Science and the "Good Citizen": Community Based Scientific Literacy

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Science literacy, often defined as competency in school-like science activities, is frequently touted as a key to good citizenship. Based on a two-year ethnographic effort regarding science in the community, we suggest that science as taught in schools has no determinate relation to the activity of good citizenship. Rather, when considering the contribution of scientific activity to the greater good, the analysis must consider the entire situation. Science must be seen as forming a unique hybrid practice, mixed in with other mediating practices, which together constitute what can be called "scientifically literate good citizenship." This case study, an analysis of an open-house event organized by a grass-roots environmentalist group, presents some examples of activities that embed science in "good citizenship." We provide an analysis of some of the factors involved in this hybrid science. Through a series of vignettes, we focus on the activists' use of landscape and spatial arrangements, the importance of multiple representations of the same entity (e.g., a local creek), the relational aspect of knowing and becoming part of a community, and discursive formations that insert scientific into moral discourse. Our analysis raises questions about learning, citizenship, and the complex and mediated relations between community, citizenship, politics, and science as played out on a local scale.

KEYWORDS: Activity theory, computer-mediation, graphs, semiotics, workplace

Those who argue in favor of wide spread scientific literacy often suggest that scientific literacy is a vital attribute of a well informed, good citizen. The American Association for the Advancement of Science (AAAS) claims that a good science education should contribute to the development of "compassionate human beings…protecting a society that is open, decent, vital" (AAAS 1989, 1).

The document then provides lists of scientific topics that children have to study and know before they can be considered scientifically literate. Although we were originally sympathetic to the AAAS argument, we have come to a different understanding of scientific literacy as a result of our two-year participant observation study of environmental activists' attempts to educate one community about water use practices.

We observed how, in their work with community members, the activists mixed science with many other aspects of community life such as local history, moral imperatives, governance and personal relationships. Science, in this case, was a part of "good citizenship" because it was a part of a larger situation that included the appropriate use of science along with other factors. That is, consistent with other reports about science enacted at the boundaries between formal science and non-scientific organizations for ostensibly scientific projects, a hybrid practice that mixed the scientific with other considerations emerged (Edmond 2001; Miller 2001; Shrum 2000). We present some of the mixtures we observed in this community.

The purpose of this paper is to reconfigure the notion of science literacy in service of good citizenship. We treat phenomena such as "good citizenship" and "scientific literacy" as properties of situations instead of properties of individuals (Roth in press). Because of this perspective, our article highlights the importance of the *relations* between scientific activity and other aspects of community life in the enactment of scientifically informed projects that support the common good.[1] We conceptualize these relations as the formation of a new, hybrid practice. This practice is not school–science- or lab-like, nor is it the usual discourse in which community members engage. It has elements of both – it is a morally justified, scientifically literate practice (Edmond 2001). Through this lens of looking at scientific literacy in the community, the non-scientific "mediating practices"[2] with which this enacted science is involved become the key determinants of an event's moral status. We set out an analytic framework to articulate these mediating practices and show how they are crucial to science's engagement in good citizenship.

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[1] We do not claim to be making normative statements about what the common good is. Although we consider our case study to support the common good, other readers may have differing opinions. The point that we make is that whatever arguments are marshalled to make some event good or not, a close reading of the extra scientific factors of the events is crucial.

[2] In this context, the word "mediate" does not connote mediation of conflict. We use it in the sense of its Latin root, mediare, which means, according to Collins English Dictionary, "to be in the middle."

Theoretical Perspective

We present our arguments from a theoretical perspective that focuses on social/material entities. This perspective emphasizes the situated and mediated nature of social activity. By "situated" we mean that rather than put our analytic lens on "Durkheimian things,"[3] such as class, values, or literacy we focus on how these "things" are created and reproduced through situated action (Garfinkel 1996; Suchman 2000). How does the interaction between individuals result in something we call "class difference?" What does a literate person do that distinguishes them from an illiterate one?

We use the notion of "mediated" to mean that activity does not exist in itself but is supported and enabled by particular circumstances; these circumstances are said to "mediate" the activity. For example, when restoring a stream, one's involvement with the stream is not direct. Rather, it is mediated by the shovels, boulders, waders and other tools on site; it is also mediated by the social arrangement, the division of labor that supports one's participation (Engeström 1987; Hutchins 1995). From this perspective, the activity of restoring a stream cannot be thought of as independent of these other, mediating circumstances. "Mediating practices" refers to the things people do in order to accomplish their ostensive goal. For example, in order to teach a typical lesson on physics, the teacher must keep students relatively quiet and attentive. Her skilled actions to do so are "mediating practices" in the teaching of physics. Though they are not often considered in models of information transmission, without them the students would not learn the lesson.

