Adults Learning about Shale Gas Development: Information Sharing, Community Engagement, and Critical Science Literacy

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Abstract: This paper examines how rural adults in a non-formal education class on Marcellus Shale gas development developed and applied critical science literacy. Through expanding their scientific knowledge, adults shifted how they learned about and shared information with others, their relationship with science, and their self-perceptions as scientifically knowledgeable citizens.

Introduction

The rapid development of natural gas across the United States—and the controversy, confusion, and ambivalence concerning the risks and benefits of shale gas drilling (Alter, Brasier, McLaughlin, & Willits, 2010; Brasier et al., 2011; Schafft, Borlu, & Glenna, 2013)—provided an ideal opportunity for Penn State researchers to educate adults about the physical and social science of shale gas development (SGD), including hydraulic fracturing. This paper presents findings from a study that examined the experiences of rural community members who attended the Marcellus Shale Community Science Volunteer Program (MSCVP), an 8-week, non-formal education course. To our knowledge, this is one of the first non-formal adult education classes on SGD in the U.S.

To date, much of the literature on informal science education has focused on children or families in museums or similar settings (e.g., Borun, Chambers, & Cleghorn, 1996). The National Association of Research in Science Teaching has called for a deeper understanding of informal science learning in real-world situations (Dierking, Falk, Rennie, Anderson, & Ellenbogen, 2003), and environmental issues have garnered increased attention in adult education (Hill & Clover, 2003; Lange, 2010). Accordingly, this paper elucidates how adults understand science, develop and apply critical science literacy, and engage in their communities with increased scientific understanding. We argue that the opportunity to expand scientific knowledge shifted how they learned about and shared information with others, their relationship with science, and their perceptions of themselves as scientifically knowledgeable citizens.

Theoretical Framework

The course objectives and study findings are situated in literature on informal science education, environmental adult education, and critical science literacy. Informal science education approaches the learning of science as an "organic, dynamic, never-ending, and holistic phenomenon of constructing personal meaning" (Dierking et al., 2003, p. 109) that takes place in authentic, real-world contexts. Emphasizing the multiple ways, places, and types of learning, informal science education literature underscores the value of scientific learning within and beyond the classroom, and considers scientific knowledge to be constructed through personal experience and meaning making (Dierking et al., 2003).

One field that has extensively applied tenets of informal learning is environmental adult education. Following this literature, we view learners as active participants and emphasize the dissemination of information across diverse groups and throughout communities, and the importance of knowledge building by participants (Haugen, 2010; Jansen, 1995; Roy, 2000). Furthermore, environmental adult education provides a theoretical basis for the relationship between socio-political matters, science, and the environment demonstrated within this study.

Critical science literacy, which informed the design of the course and the research questions for this study, is conceptualized as the combination of functional and technical scientific literacy with "critical engagement with text, ideas, and ways of knowing and being that frame the discourse and practice of science" (Barton & Tan, 2010, p. 4). In examining how scientific information is applied and used to effect change, critical science literacy scholarship acknowledges scientific knowledge as situated in specific socio-historical contexts (Weinstein, 2008). The controversial and expedited nature of SGD, coupled with rural Pennsylvania's history of economic growth based on resource extraction (i.e., coal), called for an approach to scientific literacy that considers the historic, cultural, and social contexts within which scientific information is received and understood, both individually and collectively.

Context and Research Methods

In response to Pennsylvanians' limited knowledge of drilling procedures, water, and other SGD topics (Alter et al., 2010), this National Science Foundation project (Marcellus Matters: Engaging Adults in Science and Energy) includes four components: the MSCVP course, an online network for participants, community-based theater, and environmental planning workshops. The project focuses on rural counties with intensive drilling, and aims to increase adults' ability to evaluate claims about the benefits and risks of shale exploration, and to develop an educational model that can be adapted for other rural areas experiencing SGD.

The MCSVP course, the focus of this paper, seeks to enhance rural adults' knowledge of science and engineering related to energy consumption, production, and policy, thus enabling them to both share their knowledge and foster deliberation in their social networks about this complex, divisive social-scientific issue. Along with Penn State colleagues, we were involved in designing the course, which meets weekly and covers 8 topics: energy choices, the scientific inquiry process, geology and seismic testing, engineering, water, land-use planning, socio-economic impacts, and strategies for fostering dialogue about SGD. Two themes cut across the classes: understanding how science is done and critical science literacy, that is, evaluating the accuracy and trustworthiness of SGD information. The course includes presentation, discussion, interactive activities, and experiential activities such as testing water and visiting a drilling site.

This paper examines the first course that was offered after pilot testing. Specifically, we address the following questions: (1) How do participants share and apply what they learned in the program? (2) How do participants understand science and themselves as scientifically knowledgeable individuals? All 22 students in the class were invited to participate in the study, and 13 (5 women, 8 men) agreed to do so. The participants were adults age 40 or older who had attained postsecondary degrees (ranging from associate to graduate level), and had resided in their respective communities for several decades. They included current and retired educators, business and sales people, farmers, and factory workers.

