Title: 'If they only knew what I know': Attitude change from education about 'fracking'

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Abstract

A simple explanation for why another’s perspectives on unconventional gas development via hydraulic fracturing differ from one’s own is that people are uninformed. Such an answer employs the deficit model of communication and understanding – shown for a quarter century to be inadequate for explaining public perceptions and behaviours. A more likely explanation, but far more challenging for an easy ‘fix’, is that values fundamentally shape views. In autumn 2014, I taught an undergraduate course entirely on unconventional gas development via hydraulic fracturing (UGD, often called ‘fracking’). I evaluated the effects of intensive education on attitudes about UGD by presenting my students with the same survey on the first and penultimate days of class. Overall attitudes changed little – despite substantial increases in self-reported knowledge and changes in beliefs about impacts associated with UGD. This poses a challenge for energy policies and regulation built off the assumption that additional education can readily change attitudes. I consider ways of approaching policy that respond to education’s limited effects on attitudes about UGD.

Keywords

Deficit model; fracking; hydraulic fracturing; risk communication; risk perception; shale gas

1. Shale gas development, public perceptions, and education

An emerging literature has begun to explore how unconventional gas development via hydraulic fracturing (UGD)[1] has been framed in news media (Ashmoore et al. 2016; Evensen et al. 2014a; Jaspal and Nerlich 2014; Mazur 2016; Olive 2016; Vasi et al. 2015), social media (Hopke and Simis 2015; Jaspal, Turner, and Nerlich 2014) and public discourse (Bomberg 2015; Cotton et al. 2014; Cotton, 2015; Hilson 2015; Kroepsch 2016; Molinatti and Simonneau 2015; Williams et al. 2015). The foregoing research reveals the complex and nuanced ways in which perspectives on this issue are negotiated and emerge – supported by substantial research on public perceptions of UGD (e.g., Anderson and Theodori 2009; Boudet et al. 2014; Braiser et al. 2013; Clarke et al. 2015; Evensen et al. 2014b; Evensen 2015a; Evensen and Stedman 2016; Israel et al. 2015; Jacquet 2012; Jacquet and Stedman 2014; Malin 2014; Morrone et al. 2015; Perry 2012b; Sangaramoorthy et al. 2016; Schafft and Biddle 2015; Stedman et al. 2012; Stedman et al. 2016; Theodori 2013; Theodori et al. 2014; Willow 2014; see Thomas et al. 2017 for a review). These findings often contrast with institutional framings of UGD, which can paint public perceptions as misinformed and/or uninformed (Williams et al. 2015).

Notably, the UK Government has implied that the key to increasing public support for UGD is 'the provision to the public of established scientific knowledge about risks' (Williams et al. 2015, p. 3). This contention is central to the UK Government's policy aims of moving forward with UGD at a rapid pace. Andrea Leadsom (2015), the then UK Minister of State at the Department of Energy and Climate Change, wrote, 'The UK has over 50 years' experience of safely and successfully producing gas in this country, both for onshore and

[1] Note: I use the term 'unconventional gas development via hydraulic fracturing' (UGD) throughout this article to refer to the set of processes and associated effects that attend this form of energy extraction/development. Whilst no term is perfect, social-psychological research into how this word is used provides nuanced discussions of why to avoid use of 'fracking' (see Evensen et al., 2014b; Wolske and Hoffman, 2013).

offshore. We will be using all our expert knowledge as we explore for shale gas…It's an inconvenient truth for those who don't want to acknowledge the economic and environmental benefits that Shale gas could bring.' Failing to acknowledge the scientifically established benefits of development, thus, ostensibly explains opposition.

Decades of research on the deficit model of communication and understanding have long shown that such simplistic institutional framings are flawed or at least lack necessary nuance (Fischhoff 1995; Sturgis and Allum 2004). The deficit model contends that people perceive something as a problem because they lack knowledge (often scientific) about the issue; thus, providing them with more knowledge will lead them to change their attitudes. Heberlein (2012) provides an insightful review of research illustrating why the 'cognitive fix' (education) rarely changes attitudes. In relation to UGD, Williams et al. (2015, p. 1) rely on a series of deliberative focus groups across northern England to demonstrate that public concerns about UGD 'cannot be satisfactorily explained by a lack of understanding on the part of participants'; recent research in the US supports the contention that a lack of understanding is insufficient explanation for opposition (e.g., Fernando and Cooley 2016; Kroepsch 2016; Sangaramoorthy et al. 2016); yet, some emergent survey research in the UK suggests that additional information can shape attitudes on UGD (Whitmarsh et al. 2015).

