Obstacles to Curriculum Greening: The Case of Green Chemistry

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Abstract

Purpose This paper articulates how the efforts of curriculum greening reformers are mediated by surrounding constituents, including departmental colleagues, chemistry colleagues from outside their department, campus administrators, and students. *Design/methodology/approach* I perform a "field" analysis, which is informed by: (1) a review of the green chemistry literature from the chemistry discipline; (2) interviews with key informants; and (3) a content analysis of key websites. *Findings* Surrounding constituents mediate reformer efforts through the resistance they exert, or through the resources they provide, such as green teaching materials, and the resources required to integrate the materials. *Originality/value* This chapter addresses a gap around the way curriculum reform efforts are mediated by surrounding constituents. Beyond chemistry, this analysis can help reformers of other disciplines better circumvent sources of resistance, and accentuate the forces that can help their efforts.

Keywords

Curriculum greening · Green chemistry · Environmental education · Sustainability · University greening

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1 Introduction

Universities are central to sustainability efforts. Beyond the tremendous resources consumed and waste produced, they significantly impact student understandings of human-environment relations through the systems of ideas, practices, and values they impart. This ideological impact is arguably most significant as it imparts beliefs and value systems that permit, facilitate, and even encourage environmentally destructive behavior (Schnaiberg and Gould 1994). Alternatively, curriculum greening offers the potential for societal transformation, for it can promote deep eco-literacy, compel students to question and change environmentally destructive norms and processes, both within and outside the university, and orient graduates towards the building of a sustainable society (Martin and Jucker 2005), instead of becoming "part of the rearguard of a vandal economy" (Orr 1994). For these reasons, reformers have spent the last four decades trying to green mainstream education, turning specifically to university curricula in the 1990s (Haigh 2005). However, they are still far from their stated goal of ensuring "all university graduates are environmentally literate and have the awareness and understanding to be ecological responsible citizens" (ULSF 2001).

The social sciences have a key role to play in accounting for the lag, for its research methods and concepts can illuminate the social factors that are hindering or even stalling reform efforts. Previous social science research has found curriculum-greening efforts are hampered by several factors, including disciplinary boundaries (Higgitt et al. 2005) and traditional curriculum culture, which emphasizes teacher-centered approaches and top-down modes of communication (Posch 1996; Tilbury 1999). Additionally, Haigh (2005) articulates how curriculum-greening efforts can be stifled by the following factors: (1) confusion about curriculum greening's remit; (2) the university tradition of prioritizing research over teaching; (3) financial incentive structures; (4) tokenism; and (5) academic values that adhere to an industrial model of progress. While these analyses are important for illuminating larger social dynamics, they under analyze the individuals who mediate curriculum-greening efforts.

To address that gap I pursue a "field" analysis (Bourdieu 1992) of the chemistry discipline, focusing on how reformer efforts are mediated by other constituents, such as departmental colleagues, campus administrators, and students. Chemistry is a strategic case because it has yet to experience widespread change, despite the fact there have been serious attempts to green the curriculum over the last two decades. Although a few schools (such as Hendrix College, Simmons College, and Scranton University) have impressively infused green chemistry principles throughout their curriculum, chemistry departments at more than 1200 American four-year colleges and universities have fallen well short of where they could be. Drawing from a review of the green chemistry literature and interviews with key informants, I found other constituents mediated reformer efforts by their resistance levels or through the resources (such as access to green teaching materials and resources required for integrating the materials) they provided.

In the next two sections I discuss my methods and theoretical framework, and then trace the emergence of the environmental education movement, which includes addressing nascent efforts to green the chemistry curriculum and the failure of such efforts to exert a greater impact. Thereafter I discuss how surrounding constituents mediated the reformers' curriculum-greening efforts. By illuminating the chemistry case, this sociological analysis can help us better understand the curriculum-greening process for all disciplines, thereby enabling us to quicken the greening of curriculum, campus and society.

