might happen to the trout in the streams drawing on his knowledge of how fish breathe and food webs.

Water Scenario Social Science

The human community aspects of the Nestle well scenario get introduced to a small extent in the scenario (left-hand box of Figure 1). For example, in introducing the scenario, the interviewer mentions that the well and bottling plant could provide some jobs in the nearby town. However, in the interview questions, an emphasis is placed on the science of the situation. Several students including Michael though, bring up additional social concerns related to building the well and the bottling plant. When asked if he thinks building the well could have any other impacts, Michael mentions two human community impacts: that people who live nearby may need to dig their wells lower and that people who have recreational fishing businesses might go out of business or go bankrupt. In both cases, Michael uses his understanding of environmental systems to consider potential impacts on human communities (left-hand box of Figure 1) and environmental system services (bottom arrow of Figure 1).

Citizenship Reasoning about Water Scenario

Michael is a clear example of someone whose personal identity impacts his perceptions and decisions about an issue. When asked if what we had just talked about during the introduction to the scenario would affect his decision about whether to buy Ice Mountain Water, he replies, "Yes. Because if that interferes, if the fish in the lake, I'm a big fisherman, so is my father. If that made the fish population go down we probably wouldn't buy Ice Mountain. We probably wouldn't buy property up there." His identity as a fisherman (once again he mentions his father as part of this) plays an important role how he frames the issue, thus playing a role in what he considers when making his decision (see Figure 2).

When asked what other information he would like to know, Michael responds with a statement that indicate thoughts about both social and environmental system aspects of the issue.

> If they had like smokestacks and stuff to make air pollution that could make it so that we wouldn't go down there. I know it takes in a lot of jobs but it also has a negative effect on the citizens. (Anything else?) How much water exactly is going through and coming back into the creeks and the rivers and how much is, well I know how much is being taken out but I want to know how much of a percentage is being taken out.

Michael, like many of the interviewed students, tries to find evidence in the information that is subsequently provided to him by the interviewer to support his position, which is to oppose building the well. Unlike many of the other students who sometimes misinterpret information to support their own position, he finds some information in the sources that he can reasonably use to support his position. He acknowledges that there are other sources that say the well would not harm the trout, but finds one piece of evidence to suggest that there may still be unknown impacts with respect to the Muskegon River. As he reasons through the information he has been presented with he states:

> Are they taking 150 gallons per minute or are they going to take 300 to 400 per minute? … It says there's no impact on the fish because the temperatures wouldn't change. Still, the air pollution they didn't talk about that but I guess they seem like they're doing the right thing but they're still getting rid of our natural resource that is great. All our fresh water they're planning on distributing everywhere and I still don't like that. I guess the information from the Muskegon River is missing, so you wouldn't know what would happen to the Muskegon River if you were to take more so that would, I probably wouldn't want to, I wouldn't pass the bill saying that they could because of the Muskegon River.

In the end, Michael acknowledges that some of the information doesn't support his position, but he still decides against supporting the well. He invokes something like the precautionary principle indicating an interest in playing it safe and saying that, "I would vote against it because I don't know where all the information came from and I wouldn't want to affect the environment in a bad way even if I don't live there because I believe fresh water is a great resource in Michigan so I'd vote against it."

Who Does Michael Trust?

Michael is interesting because he keeps his evaluation of whom he trusts and whom he doesn't separate from what he decides. He only uses information that supports his position in stating his position, but he doesn't distort the other information either. "Who do you trust?" and "What do you decide?" apparently function as two independent questions for him. He does not trust the Michigan Citizens very much because he has not heard of them and does not know if they base their opinion on research; he wants to see their bibliography. He is also not sure about Trout Unlimited because he has not heard about them. Thus, he uses reputation as one important criterion for deciding who to trust. Michael does not trust Nestle because he thinks they may be leaving information out and only providing information that supports their own position. Along with reputation, he also uses his understanding of what good science entails as a criterion for deciding who to trust.

When asked about whom he trusts, Michael states:

> Yeah, I trust the Department of Environmental Quality more than I would the [Michigan] Citizens because they actually do all the tests and they evaluate what happens over a period of time. With the citizens they're just, I don't know if they research their information or not but if they didn't that would influence what I think about them and if they actually had like a bibliography on where they got their information from I would trust them more.