To evaluate empirically the extent to which additional understanding about UGD can change overarching views on the topic – albeit within a specific audience – I measured 21 students' attitudes, beliefs, self-reported knowledge, and sources of information on this issue at the start and end of an undergraduate college course entirely on UGD. The course, titled '"Fracking" and the Policy Process', was offered at Oberlin College (Ohio, USA), in the fall semester 2014. In line with the failure of the deficit model to adequately account for attitudes and behaviours – and the importance of issues beyond scientific information to evaluation of UGD (e.g., ethical considerations and complex social attachments [see Cotton 2013; de

Melo-Martín et al. 2014; Evensen 2015a; Evensen 2016; Fry, Briggle, and Kincaid 2015; Jacquet and Stedman 2014; Perry 2012b; Willow and Wylie 2014]) – I expected even intensive information on this topic to have little effect on summary attitudes about UGD. I operationalised summary attitudes as support for or opposition to UGD. Whilst my hypothesis allowed for changes in factual beliefs, I did not expect the information gained to change attitudes. Heberlein (2012, 16) explains of attitudes, 'Attitudes differ from knowledge because they are driven by the love-hate, good-bad aspect of emotion'. The effects of education (or lack thereof) foreshadow the relative viability of policies based on the assumption that education will shift attitudes.

2. Survey design and administration

As the first order of business on the first day of class (2 September 2014), I distributed a 10-15 minute survey to all students that measured their attitudes towards, beliefs about, knowledge on, and sources for information on UGD. I told them explicitly the survey would in no way affect their course grades but was to help me structure the course to best meet their needs and goals. I distributed nearly the same survey on 4 December. I asked students to provide their names to allow for matched-sample longitudinal/panel data. The course offered a natural experiment for assessing the effect of intensive instruction about UGD on attitudes and beliefs. The goal of the course was not attitude change on this issue; the primary learning goal was for students to understand and appreciate the complexities of formulating policy on and regulating UGD. I sought to provide the background and tools necessary for students to evaluate and devise policy on this complex issue.

I readily admit the limitations associated with generalising from a very specific sample of college students to the general public. Let me be explicit, I am not claiming widespread transferability of these results. Nevertheless, these students were exposed to a substantial amount of information on UGD over three months; this is an extreme case of information sharing – if additional information and full understanding of UGD could change attitudes, it should have done so in this case. I offer this research as one empirical test of what theory on education/cognitive fixes would lead us to expect. Despite limitations of the sample and the survey approach, a strength of this research that has not been replicated elsewhere is the repeated measures longitudinal approach and the ability to assess that the sample actually learnt a substantial amount about UGD and its impacts. The one other study to date testing the effect of information provision on this issue experimentally used a single survey with a paragraph offering additional content about UGD (Whitmarsh et al. 2015). The surveys in my course measured change before and following substantial knowledge acquisition.

During the 13-week course, students were assigned a compendium of readings on biological, physical, and social science research on UGD (including: a full-length academic book, 16 peer-reviewed research articles, 10 research reports, abstracts from 25 additional research articles, and other materials). I selected this research from leading academics publishing on all aspects of UGD; nearly all the readings were published after 2011. The research covered the full range of (potential) impacts and issues associated with UGD, primarily in the US (due to the focus of much extant research), but also with some attention to Canada and Europe. Students also read mass media and social media coverage of this topic from all slants and perspectives and watch clips from documentary films on the issue.

For two-and-a-half hours in class each week, I provided context on the readings and helped the students digest and internalise the material. In class, students participated in numerous small and large group activities to process the science they learned (see, for example, Evensen 2015b). Students also had seven writing assignments in which I required them to engage critically with the content (I am happy to share the assignments upon request).

I had no control group for my survey and do not claim representativeness for my sample. The course was relatively even on sex (12 female, 9 male), distributed between second and third year students (10 sophomores, 9 juniors, 2 seniors), and contained students in a range of majors across physical, biological, and social sciences and humanities. Nevertheless, the course was at Oberlin College, which is known for attracting liberal-thinking, 'progressively-minded' students. Other students at Oberlin likely discussed UGD with the students in my course, and my students were likely exposed to material on UGD outside of that with which they interacted as part of the course. My core interest is in whether substantial information prompted attitude change, not whether the information *I provided* prompted such change. If students were exposed to additional information, this simply increases the magnitude of already substantial context they processed on this topic. I know that the information I provided was not only read, but also retained, due to my assessment of the students' assignments.

3. Results and discussion

At the start of the course, average self-assessed knowledge of UGD was 3.05 on a scale of 1-6; this grew significantly ($p < 0.001$)[2] to 5.50 by the end of the course (Figure 1). Twenty of the 21 students reported some increase in the extent to which they were well-informed about UGD (Figure 1).

3.1. Support / opposition

[2] Unless otherwise noted, statistical significance in this article is measured via paired-samples t-tests for within-group differences.

