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Lifelong Learning Group

Marcellus Matters EASE:

Community Science Volunteers

Summative Evaluation Report

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Background

Marcellus Matters: EASE

Marcellus Matters: Engaging Adults in Science and Energy (EASE) was a program of Penn State University's Marcellus Center for Outreach and Research (MCOR), in collaboration with other experts across the university. The first year of program activities took place in 2012, and the project continued through September 2016. EASE was a multidisciplinary initiative that provided adults in rural Pennsylvania with opportunities to increase their knowledge of science and energy systems and engage in scientific inquiry and investigation through the lens of natural gas development.

The present report addresses one of the four program activities, the Community Science Volunteers (CSV) course.

Community Science Volunteers

Approximately 148 individuals fully completed the Community Science Volunteer program, across seven iterations between 2012 and 2016. Throughout each course, weekly sessions, mostly classroom-based, addressed a series of topics relevant to Marcellus shale, gas drilling, and related science concepts and/or community issues. (A full list of session topics for each cohort appears in Appendix B.)

Table 1. Participation numbers, dates, and locations for iterations of CSV

Location	Dates	Participants Started	Participants Completed
Cohort 1: Clearfield County	9/11/12-10/30/12	21	19
Cohort 2: Clinton County	3/25/13-5/13/13	28	22
Cohort 3: Sullivan County	7/08/13-8/26/13	14	10
Cohort 4: Indiana County	9/16/13-11/18/13	18	14
Cohort 5: Clearfield County	6/16/14-8/11/14	22	18
Cohort 6: Lancaster County	2/3/15-4/21/15	52	42
Cohort 7: Lycoming County	6/16/15-8/25/15	23	23

Because each class involved an eight- to ten-week commitment and was based in an individual community for each iteration, the CSV program was cohort-based and structured around sustained,

consistent participation.[1] As this was the most contact intensive activity of EASE, it was in this effort where the most significant impact on individuals was expected, both in terms of building their individual science literacy and in terms of their continued action in their communities.

Summative evaluation of the CSV program included a set of post- and delayed post measures beginning in the fall of 2012; these instruments were developed alongside formative-stage instruments and revised based on findings from the formative evaluation. A full report from the formative evaluation phase can be found online: http://www.informalscience.org/marcellus-matters-ease-marcellus-community-science-volunteer-formative-evaluation

Summative evaluation sought to answer the following questions:

To what extent was the Community Science Volunteers program effective at cultivating…

- Participants' knowledge of gas drilling-related science content?
- Participants' confidence related to knowing about and discussing gas drilling-related issues?
- Participants' informal use and/or sharing of new gas drilling-related information in their communities?

Methods

The summative evaluation was a census study of all participants in each cohort, and it consisted of a post-program questionnaire designed to measure the success of the program at developing specific content knowledge and skill sets. The instrument included self-reported retrospective pre- and post-levels of understanding related to energy development, self-reported retrospective pre- and post- scores of related to new skills and knowledge, and self-reported activity logs summarizing participant action related to the program. The questionnaire was distributed as a paper-pencil form, then collected by EASE program staff. An abbreviated version of the same measure was also administered by mail several months later. Completed questionnaires were then forwarded to the evaluation team for analysis.

Open-ended responses were coded using emergent categories; where applicable, these coded items were analyzed alongside parallel quantitative items using SPSS. De-identified individual responses to items were analyzed in aggregate across each session, and where possible paired in order to measure change from the pre- to the post- and delayed-post conditions.

As part of regular program activities, participants also took a pre- and post- knowledge assessment; scores from that assessment are described here as paired secondary data that can be triangulated against findings from the evaluation data.

[1] Notably, the course was extended from eight weeks to ten weeks after the third cohort in response to formative feedback from participants.

Limitations

There are two main limitations to this study to consider when interpreting results. First, by design, the study included self-reported assessment of knowledge, skills, and areas of growth. While this approach is appropriate to the scale of this evaluation, and the time separation of measures does help to counteract some desirability biases, the nature of self-reported assessment is biased by the perspective of that individual. However, given that the type of measures involved in summative evaluation relate primarily to community members' preparedness to engage in civil discussions and their confidence about the same, combined with data that did not show an obvious overestimation of abilities in the pre or any of the post conditions, the self-assessments for this population appear to be reasonably informative for understanding achievement of the project goals. The retrospective pre/post design of the summative also attends to this potential limitation. The retrospective pre/post method is useful in this regard because it allows participants to provide a reflection of the degree of perceived change in any particular area by reflecting on both the pre- and post-conditions side-by-side, and it can control in issues such as "response shift bias."[2] It can therefore serve to triangulate with secondary pre- and post-program assessment data, as well as allow for easier comparison in light of changes to the program and variability across participant groups. Nonetheless, additional observational assessments by program managers should be used to interpret these results.

In addition, while the very high response rate to the data collection means that the data almost fully represents the population of participants, the small numbers in each individual county present some limits to what can statistically be said about variation between counties. Non-parametric statistics are used here to address these limitations; however, all statistical analyses should be considered conservatively, and with respect to descriptive statistics as well.