2 Methods and Theoretical Framework

To shed light on the curriculum-greening process I chose to analyze the chemistry case. There are two factors that make this a strategic case to analyze: (1) there has been an active movement within the discipline to green its curriculum; and (2) those efforts have yet to yield widespread curriculum greening. Although a handful of schools have impressively infused green chemistry principles throughout their curriculum, chemistry departments at more than 1200 American four-year institutions are far short of where they could be. These factors provide a great opportunity to understand the forces that stymie active attempts to green a curriculum.

In trying to illuminate the mediating "micro" factors I drew on Sarah Creighton's research (1998), which focuses on the way university greening initiatives are driven by the leadership and activities of campus constituents, such as students, administrators, trustees, professional staff, faculty, and the surrounding community. While curriculum greening is only lightly addressed in her analysis, this topic is well served by an analysis grounded in the efforts of people, for if curricula is to be changed, it is people who will be driving those changes.

My approach also draws on Bourdieu's "fields" concept (1992), which seeks to understand how the efforts of some are mediated by neighboring constituents. In this case, the analysis focuses on the way curriculum-greening efforts are mediated by departmental colleagues, chemistry colleagues in the larger discipline, campus administrators and students. This included identifying how these individuals supported efforts, how they hampered them, and how reformers sought to circumvent obstacles.

My analysis was informed by three activities: (1) a review of the chemical discipline's literature on green chemistry; (2) a review of key websites dedicated to green chemistry (such as the American Chemistry Society's (ACS) website, the Beyond Benign website, and the University of Oregon's Greener Education Materials for Chemists database); and (3) interviews with seven key informants, each of whom are academics in chemistry departments where some level of curriculum-greening has occurred. The review of the literature and websites provided an overview of the issues, whereas the interviews served to deepen that knowledge and better explain the process behind curriculum-greening efforts. Moreover, I intentionally sought out individuals from institutions with curriculum-greening

success because they would be ideal candidates to identify: (1) factors that enabled curriculum-greening to succeed; (2) factors that hindered those efforts; and (3) strategies for successfully circumventing those obstacles.

3 The Environmental Education Movement

Since 1975 there has been a concerted effort to improve the education system's provision of environmental education (Haigh 2005). One area where universities have experienced success is environmental studies, as there was a tripling of programs between 1975 and 2000 (Brint et al. 2009), and the programs are now found at most universities. However, progress in other areas has been disappointing. For example, few universities require students to take courses aimed at enhancing environmental literacy. Because courses are usually electives, most students complete degrees without being exposed to environmental perspectives. In the few instances where eco-literacy courses are required, the courses tend to be introductory level courses that are not integrated with the student's main course of study (Haigh 2005). While these courses aim to ground students in core ecological issues, Haigh (2005) argues they are problematic because they are "often seen as something apart from the learner's main education, a discrete package of knowledge, another course to be passed and forgotten, but not something generally relevant to their course of study" (p. 38).

Another disappointment has been the relatively slow integration of green chemistry principles. Green chemistry is a movement within chemistry that emerged in the early 1990s, and aims to lower the amount and toxicity of chemicals produced. Towards that goal, green chemists work to select and design chemicals "with reduced toxicity and [with] reaction pathways that eliminate by-products or ensure they are benign" (Poliakoff et al. 2002, p. 807). It's argued that this, in turn, will lead to less toxic waste, fewer environmental harms, and less human exposure to dangerous toxicants (Anastas and Warner 2000). Many chemistry leaders view green chemistry's development as a revolutionary event, with the potential to eliminate the intrinsic hazards of particular chemical products or industry processes (Anastas and Warner 2000; Poliakoff et al. 2002; Cannon and Warner 2011). At the same time, however, some suggest the revolution has stalled, tracing the lack of progress to a lag in the greening of university curriculum: "only when more universities teach green chemistry will graduates be able to apply these principles when they enter industry" (Poliakoff et al. 2002, p. 810).