A second implication of the term "mediated" is borrowed from semiotics; signs mediate referents, the things in and of the world (Nöth 1990). In this case, mediation brings attention to the fact that we often interact with an entity (e.g. a stream) not directly, but through sign assemblies, including maps, water quality tables, and flow volume recordings (Roth Masciotra and Bowen 2002). These representations often determine what we do with the "thing" that they represent. In the case of the stream, a plan to do restoration work in the creek is mediated by a number of representations (maps, indicators, photographs) of the creek's health. The representations *stand in* for the creek, and help to determine the steps taken to restore it. They *mediate* the restorationists' engagement (Lee and Roth 2001).

We use the phrase social/material to indicate that most of what we take for sociality is highly dependent on and deeply intertwined with materiality (Callon and Law 1995; Foucault 1978; Ingold 1996a, 1996b; Latour 1996). Something as straightforward as attending school depends on many material entities, such as pens, paper, school buildings, clothes, transportation vehicles, furnaces and so

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[3] See Garfinkel, 1996, pp. 5–7.

on. From this perspective, purely social or psychological explanations about "society" or "literacy" make as little sense as purely material or technological ones. Instead, the interaction between the two aspects of life is the focus of a social/material approach.

In this paper, the situated, mediating social/material circumstances of sociality provide us with the analytical tools to closely focus on what is happening at the site of the action in which we are interested (Goodwin 2000; Law 1995). Our argument about the existence of a morally justified, scientifically literate practice relies on a description of the situation that includes many specific details about how people support or augment scientific knowledge. These details become invisible to theoretical approaches that seek to abstract and generalize.

We begin our argument by introducing the environmental activist group with whom we worked and their situation within the community. We then present three analyses of different portions of a one-day educational open-house event that the activists had organized. We complete this paper by reconsidering the notions of scientific literacy and by reflecting on the relationship between education, science, and citizenship.

The Municipality of Oceanside, the Henderson Creek Project

The community of Oceanside sits on a peninsula in North America's Pacific Northwest. Oceanside is bordered on one side by open ocean and on the other by Sandwich Inlet.[4] The peninsula is part of a region initially inhabited by indigenous peoples that has been taken over by people of European ancestry about 145 years ago. Since that first contact, many of the marine species in Sandwich Inlet that had provided the staple food for the First Peoples have disappeared, or exist in drastically reduced numbers (Sandwich Inlet Study 1996). Although some of these declines can be attributed to over-harvesting, the exact cause of much of the disappearance remains unexplained. Land use has been strongly implicated. The peninsula has been farmed for more than 100 years, drained by a ditch system that has modified and augmented many of the local creeks and wetlands. Industrial developments also discharge pollutants into the ditches. With increasing population and development, storm drains, too, became part of the ditch/creek system. Thus the inlet receives agricultural, septic, industrial and road waste through the waterways that drain into it. Both governmental (CRD 1998) and local action is being taken to address the problems with this scenario.

In 1997 the Henderson Creek Watershed Project ("the Project") was brought to life by a small number of local residents who were able to secure funding to hire a coordinator. The Project seeks to "protect and enhance the Henderson Creek stream system" (Henderson Creek Project [HCP] 1998, 23) to

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4 All proper names are pseudonyms.

provide sufficient water for both the ecological and human needs of the watershed. At this time, the Project has a paid coordinator, Meagan MacDonald, who generates and coordinates all activities. However, the goal of the Project is to become integrated into the community to such a degree that the coordinator position is no longer necessary. Meagan stated, "What we want to see happen is that the community embraces the concept of a healthy watershed and takes it on themselves" (undated newspaper clipping). The mechanism through which the Project hopes to accomplish this is its stewardship program.

The stewardship program seeks to educate landowners in watershed stewardship techniques because "every watershed resident influences the health of Henderson Creek" (HCP 1999d). The stewardship package they provide to initiate stewards includes brochures on a variety of issues. These brochures provide information on how to (a) disconnect a downspout from the storm sewer system; (b) plant with native plants (which reduces dependence on fertilizers, pesticides, and herbicides); and (c) pave with hole-filled concrete bricks that let rainwater into the ground (HCP 1999c). The Project intends to make stewardship compelling yet attractive and fun, increasing community participation and helping to reverse the environmentally destructive trend that was set in motion with the arrival of the European settlers.

The open-house event (the "Open House") analyzed below was meant as a "kickoff" to the stewardship campaign. This event was a major thrust of the activists' activity and took about three months to plan and enact. The Project applied for and received a $5,000 grant from a provincial government agency to hire a coordinator and to cover the expenses of staging it. The resulting event involved substantial planning and thought by the activists in order to provide opportunities for community members to engage in scientifically informed moral discourse about the creek.