Data sources included observations of 6 out of 8 classes, interviews (n=21), and activity logs (n=65). Data quality was enhanced by triangulating methods (Mathison, 1988). Nine of the 13 participants agreed to be interviewed *and* complete activity logs; the other 4 only completed

the logs. Interviews were held at the beginning and end of the course and six months after it ended. Interviews focused on participants' views on SGD, means of gathering and assessing information on SGD, application of what they learned in class, and self-perceptions as knowledgeable about science and SGD, among other topics. Participants used researcher-created activity logs (bi-weekly during the course and monthly for the 6 months after the course) to indicate (1) *how* they applied what they learned (open-ended responses for 3 categories: personal, interpersonal, community/public) and (2) *how often* they did so (3-point Likert scale).

Guided by the research questions and content analysis (Braun & Clarke, 2006; Patton, 1990), we identified a coding scheme, themes, and subthemes, and then compared our analysis for analytical triangulation. The quantitative activity log data were analyzed to determine the average frequency of applying knowledge in personal, interpersonal, and public domains, and open-ended responses were analyzed to ascertain the most common types of activities.

Findings

The participants entered the course with a range of positions on SGD and motivations for taking the course. The three who were strongly opposed to SGD, as well as the two who were strongly supportive, indicated that they wanted to substantiate their positions by taking the course. For the most part, at the end of the study they agreed that the course did help them support their original positions, but also added nuance and complexity to their prior understanding of SGD – both on social and scientific issues. The four other participants situated themselves somewhere in between: "It's [SGD] a great opportunity for the country, you know. It poses a threat as well…It's really a double-edged sword"; "I'm a fence-sitter….Two years ago, I was totally against it. But now…I can see more of…the driller's perspective and others' perspective…So…that's why I took this program. I need help!"

Regardless of their position on SGD, as participants gained information during and after the class, they gained confidence in sharing their knowledge, believed that family and friends perceived them as more knowledgeable, became more critical consumers of SGD information, and became more involved with public events in their communities. Since citizens turn to the media as their primary source of information about SGD (Alter et. al., 2010), a key objective of the class was to cultivate critical science literacy by providing strategies for understanding, questioning, and assessing the content of science information sources such as the newspaper. Participants overwhelmingly demonstrated application of these techniques to information that they read, saw, or heard, as evidenced by the following comments: "I read it [media sources] with more of the mind"; "Separating the myths from the facts, I think that's the real challenge"; "I wonder what is real and what isn't while I listen and read"; and "Now I kind of read something and wonder where does their knowledge come from and try to find their sources." For instance, Abby explained that after the class she was compelled to question what she heard and read, look up multiple sources on a topic, and critically investigate the methods and funding sources of research. Earl developed a clearer understanding of scientific causation from a specific class session, commenting, "I guess it comes down to the causation and, you know, that part of the class [causation] I've really learned to use a little more when I'm reading articles."

During class periods, several participants were observed critically questioning the instructors and material. For example, in one session learners have to make decisions about the development of a hypothetical plot of land, within specific parameters. The participants were observed thinking beyond the information given to them and creatively arriving at solutions (e.g., questioning who gets to make SGD policy decisions, how soil types affect well placement).

Participants developed a more skeptical, questioning attitude not only toward SGD information sources, but also toward scientific inquiry, scientists, and research. On the whole, they shifted from an unquestioning view of science as "cold, hard facts" and a "know-it-all source of knowledge" to a more complex, nuanced understanding of science as constructed. This shift echoes the course's emphasis on learning how science is done (Danahy, 2014). For two participants, however, this had an unintended consequence: abandoning trust in science as a source of information and turning instead toward individual, personal experience as more credible, as evidenced by Abby's comment:

> I can't understand why people don't believe people anymore….There's a video of this woman talking [about her personal SGD experience]…And it's really compelling. It's really sad that…she's been harmed so much by what's going on, and that people just, I don't know. Do they just not believe her?

Other participants indicated some disappointment upon learning that science does not always provide definitive answers or that scientists begin with assumptions. Ron elaborated on the latter point in all three interviews:

> The other thing that just really boggled my mind was…when they told us when scientists are doing a study they have to do some assumptions….In street vernacular it's like pulling numbers out of your doofey. Okay? I want science to be more than assumptions.

In the second interview he explained, "I probably don't trust that [university Marcellus research] as much as I used to" because learning that scientists make assumptions "kind of burst my bubble, a little bit." This skepticism led him to ask questions about scientific research such as, "What's in this for you?....Which side do you lean toward? And [do] your comments and your numbers tend to lean to that side with you?" Despite a more skeptical stance toward scientific research, the activity log data show that all of the participants continued to engage in scientific reading throughout the study and found the technical material covered in the class to be of value.