Despite the increase in information provision and information internalisation, few students markedly changed their attitudes in terms of support for or opposition towards UGD. At the onset of the course, all 21 students opposed UGD to some extent (Figure 2). To measure support/opposition, I asked students to report the extent to which they supported/opposed UGD on a six-point scale ('strongly oppose', 'support', 'slightly support', 'slightly oppose', 'oppose', and 'strongly support') in four different locations: 'your community (hometown)', 'your community (Oberlin)', 'your state', and 'USA'. I ran an exploratory factor analysis (principal axis factoring) on the four variables; it produced a solution with one factor.[3] Therefore, I averaged the four variables into one measure of support/opposition. A factor analysis of these four variables in the second (later) survey showed even greater congruence in support/opposition across geographic locations.[4]

At the end of the course, the distribution of students supporting and opposing UGD shifted slightly, with support/opposition becoming marginally more bimodal (Figure 2). Average support/opposition changed less than one-tenth of a point on the six-point scale (from 1.82 to 1.91). One-third of the students did not change at all in support/opposition (Figure 3). Ten students became more opposed and four students supported UGD more. Whilst the few students who increased in support seem to have increased by a greater degree than the decrease in support by those who became more opposed, this could be partially attributable to a basement effect because the students were highly clustered towards the opposition end of the scale at time 1.

3.2. Beliefs about impacts

[3] Factor solution based on eigenvalue cut-off of 1.0. Factor loadings: 0.93 (hometown), 0.89 (Oberlin), 0.70 (state), 0.47 (USA)
[4] Factor loadings: 0.84 (hometown), 0.83 [university town], 0.99 (state), 0.90 (USA)

I asked students in each survey to report their beliefs on the question, 'How *likely* do you think the following effects of shale gas development are in areas where shale gas development is occurring?' I distinguish beliefs from attitudes here in that the key aspect of a belief is the 'absence of emotion' (Heberlein 2012, 16). Beliefs are statements believed to be true (regardless of their actual veracity). I included a list of 24 social, economic, and environmental impacts potentially associated with UGD. For eight of these impacts, beliefs changed significantly (Table 1). Seven of the significant changes were increases in perceived likelihood (for: increased traffic, decreased road quality, changes in community character, decreased air quality, increased rental housing prices, increased stress, and increased crime). Notably, all these impacts are negative, with the possible but unlikely exception of 'changes in community character'. One impact – a positive impact – decreased significantly in perceived likelihood (increased jobs for locals). Also noteworthy is that some of the most publicised (see Ashmoore et al. 2016; Evensen et al. 2014a) effects of UGD (e.g., decreased water quality, decreased human health, short-term local economic growth, long-term local economic growth, landowner incomes from leases / royalties on gas) showed little – and non-significant – change.

3.3. Information on UGD

The sources of information that students consulted to obtain information on shale development varied somewhat over the three months. I asked students to report how frequently they read or heard about UGD from each of 15 sources ('never', 'occasionally', or 'often'). Only four sources showed significant changes, all increases (see Table 2). Increased use of Internet searches, Internet news sources, and information from organisation websites is likely attributable to: (1) assigned readings (some of which came from organisation and government agency websites or Internet news sources), (2) the course final project (which required independent research on an aspect of UGD), and (3) engaged students (e.g., many students posted links to recent news articles on UGD on our course online discussion board). The fourth significant increase was in exposure to information from 'university scientists', which relates directly to authors of the research articles I assigned.

4. Conclusions and implications

Oberlin College has a very liberal-leaning student body – as manifest in all 21 students opposing UGD in the first survey (i.e., responding 1-3 on the six-point scale). Nevertheless, during the first class, when I asked students to share their reasons for enrolling in the course, many stated their desire to learn more about UGD and/or to have their perspectives on the issue challenged. The majority of the students in the course were not obstinately entrenched in their views. (Indeed, many students at Oberlin have deep-rooted views on this topic, but those are not the students who bothered to enrol in a course on the subject.)

When I presented the results from the two surveys on the final day of class, some students were incredulous that after the three months of learning, some of their peers could support UGD more – others felt the same way about students who increasingly opposed development. Students who had moved in both directions identified themselves and offered cogent rationales for their shift. Inevitably, issues that we learnt about in association with UGD had varying relevance to the students – different facts learnt pushed different students in opposite directions.

My 21 students were exposed to a panoply of the best and most recent research on UGD. Furthermore, I know they internalised the information, because I assessed each of them via seven written assignments. All 21 students not only passed the course but performed well. Despite substantial increases in self-reported knowledge, support/opposition changed little. Moreover, several significant changes in beliefs about likelihood of impacts associated with development seem to have had little effect on support/opposition. This lends support to arguments that, despite high correlations, beliefs about impacts are not necessarily good predictors of overarching attitudes; actually, causality might run, at least partially, in the other direction (i.e., support/opposition might *lead to* determination of likelihood of impacts [Fergen and Jacquet 2016; Sovacool 2014]).