Interestingly, he trusts the Michigan Department of Environmental Quality even though they don not agree with his position. Overall, Michael has multiple relatively sophisticated ways to decide whom he trusts. However, his decisions about whom he trusts seems to be kept separate from his final decision about the scenario.

Among the students interviewed about water, Michael stood out as an individual with relatively connected understanding. When prompted to, he activated schemas related to all four parts of the loop diagram including human communities, human actions with environmental impacts, environmental systems and environmental systems services (see Figure 1). When considering a single topic or issue, Michael could see multiple points of view and had relatively sophisticated ways of using the structure of his understanding to reason about these points of view. In addition, Michael has a strong personal identity related to water. Michael is a fisherman (as is his dad), so questions about water and particularly about potential harm to trout take on personal significance for Michael. It seems likely that his interest in understanding water science relates to his personal identification as a fisherman. This is an example of how connections between the Loop Diagram for Environmental Science Literacy (Figure 1) and the Environmental Decision Making framework (Figure 2) are interconnected and reflexive. Michael probably was interested in and developed the elaborated ideas about water science that he shares at least in part because of his strong personal identity as a fisherman. The strong connections between Michael' identity, the structure of his understanding, and the way he reasons about water topics is evident throughout his interview.

General Trends

Who Am I? Perceptions of identity, roles, agency and community

In both the water and strawberry interviews, we found that family values and practices played a role in many of the students' discussions and decisions. In the strawberry interviews, family values and practices played a part in students' decisions about what products to buy at the grocery store and why they buy particular food. For example, many students mentioned that they buy products based on nutritional information such as calories and amount of sugar because their parents pay attention to these criteria when buying food for the family. One student mentioned that his mother has high cholesterol, so she watches what she eats and shops at health food stores. In the water interviews, students mentioned parents purchasing bottled water, parents having an influence on knowledge and undertaking of practices to protect water, parents' influences on perceptions of what makes for high quality water, and family practices like recreational fishing. For example, as previously discussed Michael often went fishing with his father, which strongly influenced his values regarding water issues.

We also found other aspects of students' identities that played a role in students' decision making processes. For example, in one of the strawberry interviews, a student talked about how he tried to eat healthy foods to stay fit for wrestling. Another student's concern with freshness of food was a prevalent criteria that he used to complete both ordering tasks and that influenced his view of the environment. In the water interviews, all of the students seemed to have some sense of identity related to science. In their talk, they discussed the importance of science for making decisions in their lives (especially among students who were asked the extra questions about their science aspirations and the importance of science at the end – and who were likely primed by the interview itself to talk this way), and mentioned the importance of having scientific studies as evidence in debates such as the Nestle Water debate. This orientation toward science seemed universal (none of the students said anything to indicate that they don't care about what the science says).

Students valued the natural environment and saw it as an important part of their daily lives. Most students talked about the importance of the natural environment in terms of its significance to humans. Students mentioned values such as the need for an aesthetically pleasing environment, a place to grow food, the water that we need to survive, and the importance of trees because they provide us with oxygen. In Michael's water interview, he was particularly adamant about wanting to protect water in Michigan. In part, he wanted to protect the water resources for recreational fishing purposes. In the citizenship interviews, students were asked if they did anything in their daily lives that they viewed as environmentally friendly. All students mentioned recycling and some students mentioned not littering, not using pesticides in their gardens, turning off lights, and planting trees or plants. To varying degrees, all students seemed to have personal identities related to being people who wanted to protect the environment.

Initial perception or framing of situation based on cultural models (human consumption or environmental impact)

In the strawberry interviews, we framed the first ordering task in terms of human consumption; we asked them to order the products in terms of how nutritious the various food products were. The second ordering task was framed more in terms of environmental impact. Because the two tasks were initially framed for students in particular ways, we saw more evidence of how their identities influenced their decisions. Students did have an opportunity to

frame an issue when we asked them if they thought it was important to know where food comes from (provenance of food). Students framed this issue in terms of either human consumption (e.g., if someone has diabetes, she/he needs to know if there is too much sugar in the food) and/or environmental impact (e.g., if the products have to be transported farther; they may not be as fresh, the farther products have to travel, the worse the impact on the environment).

In the water interviews, many of the students seemed to initially frame issues in terms of human consumption unless they were specifically scaffolded to take on an environmental impact frame. Even when scaffolded to take on an environmental impact frame, some would still keep the human consumption frame as the prominent frame. For example, one student was concerned about water for people in other towns, but not about the trout. She brought up her concern for the people in other towns even though it was not introduced in any information presented about the issue. We could see how students were framing the water issues when students were asked what other information they would like to have. Some of the students ask for scientific information, while others say they want to find out more about the people issues (e.g., what did the people where the previous well and plant was built think about it?)