Findings

Following their participation in the CSV program, respondents were asked to rate how well they understood the relationship between Marcellus shale development and each of five affected domains before and after their participation in the program. Analysis of mean showed a significant increase at a $p<.01$ level for all items. To better understand the nature of this group-level positive change, a Cohen's kappa was run to determine the level of agreement between individuals for each item. The item referring to the relationship between Marcellus Shale and the natural environment had the highest level of consistency between respondents with significance at the $p<.05$ level. These data suggest that items that have a greater level of personal relevance (e.g., the risks and possible affordances of where a drilling platform is located) might elicit greater levels of disagreement than items about generally agreed upon topics (e.g., the overall importance of environmental health).

[2] For more on response shift bias, see Rohs, F.R. (1999). Response shift bias: A problem in evaluating leadership development with self-report pretest-post measures. *Journal of Agricultural Education, 40*(4): 28-37.

Table 2. Participant self-reported understanding scores (retrospective pre-and post-ratings); results of comparison of paired pre/post scores*

Understanding how Marcellus Shale development relates to…	BEFORE Mean	AFTER Mean	BEFORE Median	AFTER Median	Sig. p-value
…water resources? (*n*=105)	3.81	5.74	4.00	6.00	.000
…energy choices in Pennsylvania and the U.S.? (*n*=107)	3.76	5.72	4.00	6.00	.000
…the natural environment? (*n*=107)	3.93	5.64	4.00	6.00	.000
…land use? (*n*=106)	3.52	5.63	3.00	6.00	.000
…people and communities? (*n*=107)	3.46	5.54	4.00	6.00	.000

**Wilcoxon Signed Rank test for significance*

Table 3. Magnitude of similarity between participant self-reported understanding scores (retrospective pre-and post- ratings); results of comparison of paired pre/post scores*

Understanding how Marcellus Shale development relates to…	Cohen's κ	p-value
…the natural environment? (*n*=107)	.068	.036
…energy choices in Pennsylvania and the U.S.? (*n*=107)	.037	.248
…water resources? (*n*=105)	.023	.498
…people and communities? (*n*=107)	.007	.812
…land use? (*n*=106)	-.015	.643

**Cohen's kappa test for agreement*

Respondents were also asked to indicate what they gained from the program by rating a series of skill and comprehension items. Analysis of mean showed a significant increase at a p<.01 level for all items. Further analysis through a Cohen's kappa showed significant slight to fair levels of group-level consistency on all but three items. The item with the highest level of group agreement (K=.391, p<.01), significant at the p<.01 level, was how well respondents felt they understood how to talk to people who agreed with them on a "hot topic". Interestingly, responses to the item about talking with people who disagreed on a "hot topic" were less consistent (K =.210, p<.01). The mean scores for this item did increase, which could indicate that though respondents at the group level did generally feel more prepared to talk with people who disagreed with them, the extent of this change was not predictable or unanimous. Moreover, the post-program score for talking with people who disagreed (M=4.96) was only marginally higher than the pre-program score for talking with people who did agree (M=4.76).

Table 4. Participant self-reported scores of knowledge and skills gained (retrospective pre- and post- ratings); results of comparison of paired pre/post scores*

I understand…	BEFORE Mean	AFTER Mean	BEFORE Median	AFTER Median	Sig. p-value
…that energy choices are complex (*n*=107)	4.74	6.00	5.00	6.00	.000
…how science is conducted (*n*=107)	4.70	5.68	5.00	6.00	.000
…and identify fact, opinion, and bias in media reports (*n*=108)	4.57	5.66	5.00	6.00	.000
…how to determine what sources of information to trust (*n*=107)	4.57	5.64	4.00	6.00	.000
…methods for collecting data (*n*=108)	4.56	5.64	5.00	6.00	.000
…the difference between correlation and causation (*n*=107)	4.45	5.63	5.00	6.00	.000
…what is to be factual (*n*=107)	4.42	5.59	4.00	6.00	.000
…how to hold constructive conversations (*n*=108)	4.41	5.56	4.50	6.00	.000
…the perceptions of risk/reward in natural gas development (*n*=108)	3.78	5.56	4.00	6.00	.000
…the science of natural gas development (*n*=107)	3.64	5.51	4.00	6.00	.000
…how to talk with people who agree on a "hot topic" (*n*=107)	4.76	5.50	5.00	6.00	.000
…how to evaluate scientific studies or reports (*n*=107)	4.28	5.48	4.00	6.00	.000
…how to share scientific information with others (*n*=108)	4.20	5.45	4.00	6.00	.000
…how to interpret scientific data or findings (*n*=106)	4.36	5.44	4.00	6.00	.000
…the engineering of natural gas development (*n*=106)	3.25	5.31	3.00	6.00	.000
…how to talk with people who disagree on a "hot topic" (*n*=107)	3.80	4.96	4.00	5.00	.000

**Wilcoxon Signed Rank test for significance*

Table 5. Participant self-reported scores of knowledge and skills gained (retrospective pre- and post- ratings); results of comparison of paired pre/post scores**

Understanding how Marcellus Shale development relates to…	Cohen's κ	p-value
…how to talk with people who disagree on a "hot topic" (*n*=107)	.210	.000
…how to talk with people who agree on a "hot topic" (*n*=107)	.391	.000
…how to hold constructive conversations (*n*=108)	.215	.000
…what is to be factual (*n*=107)	.173	.000
…how to determine what sources of information to trust (*n*=107)	.272	.000
…how science is conducted (*n*=107)	.314	.000
…the difference between correlation and causation (*n*=107)	.214	.000
…how to interpret scientific data or findings (*n*=106)	.266	.000
…how to evaluate scientific studies or reports (*n*=107)	.207	.000
…how to share scientific information with others (*n*=108)	.173	.000
…methods for collecting data (*n*=108)	.255	.000
…the science of natural gas development (*n*=107)	.024	.473
…the engineering of natural gas development (*n*=106)	-.012	.708
…the perceptions of risk/reward in natural gas development (*n*=108)	.030	.371
…and identify fact, opinion, and bias in media reports (*n*=108)	.202	.000
…that energy choices are complex (*n*=107)	.149	.000