I readily acknowledge the limitations of this study: these findings represent one relatively small group of students at a unique liberal arts college. Certainly, conversations and materials outside of the research presented and discussed in class could have influenced students. Nevertheless, this happens in the ‘real world’ as well when groups try to communicate about something such as UGD. If entities, such as the UK government, operate under the assumption that additional knowledge of risks and benefits will change views on support for or opposition to UGD, communication to this effect (should it somehow occur) would not occur in a vacuum.

Whilst the findings from my course may not be generalisable to populations in the broad sense, they at least offer initial empirical evidence for the theoretically-substantiated proposition that deficit model thinking applies poorly to changes in attitudes about UGD. The case of my course is an extreme example; no level of communication from government, industry, or the non-profit sector could ever approach the amount of information my students were exposed to and internalised during the course. Whilst the sample size and scope was limited, the information provided was not. Another aspect of this study, not replicated elsewhere, is that the students had substantial time to digest and process the information they received. Whilst attitude change might appear to occur when survey respondents read varying statements, whether those ephemeral attitudinal assessments are reliable in the long-term is a separate question.

To the extent that government and industry think that more familiarity with the 'facts' on UGD can change support/opposition (Williams et al. 2015); these findings question that assumption. Indeed, no communication intervention to the general public (or a segment thereof) would ever approach the amount of information gained by my students in this course. By the end of the course, these students likely knew more about UGD than most policy makers who call for additional information provision; yet, their attitudes changed little. One might assert that previous knowledge could have already cemented the view of the students. Whilst this is true, and it is obvious that some previous values or experiences did shape attitudes, less than 40% of the class agreed at all that they were well informed about UGD before the course started. It is possible the students learned *too much* – a depth of nuanced knowledge from a range of sources.

Perhaps government and industry actors (and academics and members of the general public) – who base their desired policies and communication strategies on claims about lack of information and misinformation – would benefit from focusing less on how to *change* attitudes and more on appreciating why attitudes exist. These groups could benefit from *working with* public attitudes to envision policy that responds to citizen concerns and needs on this issue. An emerging literature on procedural justice concerns in association with UGD suggests that such a focus is one road forward (e.g., Cotton 2013; Cotton 2016; Evensen 2015a; Evensen 2016; Fry et al. 2015; National Research Council 2014; Orland and Murtha 2015; Perry 2012a; Sovacool and Dworkin 2015).

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Table 1: Beliefs about impacts potentially associated with shale gas development

Impact	**Likelihood[a] (mean response, POST-test)**	**Likelihood (mean response, PRE-test)**	**Change in mean likelihood[b]**
Increased traffic	3.86	3.14	**0.71*** **
Decreased road quality	3.81	2.90	**0.90*** **
Changes in community character	3.67	3.33	**0.33***
Decreased local beauty	3.62	3.62	0.00
Decreased peace and quiet	3.62	3.43	0.19
Decreased air quality	3.57	3.19	**0.38***
Decreased fish and wildlife health	3.57	3.62	-0.05
Decreased water quality	3.57	3.62	-0.05
Decreased human / public health	3.52	3.52	0.00
Decreased quality of outdoor recreation	3.52	3.57	-0.05
Lowered property values	3.48	3.33	0.15
Increased rental housing prices	3.47	2.42	**1.05*** **
Increased stress	3.45	3.10	**0.35***
Increased industrialization	3.43	3.33	0.10
Less tourism locally	3.33	3.19	0.14
Short-term local economic growth	3.29	3.43	-0.14
Increased crime	3.19	2.57	**0.62*** **
Landowner income from leases / royalties on gas	3.00	2.95	0.05
Increased energy independence	2.67	2.57	0.10
Lower taxes locally	2.43	2.52	-0.09
Increased jobs for locals	2.38	2.81	**-0.43***
Decreased greenhouse gas (carbon) emissions	2.25	2.00	0.25
Preservation of agricultural land	1.76	1.62	0.14
Long-term local economic growth	1.62	1.81	-0.19

[a] All likelihoods were evaluated on a scale of 1-4 (‘not at all likely’ to ‘very likely’)
[b] Statistical significance for change in mean (paired-samples t-test): * $p < 0.05$, *** $p < 0.001$

