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Questioning Reality, Questioning Science: Teaching Students in the Food and Agricultural Sciences about Epistemological, Ethical, and Empirical Controversies

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Abstract: The effective application of food science depends on social constraints, yet the training for food scientists does not adequately consider the contested social context under which food is processed, packaged, and prepared. We recently co-taught a new course ("Arguing about food") intended to introduce students to critical perspectives on the epistemological, ethical, and empirical assumptions that characterize contemporary food controversies. Through a series of guest lectures, readings, and discussions, students engaged with contrasting views on data quality, food ethics, nutrition, safety, governance, and the scientific enterprise as a whole. A key feature of the course was that we did not seek to defend any particular position. Rather, we examined how different values could lead reasonable people to take different views on scientific issues. Course requirements included a pass/fail quiz, a series of written reading responses, a group project devoted to a case study, and active attendance and participation. The students were engaged and challenged by the material, and at the end of the semester, reported that the course had also been useful and informative to them as young professionals embarking upon careers in the food and agricultural sciences.

Introduction: The Need for a Serious and Informed Discussion About Food Controversies in Food Science Education

Physical and biological scientists are trained in the use of experimental and observational studies to generate reliable information about the world, and these studies are often used to inform personal, commercial, and political decisions about how to act in society. However, the distinction between statements about how the world is and the larger decision about what people should do in society is not commonly considered in scientific training and often unappreciated by the scientists themselves (Kleinman 2009). For example, the observation that a certain number of mice develop tumors when fed a specific chemical alongside their normal diet can be used to inform the argument that the chemical is safe for people to drink at a given concentration. While the measurement on the rodents is a well-controlled scientific experiment, the conclusion regarding the impact on people needs support from additional arguments. It is not commonly appreciated amongst many scientists that the practical decisions that emerge from their experiments (for example, "this chemical is safe") involves both empirical data as well as social values.

In a science curriculum, the emphasis has to be on the role of science to answer practical questions within its realm of enquiry. It's also important, however, that scientists—especially food scientists, whose field of study is so deeply contested—understand the limitations of science and how it ties into the other reasons that people make decisions. This critical reflexivity is often stymied by 2 powerful discourses which have long pervaded the natural sciences as a whole: scientism and technological progressivism (Kleinman 2009). The key tenets of scientism are that science is objective, value-free, politically neutral, rational and nonemotional, separate from opinion, and a special domain for scientists (Kleinman 2009). As noted by Kleinman (2009:4), "This belief in the cognitive superiority of facts over values leads to the conclusion that only trained scientists—experts at unearthing facts—can appropriately participate in decision making on technical matters." Similarly, technological progressivism is characterized by the assumptions that progress is good, technology will improve society, and the forward march of progress is inevitable (Kleinman 2009). These discourses have a powerful hidden impact on the way that science is practiced, and food scientists are thus often unaware of the gap between scientific observations and citizen's practical decisions about food. Indeed, many scientists remain convinced that

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public skepticism toward science is the result of an "information deficit" that can be resolved by educating lay citizens as to the error of their ways (Besley and Nisbet 2011).

When scientists dismiss public worries and concerns as simple-minded ignorance, important ethical questions about our food supply and the scientific enterprise as a whole can go unasked and unanswered. Scientists' inattentiveness to the complexities of these issues has negative consequences for (i) the scientists themselves, who may feel conflicted that their personal food choices do not align with "the science," (ii) their employers, who depend on social acceptance in order to sell food scientists' products, and (iii) society as a whole, if food scientists cannot effectively communicate their perspectives in political debates about food. These consequences were recognized by the CEO of a major agricultural biotechnology company in 2000:

> "[We] focused so much attention on getting the technology right for our customer—the grower—that we didn't fully take into account the issues and concerns it raised for other people. We didn't understand that when it comes to a serious public concern, that the more you stand to make a profit in the marketplace, the less credibility you have in the marketplace of ideas. When we tried to explain the benefits, the science, and the safety, we did not understand that our tone—our very approach—was seen as arrogant (Hendrik Verfaillie, as quoted in Van Yoder 2001:40 and Schurman and Munro 2009:191)."