**Cohen's kappa test for agreement*

In the delay condition (several months after their completion of the CSV course), participants were asked to answer the same two batteries of questions in relation to their post-program understanding, knowledge, and skills. In examining respondent data for both sets of ratings, no items showed significant deterioration of learning over time; these data suggest that sustained participation in the program not only contributed to learning gains, but also supported sustained understanding, knowledge, and skill for the adult learners who completed the course.

As part of the program-administered pre- and post- assessments, respondents were also asked a series of questions pertaining to their level or trust in various groups, as well as their level of belief in different statements about the Marcellus Shale development. Mean values were calculated for each item on both pre- and post- tests. These scores were compared with a t-test to determine if the change in mean score from pre- to post- was significant.

Respondents felt less negative about items related to shale gas development (e.g., "I believe shale gas drilling will ruin our rural landscape" and "I have less trust in the natural gas industry and science institutions and more trust in environmental groups") following their participation in the program. In response to the statement "I believe that shale gas drilling will contaminate my drinking water" respondents reported significantly less agreement ($p<.01$) after the program ($M=1.89$) compared to before the program ($M=2.31$). This was also true for the negative statement that shale gas drilling would "ruin our natural landscape" to which respondents significantly disagreed ($p<.01$) more after the program ($M=2.85$) compared to before the program ($M=3.11$). These data could indicate that respondents gained awareness of how shale gas drilling works, and their fears about contamination or the ruination of the landscape were lessened due to what they had learned. Respondents also felt more capable of discerning the credentials of experts ($p<.05$) with a mean rating significantly lower before the program ($M=2.92$) compared to after the program ($M=3.73$). However, respondents did not significantly change level of trust in the media reporting about Marcellus Shale, that Marcellus Shale development would improve their community economically, that their cost of living has increased due to Marcellus Shale development, or that the benefits of the Marcellus Shale development outweighs the costs. This shows that while respondents' fears (e.g., about drinking water or crime) lessened, their trust in the economic benefits of the Marcellus Shale development were not greatly changed. Cohen's kappa showed that respondents were significantly consistent ($p<.01$) in how they rated their trust on all items except for their level of belief in their ability to evaluate the credentials of an expert ($K=-.02$, $p=.81$).

Table 6. Participant self-reported scores of beliefs and trust (retrospective pre-and post-ratings); results of comparison of paired pre/post scores*

Pre vs. Post Beliefs and Trust	BEFORE Mean	AFTER Mean	BEFORE Median	AFTER Median	Sig. p-value
I trust the accuracy of what is reported in the media about Marcellus Shale. (*n*=115)	2.49	2.59	2.00	3.00	.541
I believe Marcellus Shale gas drilling will negatively impact my quality of life. (*n*=116)	2.70	2.41	3.00	2.00	.023
I believe crime is increasing because of Marcellus Shale gas drilling. (*n*=114)	2.49	2.19	3.00	2.00	.031
I am certain natural gas drilling will contaminate my drinking water. (*n*=115)	2.28	1.87	2.00	1.00	.000
I believe Marcellus Shale gas development economically benefits my community. (*n*=95)	4.19	4.05	3.00	4.00	.224
I believe shale gas drilling will ruin our rural landscape. (*n*=116)	3.10	2.81	3.00	3.00	.036
I have less trust in the natural gas industry and science institutions and more trust in environmental groups. (*n*=112)	2.53	2.29	3.00	2.00	.023
I know how to evaluate the credentials of an expert. (*n*=21)	2.92	3.73	3.00	4.00	.014
My cost of living has increased due to Marcellus Shale drilling. (*n*=21)	2.69	2.55	3.00	3.00	.416
The benefits of Marcellus Shale drilling outweigh the costs. (*n*=21)	3.19	3.55	3.00	3.00	.340

**Wilcoxon Signed Rank test for significance*

Table 7. Participant self-reported scores of belief and trust (retrospective pre-and post-ratings); results of comparison of paired pre/post scores*

Understanding how Marcellus Shale development relates to…	Cohen's κ	p-value
I trust the accuracy of what is reported in the media about Marcellus Shale. (*n*=115)	.135	.009
I believe Marcellus Shale gas drilling will negatively impact my quality of life. (*n*=116)	.296	.000
I believe crime is increasing because of Marcellus Shale gas drilling. (*n*=114)	.217	.000
I am certain natural gas drilling will contaminate my drinking water. (*n*=115)	.320	.000
I believe Marcellus Shale gas development economically benefits my community. (*n*=95)	.241	.000
I believe shale gas drilling will ruin our rural landscape. (*n*=116)	.290	.000
I have less trust in the natural gas industry and science institutions and more trust in environmental groups. (*n*=112)	.358	.000
I know how to evaluate the credentials of an expert. (*n*=21)	-.024	.811
My cost of living has increased due to Marcellus Shale drilling. (*n*=21)	.315	.006
The benefits of Marcellus Shale drilling outweigh the costs. (*n*=21)	.300	.008

**Cohen's kappa test for agreement*

Program directors collected pre- and post- questionnaires to collect information on what participants learned as a result of the Citizen Science program. Examination of the results from these pre- and the post- scores across the counties showed that the total scores of participants generally increased, but some questions were more frequently missed than others, and participants showed some variation in score change by county. For example, Clearfield County had the most

instances of decreased scores between the pre- and the post- exams, with 6 questions having fewer people answering correctly on the post exam compared to the pre exam; meanwhile, Lycoming County had the fewest cases of decreased correct responses with only a 4.3% decrease for only one question.