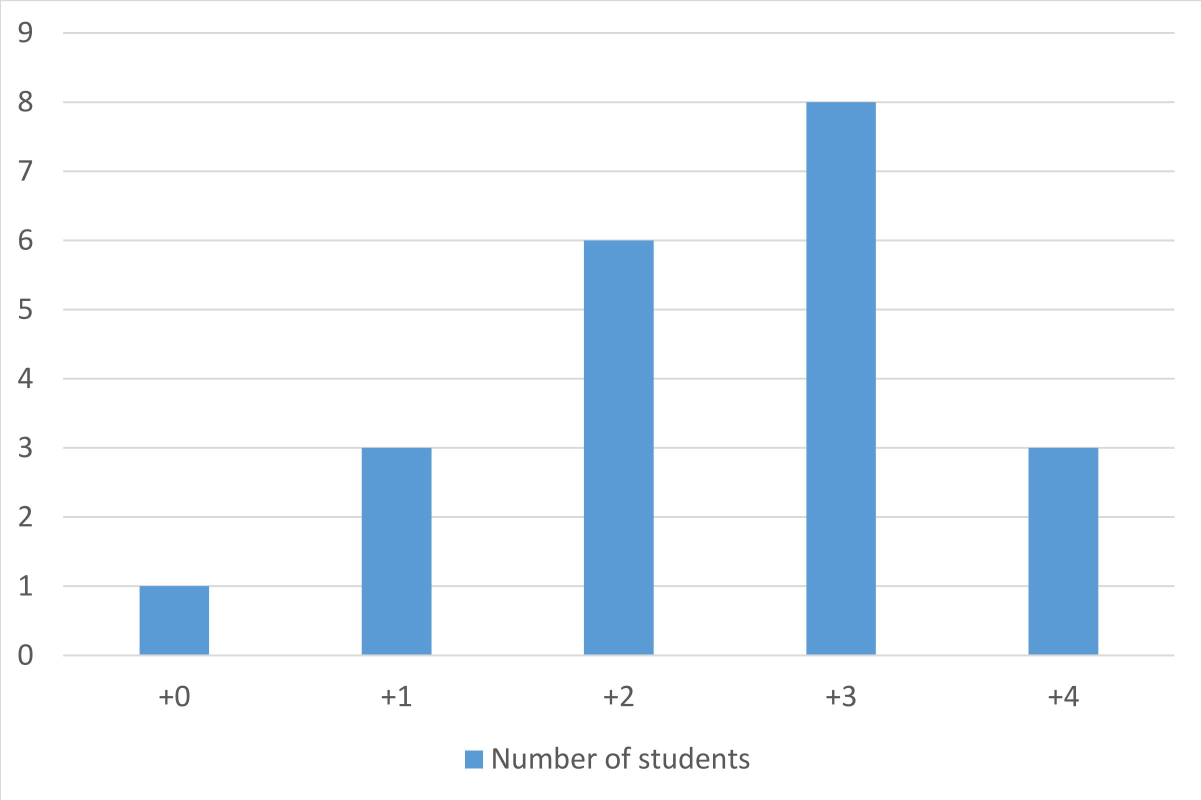
Table 2: Sources of information on shale gas development

How often have you read or heard about shale gas development from each source?	**Mean response[a], POST-test**	**Mean response, PRE-test**	**Change in mean[b]**
Internet – search	2.86	2.19	**0.67*** **
Internet – other news source	2.76	2.29	**0.48** **
Internet – newspaper	2.67	2.43	0.24
Environmental groups	2.67	2.52	0.14
Internet – organization	2.67	2.24	**0.43** **
Family and friends	2.57	2.33	0.24
Social media	2.52	2.29	0.24
University scientists	2.43	1.90	**0.52** **
National newspaper	2.43	2.24	0.19
Other people in the community	2.43	2.33	0.10
Government agencies	2.14	1.86	0.29
Local newspaper	2.00	1.76	0.24
Industry	1.95	1.71	0.24
Television	1.52	1.71	-0.19
Radio	1.38	1.48	-0.10

[a] Frequency of exposure to information sources was evaluated on a scale of 1-3 (‘never’, ‘occasionally’, ‘often’)