Learning and Relating through Community Science

The overall purpose of the Open House was to engage the public in talk and activities about Henderson Creek, with the intent of interesting them in the stewardship program. This event was designed to bring science (in this case stream ecology and hydrology) into everyday life. In the following three analyses, we articulate features of community-level science enacted by the activists that, we believe, can contribute to better citizenship. We are therefore sensitive to those activities that we see as "learning science" and to those that would contribute to "good citizenship." We highlight the activists' efforts to make science and creek talk relevant to and become a part of people's everyday lives. In doing so, we are concerned with the situated activities of participants. We interpret interactions with people (Who are visitors talking to? What registers/genres do

they use?) and materials (What inscriptions and artifacts are they using?), and contexts (How do visitors activities relate to the setting?).

First, we articulate how the activists mix aspects of the setting with ecological features of the creek and historic narratives of the community. Next, we analyze the variety of representations and relationships that enable the discourse about the creek at the Open House. Finally, we show that in their moral-scientific talk about the creek, the activists employ a typical pattern, which we call the "stewardship triad."

A "Bucolic Location" – Relating Space to Science and Community

Material arrangements frame meaning-making social relations (Bourdieu 1990; Lave 1988). Space, the objects in it, and their arrangement are important resources for making meaning and creating relationships (Goodwin 1995; Latour 1996). In the Open House, the activists drew on these resources by choosing to use space and the arrangement of objects to deliberately introduce connections between scientific topics and other aspects of everyday life and to forge links between people's spoken/read and bodily experienced links. By doing so, they tightly wove the scientific discourse (a practice) into other aspects of everyday community life.

The Project decided to locate the Open House in the hall and grounds of St. Michael's Church. As their public service announcement indicates, this particular location was more than just space that they filled up with their displays; it associated the project's work with a major theme in the community—its heritage.

> The choice of St. Michael's church as a venue for this event extends beyond its bucolic location. Henderson Creek flows through a valley originally graced by open prairie and garry oak meadows maintained by the Wseseynish people living at Tsarcum; the beauty of the area also attracted the first European settlers to the Sandwich Peninsula in 1855. (HCP 1999b)

In this public service announcement, the Project makes reference to three strands of the region's history: its natural, First Nations and pioneer history. The community takes great interest and pride in history: it maintains two museums dedicated to local history and is currently engaged in a campaign to raise the funds for a third. This pride is not limited to the pioneer descendants. The First-Nations community has published numerous historical books that are used in local schools. St. Michael's church, the site of the Open House, was one of the first structures built in the community and is the one of the oldest churches in the province. The Project made this historical link explicit by hiring a local historian to spend the afternoon in the church's graveyard, telling stories of the pioneers buried there. They also reproduced the first map ever made of the re-

gion, and illustrated it with colors and icons representing the different landscape features written in the surveyor's diary. Thus the creek became part of the historical narratives of the community. The activists constructed it historically through narrative, and used the choice of the site to embody and reinforce this construction. The community's history-related practices were therefore set up to mediate those related to science.

Meaning was also woven into the landscape itself on a physical scale:

> The Open House site was nestled in the lower portions of the Mount Newcombe Valley, with Henderson Creek running only hundreds of yards away. The farmer whose fields were adjacent to the church had mowed a pathway to the creek through his hay field. Signs were made, encouraging visitors to walk down and along the creek. [Field note]

In this instance, the landscape was transformed into a sign system, a frame that mediated their messages (Brown and Duguid 1996). A pathway was cut through the fields of hay. Directional signs led visitors down to the creek, where interpretive signs informed them about what they could see. The activists had carved meaning into the valley, and changed a landscape into a directed, purposeful walk. The swathe through the hay and the signs all indicated that people were free and encouraged to walk through what was otherwise private property. Thus, private property rights were temporarily suspended, and people were guided to experience the creek as it flowed through the valley.[5] Through the activity of walking down to the creek, visitors obtained a first-hand, embodied experience of it. This experience, situated in the familiar Newcombe Valley, was a new way of engaging the landscape for most people.

Inside the church hall, the Project, middle-school students, and other stewardship groups posted displays on tabletops arranged around the periphery of the room. Many of the posters dealt with scientific topics such as "how a stream works," "ecosystem features of the Sandwich Inlet," or the contribution of chicken farms to fecal coliform[6] loading in the stream. The space and its contents strongly resembled an academic poster session. The physical experience of those moving about in this environment and engaging in discourse while pointing to and talking about various representations of the landscape fit with experiences had while in the legitimized environments of a trade show, a municipal public-information session, or an academic conference. Thus, again, space

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[5] Henderson Creek flows entirely through private property as it travels through the valley on the way to the ocean, so this is a rare opportunity for visitors to observe the creek closely.

[6] Fecal coliform are bacteria that are taken to be indicative of sewage contamination of a watercourse.

framed and therefore mediated the meaning-making processes them. The activists' message was presented within familiar, legitimate bounds.

The scientific representations were situated within the physical environment of the creek that they purported to represent. Many visitors, after reading about Henderson Creek in the activists' displays, walked down to the creek to "see for themselves." This created an opportunity for people to make the connection between their embodied experience of the natural world and the artifacts and representations that were displayed by the activists. Thus, through the construction of a spatial arrangement, the activists supported the purpose of this part of the event, which was to present the community with opportunities to engage with the creek in a way that supported the scientific talk and representations.