Several of the questions seemed to be more difficult than others, as evidenced by lower correct response rates on the post- exam. The counties' having differing results when comparing pre- and post- scores could indicate differences between preferred learning styles, the types of participants involved, or other environmental factors that would affect how much people learned from the program. However, a few of the questions had at least three counties with lower percentages of correct scores on the post- exam compared to the pre- exam scores. The target concepts covered by these questions included the assessment of ability to read a plot, facts about the time it takes to drill, identification of social influences, and federal funding of energy. For example, a question that evaluated participants' ability to analyze a graph ("According to the plot, about how many chickens did the United States have in 2010?") had the most number of counties selecting the incorrect answer on the post assessment. Possible explanations for these disparities in pre- and post-assessment scores could be difficulty with the questions themselves, variation in the content presented, and/or variation in teaching techniques among presenters.

Table 8. Participant exam scores (pre-scores); results of analysis within each cohort*

Pre Knowledge Exam - Percentage of County Group Answering Correctly	**Clinton** (*n*=26)	**Sullivan** (*n*=12)	**Indiana** (*n*=18)	**Clearfield** (*n*=19)	**Lancaster / Lebanon** (*n*=36)	**Lycoming** (*n*=23)
Which energy source receives the most federal dollars to support?	8.00%	33.3%	17.6%	36.8%	16.7%	21.7%
The typical TDS concentration of salt water is about…?	12.0%	0.0%	22.2%	16.7%	16.7%	13.0%
What percentage of the hydraulic fluids is water?	38.5%	50.0%	61.1%	73.7%	27.8%	65.2%
What uses the greatest amount of water on a daily basis in Pennsylvania?	20.0%	16.7%	27.8%	31.6%	30.6%	26.1%
What is generally considered to be the greatest depth for potable water in Pennsylvania?	34.6%	33.3%	16.7%	31.6%	25.0%	34.8%
Ethane cracking involves…?	40.0%	30.0%	55.6%	44.4%	44.4%	47.8%
Hydraulic fracturing has been scientifically demonstrated to?	88.5%	91.7%	72.2%	73.7%	75.0%	87.0%
Which is the strongest influence on how people think about the risks and benefits of Marcellus Shale development?	3.8%	16.7%	16.7%	10.0%	11.1%	13.0%
A Pennsylvania legislator recently said X, suggested this is because of Y. Circle all statements that are true.	92.3%	83.3%	100.0%	89.5%	80.6%	82.6%
How long does it take to drill a single Marcellus Shale well using pad-drilling technology in Pennsylvania?	42.3%	66.7%	16.7%	26.3%	38.9%	26.1%
According to the plot, about how many chickens did the United States have in 2010?	50.0%	50.0%	11.1%	42.1%	52.8%	47.8%
According to the plot, what is the relationship between the number of chickens in the U.S. and Major League Baseball player's salaries?	43.5%	60.0%	86.7%	52.9%	58.3%	39.1%

**Percentages of correct answers by cohort*

Table 9. Participant exam scores (post-scores); results of analysis within each cohort*

Post Knowledge Exam – Percentage of County Group Answering Correctly	Clinton (*n*=22)	Sullivan (*n*=10)	Indiana (*n*=14)	Clearfield (*n*=17)	Lancaster / Lebanon (*n*=39)	Lycoming (*n*=23)
Which energy source receives the most federal dollars to support?	22.7%	20.0%	14.3%	25.0%	30.8%	21.7%
The typical TDS concentration of salt water is about…?	23.8%	30.0%	38.5%	18.8%	12.8%	30.4%
What percentage of the hydraulic fluids is water?	59.1%	70.0%	64.3%	50.0%	69.2%	82.6%
What uses the greatest amount of water on a daily basis in Pennsylvania?	40.9%	30.0%	35.7%	31.3%	41.0%	43.5%
What is generally considered to be the greatest depth for potable water in Pennsylvania?	40.9%	60.0%	14.3%	37.5%	35.9%	43.5%
Ethane cracking involves…?	75.0%	44.4%	78.6%	68.8%	84.6%	65.2%
Hydraulic fracturing has been scientifically demonstrated to?	75.0%	90.0%	92.9%	88.2%	76.9%	91.3%
Which is the strongest influence on how people think about the risks and benefits of Marcellus Shale development?	14.3%	20.0%	0.0%	6.3%	7.7%	13.0%
A Pennsylvania legislator recently said X, suggested this is because of Y. Circle all statements that are true.	95.5%	100.0%	100.0%	100.0%	92.3%	95.7%
How long does it take to drill a single Marcellus Shale well using pad-drilling technology in Pennsylvania?	22.7%	50.0%	42.9%	25.0%	56.4%	30.4%
According to the plot, about how many chickens did the United States have in 2010?	27.3%	40.0%	35.7%	50.0%	51.3%	43.5%
According to the plot, what is the relationship between the number of chickens in the U.S. and Major League Baseball player's salaries?	86.4%	70.0%	85.7%	75.0%	64.1%	52.2%

**Percentages of correct answers by cohort*

Part of the post- program data collection included asking respondents to describe activities they had taken part in outside of the program that pertained to the Marcellus Ease development or shale gas drilling. Participants were asked to record these activities directly following the program and also after a delayed period of time. The types of activities they could list as having participated in included Personal, Community, and Interpersonal domains, with an option to list any other activities in which they had participated (see Table 10 for the prompts associated with each domain).