Decision making

As already mentioned, how students framed themselves and the situation influenced their decisions. Furthermore, students' identities appeared to influence how students framed the various tasks and issues in the interviews. For example, in the strawberry interviews the nature of the nutrition ordering task placed students in the role of a consumer. But how students ordered the products depended on their values and identities. Adam did not have a very high opinion of Michigan; he thought that produce grown in Michigan was not nutritious. Thus, he placed the products from California and New York as more nutritious than the ones from Michigan. Other students valued their health and paid attention to the nutritional value of their food in their everyday lives. Their daily eating habits influenced how they ordered the products. For example, one student said that his mom looks at the amount of carbohydrates when buying products. When he completed the nutrition ordering task, he carefully examined each food product label, looking at the number of calories and amount of sugar and based his decisions on his label analysis.

In the water interviews, we found it interesting that the students seemed to be able to come to an immediate decision and still want more information. Just because they made a decision, it did not mean that they stopped looking for more information. It was possible that some of them wanted more information to try to find support for the beliefs they have already established in their minds. Some of them may have wanted more information to help them decide on the issue if they did not have a strong feeling initially (although they all tended to have at least an initial inclination). Finally, some may have believed that they wanted more information to help them learn about the issue, when in reality, subconsciously, they were not really going to let information that contradicted what they believe change their minds.

Environmental Science Literacy

Thus far, we have mainly discussed various aspects of our environmental decision making process framework (Figure 2). It is important to discuss the implications student knowledge of environmental science literacy (Figure 1) had on students' decision making processes. Students with a greater understanding of environmental science literacy (environmental systems, human impacts, etc.) could reason more deeply about issues. For

example, Michael had an imperfect, but fairly robust and very detailed understanding of the water science. He was able to draw on this understand to correctly interpret the information he was presented with from the different stakeholder sources. In contrast, another participant in the water interview stated at the beginning of the discussion about the issue that she did not believe that groundwater and surface water systems were connected. This belief impacted her decision making reasoning; throughout the interview she asserted that the trout would not be harmed by the well. Furthermore, she seemed unwilling, even when presented with outside sources, to consider that the trout could be harmed by the well.

Who do you trust?

The students used different criteria to determine who they would trust. For example, in the strawberry interviews, the students were asked where or whom they would ask to find out more information about products, such as how they were made. Some students mentioned that they would trust company websites based on the appearances of the websites, or products that were well-advertised or from large companies. Others stated that, if talking to someone, they would trust someone based on a feeling and if what they told them made sense. On the other hand, some students in the water interviews stated that they did not trust Nestle (a big company) because the company could be lying or withholding information or providing "propaganda" just to support their own agenda. So the students do seem to be aware of the possibility of bias due to interest in an issue. Many of the students said they would use science as a basis for deciding who to trust, but their other statements indicate that they really did not (or did not know how).

What is the evidence? (Arguments based on evidence)

In the water interviews, Michael was one of the few students who actually appeared to use the evidence with some kind of logic. Like many of the other students, he looked to the evidence to support what he has already decided. However, he did not, like some of the other students, misconstrue information to try to support his idea even when a source did not validate his opinion. In the strawberry interviews, while many students said that products with less calories, sugar, or ingredients were healthier, only one student actually examined the product labels to check for these criteria.

Understanding current knowledge and seeking new information

The water interviews specifically asked students if they wanted more information before they made a decision. All the students said they want more information. Only one student of the six water interviewees analyzed actually changed her mind based on reading the information. We found that:

- Students use the information to try to support what they already believe;
- Students only use the part of the information that support what they believe;
- Misunderstanding of information leads to misapplication

In the strawberry interviews, some students activated more knowledge when they were probed. As already discussed, Adam first stated that he did not think it was important to know where his food came from. When probed, he reconsidered and gave reasons more reasons as to why it might be important to know where food comes from.