Overall, the deepened understanding of scientific inquiry led to greater application of knowledge outside of class, and more confidence in sharing their knowledge. In activity logs, participants reported, on average, 5.3 types of applied learning outside of class over each 2-week period during the course, compared to 8.4 types during each month for the 6 months after it ended. During the course, 52% of these activities took place 1-2 times, 33% occurred 3-4 times, and 15% occurred 5 or more times. The post-course data suggest a greater share of activities occurring more frequently: 45% occurred 1-2 times, 27% 3-4 times, and 29% 5 or more times.

Activity logs also show that most activities were in the *personal* domain (e.g., reading, researching, and questioning or assessing SGD information). This category accounted for 36% of all reported activities, compared to 34% after the course. For example, activity logs indicated that participants sought more information on several topics including liquefying natural gas, compressed natural gas for use in cars and trucks, inspection reports, and SGD-related permitting and violations. Barry explained that he looks to the "Internet, newspapers, mainstream media" for information and from "a variety of sources….Not just rely on any one [source]," while Earl regularly read the *New York Times* news and business sections as his main source of information.

Examples of *interpersonal* activities included speaking to family and friends about the information learned in the class, for example, talking "to friends with different views on water contamination," "with my wife about permitting," and with "family about leasing" or "economic impacts [of SGD] on our community." After the course ended, the proportion of *interpersonal* activities (e.g., talked with spouses, family, and friends about SGD and course topics; discussed concern of abandoned wells, water contamination, or energy costs with co-workers) decreased by

18%. Since participants were no longer attending classes, they may have had less impetus to discuss course topics and SGD issues with others.

Examples of *community/public* activities included attending township meetings, volunteering to test water, and attending SGD-related rallies, among others. For instance, a teacher said, "I've talked about it in my classroom. And basically use it in examples of things that are going on now and things that are going on around us. My kids in my environmental science class do [a regular assignment on] current events." Importantly, the proportion of community/public activities increased by 22% after the course. This suggests that over time the way participants applied learning outside of class shifted from interpersonal to public settings.

The latter finding may stem from participants' increased confidence and concern, passion, or involvement with SGD issues. When asked if she felt more confident sharing her SGD knowledge six months after the course, Abby replied, "Oh, my gosh, yes!" and added, "You know, I'm certainly not an expert by any means, but I know that just among family and friends, and in the community *now*, I suppose they would perceive [me as knowledgeable]." Earl related his confidence to refining his position on SGD: "I become more confident or…you know, in my knowledge of it, so I could actually move my opinion of it." Lynne gained confidence by "just learning the science of it. Learning where our energy comes from, and how we use our energy, and some of the geology." Ron summed up his increased understanding and confidence: "Yeah, I mean, I realize how little I know, but I know more now than I did before."

By the study's end, two participants expressed a high level of passion and commitment to SGD matters. Abby had always been concerned about the environment, but the class "started the whole ball rolling," compelling her to heighten her involvement and to follow SGD issues more closely. However, this passion and concern carried a cognitive and emotional burden:

> I don't want to be out there anymore. I want to stop talking about it [SGD]. I do, and I wish I didn't know what I know….Because I've become quite involved with this….And it's taken up a bit of my time….I don't want to go out there and take water samples [with Senior Environmental Corps]. And I did it this winter when it was freezing cold….I don't want to do this….I want to go canoeing and I want to go, you know, visit people and sit and not talk about this [*laughs*], and talk about something that's a no-brainer that you don't have to think about….What scares me the most now is, thank you very much, I think I'll be following this for the rest of my life. I think I'll be taking water samples till I'm so sick of it, you know, till I get too old to walk over that bank.

Similarly, reflecting on her deep concerns about climate change, Anita remarked, "Sometimes it's just too much to bear." These comments highlight the emotional dimensions of learning about and becoming more publicly involved in environmental and energy issues—a hidden aspect of developing critical science literacy.

Conclusion

By creating a space where social and physical science experts shared technical information with citizens, participants increased their scientific confidence and involvement in accessing SGD information, speaking with others about these topics, and participating in SGD-related community events. The course's emphasis on critical science literacy and scientific inquiry helped to complicate participants' understanding of science. However, the study suggests that developing a less naïve view of science can have unintended consequences such as increased trust in personal experience or interpreting scientific assumptions as "making it up."

This study encourages further research on adult's perceptions of themselves as scientifically knowledgeable, the emotional dimensions of critical science literacy, and the role of non-formal adult education in helping communities adapt to and have informed discussions about SGD and other environmental issues. The course design and outcomes can inform future endeavors to involve citizens in understanding complex, contentious social-scientific topics.

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