Table 10. Prompts associated with each domain of program-related activity

Category Name	Description on CSV Activity Log
Personal	In **your personal life** (e.g., studied up on a topic discussed in class, made a decision about your property, used information at work, questioned something you read or heard about Marcellus).
Interpersonal	In **conversations with others** (e.g., talked about what you learned in class with friends, family, co-workers, others; helped people with different views on Marcellus have a respectful conversation).
Community	In **your community** (e.g., attended a meeting or presentation on Marcellus Shale, joined or volunteered for a group related to Marcellus Shale, wrote a letter to the editor, contacted a legislator or policy maker).
Other	**Other ways** that you've used what you learned in the program.

Respondents were also asked to select the number of times they participated in each activity: 1-2, 3-5, or 6+ times. Qualitative analysis of the activity logs from respondents showed several trends. Broadly, respondents reported fewer activities performed on the delay form than the post form.

Items listed in the "Other" category included activities such as looking into starting a dialogue in their county, as well as more abstract outcomes like improved outlooks and greater open-mindedness. Community-related activities included contacting legislators, making presentations to interested groups, and participating in various community organizations and events (e.g., "spoke at borough council about impact fee funds"). Respondents also listed continued research, reading more articles on shale gas development, and utilizing resources from the classroom. The activities listed show the respondents report actively seeking out information and continued education. When asked to report on their Interpersonal activities respondents listed activities that included engaging their family, friends, coworkers, or neighbors in conversations about shale gas development.

The most frequent category on the immediate post response was Personal activities, with the cohorts participating 3.34 times more on average than in any of the other categories. The Personal activity category was also the most frequent among the delay responses. The second most frequent category was Interpersonal activities, followed by the Community category. Respondents used the "Other" category half as often as the Personal, Interpersonal, or Community categories. When asked to report on their activities in the delay condition (several months after the program), respondents on average recorded activities in the Personal category 2.92 times more than they recorded any of the other types of activities.

For both the post and the delay activity logs, the most used category was the Personal category, followed by Interpersonal activities, then Community activities, and finally, others supplied by respondents. Participants tended to report frequencies of 3-5 times and 6+ times for Personal activities than for the other three activity categories; meanwhile, activities in the "Other" category were much more likely to have people listing an activity in the 1-2 times category than either of the other time frequencies. Both high- and low-frequency activities for individuals appear to be consistent with the overall representation of those activities in the larger group; that is, Personal

activities were both the most common type of post-program action across all participants and the most common action by most individual participants.

Lycoming County was the only cycle which had percentages of people reporting activities in the other category more frequently than the community category for both delay and post. In the Lancaster/Lebanon Counties group, the average number of actions per person increased from post to delay for the personal, community, and other categories. Their personal, community, and other category was utilized on average more frequently (higher average reporting in the 3-5 times and 6+ times categories) on the delay report compared to the post. In the self-reported delay responses, 13% more of the respondents reported completing personal actions, a 24% increase in community actions, and an 11% increase in the other categories. The community category increased in all time categories. The interpersonal and community categories also increased their 3-5 times averages. This cluster was the only group to exhibit such changes between post and delay. While there were more people in the post report (N_{post}=19, N_{delay}=12) the average number of times people recorded an activity for the personal, community, and other categories increased on the delay form compared to the post reporting. Similar findings were also found and published by Prins and Frey (2016)[3].

Team Reflections

In a final group debrief, the project team as a whole was asked to outline what their goals had been for the CSV program, what they felt participants had gained through the program, what they themselves would identify as major takeaways or lessons learned, and what they identified as the legacy of the program (Figure 1).

[3] Prins, E., & Frey, S. (2016). Community science education: Critical science literacy and community engagement related to shale gas development. *Adult Education Research Conference, 32*. Retrieved from http://newprairiepress.org/aerc/2016/papers/32