The activists used a number of "prompts" to frame the talk and motion, including making pathways, assigning knowledgeable people at strategic locations and placing their representations within a special kind of built environment. The actual object of their inquiry, the creek, was present and represented through a historically constructed discourse, linking "personal experience" and the "discursive understanding" meaning-making systems (Ricœur 1991). Thus science, so often considered "value free," is situated in narratives that are local and value-laden, as well as in people's embodied experience of a landscape. Through the mediating elements and practices employed, learning about a creek's ecology becomes part of one's experience of inhabiting a community.

Learning a Heterogeneous Science through Relationships

Relationships are an important part of learning and doing science at a local level. We consider that learning about and appreciating diversity in the community is a "good citizenship" activity. At the Open House, visitors had opportunities to experience the variety of relationships that supported and constituted the Project, which constitutes a heterogeneous, dispersed, and marginal[7] community of practice. It depends on good relations with homeowners, schoolteachers, scientists, university co-op coordinators, bureaucrats, and others to get its work done. In one sense, the Project could be defined as the living sum of these relations. The Open House was an opportunity for the usually dispersed contributing organizations and individuals to be present at the same time, in the same space. Many groups brought displays or set up activities. There were displays on the history of the watershed, watershed ecology, and stewardship activities by the Project; displays by middle- and secondary-school students; displays from other watershed groups on the peninsula; First-Nations art, featuring the Project's

7 Here we mean "multiply marginal" in the sense that Star developed the concept, which implies belonging, peripherally to multiple communities. We do not use it to indicate that the Project is disempowered or marginalized over and over again. See Star, 1991.

logo-in-progress; information from conservation organizations and local nurseries; representatives from the federal government; presentation of stewardship certificates to the first group of stewards by the mayor of Oceanside (HCP 1999a). Through the diversity of representations at the Open House, scientific terms such as "watershed" become associated with, and therefore mediated by, political, historical and other discourses, resulting in a hybrid discourse that contains elements of local importance and scientific relevance (Irwin, Dale and Smith 1996).

We emphasize the relational aspect of this learning landscape, something often downplayed in literature on science education. Relationships at the community level are important mediators of scientific activity. It is important and not trivial to know who in a community can help with what aspect of your scientific project. A second aspect of relationships in a small community is that certain people or groups in the community have their own implicit meaning to others. By associating with some people, the Project positions itself relative to others and gains or loses access to potentially enabling relationships.

In the following vignettes, we describe and analyze four instances where scientific talk, through different mediating practices, became mixed with community concerns.

Multiple Sites for Making Meaning

1. The First Nations carver, a nationally recognized artist, whom the Project had hired to design the logo for their stewardship program, chatted amiably with passers-by. On a card table, he displayed the logo-in-progress along with some of his other recent work. When completed, the logo would be affixed to lawn plaques that stewards would be able to display.

Visitors who talked to the carver likely entered into discussion about the animals that once lived in the valley, the landscape features pre-settlement, the place the creek had in their spiritual lives, and the effect of treaties on his Nation's lifestyle. His representation of Henderson Creek, a logo commissioned by the Project, represented the animal life in artistic form and included geographic features of the watershed that were of significance to his people. The carver frequently pointed to the representation and talked about the ways, for instance, in which his people used the small island just off the mouth of the creek. He provided visitors with opportunities to understand the creek, elsewhere in the Open House represented by dissolved-oxygen levels and coliform counts, in terms of a its connections to a different culture and way of life. In his person, there existed a resource to link science to history and First-Nations culture.

2. Late in the morning, all the visitors were called to a central location. The mayor of Oceanside presented a speech in which he praised the efforts of the Project and those who

had taken up the important task of being stewards. Stewardship certificates were awarded to the dozen stewards.

The mayor's presentation was a symbolic act that had the potential to strengthen to position of the Project in the community because he spoke *as* the mayor at a public event and thereby represented the council and municipal government. In the speech, the mayor combined aspects of scientific and political discourse, putting each into new relations and thereby transforming them. For example, he brought together "watershed" and "healthy ecosystem" with his government and its stated policies. This juxtaposition provided a link between institutions and environmental features that had not existed before. Through his participation, the Project demonstrated that they were considered a legitimate organization by the elected local government.

3. Karen, the water technician hired by the Project and a supporting farmer to monitor water levels in both the creek and the water table, led children in the construction of "groundwater aquifers" in upside down two-liter pop bottles with their bottoms cut off. The children had a choice of materials from which to construct aquifer—sandy, clay-type or organic soil and also could put "impervious surfaces"[8] on top of the aquifer. Once they had made their soil cocktail, Karen poured water onto it and the children could see the water's path through the container's clear walls. As the children built and watched their experiments, Karen commented that these pop bottles mimicked different types of soil strata in the municipality and the flow of ground water through them.