In America there are chemistry departments at over 1200 four-year colleges or universities, with over 600 offering bachelor degrees certified by the American Chemical Society (Cannon and Warner 2011; UC Santa Barbara Library 2014). While efforts to teach green chemistry principles can be traced as far back as the mid 1970s (Morton 1982; Woodhouse and Breyman 2005), it has yet to be widely

adopted by American higher education. For example, only eight of the 1200+ departments have comprehensively incorporated green principles into their undergraduate curriculum, and only four offer postgraduate degrees in green chemistry. A less demanding reform would be for schools to have added an undergraduate green chemistry course, or have aligned a pre-existing course with green chemistry principles (such as the organic chemistry lab at University of Oregon). However, here too, the picture is disappointing. Woodhouse and Howard (2009) found most universities fail to offer even a single green chemistry course, and this corresponds with my own findings. While I was able to find 38 institutions that offer coursework in green chemistry (21 of which were listed on the ACS's green chemistry website), that represents less than 7 % of the 600+ ACS certified chemistry programs. Additionally, most of these offer green chemistry as an "elective," which means the majority of chemistry majors can complete degrees without exposure to green chemistry principles. So far, chemistry's curriculum greening has been tokenistic at best, which has under mined the green chemistry revolution's potential impact.

4 Mediating Factors

Once an instructor decides to green a course, their success is mediated by the activities, either supportive or hindering, of neighboring constituents. In this section I explore the respective roles of department colleagues, chemistry colleagues from outside their departments, campus administrators, and students. Beyond elucidating how some resisted curriculum greening efforts, I explain how reformers responded to the resistance, as well as how some constituents provided much-needed support.

4.1 Departmental Colleagues: Potential Roadblocks

Departmental colleagues can be supportive of greening efforts or can be quite resistant to them. Regarding resistance, many green chemistry proponents have faced departmental colleagues who sought to undermine them, either by disparaging or by politicking against efforts to green departmental courses. The resistance can come from numerous sources: (1) turf protection, as some fear greening efforts will reduce the coverage of topics and experiments they hold dear (personal communication); (2) inertia to change, fed by the "if it ain't broke, don't fix it" attitude, which necessitates proof that green chemistry can be an improvement over the traditional curriculum (Kirchhoff 2009; Klingshirn and Spessard 2009); and (3) obstructing beliefs, four of which are detailed below.

According to an informant, resistance can come from the misconception that green chemistry merely consists of minimizing the use of dangerous materials and production of toxic waste in the laboratory. In his case he approached a colleague about greening her organic chemistry lab, but the colleague resisted, based on her belief her course had already been greened (personal communication). It turns out

she had already revised the course to eliminate dangerous experiments, and to minimize both the use of dangerous materials and production of toxic waste. What was missing, however, was the pedagogical component. Although the instructor decreased the lab's ecological impact, she did nothing to educate students about the changes made, or why she made them, thereby side-stepping an important thrust of the green chemistry movement: making students more aware of chemistry's potential toxicity (Cannon and Warner 2011). As a green chemistry proponent emphasized, discussing the process of selecting and rejecting experiments is an important part of the student's learning experience (Goodwin 2004).

A second obstructing belief is the misconception that green chemistry is "hippy chemistry" (Klingshirn and Spessard, 2009, p. 90), that is to say less rigorous, and disadvantageous to students (Kirchhoff 2009). Green chemistry proponents have responded by arguing such objections have no scientific basis as: "the principles of science underlying traditional chemistry are exactly the same for green chemistry" (Klingshirn and Spessard 2009, p. 90). Moreover, they believe that successfully addressing this belief has tremendous potential for winning over adherents, emphasizing that green chemistry's pedagogical value is what has the most power to win colleagues over: "If proponents can convince colleagues that green chemistry is rigorous and is simply an alternate way of viewing key chemical concepts, implementation becomes more attractive" (Klingshirn and Spessard 2009, p. 90). Case in point, while Collins (1995) originally feared that greening chemistry courses would undermine the chemical knowledge being taught, those fears lessened when he discovered "the nature of the superb green chemistry that already exists," and that "green chemistry is real chemistry" (p. 965). Moreover, after greening his own courses, he became a significant green chemistry innovator and proponent at Carnegie Mellon University.