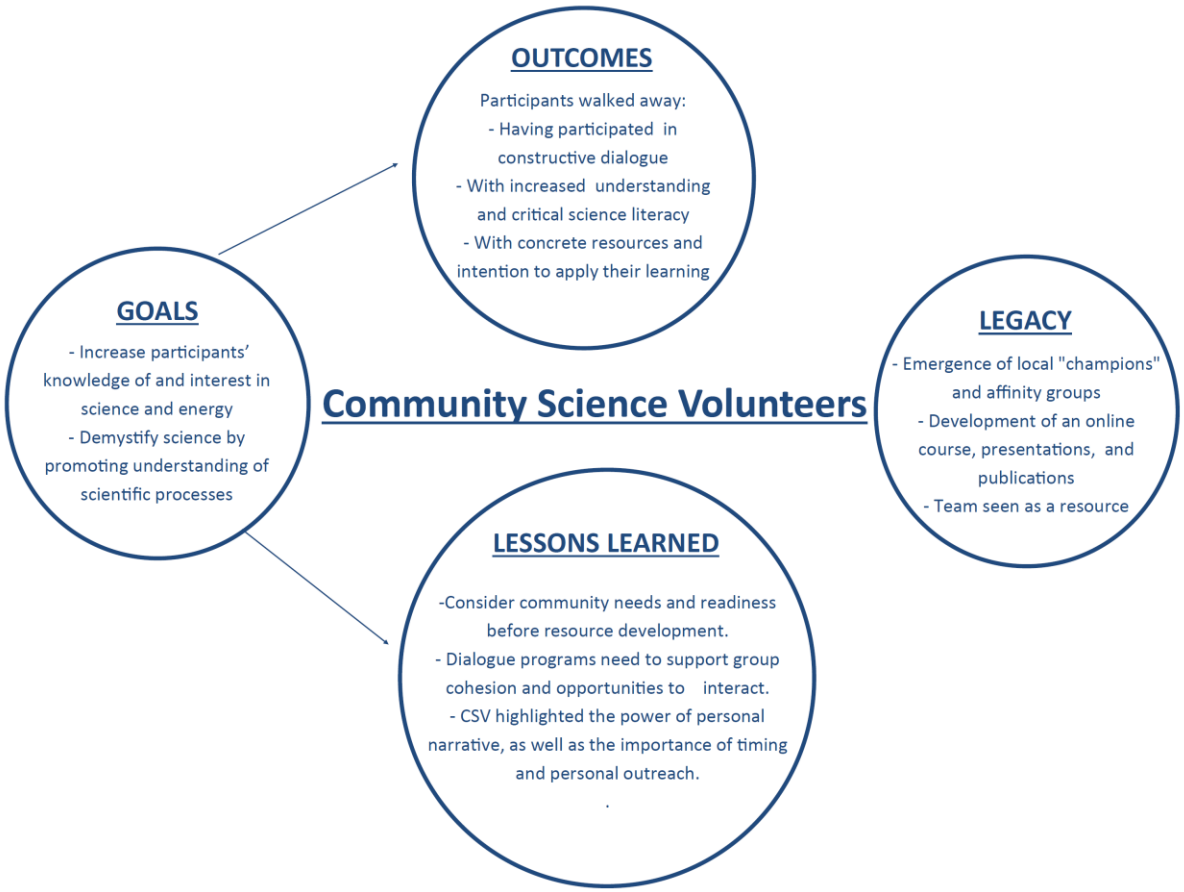

Figure 1. Team reflections on the Community Science Volunteers program

In reflecting on CSV, project team members observed increases in critical science literacy among the participants they had worked with, as well as intention to act, sometimes even in the form of newly organized community groups (e.g., a "breakfast club" founded in Sullivan County to discuss and share information about shale gas development). Team members also gave examples of participants' reporting extended use of course materials (i.e. referring to binders containing CSV course readings). In terms of their own learning, the project team underscored the importance of framing communication as important early on in their contact with participants, as well as the need to support group cohesion for participants and to maintain personal outreach and long-term relationships in communities. As a direct result of this learning, the legacy associated with the CSV program will include not only a robust online version of the course and faculty presentations and publications, but also the presence of local champions for community dialogue on shale gas development in participating communities, as well as team members' being viewed as resources for expertise and support by both colleagues and program participants.

Conclusions

Overall, the multi-year process of developing, implementing, and refining the CSV program for adults in rural communities affected by Marcellus shale gas development showed several important indicators of success:

- Gains in self-reported knowledge of relevant science content
- Gains in demonstrated knowledge about shale gas development and ability to analyze argumentation
- Gains in self-reported confidence about engaging with science and participating in civil dialogue
- Concrete descriptors of relevant use and sharing of relevant scientific information and/or community action

Although secondary data indicated that gains in specific science content knowledge varied from county to county, in general the program appears to have been effective at cultivating increased knowledge of gas-drilling related science content, particularly in relation to how shale gas drilling works (i.e., the process of extraction), and this was especially strong for participants in Lycoming County. Secondary data also indicated that after participating in the program, community members tended to feel less negatively about some of the impacts of shale gas development, although their opinions about economic effects of shale gas development did not appear to change.

In addition, participant data suggested that the program helped people feel more capable of holding constructive conversations with those who agreed *and* disagreed with their perspectives, as well as more capable of sharing scientific information with peers. Other areas of growth included understanding what factual means and how science is conducted, understanding the difference between causation and correlation, and understanding how to find trustworthy sources of information. Additionally, participants felt more prepared to distinguish between bias, opinion, and facts in media reporting and recognized the complexity in decision-making about energy choices.

Importantly, participants in the CSV program also indicated that they made informal use of and/or shared information about shale gas development in their communities. As part of these forms of extension, people were most likely to participate in activities that furthered their own understanding (e.g., applying critical science literacy skills) and/or engaging those around them (e.g., attempting to open dialogue with neighbors). Moreover, reflections from project team members suggest that participants' activities and intentions may have extended even beyond what they articulated themselves, as evidenced by the documented formation of local affinity groups and anecdotal use of project resources. Finally, the CSV program was observed to result in the emergent outcomes of making university faculty more visible and accessible as resources for community members and supporting the sustained enthusiasm and momentum of key individuals in participating communities.