The water technician Karen engaged the children in a classic scientific practice by setting conditions to help them make models of "natural phenomena." Her discourse structured the event so that the talk moved between the properties of the materials they used and those of the entities represented. These elaborations therefore provided opportunities to better understand groundwater flow. Karen provided an opportunity for children and other visitors to experience "hands-on" pedagogy, which led the learner through an exercise, forming relationships between what they did with their hands and what was going on underneath the ground of their community. In this situation, though, there was no right or wrong. The participants made their "aquifers," did the experiment of pouring water on them and got results. Karen then related these results to soil type and ground water flow.

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[8] 'Impervious surfaces' such as roofs, parking lots and roads have a major impact on streams as they keep water out of the ground, and contribute through their connection to storm drains to flash floods of dirt and petrochemical-laden water during 'storm events'. A 12% coverage with impervious surfaces is enough to impact a salmon stream, and 18% is correlated with over 90% loss of salmon.

4. Two Project members had spent the early morning collecting small animals from the creek and stored them in an aquarium in the shade of a weeping willow tree. Trout, stickleback, newts and a crawfish were present in the aquarium, evidence that what some called a "muddy ditch" was indeed a living thing. The Project members placed dissection microscopes next to the aquarium, along with ice-cube containers holding some of the small invertebrates that lived in the creek. Visitors could examine these creatures through the microscopes and discuss them and their significance with the attending committee member.

Visitors to the aquarium had an opportunity to see the creatures that lived in the creek. Since many people in Oceanside do not know Henderson Creek exists, showing them that there are different species of fish and invertebrates in the creek is important. The aquarium was also a representation of the creek, presenting a stylized, concentrated view of the creatures that live in it. The Project members stationed at the aquarium were eager to tell visitors the locations where the animals had been found, and to work with them at the dissecting microscopes, handling, viewing, and talking about the creatures which they were examining.

In our four episodes, we see the creek and watershed represented in discourse, visual art, muddy models, and fish swimming in an aquarium. These representations did not stand alone, but functioned in the coordination of activity through which meaning was made (Amann and Knorr-Cetina 1990; Lynch 1994); they mediated all instances of formal scientific discourse. In the four episodes, people participated in discourse about the importance of the environment in civil politics, engaged with microscopes and specimens, identified fish species, packed bottles with dirt and poured water on them, and other activities.

The creek was represented in multiple discourses, artifacts, gestures, and activities. For each Open House participant, an identification of a creek invertebrate and construction of an "aquifer" provided a resource for change, that is, learning about some aspect of the Henderson Creek and the watershed it empties. Creek science as it is enacted in this open-house setting includes many of the mediating elements that bring science into society: historical narratives, economic interests, environmental and governance concerns. This variety of meaning making events available to the Open House participants stands in contrast to the usual hegemonic discourse that predominates textbook approaches to science (Barton 2001). Scientific discourse, mediated as in the case of the Open House by other community-based practices, supports the values of inclusion and valuing heterogeneity that (in our view) are crucial to good citizenship.

We recognize that history and stream science are different activities. But at the site of confluence of practice that a grass-roots situation presents, multiple

disciplines are brought to bear on solving problems[9] (Fourez 1996; Maxwell 1992). Both history and ecology therefore have to be enacted to bring about the restoration of a creek. Events such as the Open House are valuable as a way of learning about this multidisciplinary practice of science in the community, through engaging in multiple activities organized around a variety of representations of the creek.

Participating in Project Relationships

Through the Open House, the activists displayed their relationships to recognized entities in the community. Visitors could witness the endorsement of the stewardship program by the mayor, notice local middle school students' work, admire native art, buy a plant from the nursery, or walk in the path cut through the farmer's hay fields. The Open House was an opportunity for the Project to publicly demonstrate its "good citizenship" by showing visitors with whom it was associated. For a group that relies on community acceptance and support for its existence, this legitimizing aspect of relationships is considered crucial. It supports their identity as a reasonable, trustworthy cause, worthy of public support.

The participatory, equitable, heterogeneous and situated nature of the relations at the Open House fostered a relevant and complex understanding of science in the community. The understanding is relevant because visitors engaged in co-creative interactions, where they had an active hand to play in forming the discourse. These interactions made the event complex because the creek was embedded in multiple understandings and concerns of different individuals, the people who discussed these concerns were also known to be associated with different parts of the community and these associations have salience to visitors. People had an experience of engaging with multiple representations of the creek embedded in a network of relations that give these representations another layer of meaning. Through this dense ensemble of mediating relations, the scientific discourse provided a common thread for a variety of discussions about the many aspects that make up a community. Science became mixed with and mediated by personal relations and the variety of different professions, hobbies and lifestyles in the community. We consider this mixture is an example of scientifically literate good citizenship.