Going Beyond "Myth-Busting": Teaching Students How to More Effectively Engage in Public Debates about Food Science and Technology

For the 2016 spring semester we offered a new course, "Arguing about Food," designed to address these challenges (see Supplementary Material: Condensed Syllabus). The co-authors on this paper drew on their respective backgrounds in sociology and food science to co-teach the course. The first author (Chiles) was immersed in the relevant thinking from the social sciences, and because his background isn't in food science, he could to some extent "burst the bubble" of a disciplinary community talking about itself. The second author (Coupland), who first came up with the idea of the course, is a longstanding professor of food science who has also been extensively involved in leadership positions at the Institute of Food Technologists (IFT). After a series of discussions, we found a great deal of common ground between our widely divergent experiences, and the decision to launch the course was made. The 16 students who enrolled in the course were largely undergraduate students in food science with a significant minority of food science graduate students and a few from other disciplines. While our intention at the outset of the semester was first and foremost to develop a new and engaging course curriculum, as our enthusiasm for the course grew, we wanted to share what we'd learned with other food science educators. Our main objective for this paper was thus to discuss our experiences while implementing this new approach to teaching. We felt that it was also important, however, to include students' voices in our assessment. Accordingly, at the conclusion of the semester, with approval from our university's Institutional Review Board and our students' informed consent, we conducted a qualitative analysis of students' assignments, comments, and presentations. Qualitative analysis was appropriate for this type of research because it provides rich description and unique insight into social processes, complex events, hidden assumptions, local cultures, subjective meaning, competing standpoints, and, perhaps most significantly, the role that the researchers themselves play in the research process (Ragin and others 2004). The purpose of this type of analysis is not to isolate variables and make predictions, but rather to obtain "detailed knowledge of specific cases, often with the goal of finding out 'how' things happen (or happened) . . . Qualitative researchers' primary goal is to 'make the facts understandable' (Ragin and others 2004:10)." Qualitative analysis can also provide preliminary, comparative, complimentary, and/or confirmatory results that can be used in tandem with quantitative approaches (Small 2011). In this specific instance, our objectives were 3-fold: first, we sought to identify useful examples of student participation which could help to illustrate the basic workings of the course, second, we wanted to understand and qualitatively represent the full scope of students' varying reactions to the course material, and third, we looked to glean insight about the types of experiences in the course that the students told us had left the most enduring impressions on them. In what follows, we present the outcome of that inquiry.

Curriculum and Pedagogical Methods

Our course curriculum was guided by 4 sequential and cumulative pedagogical methods, which we introduced in the following order. First, we taught students about the basic of epistemology (the study of what can be known, how it can be known, and who can know what); second, we encouraged students to be both skeptical as well as empirically rigorous in their inquiries; third, we compelled students to take competing perspectives seriously; and fourth, we required students to put "principles into practice" by inviting them to apply what they'd learn toward a more holistic understanding of their case studies.

Teaching epistemology

We taught the course from the lens of social constructionism, a theoretical framework which critiques and analyzes the assumptions, methods, and socio-historical contexts of knowledge. While this is a widely held position in the humanities and social sciences, it is not broadly understood in the physical sciences. By its name, social constructionism assumes that knowledge is a process of active construction rather than "discovery." This perspective sees knowledge (both scientific and nonscientific) as being shaped to a great deal by culture, race, gender, social class, language, technology, political power, social priorities, ideologies, historical biases, bureaucratic contexts, intra-disciplinary assumptions and politics, and financial incentives/constraints (Burr 2015). While some philosophical skeptics would go so far as to question the basis of any and all ontological claims, what matters for our purposes is not the disputation of empirical observations but rather the interpretations and conclusions that result from these observations. For example, in the rodent study on the safety of a food ingredient study case introduced above, the observation that a certain number of rodents became ill is not disputed, while the implication that the ingredient is safe for humans is. In short, as noted by Babbie (2015:27), "scientific knowledge at any given time is what people agree it is."

