



Engineering Education Outside the Classroom: Informal Learning Environments as Settings for Engineering Education for both the Public and Engineers

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Introduction

How engineers view the public and their knowledge has an effect on the ability of engineers as professionals as well as educators to engage, teach, and be taught by the public. If engineers as both professionals and educators see the public's knowledge about engineering as deficient; does this view of the public and their knowledge not constrain the field to a mundane and even domineering way of acting towards the public in regards to their role in the field as merely being lectured to about what is right and wrong? But, if, on the other hand, we as engineering professionals and educators saw the public as possessing a qualitatively different way of knowing engineering, that was no more or less correct than the way we know it; would that not open up a new avenue of including the public in learning with us? Would this not be a view that welcomed the public to be involved with us in our work, which welcomes their feedback to make more informed choices regarding public matters, in a way that would even give the public impetus to want to become engineers themselves. Would the engineering profession and its educational institutions, along with the public, not mutually benefit from a view of the public that honored its knowledge in regards to engineering?

With the questions above in mind, I have written the following paper to challenge the dominant belief in the engineering educational and professional community that the public's view of engineering is somehow deficient. I have termed this belief as "dominant," not just because two of the most influential engineering-related agencies, the National Academy of Engineering (NAE) and the National Science Foundation (NSF), have both claimed that the lack of public understanding of engineering was having a negative effect on the engineering field and society in general.¹ (p. 7) I have termed the belief as "dominant" because it is a view that has given the profession and educational institutions the idea that its knowledge is somehow superior than the public's own knowledge with respect to engineering. In previous work, Beddoes & I² have already questioned if engineers' perception of a public lacking in understanding of engineering was really true, or if, as Science, Technology & Society (STS) research had suggested since the 1980s, that engineers were perceiving any public skepticism about the benefits of engineering as due to a public that was uneducated and misinformed, without any substantial proof. (pp. 1-2) Instead of accepting the prevailing view of the public's understanding of engineering held by these organizations, I question back in return, is this view of the public not equally damaging towards society as well? Does it not limit the public's access in working with the profession?

Furthermore, does it not limit what engineers might learn from the public, and what the public might learn from engineers?

In this paper, I go beyond arguing if the NAE's and the NSF's view of the public's understanding of engineering really is correct, and offer a counter-example in the form of a conversational analysis of an interview. Using this analysis, I examined the experience of a graduate engineering student, whom I have pseudonymized as Way Bitsuie, engaged in a public forum about engineering. Through this analysis, I found evidence that the public did, indeed, come in with significant knowledge about the engineering topic at hand, which I have shared below. Furthermore, through the analysis of Way's experience with the public, I found greater significance for engineering education as well. I believe that the analysis I have performed begins to illustrate that through more engagements like the one Way participated in, new opportunities and possibilities for engineering education can be found that could be used to further educate both engineers and the public in meaningful ways, and garner new interest from the public to become engineers themselves.

Literature Review

I have cited the literature below mainly to help the reader understand the background of my standpoint about engineering in regards to how it has historically been communicated as an organization to the public, the effect that this mode of communication has had on relations with the public and why it should be changed, and possible ways to change and subvert this mode of communication. To accomplish this, I have written a background about how engineering has been communicated with the public in a historical sense to give the reader some idea about the state that engineers and the public are in at the moment. Afterwards, I move on to a brief review on the matter of how this type of communication silences the public's knowledge about engineering. Finally, I have included some background about a possible way to subvert the traditional form of public communication in relation to the public forum about engineering that I studied. Taken together, the connection between the literature cited is this: the reader will learn a small background about how engineering is communicated with the public, how this is a poor method to engage the public, and research into different ways of educating the public through settings like the one studied in my research.

As I mentioned in the introduction, the dominant perception of the public's knowledge of engineering from the perspective of influential engineering institutions such as the NAE and the NSF has been characterized by a lack of understanding. I have already co-authored a paper about this perception, and so as not to beat a dead horse, I will briefly sum up this perception through a direct quotation, "Since the 1980s, science and engineering (S&E) communication has been dominantly geared towards educating a public perceived as misinformed and/or having a deficit of knowledge."² (p. 1) The perception of a public with a lack of understanding of engineering was related by Wynne³ to the term "deficit model", which characterized a style of science and engineering communication based on the assumption that any public disinterest, skepticism, or criticism towards science or engineering was based on being either misinformed or possessing insufficient information about the fields. As Bucchi & Neresini⁴ wrote further:

This model has emphasized the public's inability to understand and appreciate the achievements of science—owing to prejudicial public hostility as well as to misrepresentation by the mass media—and adopted a linear, pedagogical and paternalistic view of communication to argue that the quantity and quality of the public communication of science should be improved. (p. 450)