Implications

Our study has important implications for environmental science literacy citizenship. Our findings suggest that many aspects, such as students' identities and values, influence how they make decisions perhaps more than their knowledge of coupled human and natural systems. Thus, it is important to learn more about how students' identities, roles, and agency and how they frame issues influence how they make decisions. It is also essential to understand student knowledge of connected human and natural environmental systems (Figure 1, Loop diagram) and how they draw on this knowledge when making decisions. Our findings also show that students usually only activate their knowledge of environmental science literacy when probed. Furthermore, when students are making decisions, we find that they use various criteria to decide who and what sources to trust, to reason using evidence, and to make sense of existing and new information. Sometimes students make immediate decisions based on their local framing of self and the situation; they decide without much conscious thought about environmental impacts or careful evaluation of evidence. Occasionally, students examine the evidence, use their current knowledge of environmental science literacy and apply this knowledge in making a decision. We believe that an environmentally literate citizen should be able to make conscious decisions that take into account the three aspects of decision making: Who do I trust?, What is the evidence?, and Understanding current knowledge and seeking new information. Therefore, when teaching environmental science, we need to carefully consider how science practices connect to students' citizenship practices in order to determine ways to best teach them to be environmentally literate citizens.

References

Arvai, J. L., Campbell, V., Baird, A., & Rivers, L. (2004). Teaching students to make better decisions about the environment: Lessons from the decision sciences. *Journal of Environmental Education, 36*(1), 33-45.

Belenky, M. F., Clinchy, B. M., Goldberger, N. R., & Tarule, J. M. (1986). *Women's Ways of Knowing: The Development of Self, Voice, and Mind*. New York: Basic Books.

Brophy, J. (1998). *Motivating Students to Learn*. Boston: McGraw Hill.

Doyle, W. (1983). Academic work. *Review of Educational REsearch, 53*(2), 159-200.

Eagly, A. H., Wood, W., & Chaiken, S. (1978). Causal inferences about communicators and their effect on opinion change. . *Journal of Personality and Social Psychology, 36*, 424-435.

Epstein, S. (1994). Integration of the cognitive and the psychodynamic unconscious. *American Psychologist, 49*(8), 709-724.

Fleming, M.A., Brook, A. T., Garcia, J. A., & Konik, J. (2004). When social identities guide behavior: Thoughtful versus non-thoughtful processes of adopting a group membership. Unpublished manuscript.

Harmon-Jones, E., and Mills, J. (1999). An introduction to cognitive dissonance theory and an overview of current perspectives on the theory. In Harmon-Jones and Mills, eds. *Cognitive Dissonance: Progress on a Pivotal Theory in Social Psychology.* Washington, DC: The American Psychological Association.

Hofer, B., & Pintrich, P. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research, 67*(1), 88-140.

Kempton, W., Boster, J., & Hartley, J. (1996). *Environmental Values in American Culture*. Cambridge, MA: The MIT Press.

Kolstø, S. (2001). Scientific literacy for citizenship: Tools for dealing with the science dimension of controversial socioscientific issues. *Science Education, 85*(3), 291-310.

Leinhardt, G., Crowley, K., & Knutson, K., Eds. (In Press). *Learning Conversations in Museums*. Mahwah, New Jersey: Erlbaum.

Long Term Ecological Research Network Research Initiatives Subcommittee (2007). Integrative Science for Society and Environment: A Strategic Research Plan. Long Term Ecological Rsearch Network.

Macdonald, S., & Silverstone, R. (1992). Science on display: The representation of scientific controversy in museum exhibitions. *Public Understanding of Science, 1*(1), 69-87.

National Science Board. (2004). *Science and Engineering Indicators 2004* (No. NSB 04-01). Arlington, VA: National Science Foundation.

Pedretti, E. (2004). Perspectives on learning through research on critical issues-based science center exhibitions. *Science Education, 88*(Supplement 1), S34-S47.

Perry, W. G. (1970). *Forms of Intellectual and Ethical Development in the College Years*. New York: Holt, Rinehart and Winston, Inc.

Petty, R. E., & Wegener, D. T. (1999). The elaboration likelihood model: Current status and controversies. In S. Chaiken & Y. Trope (Eds.), *Dual process theories in social psychology* (pp. 41-72). New York: Guilford Press.

Redman, C.L., Grove, J.M., Kuby, L.H. (2004). Integrating social science into the long-term ecological research (LTER) network: Social dimensions of ecological change and ecological dimensions of social change. *Ecosystems, 7,* 161-171.

Sadler, T. (2004). Student conceptualizations of the nature of science in response to a socioscientific issue. *International Journal of Science Education, 26*(4), 387-409.