At the very beginning of the course students were asked a series of epistemological questions on science, facts, and expertise. While we were impressed by the diversity of thoughtfulness of the answers, the discourses of scientism and technological progressivism were nonetheless deeply engrained in many of our students' responses. For example, several students wrote that scientific facts were based upon "real, convincing, unquestionable evidence" and "irrefutable evidence." Another student wrote that "facts can be supported by rationally gathered observations or experiences from bias-free sources." Similarly, many students argued that scientific knowledge existed independent of social agreement. There was also a deep valorization of expert knowledge as a privileged domain. For example, when asked how scientific disagreements should be resolved, 1 student argued that "scientific experts should have the authority to decide instead of other, less informed groups since they are the experts." We devoted the first week of class toward extensive discussion about the assumptions and principles which were at the core of these perspectives.

Teaching skepticism and empirical rigor

The next week of class was devoted to explaining the core foundational concepts of toxicology. While toxicology was fairly familiar to food science students, it was not familiar to the other students in the class. We thus sought to provide a comprehensive overview of the field because so many food controversies are about whether something was safe or not. Furthermore, focusing on toxicology provided a practical case of the process of making a practical decision informed by a rigorous examination of empirical data.

The epistemology and toxicology material provided a "toolkit" that could be applied to thinking about other arguments, and we assessed students' comprehension of these core concepts through a pass/fail quiz (see Supplemental Material: Sample Questions for Epistemology/Toxicology Quiz). The quiz included an essay question which asked the students to make an epistemological critique of the field of toxicology, and their responses provided an excellent indication of how well they had absorbed the course material. In their answers, students noted that scientific questions are framed by cultural contexts and disciplinary training, that "facts" emerge from the repetition of findings, peer review, and expert consensus, and that much toxicological research is driven by commercial interests and product potential. Several students also pointed out that the balancing of risks and benefits for various chemicals was a matter of social judgment, particularly when it came to speculating on future levels of public exposure. For example, 1 student observed that "Even though ['Brand X' fruit juice] in high enough doses is a toxin, they have decided to focus their research on where the antioxidants are beneficial. Based on the scientists who frame the question and the experimental methodology, a compound can be found either to be [toxic or healthy]." There was a clear distinction between these responses and the survey of attitudes taken at the start of the semester. By focusing on specific cases, rather than general statements about science and knowledge, the students became more critical in their responses. A focus on specific controversies (for example, the use of BPA in food storage) was a feature of the remainder of the course.

Interrogating competing perspectives

The bulk of the remainder of the semester involved bringing in guest speakers to provide contrasting perspectives on food ethics, science, and politics. An important principle in all of these discussions was that we were there to study and try to understand the arguments offered and never to "bust myths", "stand up for science" or otherwise try to prove anyone wrong. We wanted to see how different values could lead to different conclusions from a remarkably similar set of scientific facts. The first author presented a crash course in epistemology to the students, and these concepts were used as a point of reference for the remainder of the semester. An expert in sensory science talked about the ways psychological factors might lead us to weigh risk in different ways. The second author channeled Roger Pielke Jr. (2007) and talked about the intersections of science, policy and politics. One of our food science faculty colleagues questioned the ways nutritional studies lead to dietary guidelines and how bias can enter the evidence pool. A public safety advocate, an FDA official, and a corporate attorney spoke about their respective work on food ingredients. An agricultural economist talked about his optimistic vision for the role of scientific innovation, while a rural sociologist used his own experiences with craft food production to question ideas of scientific progress. A former food company executive talked about how the food industry responds to controversial topics, and a science journalist described how reporters approach scientific controversies by discussing his own work on the environmental impact of food product additives. We weren't trying to cover specific content with these speakers, rather, we sought to generate a large range of considered positions that the class could respond to. We were looking for good arguments.

At the end of each week, students wrote response papers which summarized the key points from the lectures/readings (see Supplementary Material: Guidelines for Response Papers) and used these insights to inform their understanding of their case study project (see below). At first, many students struggled to adequately integrate and summarize the key points and/or apply the course materials to their chosen topics. We therefore gave the students the opportunity to rewrite the first paper, clarified the instructions, and thereafter witnessed an improvement in the quality of subsequent papers. Reading and grading the response papers gave us a great deal of insight into how the students were grappling with the sticky issues of epistemology, risk assessment, the significance of social values, and public vs personal responsibility for food safety and nutrition.