Beddoes and I² wrote to effects of the deficit model of communication as creating an information flow that was one-sided flowing from engineers to the public, where only the public was expected to change its views about engineering, and where the public was generalized as only having one simplistic and misinformed view of engineering or having no view at all. (pp. 3-6) I found Clair's research into the more general topic of how individual's experiences become tossed aside a useful analogy to the way the deficit model operates to silence public knowledge about engineering. Clair⁵ introduced the term of "sequestering" in her research to explain the process in which people's knowledge can be disregarded and silenced. One way that Clair noted how stories could be sequestered by organizations was through the use of reframing devices that "trivialize" the knowledge being shared. (p. 118) Clair described the reframing technique of trivialization in the following manner, "Trivialization denies the validity of the individual's experience; it reduces the significance of the act and invalidates the target's feelings." (p. 120) Clair's research into the practice of sequestering narratives is relevant to the operation of the deficit model as a mode of trivializing public knowledge, and, more specifically, how the deficit model approach to science and engineering communication helps position the knowledge of experts within scientific fields over the knowledge that the public possesses, allowing it to be disregarded. Below, I have exemplified other literature that described ways that public knowledge can be trivialized in science and engineering communication.

Another means through which the deficit model has trivialized public knowledge has been through the view that non-technical knowledge is somehow unscientific because it is tainted by a bias of subjectivity inherent to public knowledge, making it unworthy to engage within the realms of science and engineering. Cech & Waidzunas⁶ studied the ways non-technical knowledge was discredited in S&E fields and referred to Faulkner's theorization of the social/\technical dualism that exists within the engineering field to show how technical knowledge is valued over so-called "social" knowledge and is used to create a knowledge hierarchy where knowledge of the "social" aspects of engineering is disregarded as unimportant. (Note: The use of "/" is intentional. I have incorporated it to visually illustrate the opposing way each type of knowledge is treated in technical fields such as engineering indicated by the research of Cech & Waidzunas. For more examples of the usage of "/" see Clair.^{7,8}) Cech & Waidzunas brought up the effect of technical/\social dualism in engineering where to be considered an engineer, one had to throw themselves into technical activities while also de-valuing social ones. (p. 4) Faulkner's social/\technical dualism is an important component of the deficit model because as Tanona et al.⁹ argued:

Analysis of the norms that scientists hold regarding their communication with the public indicates that there are several core values many of them hold, including objectivity, accuracy, and lack of bias. It is plausible that these norms influence scientists' choice of communication strategies. (p. 29)

I found that the work by Cech & Waidzunas pointed towards the distinct possibility that public

knowledge could be viewed as too biased, inaccurate, and subjective and therefore trivialized in discussions about engineering.

Despite the historical mode of deficit model communication that has characterized the relationship between the public and engineering, conclusions made from research by Bell et al.¹⁰ indicate that informal settings may provide a manner in which publics can learn about engineering with a more positive outcome. In their book about informal learning environments, Bell et al. have identified informal learning environments as spaces that actively promote learning. Potentially, informal learning environments offer the opportunity to promote science and engineering learning, which Bell et al. spoke to when they said, “There is mounting evidence that structured, non-school science programs can feed or stimulate the science-specific interests of adults and children, may positively influence academic achievement for students, and may expand participants’ sense of future science career options.” (p. 3) Furthermore, Bell et al. also said, “It is generally accepted that informal environments provide a safe, nonthreatening, open-ended environment for engaging with science.”

I have connected the public forum I studied, a public engagement about an engineering topic, to Bell et al.’s research that suggested that the event could be seen as an informal learning environment, and as such, the event might have the potential to promote an exciting new way of conducting engineering education. Many questions popped into my head in relation to Bell et al.’s work and how it countered what I had studied about the deficit model of communication: Could an informal setting of learning like a public engagement on an engineering-related topic subvert the sequestering nature of the deficit model approach to science and engineering communication? Could the public, indeed, learn about engineering outside the classroom in an empowering and meaningful way? Could engineers use the forum to learn about engineering from the public? The implications of such a learning setting is significant for engineering education in several ways, but perhaps none more importantly than what Bell et al. suggested through their research that the majority of learning in a person’s life is done outside the classroom. (p. 29) For engineers, informal learning environments could be new settings to practice and learn engineering throughout their careers. For the public, informal settings could be a place to connect with engineering throughout their lifetimes. In conducting the study, I could see the potential of the forum, and I wondered if it could deliver on the opportunity to engage the public in the way Bell et al. had posited that it could.

I have included research by Dorie et al.¹¹ into informal learning environments to better explain to the reader what an informal learning environment can be like and how this connects to my study into the public forum. As Dorie et al. explained, informal learning environments have existed in several morphologies. They can range from self-directed to collaborative in nature, motivated by the “commonality of shared interests between individuals,” and taking place in designed spaces such as museums and libraries. As the reader will see below, the public forum falls well into these characterizations.