Appendix A: Summative Evaluation Questionnaires

Immediate Post

Please answer the following questions at the end of today's session. These questions ask you to think back on what you knew about Marcellus Shale and gas development before you started this program, and then compare it to what you know now. The last questions ask about how you may have used any of the things you learned in this program.

Using a scale from 1 to 7, please respond the following statements about **your knowledge and skills before you began this program**.

Circle one number on each line below. One (1) means "not at all" and 7 means "very well."

Before you began this program, how well did you understand how Marcellus Shale development relates to…

	Not well Very at all						
People and communities?	1	2	3	4	5	6	7
The natural environment?	1	2	3	4	5	6	7
Land use?	1	2	3	4	5	6	7
Water resources?	1	2	3	4	5	6	7
Energy choices in Pennsylvania and the U.S?	1	2	3	4	5	6	7

Before you began this program, how well did you…	Not well Very at all						
Talk with people who disagree on a "hot" topic?	1	2	3	4	5	6	7
Talk with people who agree on a "hot" topic?	1	2	3	4	5	6	7
Understand how to hold constructive conversations with people?	1	2	3	4	5	6	7
Know what is factual?	1	2	3	4	5	6	7
Know how to determine what sources of information to trust?	1	2	3	4	5	6	7
Understand how science is conducted?	1	2	3	4	5	6	7
Understand the difference between correlation and causation?	1	2	3	4	5	6	7
Interpret scientific data or findings?	1	2	3	4	5	6	7
Evaluate scientific studies or reports?	1	2	3	4	5	6	7
Share scientific information with others?	1	2	3	4	5	6	7
Understand methods for collecting data?	1	2	3	4	5	6	7
Understand the science of natural gas development?	1	2	3	4	5	6	7
Understand the engineering of natural gas development?	1	2	3	4	5	6	7
Understand perceptions of risk and reward in natural gas development?	1	2	3	4	5	6	7
Identify fact, opinion, and bias in media reports?	1	2	3	4	5	6	7
Understand that energy choices are complex?	1	2	3	4	5	6	7

Using a scale from 1 to 7, please respond the following statements about **your knowledge and skills now, at the end of the program**.

Circle one number on each line below. One (1) means "not at all" and 7 means "very well."

At the end of this program, how well do you understand how Marcellus Shale development relates to…

	Not well at all						Very well
People and communities?	1	2	3	4	5	6	7
The natural environment?	1	2	3	4	5	6	7
Land use?	1	2	3	4	5	6	7
Water resources?	1	2	3	4	5	6	7
Energy choices in Pennsylvania and the U.S?	1	2	3	4	5	6	7

At the end of this program, how well do you…	Not well at all						Very well
Talk with people who disagree on a "hot" topic?	1	2	3	4	5	6	7
Talk with people who agree on a "hot" topic?	1	2	3	4	5	6	7
Understand how to hold constructive conversations with people?	1	2	3	4	5	6	7
Know what is factual?	1	2	3	4	5	6	7
Know how to determine what sources of information to trust?	1	2	3	4	5	6	7
Understand how science is conducted?	1	2	3	4	5	6	7
Understand the difference between correlation and causation?	1	2	3	4	5	6	7
Interpret scientific data or findings?	1	2	3	4	5	6	7
Evaluate scientific studies or reports?	1	2	3	4	5	6	7
Share scientific information with others?	1	2	3	4	5	6	7
Understand methods for collecting data?	1	2	3	4	5	6	7
Understand the science of natural gas development?	1	2	3	4	5	6	7
Understand the engineering of natural gas development?	1	2	3	4	5	6	7
Understand perceptions of risk and reward in natural gas development?	1	2	3	4	5	6	7
Identify fact, opinion, and bias in media reports?	1	2	3	4	5	6	7
Understand that energy choices are complex?	1	2	3	4	5	6	7

Since the program began, have you used any of the things you learned about Marcellus Shale or gas development? Please list specific examples below and circle how often you did each one.

In **your personal life** (e.g., studied up on a topic discussed in class, made a decision about your property, used information at work, questioned something you read or heard about Marcellus).	1-2 times	3-5 times	6+ times
1. _____	x	x	x
2. _____	x	x	x
3. _____	x	x	x
4. _____	x	x	x
In **conversations with others** (e.g., talked about what you learned in class with friends, family, co-workers, others; helped people with different views on Marcellus have a respectful conversation).	1-2 times	3-5 times	6+ times
5. _____	x	x	x
6. _____	x	x	x
7. _____	x	x	x
8. _____	x	x	x
In **your community** (e.g., attended a meeting or presentation on Marcellus Shale, joined or volunteered for a group related to Marcellus Shale, wrote a letter to the editor, contacted a legislator or policy maker).	1-2 times	3-5 times	6+ times
9. _____	x	x	x
10. _____	x	x	x
11. _____	x	x	x
12. _____	x	x	x
Other ways that you've used what you learned in the program.	1-2 times	3-5 times	6+ times
13. _____	x	x	x
14. _____	x	x	x

Delayed Post

Please answer the following questions about the 8-week program you took part in a few months ago. These questions ask you about what you remember about Marcellus Shale and gas development and how you may use any of the things you learned in this program.

Using a scale from 1 to 7, please respond the following statements about **your knowledge and skills now, a few months after the program ended**.

Circle one number on each line below. One (1) means "not at all" and 7 means "very well."