Slovic, P. (2006). *"If I look at the mass I will never act:" Psychic numbing and genocide*. Eugene, OR: Decision Research, Inc. (available online at www.decisionresearch.org).

Smith, D. C., and Anderson, C. W. (1999). Appropriating scientific practices and discourses with future elementary teachers. Journal of Research in Science Teaching, 36(7), 755-776.

Tversky, A., & Kahneman, D. (2000). Judgment under uncertainty: Heuristics and biases. In T. Connolly, H. Arkes & K. Hammond (Eds.), *Judgment and Decision Making: An Interdisciplinary Reader* (pp. 35-52). Cambridge: Cambridge University Press.

Zeckhauser, R., & Viscusi, W. (2000). Risk within reason. In T. Connolly, H. Arkes & K. Hammond (Eds.), *Judgment and Decision Making* (pp. 465-478). Cambridge: Cambridge University Press.

Appendix A

Strawberry Interview Protocol

Citizenship & Biodiversity Think-Aloud

Baseline Questions:

	Question	Target Role
1.	How often does your family go to the grocery store to buy food?	Consumer
2.	Do you go to the store to buy food yourself?	Consumer
3.	What product do you usually buy? (e.g. cookies)	Consumer
4.	How do you choose among all the varieties of that product? For example, how do you choose what types of peanut butter to buy? What criteria do you use?	Consumer/ Learner
5.	What resources do you use to make decisions on what to buy? (for example, family experience, what you learnt in class) (probe – is it based on taste, brand name, family tradition, nutritional information etc.)	Learner/ Consumer
6.	Do you have any other ideas about this issue that you'd like to share?	
7.	Have you studied a lot of science in school? What kinds of things have you learned about (what courses have you taken)?	Learner
8.	Are you interested in a career in science? If so, what kind of job?	Student identity
9.	Do you think that everyone should know some things about science even if they aren't going to be scientists?	
10.	What kinds of things do you think people should know about science?	
11.	Why do you think it's important for everyone to know these things?	

Strawberry items Think Aloud

1. Present the student with a selection of foods, from fresh to preserved, simple packaging to elaborate packaging.

E.g.

	Food	Treatment
1.	Strawberries	Fresh and frozen, organic and non-organic/GM giant strawberries
2.	Strawberry jam	In a jar, sweetened, jellied, cooked

3.	Strawberry pop tart	Sugared, cooked, preserved, cardboard packaging
4.	Large carton of strawberry yogurt	Single large carton with multiple servings
5.	Small cartons of I serving size strawberry yogurt	Small single size servings

	Food	Labels
1.	Strawberries	-Industrially grown, pesticides applied, grown in California at a large strawberry farm -Locally grown, from a farmers market in Lansing (e.g. Okemos or Allen street, small family farm -Organic, no pesticides used.
2.	Strawberry jam	-Grown and packaged in California -Locally grown and packaged
3.	Strawberry pop tart	- Processed and packaged in California
4.	Large carton of strawberry yogurt	- Dannon, packaged in Utah
5.	Small cartons of I serving size strawberry yogurt	-Dannon, packaged in Utah

Ask the student to do the following and justify her choice:

1. arrange the items in order of nutritional benefits
   - gets at how they decide what is the most beneficial to health, what resources they use to make their decisions, what is common in their family with regards to these products (e.g. always eat pop-tarts for breakfast)

   - How do you know where the product comes from i.e. how did it end up on the grocery shelf? Do you think information is important? Who can you ask? How do you find out? (probe – gets at who do you believe/trust; if they are at all concerned about transport/food production process; probe on GM foods/growth process and consequences)

2. arrange the items in terms of most friendly to the environment to least friendly
   - How do they define "friendly to the environment"?
   - What criteria do they use to arrange the stuff?

Additional questions – depending on time

3. Why is our natural environment important?

4. How would you describe the natural environment? Or What do you think of when you think of the natural environment? (probes: forests, lakes, mountains, animals, gardens, yards, parks, etc.)
5. Why do you think it might be important to take care of or protect our environment?
6. What kinds of things do you do that are environmentally friendly/conscious?
7. Are you aware of the environmental impact of turning off the lights in your home? Taking showers?
8. Have you heard anything about what's happening to the polar bears' habitat/home in the news, at school, or from friends/family?