Up until this point of the paper, I have been vague about what constituted the public forum. In the next section, I have described the forum in specific detail and also connect the forum to the idea that it acted as an informal learning environment. Also, up until this point, the voice of this manuscript has been only of me, the author. Beginning in the next section, I have used the voice of Way Bitsuie to help provide evidence and support some of the claims that I have argued. I

decided to include Way's voice in the description of the public forum because I wanted the reader to get a sense of the manner in which Way perceived the event, which I thought was necessary since I am using Way's experience of the event to understand how the event affected him. I have left discussion of the method I have chosen to adopt to transcribe Way's speech until after the description of the event. Discussing methods after using data may be seem "un-scholarly" to some readers, but rest assured that this practice is common in the field of communications and can be seen in Clair's⁷ work.

The Keystone Discussion Series as a Public Forum and an Informal Learning Environment About Engineering

The public forum about an engineering-related topic that I have been abstractly referring to until this point is The Keystone Discussion Series (KDS), a program annually held by Purdue's Ecological Science & Engineering (ESE) Program. The year I studied it, 2013, was the second time it had been held. Generally speaking, the KDS has aimed the focus of its discussion on S&E topics that have reached a level of national importance. In 2013, the topic of the KDS was about what is colloquially called "fracking," but which in petroleum mining is also referred to as "high-volume gas extraction." Way cited the national-level controversy surrounding fracking as a main reason why students within the ESE program decided to make it the topic of their public forum, but definitely not the only reason. When I asked Way, "As a group, what was something you agreed on quite easily?" Way responded with several reasons that made fracking a fascinating topic to address in a public forum. Way said, "Um...I think the topic was pretty well agreed on. It's, it fit all the goals of Keystone, and it was very politically charged, so it was something we could break down, it had all these other multiple facets, which, it's, it's a topic rich in general content in general. And, rich in media, so, people have heard of it, but there was a real opportunity to further knowledge of it, and get a lot more depth into it. So, I think that was pretty well agreed on." Overall, Way and the rest of the Keystone Leadership Team (KLT) thought fracking was a good topic to engage an audience because over recent years and on a national scale, the topic of fracking had garnered contested understandings related to its benefits and detriments to local communities where the natural gas had been mined, and on the national level where the natural gas was brought to market.

Way described the purpose of the forum as being a means to "deconstructing or depoliticizing a, uh, environmental topic to basically get down to the facts and weigh many factors, which can't exactly be judged or quantified side-by-side, but must all be considered." Way explained the KDS as consisting of four events, which were: 1) a lecture given by Ian Urbina, a journalist for the New York Times, who had done much reporting on the topic; 2) the presentation of two documentaries, each with decidedly opposite and conflicting conclusions about the benefits and dangers of fracking; 3) a "World Café" event, where the general public performed small table discussions that generated questions for a later held panel discussion; and 4) a panel discussion where experts on different sides of fracking, such as its local, economic, and environmental impacts, shared their insights and were to be questioned using questions generated from the earlier held World Café.

I took Way's description of the format of the event to be that the event was presented in more or

less three components. One component was the two events where the public could come and listen to an information source in the forms of a speaker knowledgeable about fracking issues, or as two documentaries that reported two opposing perspectives of fracking. Taken together, these two events allowed the public to form a general background about fracking, an engineering-related topic, and experience the controversy as it had played out nationally. The second component was the World Café. The World Café allowed publics to pool together their knowledge about fracking, knowledge they may have gained before the KDS as well as knowledge they may have gathered from the first two events of the KDS. I thought of the World Café event as a component of the program that allowed the public to process the knowledge it had. Finally, the third component, which was the panel discussion, was what I have referred to abstractly as the actual public forum about an engineering-related topic. The panel discussion allowed the public to voice their questions about fracking and have those questions answered by people considered experts regarding certain fracking issues.

As an entire program, I took the KDS to be an informal learning environment for several reasons. At its most basic level, learning in the event was completely voluntary and self-directed. Publics determined their own learning objectives, the level to which they wanted to be involved, and they did so in a designed setting that lacked cultural pressure to learn in a way other than the way they desired. Therefore, Way's description of the KDS provided reasons for me to see the event as an informal learning environment for the purposes of engineering education.

Methodology & Method

I recruited Way Bitsuie as part of a more comprehensive study of the KDS, which I created to investigate how engineers talk about their interactions with the public and what perceptions about public knowledge this discourse revealed. Simply put, I interviewed Way because he was an engineer working on a public engagement about an engineering topic, which is what my study required a focus on. I performed a structured interview with Way almost two months after the conclusion of the KDS program, at my office for one hour, asking him questions about his role in the KDS, why he joined the program, how knowledge was shared at the program, how he perceived the public and the knowledge they brought with them, and how he thought participating in the program helped him as an engineer. I pseudonimized Way Bitsuie's real name to keep his identity anonymous. In the analysis that follows, I have chosen to refer to him as Way, without mention of the last name, purely for the reason that I have already established that he had a last name here. Because the setting of this story is in a Western setting, where people traditionally have first names and last names, I have chosen to follow that convention. From this point onward, the reader should assume that the lack of mention of his last name is merely due to my authorial convenience.