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[9] As part of his work on the practice based description of science doing in everyday life, Fourez (1996) claims the ability to create and navigate 'rationality islands', groups of practitioners from disparate disciplines who congregate to solve a certain problem as an issue of central importance.

Stewardship Triad

In the following section, we address a major component of good citizenship, moral discourse. We assume that morals and beliefs are products of talk rather than entities in themselves (Potter and Wetherell 1987). Thus, participating in discussion of what is the morally right thing for a community to do is one way of engaging in moral citizenship. Stream stewardship is presented by the Project to the community as, among other things, a morally laudable activity. By *talking* stewardship, people were engaged in science-based moral activity. In the following, we delineate how the activists incorporate scientific discourse in moral discussions.

The stewardship discourse consistently has three elements, a triad: science, morality and stewardship.[10] This triad links individual actions (stewardship), science (the creek as an ecological entity), and morality (for the good health of all). As an entity in a triad, science is therefore always mediated by the practices related to the other entities. Figure 1 illustrates the co-presence of all three elements of the triad.

We use an excerpt from a published interview with Meagan, the Project's administrator to illustrate our notion of the stewardship triad (Figure 1): "Once residents *understand* the issues and problems… they will be *committed* to ensuring the health and integrity of the *natural processes* that sustain us all" [our emphases]. In this quotation, the understanding of scientifically articulated issues and problems is portrayed as a springboard to a moral commitment. In her statement, Meagan made the subject of the citizens' commitment the "integrity of natural processes," an ecological phrase. She wove a tight relationship between a scientifically legitimate worldview and moral commitment to a healthy world. A final reference to relevant actions by a morally responsible, scientifically aware citizen completed the triad. In Figure 1 we see that "they will be committed to *ensuring*" the health of the community and natural processes. Thus, in this case, stewardship activity flows naturally from a moral agent's understanding. In the second quotation (Figure 1), the pride of assuring a healthy ecosystem for future generations (moral citizenship) was emphasized. Here, the commitment to providing benefits to future generations, a moral argument, was central, and scientific understanding secondary. In the third quotation, the main topic was the active involvement of every citizen in the watershed's health, a call to stewardship. Although the three examples show different emphases and relations between the three elements, all three examples exhibit the interrelatedness of the three elements and therefore the mediating nature that any two have

[10] Interestingly, government stewardship brochures tend to also include an economic facet to the stewardship triad, claiming that protecting our resources is good for the future economic well being of the community.

From a newspaper article:
MacDonald emphasizes that the aim of the project is not to just *restore a creek*, but to create a means for community awareness and action, creating a local commitment to long-term sustainability that will continue long after [their] work is finished.
'This project must be driven by the community. *Once residents understand the issues and problems in the watershed and in the Saanich inlet*, I believe they will be committed to ensuring the health and integrity of the *natural processes* that sustain us all.'

From Project's Stewardship Brochure:
There are many benefits to taking part in a stewardship program. In the longterm, you can take pride in assuring a *healthy ecosystem*, and a *clean, adequate water supply* for future generations.

From the Project's Website:
Every watershed resident influences the *health of Hagan Creek*, so whether you live along the *creek or tributary*, work in Keating Industrial Park, or live in a residential area, you can play an important role in protecting the *creek system and the watershed function.*

Figure 1. A discursive triad linking scientific terms, stewardship practices and good citizenship is prevalent in written and spoken discourse about the Project's stewardship initiative. Different parts of the triad are indicated by differently shaded text boxes: words and phrases associated with stewardship are boxed, those associated with citizenship are underlined, and those associated with scientific literacy are *italicized*.

on the third. Without any one, the other two make no sense in the context of a persuasive argument.

This "stewardship triad" is a pattern basic to the stewardship discourse of the activists.[11] What can this tell us about the activists' scientifically grounded discourse? The first thing we note is that they use, in this case, science as an authoritarian version of the truth. "Natural processes," "healthy ecosystem," and "clean adequate water supply" are all treated as entities, rather than ill-defined sites of conflict. The uncertainty or deliberations around the construction of standards, so often an issue in the science studies literature (Star and Griesemer 1989), are virtually absent. The second is that they construct a moral agent whose main concern is with the well being of the whole, not just community, but

[11] Although our figure deals exclusively with written discourse, this triad is also a feature of the Project members' spoken discourse.

"web of life." Embedded in the activists' arguments is a moral stance that puts primacy not on the fate of the individual or even of the human inhabitants, but on the functioning of the natural processes and health of the ecosystem (and by doing so assumes they can be known objectively). Finally, the activists describe a moral agent who is empowered financially and intentionally to work to bring about change in their way of living.

Reframing Scientific Literacy

In the previous section we illustrated how scientific discourse was mediated by other practices at a local open house event. We now argue that situations like these are the key to science participating in a morally just society. [12] We first outline some of the moral goals stated by science educators and scientists, and then examine some of the mediating practices involved in science education and practice that we believe act against the fulfillment of these goals.