Putting principles into practice

Another core component of the curriculum involved the in-depth investigation of a case study (see Supplementary Material: Guidelines for Case Study Projects). Here, students worked in small groups on semester projects around current controversies in the ways food is formulated, processed or sold. Our criteria for selecting projects were that the issue should be real, current, somewhat disputed, dependent to some degree on scientific facts, and involve practical decisions about how food is formulated, processed or described. Topics covered included (a) laws governing the sale of raw milk, (b) the justification for a major restaurant chain's banned ingredients list, (c) the reformulation of a popular diet cola with a different sweetener, (d) FDA's consideration of rules for a "natural food" label, (e) the debate over whether an egg-free mayonnaise analogue could justifiably be called "mayo", and (f) naturally cured bacon. The goals of the case study and selected examples were presented to the class, whereupon students were encouraged to form their own groups (∼3 students) and select the top-3 topics (either from the examples or from their own ideas) that they would prefer to work on. The co-instructors made the final decisions on which groups worked on which projects.

The case study project provided a current and practical focus to the big underlying ideas of the course, and the continual interaction between the cases and the speakers provided a useful avenue by which to examine the issues from different perspectives. Students made 2 presentations for their projects: 1 at the beginning of the semester, and 1 at the end. Students were evaluated as a group for these presentations, but there was no guidance on how many of them actually spoke. At first, the students had to assemble relevant facts related to the case (for example, the laws involved, any data on the relevant chemistry, microbiology or toxicology) and then present an initial assessment of their case before the class. Overall, we found the first round of presentations provided a useful stepping stone. Most groups did a particularly good job of historicizing their case studies and putting them in social context. On the whole, however, students tended to struggle with problematizing and situating the data itself in socio-cultural context. Quite often, the facts and statistics they provided were simply taken for granted. In hindsight, we came to realize that while we hadn't asked them to explicitly address this in the context of their presentations, the issue nonetheless deserved further discussion. Here, the first author encouraged the students to enrich their next presentation by asking where the data came from, how it was produced, what the different social interests were concerned in the interpretation of the data, and what we might want to be skeptical about. The groups and individual students who had already done this during the first round of presentations really stood out.

This preliminary set of facts for each case would later be challenged by the perspectives from the different guest speakers and readings. Students were then repeatedly asked to reflect on their cases through the lens of the different speakers. For example, when the rural sociologist who visited our class talked about Hinrich's (1995) scholarship on the political and economic context of sugaring on Vermont dairy farming, the students in the "raw milk" group used his lecture to think about the political economy of raw milk production.

The student groups did their second, capstone presentation during the last 2 wk of class, whereupon they applied the course materials toward a more refined understanding of their case studies. Prior to the second round of presentations, the instructors met with each group to discuss the first presentation, listen to the students' ideas, and provide suggestions on fruitful avenues of inquiry. The richness of the second round presentations and ensuing discussions improved dramatically from the first round, and we were deeply impressed by the thoughtfulness of the investigations. Overall, the strongest groups not only integrated the course material in the analysis of the case study, but they also used the case study as an opportunity to offer a critical interpretation of the data, the readings, and the guest lectures. We were particularly impressed with the groups that acknowledged the seriousness of contrasting perspectives and sought to reconcile these perspectives in a reflexive and empirically rigorous manner.

Instructors' Observations and Student Feedback

On the last day of class, we asked the students to write up their thoughts on what they had learned from the course and how it might impact their future careers in the food and agricultural sciences. Numerous students informed us that the course had first and foremost provided them with a better grasp of the numerous challenges that befell professional food regulators. Here, students commented that they came away with an improved understanding of toxicological evidence, the need to balance risks versus benefits, and the importance of being cautious when adding chemicals which provided aesthetic value but weren't essential to the key identity characteristics of a food. "[The public safety advocate] and the accompanying [reading] made me seriously reconsider how much I trust the FDA," one student wrote. "I now feel that people's mistrust of the food industry is a little bit more justified."

Another theme from students' comments on the final day of class concerned public engagement. One student said that he/she came away with a better understanding of consumers' emotional connection to food, while several students noted that they wanted to be more active in engaging consumers over the course of their careers. One student made the sincere observation that

> "I don't think I had previously been sensitive enough to [consumers'] desires and wrote inability to accept technology off as fear and misunderstanding rather than a desire for an alternative. As an aspiring professor of food science with an interest in nutrition and human health, this gave me better insight towards how I should communicate with the public. Rather than try and explain everything away with facts and why they shouldn't be afraid of technology, I should be able to connect with people and identify their concerns and wishes regarding food in order to be able to provide better suited answers to their questions. By making value-based connections, I can be a more effective communicator than I would by just being a 'person in a white coat' who rattles off facts that don't actually address concerns."