A note on the method of transcription is also in order. The reader should have noticed, and perhaps, may have even been disrupted by the way I have transcribed Way's interview from the short excerpt above. The interview transcription below keeps the same format as that already established above, which purposefully contains as many of the conversational pauses, "ums" and other verbal disfluencies, as I could muster. Many readers may find this transcription method unnecessary and even a display of poor judgment on my part as a "scholar." I must therefore

justify this transcription as based on a methodology that aims to show, rather than summarize, how the interview participant talked about their experience, providing some idea of the difficulties in relating this information during the interview, and really provide the reader with some sense of the reflection the participant had to undergo to describe their experience. I thought that my choice of transcription method fell in line with the overall goal of this paper. I wrote this paper to show why events like the KDS are valuable tools for engineers to engage in. If this event is to be taken as a serious instrument for engineering education, of both publics and engineers alike, I wanted the reader to see the challenging and rigorous nature the event had on the cognition of an engineering student, a challenge that was in line with any other formal type of engineering education. Furthermore, as Lapadat & Lindsay¹² reported, there is no such thing as a standard transcription technique. If, in engineering education, the common technique of transcription leaves out the verbal ramblings and poor diction of those being interviewed, it does not make the transcription anymore right or wrong, it merely means that transcription method is the norm, and that it accomplishes the goals of the scholars in their particular context of research. For me, leaving in the unseemly “ums” and “ers” that we as people say all the time was important, because it makes the participant seem like a real person and it lends an authentic quality to the voice of Way’s discourse I aimed to transcribe into this paper.

I should also justify the format in which I share Way’s responses at this point too. The reader should have also noticed from the excerpt of Way’s speech above that I have presented Way’s responses in-line with the rest of the paragraph. I did this because I wanted Way’s voice to be as much part of my analysis, as my own voice. I thought that this was important because it gives a sense of narrative that shows the event from Way’s perspective. I thought this was an important thing to do because again, this research is about how Way experienced the event, and I thought it helped the argument that serious learning about engineering went on during the event, which is the overall significance of my research. For this reason, the reader will continue to see Way’s speech within the analysis of discourse I performed.

In regards to the actual method of handling data, I coded Way’s interview data into two different sub-sections: How did Way perceive the public and the knowledge it possessed; 1) before the KDS?; and, 2) After the KDS? In this regard, I analyzed how Way characterized public knowledge presented at the forum, whether or not this perception changed, and if it did change, how? I felt that by coding Way’s responses in this manner, I would be able to link Way’s perceptions about the public not only to background literature I reviewed earlier about deficit model communication, but also to Bell et al.’s suggestion that informal learning environments had the potential to provide safe and non-threatening space to learn about engineering.

Results

I had known Way for about a year coming into the interview. I knew him as a Native American graduate student at Purdue University working on his Master’s Degree in Agricultural & Biological Engineering, as well as a member of a an interdisciplinary program called Ecological Sciences & Engineering (ESE). To help clarify confusion about the organization of students as part of two separate programs, Way explained that students within their home departments affiliated with sciences and engineering could also be a part of the ESE program if they wished.

Way explained that being a part of the ESE program allowed students unique opportunities to participate in events that other students would not have had. Ultimately, Way became a participant in the KDS through his involvement with ESE program, which was the sponsoring program for the event.

Way helped facilitate the 2013 KDS, which consisted of four separate events between the months of March and April, and which I described in detail above. Way described his role in the program as minimal. He said he performed research on fracking and described it in the following way, “Uh...I did, uh, a little bit of research to just, just give people preface, and that was on the economic side, specifically. And then, um, involved in planned discussions, obviously gave input, and also set up the mechanism where people could ask questions via text.” He also helped moderate small group discussions which he described as, “[B]asically, uh, just trying to keep anybody from kind of grandstanding within the discussion and being, like I know, that somebody can even be a professor, as a student we are kind of supposed to temper them down and allow a lot of different voices to come out, generate questions, compile those questions, and kind of move a handful to the top.” As a result, even though Way characterized his role as a small one, he did have an important role, albeit a passive one, in deciding what questions would later be asked in the fourth and final program, the panel discussion.

Way perceived that the KDS mainly attracted a general public. Way’s conception of who came was a rough estimation. He did not have any solid evidence to support the claim, but he did know the groups that the KDS had been advertised towards. I asked Way, “So, in terms of the audience, um, like, who do you think came? Like, uh, do you think it was like an academic audience? Or do you think it was like a general population?” Way said, “I think it was heavily students, uh, both graduates and undergraduates. Obviously, being an ESE event, I think a lot of ESE students were there. Uh, but, looking at the audience, there was no way it was just ESE students. Um, I think there was, uh, and I am talking about the panel specifically, but also when you go back to the, uh, uh, the World Café event, we were generating questions, uh, I remember, I remember from facilitating that, uh, there were a lot of undergrads that were coming through. So, academic in the sense that they’re students and they’re very curious about this issue because they probably heard a lot about, and they want to know more.” I prompted him further by asking, “Um, did you plan for mostly students, or, was that just how it played it out?” To which he responded, “I think it was how it played out. We didn’t plan for mostly students. We planned for, for people in general. Uh, I think the general public could have come in to any one of these events and gotten just as much out of it as any student. But, being students planning it, uh, and, just telling your friends and the word of mouth surrounding the event, it obviously got advertised more to students. Uh, classrooms, where it was announced especially.”