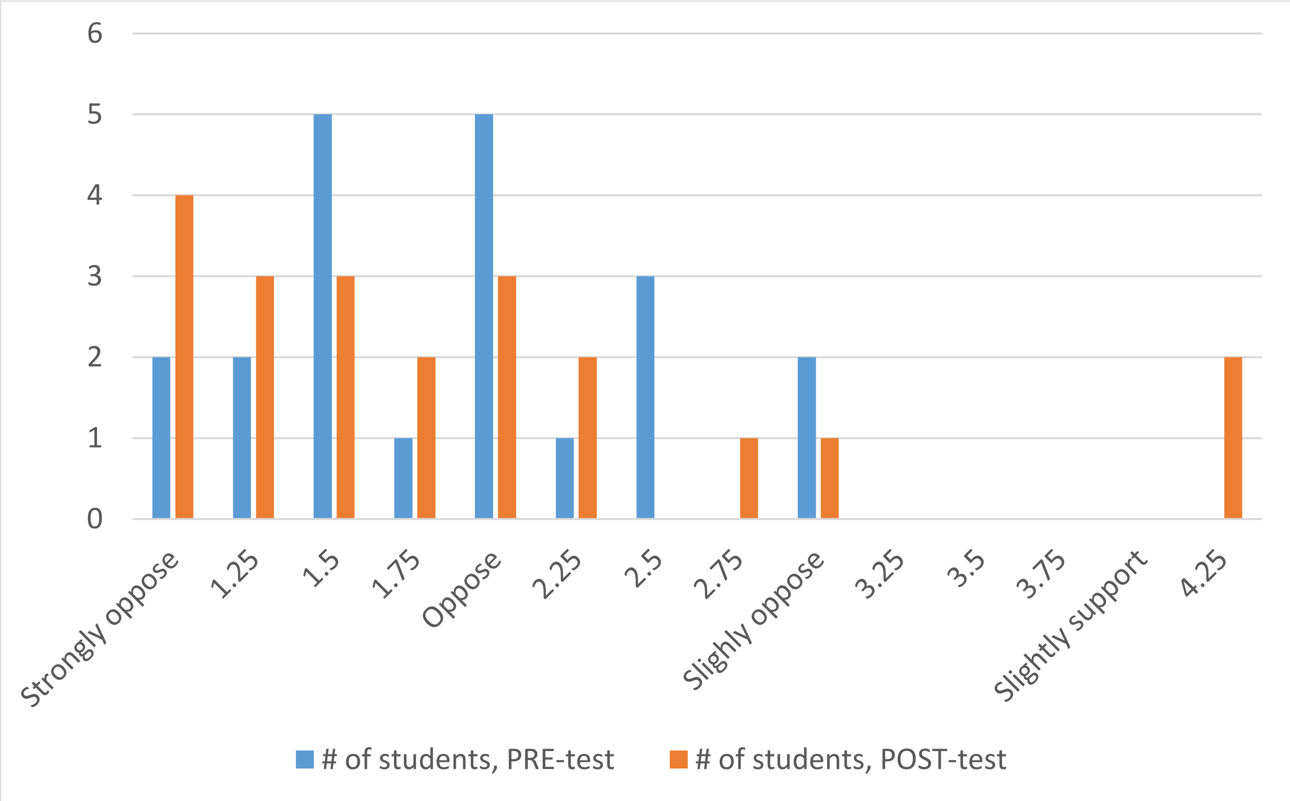
[b] Statistical significance for change in mean (paired-samples t-test): ** $p < 0.01$, *** $p < 0.001$

Figure 1: Change in degree to which students are well-informed (self-report)[a]



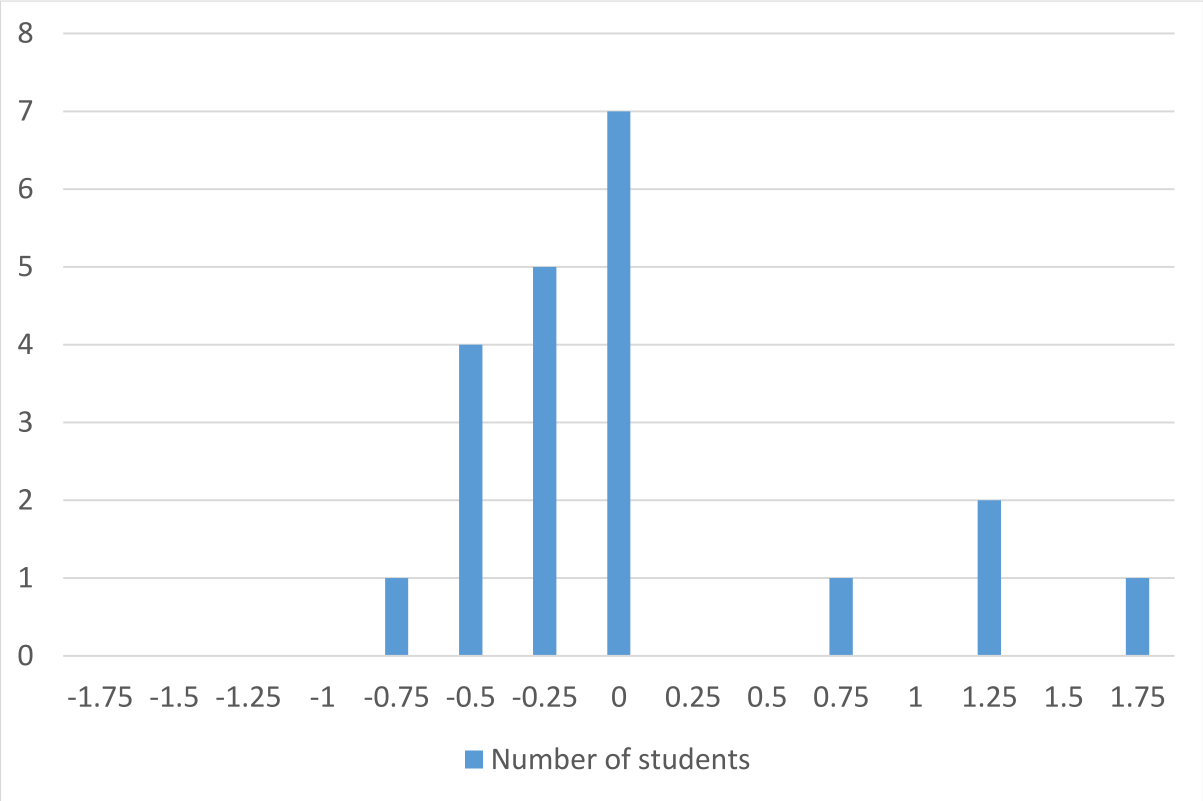
[a] This table presents change in students' responses to the statement 'I consider myself well informed on the topic of shale gas development' (evaluated on a scale of 1-6: 'strongly disagree' to 'strongly agree'); a positive value indicates the student considered himself/herself more informed at the end of the course.