Another obstructing belief concerns thinking that undergraduate education is meant to be training for graduate school or a career in chemistry, and that altering traditional experiments deprives students of that training. While many skeptics adhere to this belief, it too is seriously critiqued by green chemistry proponents, who argue teaching chemistry "should be education, not training" (Goodwin 2009, p. 49). From their perspective, a college education is not about being trained to do specific lab experiments, but rather about gaining solid grounding in chemical principles, which students should be able to apply reflexively and creatively in diverse settings. The contrast in perspectives speaks to a difference in teaching commitment: while some are committed to imparting lab capabilities, others are committed to imparting higher order thinking skills. This suggests green chemistry might be more readily adopted if the discipline prioritized the teaching of higher order thinking skills.

Fourth, some resist curriculum greening because they believe chemistry should teach students how to handle dangerous chemicals and that green chemistry fails to do this (Klingshirn and Spessard 2009). One informant explained to me that, until the last decade, working with dangerous chemicals was an unquestioned norm within the profession, which often led to cavalier decisions about experiments, which he underscored with the following example:

> About a decade ago I was working on an experiment that I knew could blow up and my unquestioned acceptance of danger was so deep-seated that instead of questioning the need for the experiment, I decided to do the experiment with my non-dominant left hand… so that if I lost my hand in the experiment, I would still have use of my dominant hand. (personal communication)

Several other informants attributed the use of dangerous chemicals to the chemists' adherence to "macho chemistry": i.e. an inclination towards achieving chemical objectives by brute force. Another explained that, to many, working with dangerous chemicals is a defining element of a chemist's identity, and it is something they take pride in. In turn, they believe that working with dangerous chemicals is a right of passage that all chemistry students should go through.

Regardless of the source, green chemistry proponents reject the assumption that classrooms should expose students to dangerous situations. For example, Klingshirn and Spessard (2009) argue students do not need to learn how to handle dangerous chemicals as few go on to practice chemistry professionally, with most only taking chemistry to satisfy vocational requirements, where chemistry is of little consequence. They also maintain that if students obtain chemistry jobs, they will have numerous opportunities to learn how to handle hazardous chemicals. This point is underscored by the fact the federal Occupational Safety and Health Act requires on-the-job safety training for the proper handling of hazardous chemicals and wastes (ibid).

Additionally, there is reason to believe the cavalier attitude will diminish over time, due to the growing social consciousness around health, safety and environmental protection issues. One chemistry professor offered that opposition is also emerging within the discipline, with some arguing students have a right to pursue their education without placing themselves in harm's way, especially when there are ways to dramatically increase the safety of lab experiments. Klingshirn and Spessard (2009) report such safety considerations are another factor that can reduce faculty resistance to green chemistry.

4.1.1 Strategies for Responding to the Resistance

The topic of colleague resistance was brought up by four of my seven informants, who countered it with a variety of strategies. One professor explained that he and his partner simply ignored the departmental naysayers, and persisted in their curriculum greening efforts. While they proved to be quite successful, they were significantly advantaged by the fact they were senior faculty, who had already obtained tenure. In cases where reformers are junior faculty, the resistance can be more daunting as resistant faculty are likely to exercise greater influence in departmental politics, and may even be able to influence the reformer's tenure process. In one case, reformers at a top-rated public university faced resistance from senior faculty, who believed green labs would not be as quantitatively rigorous (personal communication). Reformers met the challenge head-on, developing experiments that were as rigorous, if not more so, which helped win over enough skeptics to enable reform.

While successful at that university, the strategy was not as effective at another public university, where a small core of older faculty (about 25 %) has continued to actively resist reform efforts, and has refused to be swayed by any evidence provided by reformers (personal communication). The resistors argue they have successfully taught the courses for decades, and their first-hand teaching experience outweighs any evidence reformers can provide (personal communication). According to one of the reformers, the struggle has been made more difficult by the asymmetry of responsibilities between the two groups. On the one hand, most reformers are junior faculty and are carrying heavy service loads to qualify for promotion. On the other, the resistors are made up of tenured professors who carry smaller service loads, and have more time to devote to the struggle.