Way’s Thoughts on Public Knowledge Before the KDS

Based on Way’s responses to my questions, I concluded that Way perceived public knowledge coming into the KDS as “politicized” or “biased.” Way based this perception of a biased public, not necessarily because of the public consciously chose to be biased about fracking, but because he believed that the public’s main information source, the media, was misinforming them. When I asked Way, “So what do you think the benefit for the general public, or, what do you think the

benefit for the audience was?” Way responded, “I think they got [clears throat] a...a depoliticized perspective, and a lot more in depth perspective of high-volume gas extraction than could be gained through typical means. When you rely solely on the media as a source of information for this kind of thing, I think a lot of media outlets, they like to have debates, and debates can boil down to talking points, which are meant to, kind of trigger feelings, um, to either oppose, or, support something. And, it’s not really, so many things can go unanswered and unweighed. And, the very rapid, very, uh, talking points based [clears throat] conversations that go on there, but, if you go totally toward the academic side, I think, you can get, a single professor, which is probably going to talk about this, and obviously give their own opinion in a classroom, and uh, that opinion will be based on whatever facet, of, of uh, of the issue that, that professor probably has expertise in. You know, if they are a petroleum engineer and they know the exact process, than they can probably say with some confidence how often that process is going to fail, and under what conditions that it is going to fail. But, then that would probably ignore the societal parts, the changes in communities, which come with a natural gas boom. Which are very vast, and have two different sides, winners, losers, uh, heightened crime, uh, heightened jobs. Lots of uh, good things and bad things. So, I think it, it uh, it gives a more holistic perspective of the issue.”

I asked Way to explain more about his take on what depoliticizing meant to more fully explore his perception of the public coming into the KDS. I asked, “What do you mean by depoliticizing?” He replied, “So this one was on...High-volume extraction of natural gas, aka fracking. And, that is politically contentious. You have documentaries coming out, which are very biased either for or against it, which are funded by either environmental organizations, typically, or um, oil organizations, energy organizations, which have their own goals and biases. And, I think, the planning team and uh, attempts to stay very conscious of those biases. And, uh, not, allow them to, you can’t really suppress those biases, they are people’s feelings, they are people’s opinions, but, in planning an event where you want to get down to the facts and, and weigh what is a really hard, its kind of a hard personal decision to be for or against a technology like fracking because it has so many aspects. It uh, frankly, um, one of the things that was surprising me that I learned that we are on the road to meeting the Kyoto protocol mostly thanks to fracking, because it is a lower carbon intensive, uh, natural gas is lower carbon intensive. And, as a result, we are, our energy is becoming cleaner. Uh, but at the same time, the process has all these other side effects. Um, a lot of times, it can be done safely. And obviously, these are um biases, or, uh, opinions come in through but you try to, it’s formatted in such a way to represent perspectives, but...But not have a debate...Represent perspectives, and that also helps people make up their own minds. I think the audience...informing the content and how the, how the events can take place, its about representing perspective without having debate.”

Way’s explanation of depoliticizing was still unclear in my mind, even after being prompted to clarify. But, his responses to other questions helped me understand later on what he meant. For instance, when I asked Way “What helps the believability of somebody’s information? Like, what helps you believe them more? Because, like, you can’t cite, like, when you’re in speech, citing, like, you know?” he answered, “Yeah. It’s not like you’re going to say, “There’s 80 years of natural gas left for America, parenthesis Smith, 2009.” Um, I think it’s motive; it’s totally motive. It’s what helps me come to...Curious people with no, uh, no end goals. If you look at the two documentaries we looked at...One is, uh, one was made by someone who had, um, a natural gas lease on his land and who had, had drinking water contaminated, and the other one was, uh,

funded by a natural gas agency. Um, they, they both had motive and frankly they both had things, which I didn't trust. But, the people that were sitting at the table, um, had more curiosity. Or at least about more curiosity came through because of how the event was set up." I took from this that Way's idea of depoliticizing knowledge related to fracking as somehow separating motive from information so that a prior personal judgment about the benefits and detriments of fracking did not limit the investigation of the fracking topic to what people already decided fracking to be.