Today, how well do you understand how Marcellus Shale development relates to…

	Not well at all						Very well
People and communities?	1	2	3	4	5	6	7
The natural environment?	1	2	3	4	5	6	7
Land use?	1	2	3	4	5	6	7
Water resources?	1	2	3	4	5	6	7
Energy choices in Pennsylvania and the U.S?	1	2	3	4	5	6	7

Today, how well do you…	Not well at all						Very well
Talk with people who disagree on a "hot" topic?	1	2	3	4	5	6	7
Talk with people who agree on a "hot" topic?	1	2	3	4	5	6	7
Understand how to hold constructive conversations with people?	1	2	3	4	5	6	7
Know what is factual?	1	2	3	4	5	6	7
Know how to determine what sources of information to trust?	1	2	3	4	5	6	7
Understand how science is conducted?	1	2	3	4	5	6	7
Understand the difference between correlation and causation?	1	2	3	4	5	6	7
Interpret scientific data or findings?	1	2	3	4	5	6	7
Evaluate scientific studies or reports?	1	2	3	4	5	6	7
Share scientific information with others?	1	2	3	4	5	6	7
Understand methods for collecting data?	1	2	3	4	5	6	7
Understand the science of natural gas development?	1	2	3	4	5	6	7
Understand the engineering of natural gas development?	1	2	3	4	5	6	7
Understand perceptions of risk and reward in natural gas development?	1	2	3	4	5	6	7
Identify fact, opinion, and bias in media reports?	1	2	3	4	5	6	7
Understand that energy choices are complex?	1	2	3	4	5	6	7

Since the program began, have you used any of the things you learned about Marcellus Shale or gas development? Please list specific examples below and circle how often you did each one.

In **your personal life** (e.g., studied up on a topic discussed in class, made a decision about your property, used information at work, questioned something you read or heard about Marcellus).	1-2 times	3-5 times	6+ times
15. _____	x	x	x
16. _____	x	x	x
17. _____	x	x	x
18. _____	x	x	x
In **conversations with others** (e.g., talked about what you learned in class with friends, family, co-workers, others; helped people with different views on Marcellus have a respectful conversation).	1-2 times	3-5 times	6+ times
19. _____	x	x	x
20. _____	x	x	x
21. _____	x	x	x
22. _____	x	x	x
In **your community** (e.g., attended a meeting or presentation on Marcellus Shale, joined or volunteered for a group related to Marcellus Shale, wrote a letter to the editor, contacted a legislator or policy maker).	1-2 times	3-5 times	6+ times
23. _____	x	x	x
24. _____	x	x	x
25. _____	x	x	x
26. _____	x	x	x
Other ways that you've used what you learned in the program.	1-2 times	3-5 times	6+ times
27. _____	x	x	x
28. _____	x	x	x

Appendix B: List of Course Sessions by Cohort

Session Week	Cohort 1: Clearfield County 9/11/12-10/30/12	Cohort 2: Clinton County 3/25/13 – 5/13/13	Cohort 3: Sullivan County 7/08/13 – 8/26/13	Cohort 4: Indiana County 9/16/13 – 11/18/13	Cohort 5: Clearfield County 6/16/14 – 8/11/14	Cohort 6: Lancaster County 2/3/15 – 4/21/15	Cohort 7: Lycoming County 6/16/15 – 8/25/15
1	Energy Choices, Pt. I	Energy Resources (Part I)	Energy Resources (Part I)	Geology & Seismic Testing	Communication	Energy Resources	Energy Resources
2	Energy Choices, Pt. II	Energy Resources (Part II)	Energy Resources (Part II) & Geology	Shale Development Engineering	Energy Resources	Shale Development Engineering	Constructive Conversations
3	Science in Society	The Process of Science	Seismic Testing & The Process of Science	Water Resources/ Quality	Shale Development Engineering	Pipelines	Community Impacts/ Institutional Trust
4	Geology and Seismicity	Geology & Seismic Testing	Water Resources/ Quality	Community Impacts	The Process of Science	Land Use Planning	Shale Development Engineering
5	Engineering and Economic Development	Land Use Planning & Economic Impacts	Shale Development Engineering & Economic Impacts	The Process of Science	Water Resources/ Quality	Water Resources/ Quality	Land Use Planning
6	Water Quality	Shale Engineering & Institutional Trust	Land Use Planning	Land Use Planning	Community Impacts /Institutional Trust	The Process of Science	The Process of Science
Session Week	Cohort 1: Clearfield County 9/11/12-10/30/12	Cohort 2: Clinton County 3/25/13 – 5/13/13	Cohort 3: Sullivan County 7/08/13 – 8/26/13	Cohort 4: Indiana County 9/16/13 – 11/18/13	Cohort 5: Clearfield County 6/16/14 – 8/11/14	Cohort 6: Lancaster County 2/3/15 – 4/21/15	Cohort 7: Lycoming County 6/16/15 – 8/25/15

7	Community Impacts	Water Resources/ Quality	Community Impacts	Energy Resources	Geology & Seismic Testing	Community Impacts/ Institutional Trust	Economic Impacts
8	Constructive Conversations	Constructive Conversations & Network Tools	Constructive Conversations	Economic Impacts	Economic Impacts	Economic Impacts	Water Resources/ Quality
9				Constructive Conversations	Land Use Planning	Geology & Seismic Testing	Geology & Seismic Testing
10				Network Tools	Constructive Conversations	Constructive Conversations	Pipelines