At a third school the response was not to try winning the support of the resistors, but rather to wait them out. The professor explained that while he was department chair he knew the greatest resistors were only a year or two from retiring, so he delayed rolling out green chemistry reform until the main resistors retired and were replaced by more supportive individuals.

These cases underscore the point that curriculum greening can be a time and energy-consuming political struggle, where departmental colleagues need to be won over one by one, and where there is no guarantee of success. These problems may help explain why the greatest success has tended to occur at smaller schools, like Hendrix College and Simmons College. The relationship between department size and curriculum greening is one that should be further examined in future research.

4.2 Leadership from the Chemistry Discipline

While the old guard has provided plenty of resistance, other parts of the discipline have provided important support. Since the 1990s numerous individuals have exhibited remarkable leadership around green chemistry, which has contributed significantly to its institutionalization. For example, green chemistry proponents organized symposia on alternative synthetic pathways at the 1993 and 1994 American Chemical Society meetings, created the Presidential Green Chemistry Award in 1995, and established biannual green chemistry conferences in 1997. Additionally, the not-for-profit Green Chemistry Institute was founded in 1998, Paul Anastas and John Woodward published their seminal book *Green Chemistry: Theory and Practice* the same year, and the *Green Chemistry* journal was established in 1999 (Woodward and Breyman 2005).

Eventually, these initiatives led to the production and widespread dissemination of green chemistry teaching materials. In 1998 the Environmental Protection Agency and the American Chemical Society jointly developed the Green Chemistry Educational Development Project, which provided: (1) an annotated bibliography; (2) introductory activities in green chemistry; (3) real world cases in green chemistry; and 4) a short course on green chemistry (Caan 2009). Moreover, in 2001 the *Journal of Chemical Education* began encouraging submissions on green chemistry

(Caan 2009). Besides being disseminated through that journal, teaching materials were increasingly uploaded to the internet, as manifested by the University of Scranton example, and the University of Oregon's GEMS database (Greener Educational Materials for Chemists) (Caan 2009; Klingshirn and Spessard 2009). Additionally, between 2001 and 2014 Kenneth Doxsee and Jim Hutchison organized annual "Green Chemistry in Education Workshops" at the University of Oregon, where participants benefitted from the experience of those who had successfully greened their own chemistry courses. Green chemistry proponents also developed the Green Chemistry Education Network, a clearinghouse for disseminating green laboratory exercises, and for providing support mechanism to those wishing to green their courses (Klingshirn and Spessard 2009). As well, in 2003 Doxsee and Hutchison published their *Green Organic Chemistry: Strategies, Tools, and Laboratory Experiments* textbook, and by 2009 several prominent textbooks had begun to include green chemistry content, though some would claim only tokenistically (Caan 2009).

The availability of teaching materials is essential to curriculum greening. While an instructor may develop an interest in greening a course, it takes significant time and resources to develop new curricula, which can deter even highly motivated instructors. This is particularly true for courses with laboratory experiments, where developing effective experiments can take an inordinate amount of time (Klingshirn and Spessard 2009). Moreover, while faculty could spend research time on developing innovative curricula, it is less likely to occur at research universities, where faculty face strong publication pressures. With green teaching materials readily available, the task becomes infinitely easier and widespread curriculum-greening is much more possible.

Nonetheless, the availability of green teaching materials is, on its own, an insufficient condition. For example, whilegreen chemistry materials for some courses (such as the organic chemistry labs) have been readily available for over a decade, widespread adoption has yet to occur. While this underscores the necessity of having motivated instructors, even the combination of those two factors can be insufficient as interested instructors might not have access to resources required for integrating green materials into their courses. For instance, significant time is needed to integrate green materials, which instructors may be unable to devote in university settings, where research is usually prioritized over teaching. This is where campus administrators can play a major role, by providing the resources curriculum-greening projects require.