I came to understand Way's perception of the public before the KDS indirectly through questions related to the KDS's design. I asked Way, "So, when you think of the general [public], or when you are designing an event for the general public, was there any, like, direct, um, was there any special design you had in mind for a general audience? Or, um, was it, was that something that came into mind when you were designing the event?" Way replied, "I...I think that the audience was meant to be...we, we formed the event to be as appealing to as wide of an audience as possible. Um...even students are a wide audience in themselves. They come from so many different backgrounds and places at a university like this. So, I think any...anybody could have walked in there and gotten just as much out of it as a student did. Um, I can't recall within the discussion whether we said you know, we need to do this so that, you know, this group of people so that this group will come, or we need to do this so that this group of people will come." I continued by asking him why the event was not directly tailored to a specific audience in mind. "Ok. Why or why not? Why do you not think that came up?" Way prompted a clarification, "Designing for a specific audience?" I re-worded the question, "Yeah. Yeah, like, why wasn't that something that got brought up?" Way answered, "I think because the nature of the topic is national, if not global. So...So, in addressing it, you kind of want to be, you know, you want to cover everything, you want to cover a lot of different areas of knowledge, and a lot of perspectives. I think, maybe, getting more to the root of your question though, we are students and planning it, and we looked within, within reach of, uh, of the best resources we could find on it. And that probably got biased a little bit towards academia. Although I think you saw more professors on the panels than not professors, but, well actually, it was probably half and half. Which, maybe, if you were to get a sampling of panel, which sampled the general, the general public, you would uh, you would end up with half professors. Uh, so you could say, there was an academic bias that we were operating under the whole time. But, each one of the areas of academia was different." I took from Way's responses to my questions that he perceived the type of public in terms of their attachments to academia. Way felt confident that the public coming was general in the sense that they were not attached to a specific discipline, but it was also a type of public that would respect an academic-style presentation of fracking, where fracking knowledge would be presented along disciplinary lines, i.e. technical knowledge would be presented by engineers, and economic impacts of fracking would be presented by economists. Way's theorization of public knowledge before the event within an academic framework divided along disciplinary lines helped structure his perception the public and its knowledge. I theorized that Way adopted this strategy of thinking of the public because it fit in with the overall strategy of the KDS to frame the investigation based more on curiosity of knowledge itself than on supporting one's own pre-conceived notions.

Way's perception of public knowledge about engineering was also tied to a notion of bias. Way's responses to questions pointed me to this conclusion. For instance, I asked Way to describe his

perception of the knowledge public possessed before the KDS. “Ok. Um, do you think the public had an awareness of the work that goes into fracking, um, before they came into the event?” He answered, “I think they had an idea.” I prompted him further, “Yeah, um, I guess, so like, do you think they had more of like a technical awareness, or more of like a social awareness of like, or neither, or both?” I think they probably came in with, I think, I would assume that most people came in with, uh, heavy on one perspective of it. So, either perceiving it as environmental threat, or, uh, perceiving it as a mechanism to drill through the ground and, um, and increase the volume of natural gas that was coming out. You know, that would be a very engineering, uh, especially a petroleum engineering-heavy perspective. You look at a small footprint on the ground and what’s going on up to 5,000 feet, or, well, even more for some fracking wells I think, underground. But then you probably never consider the societal side or the media’s portrayal of it, or, um, other parts. So my assumption is that most people came in with knowledge of one aspect of it more than any other. I took Way’s response to imply that while people came in with knowledge related to fracking, that knowledge was limited to a certain degree to how people perceived fracking overall as a benefit or detriment. Again, Way’s view of public knowledge was conducive with the goals of the KDS he outlined, which were to strip prior bias away from public knowledge by adding more depth to people’s knowledge.

Way’s Thoughts on Public Knowledge After the Event

Way’s perception of public knowledge about fracking after the KDS was different, partly because he believed that the KDS approach to sharing knowledge about fracking was able to educate people’s views about fracking. I asked Way, “Um, do you think that the education you all provided, um, changed the level of the public’s awareness [about fracking]?” Way answered back, “I think so. It...You view it, I came to view it a lot more holistically. Of course, I was involved in it more, so I probably got a whole lot more out of it than the public that was just showing up to events, but, I would, I would think so. I would think they’re at least, uh, viewing it from more perspectives and more avenues than they were before. I asked him to explain further, “Um...Could you provide an example, um, maybe of where you saw this playing out?” He did so by retelling a situation during the World Café event, “Somebody, like, somebody gaining more out of it? Um...I think, so, when I was facilitating, I saw some EEE students come through, which is the Environmental & Ecological Engineering undergrad program here. And, they came in with very environmental-based perspectives, and I was facilitating economics-based table. So, they...Facilitating that, we kind of forced them to ask questions about the economic side of it. So, “How much money do we have?” Like, “How much of this do we have left?” “Is this actually going to be a transition fuel?” “Does that make sense economically?” Uh, start to break down that aspect, which I’m going to guess, was a, they weren’t naïve to, but hadn’t explored yet.” Way’s retelling of the situation suggested that the public’s knowledge of engineering was augmented, because after the KDS they were able to consider other dimensions of fracking that they might not have considered due to previous biases about fracking.