Traditional Perspective on Scientific Literacy

Scientific literacy is often described as a pre-requisite for a person's empowered, full citizenship. We showed earlier how AAAS directly linked science literacy and the formation of a good citizen. The resulting science education is based on helping students learn the "habits of mind" that practicing scientists supposedly possess (e.g. Roth and McGinn 1998). What is missing from the document is the description of (a) mediating practices that place science and science learning [13] in (b) situations where "good citizenship practices" are performed (McGinn and Roth 1999). In terms of helping to foster the development of good citizens, we see a number of problems with the approach based on students' ability to imitate scientists' discursive repertoire within the classroom context.

The first problem, well articulated in science studies, is that "habits of mind" cannot be considered as isolated from the material and social practices of those demonstrating these "habits" (Amann and Knorr-Cetina 1990; Law 1987; Pickering 1995). Thus, students who sit in classrooms, copy notes and engage in token hands-on activities are unlikely to acquire scientific "habits of mind" because they do not have access to tools, social situations and practices that mediate the activities of scientists (Latour 1990).

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[12] By saying this, we are in agreement with Eisenhart, who also argued for and presented case studies outlining the benefits of community-based ecological restoration practice as a legitimate way of learning science (Eisenhart 1996).

[13] We use the term "learning science" here to distinguish it from that of a "science education." The distinction is that learning science happens as one engages in scientific practice, wherever that may be, while "science education" implies a curriculum-driven course of instruction, whether done within an institution or based on an activist's specific agenda.

Second, the tension between the stated goal of active citizenship and the reality of science education in everyday classrooms makes achieving the goals of the reform rhetoric problematic. In general, the current practice of science education focuses on the students' conformity to authoritative knowledge and scientific discourse that is relevant to research scientists, whether it is "discovery learning" or traditional lecture-style learning (Roth 1998). Generally, students are taught one way of representing "nature" and are graded on their ability mimic what they are taught. Alternative meanings, espoused by the humanities or marginal cultural groups are generally ignored and sometimes mocked (Popli 1999; Roth and Alexander 1997). This type of activity encourages participants to consider "scientific" issues from one perspective and seek approval of a legitimated authority to validate their actions rather than participating in critical and democratic discourse (Burkhardt 1999).

Third, in the past science education curriculum was articulated as if the goal was to turn all students into "little scientists" (McGinn and Roth 1999). Cognitive-apprenticeship models went further in this endeavor proposing to enculturate students into the practices of laboratory science (Brown Collins and Duguid 1989). We question those who envision science education as an unreflective and uncritical enculturation into scientists' science. There is nothing inherently moral about the practice of science (Beck 1992). The language games associated with "objectivity," "scientific neutrality," and "impartiality" discourage talk about the political and social aspects of science (Burkhardt 1999). This silence in fact allows scientists to retain their morally neutral, "above politics" position while they serve corporate interests opposed to democratic governments, develop instruments of mass destruction, and argue passionately for policies that could well be considered eugenic.

A New Perspective

We find the traditional approach to scientific literacy inherently problematic and, in its claim to be value free, even antithetical to social and moral engagement. We therefore seek different ways of thinking about scientific literacy and ways of fostering its emergence. Our case-study materials articulate community-based science and science education that is politically positioned and morally legitimized. This may be an excellent instantiation of what science can be it engages participants to be first and foremost socially and morally responsible citizens. Five practices in particular mediated "pure" science and scientific discourse, giving rise to a different form of scientific literacy.

1. Deliberately and authentically using materials and space to influence social activity. The activist group used physical space as a frame for integrating science into other community narratives. The landscape was altered to mediate people's direct experience of the creek. People who attended the Open House

event worked with models, talked about alternative resource uses, about different cultural significance, and about the creek's changing identity. Appropriate inscriptions and tools such as maps and microscopes mediated their talk.

2. Mixing scientific with other ways of representing the creek. The creek, as an ecological entity, was represented in numerous ways: scientifically, historically, artistically, and in relation to citizens' everyday practices. Unlike traditional teaching of science, this way of presenting provided multiple perspectives, included other cultural models and emphasized relationships in the practice of scientifically informed citizenship.

3. Providing opportunity for personal contact with those people directly involved in the issues. Visitors were able to discuss issues with others, such as the mayor, who make decisions about the creek. Thus participants could engage in conversations whose outcome may be meaningful to the subject of their talk. We oppose this activity to in-school discussions, where the outcome of the discussion rarely effects the object (for example, the health of the creek) being discussed, but rather contributes to the evaluation of the discussants' performance.