Appendix B

Citizenship and Water Interview Questions (High School)[2]

Name of Student _____
Name of Interviewer _____
Date _____

Materials

- Interview Protocol
- Map showing Twin and Chippewa Creeks and proposed location for new well
- Water scenario info sheets (bottom of document)
- Bottle of Ice Mountain Water

Introductory questions

1. What are different ways you know of that people use water?
2. Can you think of any ways that taking a shower affects the environment?
3. What kinds of beverages do you usually drink?
4. Do you ever drink bottled water?

If yes,

   a. Why do you drink bottled water?
   b. How do you decide which brand of bottled water to buy?
   c. Do you know where ___ brand of bottled water comes from?
   d. Can you think of any ways that drinking bottled water affects the environment?

5. Do you ever drink tap water?
   a. Do you know what the source of your tap water is?
6. Would you rather drink bottled water or tap water, or do you not care? Why?
7. Do you think tap water is different from bottled water?
   a. If yes, how do you think they're different?
   b. If no, why do you think they're the same?
8. What kinds of things can people do to protect water and make sure there's enough good water in their community?
9. Do you do any of these things to protect water in your community?

Nestle Bottled Water Scenario (show map while talking about this)

I'm going to tell you about a real environmental debate going on in Michigan. The Nestle Company owns a water bottling plant in Stanwood, Michigan. They get groundwater from wells and bottle it as Ice Mountain water. The Stanwood plant bottled 226 million gallons of water last year. Because bottled water is so popular, Nestle wants to drill a new well so they can sell more water. The new well would be located near two trout streams that flow into the Muskegon River. Nestle also wants to build a new water bottling plant nearby in Evart. Some people think Nestle shouldn't drill the well because it would harm the trout in the streams. The Nestle Company says there is a lot of water available so the well would not harm the trout. Opening the bottling plant in Evart could provide some new jobs for people.

---

[2] There are two water citizenship interview protocols: one for high school students and one for elementary and middle school students. The interview questions are virtually identical. The "Excerpts for Sources" for the elementary and middle school students are simplified in attempts to make them more age-appropriate.

Water Science Understanding Questions
Here's a map showing the streams and the proposed location of the well to pump out the groundwater for Ice Mountain water.

1. (Pointing to a spot on the map) If water fell as rain here, where do you think it would go? Why?
2. Can you draw the watershed boundaries for Twin Creek and Chippewa Creek?
3. Do you think that the well could affect the flow of water in the streams? If yes, how? If no, why not?
4. How deep do you think the well would have to be drilled to get groundwater out?
5. Do you think that the well could affect trout that live in the streams? If yes, how? If no, why not?
6. Do you think that drilling the well and pumping out the groundwater could have any other impacts?

Citizenship Questions
Think of yourself in the role of a citizen as you answer these questions. If you're not eighteen, picture ahead a few years and think of yourself as a citizen of the state of Michigan who is old enough to vote.

1. If Nestle built the well and a bottling plant, would knowing what I just talked about affect your decision about whether to buy Ice Mountain water? How?

2. If Michigan voters got to vote about whether or not to let Nestle drill the well and build the new bottling plant, do you feel like right now you'd have enough information to decide how to vote?

If student says they have enough information, ask the following questions.
1. Would you vote for or against Nestle building their new well and a new bottling plant in Evart? Why would you vote that way?
2. Can you think of anything else that you might want to know about this issue?
3. If you wanted to find out more, how would you try to do that?

Provide the info from sources and time to look over. "Here's some additional information from people who are interested in this issue. You can read as few or as many of these as you'd like." (Note which ones student looks at.)

4. Did looking at this information influence your decision at all? If so, explain how?
5. Which information do you trust the most? Why?
6. Which information do you trust the least? Why?
7. Do you think there's a right answer and a wrong answer about whether Nestle should build the well and water bottling plant?
8. If someone organized a march against/for (depending on student) building the plant, would you join the march? Why or why not?

9. If the town of Evart organized a scientific study of water flow in the Muskegon River watershed and they asked people to help, would you volunteer to help? Why or why not? (If student says no because they live far away, ask what if you lived in Evart?)
10. Is there anything more you'd like to know to be able to make a good decision about Nestle's well?

<u>If student says they need more information, ask the following questions.</u>
1. What else would you want to know about this issue to help you make a decision?
2. What could you do to help you decide about this issue?
Follow up probes: Who would you talk to? Where else could you find out information?
3. If you wanted to find out more, how would you try to do that?