4.3 Administrators: Controllers of the Funding Faucet

While motivated instructors are the most important agents in curriculum-greening projects, campus administrators (such as college deans, campus presidents, and university presidents) can influence the process in numerous ways. For example, they can create obstacles to change, such as creating onerous processes for the

creation of new courses. Alternatively, they can facilitate curriculum-greening efforts by hiring full-time staff or creating campus-wide committees dedicated to the issue. As well, they can encourage curriculum greening through the development of education campaigns, competitions, and other programs. Most important, however, is the control they exert over funding and other campus resources, which is important for numerous reasons.

First, funds are necessary to purchase required equipment or materials. As well, funding is necessary for bringing curricula-greening workshops, such as the "Green Threads" workshops brought to the Universities of Louisville and Montanain 2015 (University of Louisville 2015; University of Montana 2015), or for sending interested individuals to workshops at other campuses, such as the annual 'Green Chemistry in Education' workshops offered by the University of Oregon, which, as of 2009, had been attended by representatives of over 130 schools (personal communication).

Funding can also provide teaching buy-outs to those needing time to green their courses. According to one informant, obtaining a one-year teaching buyout was vital to his ability to develop a green organic chemistry course. Moreover, while many green teaching materials are now easily accessible, another informant emphasized that teaching buyouts are still necessary, as instructors still need time to integrate materials, draw up and test new experiments, and coordinate the transition to the new course, which can include acquiring necessary materials and resources. At one prominent school, useful teaching support came in the form of graduate student funding and graduate lab space, both of which were used to develop and test new potential experiments.

Alternatively, Haigh (2005) argues a lack of funding has been an obstacle to curriculum-greening at many universities, as administrators tend to place far greater value on research, especially when it can attract external funding. This is particularly true of research universities, where less value is placed on teaching than at liberal arts colleges. This tendency might be tempered in chemistry's case, as administrators can be attracted to green chemistry's potential to reduce the university's legal liabilities, as it pertains to both student health and environmental pollution (Klingshirn and Spessard 2009). Moreover, administrators can view chemistry-greening as a fundraising tool, as happened at one public university, where the College Dean used green chemistry's cache to spark fund-raising for the construction of a new building and to brandish her legacy.

Funding's importance highlights that while faculty are the most important factor in curriculum-greening efforts, administrators can also play a pivotal role. However, their importance can be diminished if instructors can obtain funding from external sources, such as wealthy benefactors or government agencies. One example is Hendrix College, where an alumni donation enabled instructors to develop green experiments, and to successfully green their organic chemistry labs (Goodwin 2009). At UC Berkeley, a $300,000 dollar grant from the National Science Foundation enabled instructors to develop the "Public Ethics of Green Chemistry" course, which they began offering in 2012 (Berkeley Center for Green Chemistry

2010). Additionally, an earlier grant from the California Environmental Protection Agency enabled instructors to develop: (1) green curricula for their undergraduate organic chemistry labs; (2) an interdisciplinary graduate course in green chemistry; and (3) two other graduate courses addressing green chemistry (ibid).

4.4 Students: Potential Sources of Resistance or Potential Catalysts

In Creighton's analysis (1998) students factor heavily in university greening efforts, and for good reason as students have acted as the environmental conscience and main driver of environmental change on numerous issues. While course instructors are the main mediators of curriculum-greening efforts, students can play an important role, either in supporting or resisting them.

Karpudewan et al. (2008) report that students found green chemistry to be interesting, useful, and timely. Moreover, Klingshirn and Spessard (2009) report that students are more likely to buy into green chemistry when there is a strong campus interest in improving the environment. While this may very well be the tendency, students can also be a source of resistance, out of fear that taking the greener course would negatively impact career opportunities. For example, many chemistry students view their degree as a pathway to a career in the petrochemical industry, and at one highly-ranked university students became concerned that taking a green version of introductory chemistry would negatively impact their career opportunities in that industry (personal communication). At another school a similar situation occurred the first year a green organic chemistry lab was offered. Because course instructors wanted to pilot the lab the first time it was taught, they randomly picked one of the lab sections to receive the green content. This unsettled students, particularly pre-med students, who had not signed up for a "green" lab, and feared they were being forced to take an inferior version of the lab, which would disadvantage them on their MCAT exam and medical school applications (personal communication).