4. Making scientific topics relevant to participants' lives. The Open House site was an excellent opportunity for people to acquire or to enhance scientific literacy. Some of the volunteers themselves were experienced practitioners; the nursery manager knows how to cultivate literally hundreds of native plants, Karen (the water technician) has worked with the region's waterways for years, and some Project members have post-secondary degrees in science. The enacted literacy was discursive, as discourse is the predominant activity that people engaged in at the Open House. In this context, though, literacy was not just about being familiar with canonical facts such as "trout need highly oxygenated water to survive." In this case literacy involved the use of scientific talk to make connections between elements of individuals' lifeworlds, such as the relation of the creek to the settlement of the valley by their ancestors.

5. Including scientific discourse in moral, politically positioned discourse. The mission statement of the Henderson Creek Project makes it clear that they are working for both human and non-human beings in the watershed, both those who are living now and those who will come in the future. Thus their organization has explicitly moral goals. At the Open House, talk was structured around moral concerns grounded in scientific characterizations of the creek's needs. Discussion about what was right and what was wrong to do were present in the talk at the Open House, in interviews we had with Project members and in the material the Project distributed.

Through partnerships and funding agreements, the activists are also directly involved with provincial, federal and municipal governments, and can be considered to be advancing these organizations' environmental restoration mandates. Unlike the practitioners of science who claim to work out the properties of a rationally understandable world "to protect ourselves from the irrational ten-

dencies that still beset humanity" (Weinberg 1996, 15), the activists do not claim to have a superior objective knowledge. They engage in a passionate practice that, while it incorporates scientific knowledge, is fundamentally political.

Through the various mediating practices they enact, a hybrid way of talking and relating emerged, one that mixed contingencies of local setting and relationship with the decontextualized discourse of science (Irwin, Dale and Smith 1996). We argue that hybrid discourse is a typical and diagnostic feature of the integration of scientific terminology with the concerns of the host community. In this case the relevance to local community's interests, the appreciation of diversity and the moral commitments articulated in the hybrid discourse lead us to consider it evidence of scientifically literate "good citizenship."

Conclusion

The Project is politically positioned, engaged in the act of constructing new meaning-making connections, and has brought many otherwise spatially dispersed actors into one space for a day. Into this space, transformed to highlight scientific social relations in the community, visitors are invited. These visitors experience a social landscape charged with talk about community affairs, and shot through with scientific discourses such as those about "groundwater," "aquifer," and "watershed." By walking, talking and pointing, the visitors involve themselves in these discourses, learn how to interpret representations, and form new relations with other community members. The science learned at this site is intimately related to local non-scientific concerns. Thus, stewardship discourse and practice set science in relation to other practices and therefore provide a necessary stabilizing and supporting context for community-based scientific literacy. We argue that it is through participation in sites like these that people become scientifically literate in a way considered morally laudable.

Although the activists partially engage in new practices, they also rely strongly on traditional scientific practices. This leaves the critical scholar in a quandary: how is it that a group enacting a democratic science returns to the hegemonic science in order to ground its claims for democratically based cultural change? How is it that moral judgment grounded in a radically collective worldview is expressed in terms of individual action? This conundrum becomes less confusing if we return to notion of practice and ask, "What do the activists try to achieve with this talk?" They use scientifically legitimized arguments to convince others that becoming a steward of Henderson Creek is a valuable activity. In the case of the stewardship triad, then, it is appropriate to frame their moral arguments in ways in which the largely right-wing[14] and middle-class

[14] In a recent national election, the majority of the votes in this community went to a candidate of a political party that stands for massive tax cuts to business, decreased

community understands (d'Anjou and Van Male 1998). This argument re-emphasizes that science (in this case scientific discourse) is being used as a tool to achieve a certain goal, just as it is in other aspects of life, whether it is cancer research or water quality monitoring.[15] In this case, scientific discourse is enrolled in the cause of moral arguments put forward to persuade a community to take action. This hybrid statement which mixes scientific with moral discourse is a mediating practice used by the Project to bring science into the everyday life of the community.

Recent accounts support our approach to knowledge as local performances, whose mediating circumstances often support the existence of hybrid discourses (Edmond 2001; Miller 2001). Edmond (2001) writes of a "law-set," which is a term he uses to describe the confluence of legal, scientific, and lay concerns that shape the performance of knowledge in the judicial system. These law sets produce law-science knowledges that are hybrids of the discourse and practices of the scientific community and the multiple constraints and tensions that effect the performance of a legal trial. This law-science knowledge is not science being distorted by the legal process, but is its own kind of knowledge, "not reducible to issues captured by an extralegal epistemology" (Edmond 2001, 218). By emphasizing the circumstances influencing knowledgeable performance in his account, he too has shown the importance of mediating practices. Our account resonates with this approach. If we are interested in scientific literacy contributing to good citizenship, we should pay attention to the particular kinds of mediators that enable and characterize the practices we wish people to learn.

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spending on social programs, and that is associated with religious fundamentalism and whose leader believes that the universe was created 5,000 years ago.

[15] Helford (1999) has also pointed out that activists position themselves relative to a hegemonic science in order to appeal to those whom they were trying to convince.

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