Many students also stated that they had a greater appreciation for the need to work collaboratively with different interest groups toward a more informed debate over food ethics, science, and policy. Here, one student made the poignant comment that

> "Our access to a greater amount of information has in many cases proved to be a hindrance to actual knowledge. The politicization of science has caused science to become a commodity which is either 'for' or 'against' a particular cause. It is important to consider that in the pursuit of knowledge, there is no for or against, only the truth."

At the same time, this student also noted that scientific knowledge was socially constructed and inherently fallible. "The discussion of how we arrive at knowledge - particularly with regard to how the FDA decides if something is safe or not - is really something to consider when working in the food industry," he wrote. "We don't ever really 'know' if something is safe or not, so the 'knowledge' that something is safe comes from an agreement of evaluating the potential risks."

This student's thoughtful comments encapsulated the recurring course theme of scientific humility, and it was a theme that many students wrote about on that last day that we spent together as a class. We were particularly impressed by one student's final reflections:

> "Ultimately I took away a lot from this class that shapes how I view (food) science as well as how I will continue to work, but if I had to narrow it down to three points, they would be this:

1. Nothing is ever set in stone, but that isn't a reason not to make decisions based on the information available. If the potential risks or consequences or benefits of doing something are significant, it's worth considering doing it, even in the face of uncertainty.
2. Be humble enough to realize that as new information comes out, it may be worth revisiting old decisions to ensure that they still lead to the ultimate goal that they were supposed to accomplish (in the context of food legislation, that goal is usually public health and safety, although not always).
3. Sometimes you have to unpack the values behind other people's (and your own) arguments, but just because they are not articulated in the same frame, they likely still have merit. Often it is difficult to convince someone that your

values are more important than theirs but it is even more difficult, it seems, to accept that multiple values can have merit and also be at odds with one another. It is difficult to accept that a perfect (or even adequate) resolution may never be possible. But engaging in the conversation is nonetheless extremely important, you just have to learn to live with the discomfort it may bring."

Final Reflections

Our intention throughout the course was to focus on the ways in which values can impact apparently "scientific" decisions in different ways for different people. This required the students to begin to reflect on the values tacitly accepted within the food science community. While we stressed that these values aren't "wrong," asking students and professionals to question the foundations of their discipline was always going to be challenging and perhaps upsetting. Despite this we found a large majority of students to be highly engaged, open to diverse perspectives, and very thoughtful about the relevancy of the course material to their professional lives.

The end of semester student evaluations were on the whole quite positive, but there is space for improvement. In particular, we had hoped to be able to draw a more direct connection between actual scientific measurement and positions on policy, but the amount of reading required to do this in any specific case was prohibitive. On the whole, the case study groups that had a firmer focus on empirical data (for example, peer reviewed studies, chemical compositions, and methodological processes) tended to engage in more rigorous and comprehensive analysis than those based on broader topics with more legal/social frames (for example, ongoing controversy over the "natural" food label). Lastly, the data from our postcourse inquiry is limited in that we did not conduct a pre/posttest with the students. In hindsight, this would have helped to track students' intellectual growth over the duration of the semester. Further research is thus needed in order to quantify the students' learning outcomes and related metrics for these types of nontraditional courses.

In conclusion, the biggest learning experience for many students was that we all approach our work with our respective sets of social values, and many of the arguments that we have about food are conflicts about values rather than conflicts about science. Lastly, we're more convinced than ever that food scientists—really, any scientists working in applied fields—need experiences like this in order to help them understand the social context surrounding their work.

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Supporting Information

Additional supporting information may be found in the online version of this article at publisher's website:

Supplementary Material 1. Condensed Syllabus
Supplementary Material 2. Sample Questions for Epistemology/Toxicology Quiz
Supplementary Material 3. Guidelines for Response Papers
Supplementary Material 4. Guidelines for Case Study Projects