Provide the info from sources and time to look over. "Here's some additional information from people who are interested in this issue. You can read as few or as many of these as you'd like." (Note)

4. Did looking at this information influence your decision at all? If so, explain how?
5. Which information do you trust the most? Why?
6. Which information do you trust the least? Why?
7. If you had to decide right now about whether or not you think the water bottling plant should be built what would you say? Why?
8. Do you think there's a right answer and a wrong answer about whether Nestle should build the well and water bottling plant?
9. If someone organized a march against/for (depending on student) building the plant, would you join the march? Why or why not?
10. If the town of Evart organized a scientific study of water flow in the Muskegon River watershed and they asked people to help, would you volunteer to help? Why or why not? (If student says no because they live far away, ask what if you lived in Evart?)
11. Is there anything more you'd like to know to be able to make a good decision about Nestle's well?

<u>If time questions</u>
1. Have you studied a lot of science in school? What kinds of things have you learned about (what courses have you taken)?
2. Are you interested in a career in science? If so, what kind of job?
3. Do you think everyone should know some things about science even if they're not going to be a scientist?
4. What kinds of things should people know about science?
5. Why do you think it's important for everyone to know these things?

Excerpts from Sources for High School Students

Application for Determination of
No Adverse Resource Impact
For the White-Cedar-Osceola Site
Prepared for Nestle Waters North America by Malcolm Pirnie, Inc., August 2006

Zorn's 1998 paper predicts that no change in fish populations in Twin and Chippewa Creeks would occur as a result of the decrease in flow in those streams. Much larger changes than those predicted for this groundwater withdrawal would be required to affect the characteristic fish cluster. This conclusion is consistent with the findings of Nufer and Baker (2004) who found in a long-term study in Hunt Creek that brook trout suffered few adverse effects from summer withdrawals.

Letter from David Smith,
President, West Michigan Trout Unlimited
Sent to Michigan Department of Environmental Quality in March 2007

We are opposed to all groundwater withdrawals that negatively impact coldwater streams. After reviewing Nestle's application, other public documents, and our own independent review, we have a few concerns.

1. It is insufficient protection to our coldwater resources to issue a finding of **No Adverse Impact** with an allowed withdrawal amount and expect the resource to be protected under all extremes of natural variation. Specific limits should be established regarding stream flows and water temperatures which would trigger a reduction or suspension of withdrawal during extreme events.

2. Is there any evidence of potential conflict with Evart's wells on Twin Creek which are currently operating at less than full capacity?

3. Information on Muskegon River impact is missing.

Michigan Citizens for Water Conservation
March 2007 Newsletter

Water levels in Lake Superior last year were as low as they've been for 80 years. When water is low in the Great Lakes, it means water is low in lakes and streams. Every gallon of water taken by Nestle is a gallon mined from a Michigan stream, and because it's **spring water** that usually means a trout stream.

Nestle presently takes about 450 gallons per minute from Mecosta and the City of Evart. That's approximately one-quarter billion gallons a year. Nestle's proposed expansion into three more headwaters & trout streams will take another 300 to 400 gallons per minute, which means another quarter billion gallons a year.

Michigan Department of Environmental Quality
Proposed Determination of No Adverse Resource Impact, December 19, 2006

The proposed withdrawal would take groundwater discharging to Twin and Chippewa Creeks. The effect of the withdrawal is measured against the allowable withdrawal from both creeks. Nestle's proposed withdrawal of 150 gallons per minute is well below the allowable withdrawal of 480 gallons per minute. Therefore, we propose to find that Nestle's project is not likely to cause a negative impact.

Excerpts from Sources for Elementary and Middle School Students

Application for New Well Near Evart, MI
by Nestle Company

Scientific studies predict that the well will not affect trout in the streams. Much more water would need to be removed to harm the trout.

Letter from West Michigan Trout Unlimited
Sent to Michigan Department of Environmental Quality

1. Using the Nestle well could be safe for the trout most of the time, but it might harm them during a very dry or hot season.

2. Building the Nestle well might draw water away from Evart's town well, which is nearby.

3. We do not know how the Nestle well could affect the Muskegon River.

Michigan Citizens for Water Conservation
March 2007 Newsletter

Every gallon of spring water taken by Nestle is a gallon taken from a Michigan trout stream.

Michigan Department of Environmental Quality
Proposed Approval for Nestle Well

Nestle's well would remove 150 gallons per minute. We have found that it would be safe to remove up to 480 gallons per minute without affecting the trout.