Figure 2: Support for / opposition to SGD (PRE – POST comparison)[a]



[a] Support/opposition was evaluated on a scale of 1-6 ('strongly oppose' to 'strongly support'); the numbers in the table are averages for each student across responses to support/opposition in four locations: your community (hometown), your community [university town name], your state, the USA.

Figure 3: Change in support for / opposition to SGD[a]



[a] Change in support/opposition refers to the shift in average support/opposition on the six-point scale from pre-test to post-test; the numbers in the table are averages for each student across responses to support/opposition in the four locations; a negative value indicates that opposition increased – a positive value indicates support increased.

Appendix: Assigned readings from the course

Summary texts on multiple aspects of shale gas development:

Duggan-Haas D., R. Ross, W. Allmon. 2013. The Science Beneath the Surface: A very short guide to the Marcellus Shale. (Chapters 1-8)

Wilber T. 2012. Under the Surface: Fracking, fortunes, and the fate of the Marcellus Shale. (Prologue, Chapter 1, Epilogue)

Sovacool B. 2014. Cornucopia or curse? Reviewing the costs and benefits of shale gas hydraulic fracturing (fracking). *Renewable and Sustainable Energy Reviews*.

Physical and biological science research:

Vengosh A., *et al.* 2014. A critical review of the risks to water resources from unconventional shale gas development and hydraulic fracturing in the United States. *Environmental Science & Technology*.

Souther S., *et al.* 2014. Biotic impacts of energy development from shale: research priorities and knowledge gaps. *Frontiers in Ecology and the Environment*.

Moore C., *et al.* Air impacts of increased natural gas acquisition, processing, and use: A critical review. *Environmental Science & Technology*.

Newell R., and D. Raimi. 2014. Implications of shale gas development for climate change. *Environmental Science & Technology*. (selections)

Allen D., *et al.* 2013. Measurements of methane emissions at natural gas production sites in the United States. *PNAS*.

Alvarez R., *et al.* 2012. Greater focus needed on methane leakage from natural gas infrastructure. *PNAS*.

Abstracts only from:

Jackson R., *et al.* 2013. Increased stray gas abundance in a subset of drinking water wells near Marcellus shale gas extraction. *PNAS*.

Vidic R., *et al.* 2013. Impact of shale gas development on regional water quality. *Science*.

Olmstead S., *et al.* 2013. Shale gas development impacts on surface water quality in Pennsylvania. *PNAS*.

Vengosh A., *et al.* 2013. The effects of shale gas exploration and hydraulic fracturing on the quality of water resources in the United States. *Procedia Earth and Planetary Science*.

Kharaka Y., *et al.* 2013. The energy-water nexus: potential groundwater-quality degradation associated with production of shale gas. *Procedia Earth and Planetary Science*.

Best L., and C. Lowry. 2014. Quantifying the potential effects of high-volume water extractions on water resources during natural gas development: Marcellus Shale, NY. *Journal of Hydrology: Regional Studies*.

Rahm B., and S. Riha. 2012. Toward strategic management of shale gas development: Regional, collective impacts on water resources. *Environmental Science and Policy*.

Rozell D., and S. Reaven. 2012. Water pollution risk associated with natural gas extraction from the Marcellus Shale. *Risk Analysis*.

Myers, T. 2012. Potential contaminant pathways from hydraulically fractured shale to aquifers. *Ground Water*.

Osborn S., *et al.* 2011. Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing. *PNAS*.

Entrekin S., *et al.* 2011. Rapid expansion of natural gas development poses a threat to surface waters. *Frontiers in Ecology and the Environment*.

Gregory K, *et al.* 2011. Water management challenges associated with the production of shale gas by hydraulic fracturing. *Elements*.

Kiviat E. 2013. Risks to biodiversity from hydraulic fracturing for natural gas in the Marcellus and Utica shales. *Annals of the New York Academy of Sciences*.

Drohan P., *et al.* 2012. Early trends in landcover change and forest fragmentation due to shale-gas development in Pennsylvania: A potential outcome for the northcentral Appalachians. *Environmental Management*.

Maloney K., and D. Yoxtheimer. 2012. Production and disposal of waste materials from gas and oil extraction from the Marcellus Shale play in Pennsylvania. *Environmental Practice*.