Way shared that he thought that both engineers who participated in designing and facilitating the KDS and the audience that came gained something through the forum. I elicited him directly, “Do you think the program was mutually beneficial, as in, like, do you think you as an engineer and

the public were both able to take something away?” Way imparted, “I think so. I think I got...I think I saw how tense conversation could be, uh, thawed, for lack of a better word, um, made smoother, made less tense, and more information, more perspectives come out as a result of it. I think I also saw how, how essentially contested something can be, because frankly you have...You have, uh, you have benefits in apples and you have detriments in oranges and you can’t compare those or weigh them against each other. It’s so difficult. I know accountants would want to put a dollar value with each and then see if it came out positive or negative. But that’s such a far stretch to do that, so, um...I think I stopped viewing it as something to either be changed or defeated, and more as something that is, uh...is worth talking about more. Because, questions came up which we ultimately couldn’t answer. It would, it would have to be somebody’s thesis to answer some of these questions. And, err, multiple theses, and nobody’s done that yet, nobody has broached them, and they are really valid questions. I don’t remember what they were, but I remember thinking at the time, like, “Yeah, that’s a good question.” And, who knows? The fact is that you get a panel of what should be the people, and probably are the people that have the greatest amount of perspectives on this. Uh, and, very well have researched it very well...Uh, and there is still some tough questions that they can’t answer about it. Um, so that’s what, that’s what I gained. And then, I think that what the audience, hopefully they gained similar things, but, I think they came in, and hopefully they saw an event where you can basically learn more by cutting out the rhetoric.” Way’s response indicated a benefit to the public beyond the “depoliticizing” of information that he originally thought was the benefit of the KDS before his participation in it. His response also pointed to the benefit the public enjoyed of being listened to instead of just being talked at, within a safe place where people who were considered experts about an engineering topic could respect their knowledge. The designers of the KDS created a space where possible emotions of anger and confusion about fracking could be diffused, at least for the time being, and replaced by the curiosity associated with an authentic investigation into the topic. Furthermore, Way’s response indicated that engineers were also able to gain something out of their work with the public. Way pointed towards the tough questions that the public asked, suggesting that Way’s furthered his own understanding of fracking through working with the public, a benefit for any engineer.

Way’s view of public knowledge changed as a direct result of his participation within the KDS, which is evident in his responses to my questions. I asked Way, “Um, do you expect, or, did you, did any of your beliefs about the public, like, in these types of engagements, I guess, did you, did you think that any of them changed after the event?” He responded, “Yeah, I think I give, I give the public more credit now. Because, when you realize, when you, when you expand an issue like this to, um, more facets than, than just drilling into the ground. Like, just the very basic engineering facet, you realize almost everybody has some aspect of this, or, some personal experience and base of knowledge, which can relate to the bigger picture. And, and all of those are very valid beyond the very simple engineering aspects of it.” Way’s response demonstrated that because of the event, he came to respect public knowledge because he could see that it was not deficient, but instead reflected an experiential quality that combined technical knowledge with other knowledge about the broader implications of environment and society. Way’s new view of public knowledge contrasted his original perception that public knowledge lacked deeper perspectives beyond the narrow dimensions that their biases may have constrained them to have, signaling that Way’s own perspective about public knowledge had grown from what he originally

indicated he had thought before the KDS.

Discussion

From my analysis, I was able to map back some of what Way had said to my literature review about deficit model communication. For instance, Way's description of the goal of the KDS to investigate fracking in a way that would "depoliticize" it reminded me of the work by Cech & Waidzunus that spoke of the social/technical dualism present in the engineering field. I was faced with a dilemma when trying to understand the benefits of Way's goal of depoliticizing engineering knowledge. On the one hand, because Way valued information that seemed not to be explicitly tied to an agenda for or against fracking, caring only about "just the facts," he was able to lead an investigation into the topic that was not as affected by the controversy that the topic had been embroiled in. I found Way's approach to talking about fracking very useful in this sense because it avoided the anger and frustration that might hold up an investigation into the topic. But, I also found his belief that knowledge could even be "depoliticized" quite vexing because all knowledge is by its very nature, political. Beddoes & I² noted that "Indeed, the field of STS is built upon countless studies documenting that science and engineering are not value-free or objective in the ways that they are commonly believed to be. This body of literature has demonstrated that values and biases shape science and engineering in multiple ways, including the questions that are asked and researched, the ways data and observations are interpreted, the interests that are served, the technologies that are produced and the ways they are designed." (p. 3) Furthermore, Way's belief that engineering knowledge could be depoliticized, coupled with his belief that public knowledge coming into the event was deficient and misinformed and his belief that more information could "cure" this deficiency, fell in line with many of the assumptions that underlie the deficit model approach towards engaging the public with engineering.² My fear was that through the enactment of an approach based on similar assumptions that are the foundation of the deficit model, which have been critiqued by numerous scholars as being detrimental towards the public's participation in discussions about engineering, that the KDS would in effect also sequester the public's own relevant knowledge about engineering and its effect on the environment and society.