Such resistance can be demoralizing for instructors who invest significant amounts of time and energy in redesigning the curriculum. In turn, the resistance can foster cynicism and resignation, which can undermine greening efforts. However, in the above case the instructor remained strong in her conviction and worked hard to bring students on board. Eventually, she persuaded students to see that green lab experiments were just as rigorous, and had the advantages of being safer and cutting-edge chemistry. In turn, as students came to understand the course intentions and advantages, word quickly spread about the course. The following year so many students flocked to the course that instructors were forced to turn students away, even though the teaching capacity had doubled. Propelled by student enthusiasm, all labs were greened within the next two years.

Apart from becoming supporters, students can also be catalysts for curriculum-greening efforts, as occurred at Gordon College. In 2003 green

chemistry was not part of the curriculum. However, that year an undergraduate student took an interest in green chemistry and, even though her advisor repeatedly discouraged her from doing so, chose to write her honors thesis on the topic (The Green Chemistry Commitment 2015: Gordon College). Doing so had the effect of educating her advisor and the rest of the chemistry faculty, which transformed them and the college administration into enthusiastic proponents. Beyond greening their courses, the department has since developed year-long student research projects on green chemistry, and became founding members of the Green Chemistry Education Network (Gordon College 2015).

5 Conclusion

While motivated instructors are necessary to the curriculum-greening process, I have sought to show that the process can also be significantly influenced by other constituents, who can either resist change or support it. Beyond illuminating the chemistry case, this field analysis contributes to the environmental education literature by re-focusing the conversation around instructors, and the people who they vie with and against in their respective fields. In turn, this can help us better understand the curriculum-greening lag existing for other disciplines (such as architecture, engineering, and urban planning).

Looking forward, there are several ways to build on this analysis. First, although this analysis illuminated the roles played by departmental colleagues, chemistry colleagues from outside the department, campus administrators and students, subsequent research should also examine the roles played by other constituents, such as university trustees, professional staff, and neighboring communities (Creighton 1998). Second, we need to better understand the way the process is shaped by government agencies, industry (whose shadow over campuses seems to be growing longer with each passing year), and the larger political-economy within which universities are embedded. Third, while this analysis side-stepped the process by which instructors decide to green their courses, this is another issue that needs to be better understood. A fourth way to build on this research is to relate this analysis to the "macro" factors found in previous research, such as traditional curriculum cultures, interdisciplinary boundaries, and traditional academic values (Haigh 2005; Tilbury 1999).

As mentioned at the beginning of this paper, while universities have been and continue to be a significant contributor to sustainability problems, curriculum greening has the potential to be a big part of the solution. Moreover, social science researchers have an important role to play in that process, as they can identify the factors stifling curriculum-greening efforts, thereby helping reformers better navigate through the process, and accelerate the speed at which we are greening campuses and society.

References

Anastas P, Warner J (2000) Green chemistry: theory and practice. Oxford University Press, New York

Berkeley Center for Green Chemistry (2010) Ethics. Available at:http://bcgc.berkeley.edu/ethics. Accessed 01 July 2015

Bourdieu P, Wacquant L (1992) An invitation to reflexive sociology. The University of Chicago Press, Chicago

Brint S et al (2009) Expanding the social frame of knowledge: interdisciplinary degree-granting fields in American Colleges and Universities, 1975–2000. Rev High Educ 32(2):155–183

Caan M (2009) Greening the chemistry lecture curriculum: now is the time to infuse existing mainstream textbooks with green chemistry. In: Anastas P (ed) Green chemistry education. American Chemical Society, Washington, DC, pp 113–118

Cannon A, Warner J (2011) The science of green chemistry and its role in chemicals policy and educational reform. New Solut 21(3):499–517

Collins T (1995) Introducing green chemistry in teaching and research. J Chem Educ 72 (11):965–966

Creighton S (1998) Greening the ivory tower: improving the environmental track record of universities, colleges and other institutions. MIT Press, Cambridge