Jenner S., and A. Lamadrid. 2013. Shale gas vs. coal: Policy implications from environmental impact comparisons of shale gas, conventional gas, and coal on air, water, and land in the United States. *Energy Policy*.

Caulton D., *et al.* 2014. Toward a better understanding and quantification of methane emissions from shale gas development. *PNAS*.

Howarth R., *et al.* 2011. Methane and the greenhouse-gas footprint of natural gas from shale formations. *Climatic Change*.

Cathles L., *et al.* 2012. A commentary on “The greenhouse-gas footprint of natural gas in shale formations” by R.W. Howarth, R. Santoro, and Anthony Ingraffea. *Climatic Change*.

Health science:

Adgate J., *et al.* 2014. Potential public health hazards, exposures and health effects from unconventional natural gas development. *Environmental Science & Technology*.

Maryland Institute for Applied Environmental Health. 2014. Potential Public Health Impacts of Natural Gas Development and Production in the Marcellus Shale in Western Maryland. (selections)

New Brunswick Department of Health. 2012. Chief Medical Officer of Health's Recommendations Concerning Shale Gas Development in New Brunswick. (selections)

Social science:

Jacquet J. 2014. Review of risks to communities from shale energy development. *Environmental Science & Technology*.

Jacquet J., and R. Stedman. 2014. The risk of social-psychological disruption as an impact of energy development and environmental change. *Journal of Environmental Planning and Management*.

Kinnaman T. 2011. The economic impact of shale gas extraction: A review of existing studies. *Ecological Economics*.

Weber J. 2012. The effects of a natural gas boom on employment and income in Colorado, Texas, and Wyoming. *Energy Economics*.

Considine T., *et al.* 2009. An Emerging Giant: Prospects and Economic Impacts of Developing the Marcellus Shale Natural Gas Play. (selections)

Christopherson S., and N. Rightor. 2011. A comprehensive economic impact analysis of natural gas extraction in the Marcellus Shale. (selections)

Evensen D. 2015. Policy decisions on shale gas development ('fracking'): The insufficiency of science and necessity of moral thought. *Environmental Values*.

Shepard S. 2013. Wildcatting: A stripper's guide to the modern American Boomtown. *Buzzfeed*.

Braiser K., *et al.* 2011. Residents' perceptions of community and environmental impacts from development of natural gas in the Marcellus Shale: A comparison of Pennsylvania and New York cases. *Journal of Rural Social Sciences*.

Clarke C, *et al.* 2012. Emerging risk communication challenges associated with shale gas development. *European Journal of Risk Regulation*.

Abstracts only from:

Theodori G., *et al.* 2014. Hydraulic fracturing and the management, disposal, and reuse of frac flowback waters: Views from the public in the Marcellus Shale. *Energy Research and Social Science*.

Theodori G. 2013. Perception of the natural gas industry and engagement in individual civic actions. *Journal of Rural Social Sciences*.

Jacquet J. 2012. Landowner attitudes toward natural gas and wind farm development in northern Pennsylvania. *Energy Policy*.

Kriesky, J., B. Goldstein, K. Zell and S. Beach. 2013. Differing opinions about natural gas drilling in two adjacent counties with different levels of drilling activity. *Energy Policy*.

Evensen D., *et al.* 2014. A New York or Pennsylvania state of mind: Social representations in newspaper coverage of shale gas development in the Marcellus Shale. *Journal of Environmental Studies and Sciences*.

Wynveen B. 2011. A thematic analysis of local respondents' perceptions of Barnett Shale energy development. *Journal of Rural Social Sciences*.

Shale gas internationally:

The Royal Society. 2012. Shale Gas Extraction in the UK. (selections)

Public Health England. 2014. Review of the Potential Public Health Impacts of Exposures to Chemical and Radioactive Pollutants as a Result of the Shale Gas Extraction Process. (selections)

European Commission. 2014. Executive summary of the impact assessment: Exploration and production of hydrocarbons (such as shale gas) using high volume hydraulic fracturing in the EU. (selections)

Law A., *et al.* 2014. Editorial: Public Health England's draft report on shale gas extraction. *BMJ*.

O'Hara S., *et al.* 2014. Public Perception of Shale Gas Extraction in the UK: The Turn Against Fracking Deepens. (selections)

Assorted contemporary news articles (mostly from Euractive – a European news source for energy topics)

Policy and regulation:

Wiseman H. 2014. The capacity of states to govern shale gas development risks. *Environmental Science & Technology*.

Province of New Brunswick. 2013. Exploring Natural Gas in New Brunswick. (selections)

European Commission. 2014. Commission Recommendation of 22 January 2014 on minimum principles for the exploration and production of hydrocarbons (such as shale gas) using high-volume hydraulic fracturing. (selections)

Materials from state-level regulatory agencies on state policies and regulations in New York, North Carolina, Ohio, and Pennsylvania.