As I analyzed Way's responses to my questions, my fears that Way had imposed the deficit model approach to communication were assuaged considerably. I came to view his approach to facilitating public discussion as being more thought provoking than it was limiting of public discussion. But, I also did feel that Way's lack of insight into how fracking knowledge was in itself political, also limited conversation to deal with public knowledge that could be rationalized as not based on first-hand experience, and only what was reported out in the media or by experts on fracking-related issues. Way's method of deconstructing worked well when addressing knowledge that was seemingly unattached from the emotions of people. But, one of the reasons why fracking is so controversial is because it has affected people on a personal level. Many publics have blamed fracking for ruining their lives through, for example, the contamination of water, and the creation of sinkholes that destroyed once useable land. Way's approach did not take in account these stories where the personal experience of being affected by fracking is what makes it matter, and therefore sequesters them, rendering them less valuable than information that is not situated within these narratives.

I regarded Way's construction of the public as more nuanced than I originally would have thought. By this I mean that I would be incorrect to only characterize the public that participated in the forum as merely one with little understanding of the way the topic would be discussed, that upon further analysis, the public had characteristics of having first-hand experience about discussing issues along the lines in which it was formatted in the KDS. For instance, Way described the public that came as mainly from Purdue University's faculty and student body. I felt that the public's shared experience of belonging to the same institution allowed for a conversation that was more fit for the "academic" approach of dividing knowledge along disciplinary lines. The structuring of knowledge along disciplinary divisions allowed fracking to be looked at as if the technical applications of fracking were separable from its environmental and societal affects, an approach that promoted that view that technical knowledge was somehow apolitical. Since the public that was invited had been acculturated to this way of viewing knowledge, I viewed them as having a first-hand experience with viewing knowledge in this divided and very disciplinary fashion, and that furthermore helped such a view of fracking to remain unchallenged throughout the forum. But, I also must qualify my argument to include mention that the KDS's creation of a knowledge order was also beneficial in that the knowledge order allowed a deep investigation of fracking along many dimensions. Furthermore, through this approach, Way was able to respect the knowledge the public brought in as one that was able to synthesize both experiential knowledge with the technical applications of fracking. So again, my critique about the nature of the events design did not apply completely as I would have expected.

Way's observation of public knowledge challenged important assumptions about the public's understanding of engineering provided by important institutions that represent the engineering field, like the NAE and the NSF. For instance, the NAE¹ characterized the public's understanding of engineering as deficient in the following way, "Despite [considerable] efforts, the impact of engineering on our daily lives, the nature of what engineers do, and the opportunities available through an engineering education are still largely unknown to most Americans." (p.17) Way's observation of the public and its knowledge about fracking challenged the NAE's assumptions of their deficiency of understanding. The public as a collective at the KDS demonstrated an awareness of the impact of fracking, an awareness of to the nature of what engineers did to apply fracking technologies to the mining of natural gas, and an awareness of the implications of fracking on their daily lives. Way's observations about the knowledge the public brought in suggested to me that there was counter-evidence to suggest that the public does have a significant understanding of engineering, and that there are ways to access this knowledge in an informal setting. Furthermore, I saw that the KDS's strategic decision to engage the public within a forum that dealt with a controversial engineering-related topic as a crucial step towards fostering interest within the public about engineering. Public knowledge was respected through the method of communication employed by the KDS, instead of being trivialized like it has been through the deficit model approach.

Finally, the KDS displayed potential to offer a substantial learning opportunity for engineers to learn about engineering. Way spoke to both social and technical dimensions that engineers were able to learn from. From a communication perspective, engineers learned how to access public knowledge, and they helped massage that knowledge into something that anyone could learn from. From a technical standpoint, Way gained valuable knowledge from the audience about fracking from an environmental and economic perspective. This knowledge could aid Way in

future research into the specific topic, or more generally, Way learned how to use the public as a resource to access when needed. Furthermore, no engineer is knowledgeable about every facet of the engineering profession and its effects on people's daily lives. On a very basic level, an engineer looking to know more about fracking and learn about it in a well-organized and multi-faceted manner could have used the KDS to enhance their own understanding of engineering.

Conclusion

I presented an analysis of an interview with respect to the experience of an engineer, who I pseudonymized as Way Bitsuie, and his participation in a public engagement about an engineering-related topic. My analysis of that interview included his thoughts about the public and the knowledge it possessed, before and after the event. Through this analysis, I showed how Way's perception of public knowledge affected how he engaged the public, and I demonstrated how his interaction with the public changed his view of the level of knowledge it possessed. Furthermore, I showed how his understanding of public knowledge challenged previously made assumptions about the public's understanding of engineering by important institutions such as the NAE and the NSF. I hope that through my analysis, engineers and the public can further engage engineering-related topics, both in the interests of educating the public about engineering and helping to facilitate a better and more respectful way that engineers and engineering institutions perceive the public and its knowledge about engineering. I feel that Way's experience working in the KDS illustrated that when the knowledge of everyone is respected, a huge barrier is lifted between engineers and the public, which ultimately allows everyone to participate in engineering education. Ultimately, I hope that engineering professionals and educators were able to see the potential of this event as an informal learning environment that served as a way to partner with the public to both teach and learn about engineering in ways that are mutually beneficial for both parties, and as a way to further incorporate the public into engineering.

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