Goodwin T (2004) An asymptomatic approach to the development of a green organic chemistry laboratory. J Chem Educ 81(8):1187–1190

Goodwin T (2009) The garden of green organic chemistry at Hendrix College. In: Anastas P (ed) Green chemistry education. American Chemical Society, Washington, DC, pp 37–53

Gordon College (2015) Green chemistry at gordon. Available at:http://www.gordon.edu/greenchemistry. Accessed 20 May 2015

Haigh M (2005) Greening the university curriculum: appraising an international movement. J Geogr High Educ 29(1):31–48

Higgitt D, Haigh M, Chalkley B (2005) Towards the UN decade of education for sustainable development: introduction. J Geogr High Educ 29(1):13–17

Karpudewan M, Ismail Z (2008) The integration of green chemistry experiments with sustainable development concepts in pre-service teachers' curriculum: experiences from Malaysia. Int J Sustain High Educ 10(2):118–135

Kirchhoff M (2009) Green chemistry education: toward a greener day. In: Anastas P (ed) Green chemistry education. American Chemical Society, Washington, DC, pp 187–194

Klingshirn M, Spessard G (2009) Integrating green chemistry into the introductory chemistry curriculum. In: Anastas P (ed) Green chemistry education. ACS Symposium Series, American Chemical Society, Washington, DC, pp 79–92

Martin S, Jucker R (2005) Educating earth-literate leaders. J Geogr High Educ 29(1):19–29

Morton T (1982) Zero effluent laboratory: an educational experiment: a chemistry professor's viewpoint. In: American chemical society forum on hazardous waste management in academic laboratories. Available at:https://www.hendrix.edu/uploadedFiles/Departments_and_Programs/Chemistry/Green_Chemistry/ACS%20talk%20and%20lab.pdf. Accessed: 20 Jan 2015

Orr D (1994) Earth in mind: on education, environment, and the human prospect. Island Press, Washington, DC

Poliakoff M et al (2002) Green chemistry: science and politics of change. Science 297 (5582):807–810

Posch P (1996) Curriculum change and school development. Environ Educ Res 2(3):347–362

Schnaiberg A, Gould K (1994) Environment and society: the enduring conflict. St. Martin's Press, New York

The Green Chemistry Commitment (2015) Department stories: Gordon College. Available at: http://www.greenchemistrycommitment.org/faculty/highlights-and-case-studies/. Accessed 20 May 2015

Tilbury D (1999) Sustaining curriculum policy and development in environmental education: a European action research project. Eur Environ 9:24–34
UC Santa Barbara Library (2014) Chemistry and biochemistry departments—United States. Available at:http://guides.library.ucsb.edu/chemuniv. Accessed 15 Apr 2015
ULSF (2001) Talloires declaration. Available at:http://www.ulsf.org/programs_talloires.html. Accessed 29 Jan 2015
University of Louisville Sustainability (2015) Green threads: sustainability across the curriculum. Available at:http://louisville.edu/sustainability/education-research/green-threads.html. Accessed 5 Feb 2015
University of Montana (2015) University of Montana Green Thread. Available at:http://www.umt.edu/greeningum/academics-and-research/GreenThread/default.php. Accessed 5 Feb 2015
Woodhouse E, Breyman S (2005) Green chemistry as social movement? Sci Technol Hum Values 30(2):199–222
Woodhouse E, Howard J (2009) Stealthy killers and governing mentalities: chemicals in consumer products. In: Singer M, Baer H (eds) Killer commodities: public health and the corporate production of harm. Altamira Press, Plymouth, pp 35–66

Author Biography

Manuel Vallée is interested in the intersection between environment and human health. While his doctoral research focused on the social construction of pharmaceutical consumption for Attention Deficit/Hyperactivity Disorder (ADHD), since then his research has turned upstream to elucidate the social production of disease, which includes analyzing how disease is mediated by exposure to environmental toxicants, how mainstream medicine suppresses information pertaining to toxicants, how governments foster public acquiescence for aerial pesticide spraying programs in urban areas, and how universities contribute to environmental destruction.