Pushing the Boundaries

the role of Oregon's Green Chemistry Executive Order Advisory Team
as a boundary organization

by
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ABSTRACT APPROVED:

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The state of the environment, both from a preservation and toxicological point of view, is a continuing concern. One area of potential progress is the incorporation of green chemistry principles, which focus on reducing and eliminating harmful toxics in all aspects of industrial processes from the design and manufacturing to disposal of products. The incorporation of green chemistry principles presents a "wicked" policy problem, an issue involving social, environmental, and economic complexity that extends across political jurisdictions and traditional policy arenas (Allen, 2013). A critical part in addressing this wicked policy problem is including advisory groups of various experts and stakeholders. At the direction of Oregon's recent Green Chemistry Executive Order, a multi-sector advisory team was formed in order to collaboratively address approaches to green chemistry implementation. This study explores the role of Oregon's Green Chemistry Executive Order Advisory Team as a boundary organization, in an attempt to better understand the facilitation of academia-industry-government interactions by examining data gathered from interviews with the team's members, and to identify the strengths and potential improvements in the early stages of green chemistry-supporting policy through content analysis of green chemistry reports and recommendations.

Master of Public Policy essay of Anna Marie Sherman presented on June 11, 2015

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Problems cannot be solved
at the level of awareness
that created them

– Albert Einstein

ACKNOWLEDGEMENTS

I want to thank my family and friends, because without the collective effort of my support team I would have crashed and burned. Thank you for pushing me to excel in all aspects, but to also accept falling short as part of the wonderful, humbling imperfections of life. These last few years, leading up to and during this endeavor, have included the absolute hardest, infuriating, rock bottom experiences of my life, but it has also been the most rewarding, and looking back I understand the value of hardships. They provide context that allows you to really appreciate all of the positives in life, and I have many for which to be thankful.

To my excellent committee, whose guidance has not been just during the writing of this essay, but throughout the challenging and exciting Master of Public Policy Program. It was through this program that I pursued an ideal internship opportunity, which lead to my essay topic, and ultimately my career path. I found my career niche, melding my technical expertise and newfound respect for policy into toxics regulation and corporate social responsibility, and I could not be more excited. Thank you for providing me with this opportunity, and pushing me to strive for higher standards and quality.

I know the price of success: dedication, hard work, and an unremitting devotion to the things you want to see happen.

Frank Lloyd Wright

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INTRODUCTION

Toxics reduction from an environmental and human health standpoint is becoming a priority in the policy arena. As chemical capabilities improve, from research and development to toxicity testing, safety concerns and regulatory expectations of consumers increase. Allen points out that many environmental challenges facing society have been described as "wicked problems", and the management of toxic chemicals is considered to be a classic example (2013: 101). "*Wicked problems* [emphasis in original] are dilemmas that are complex due to the many barriers to forming coherent and effective policy that satisfies the many sub-issues of the interorganizational network" (Radford, 1977; Mason and Mitroff, 1981 as cited by Simmons 2013: 504). One approach to this wicked problem of chemical regulation and toxics reduction involves incorporating more sustainable processes, commonly identified as green chemistry, into industrial practices and processes. Green chemistry is the design, development, and implementation of chemical products and processes that reduce or eliminate the use and generation of hazardous substances (Anastas & Kirchhoff, 2002). There are 12 Principles of Green Chemistry, shown in Box 1, with focus on safety, efficiency, and pollution prevention.

Box 1: The 12 Principles of Green Chemistry (Warner, Cannon & Dye, 2004)

- *Prevent waste:* It is better to prevent waste than to treat or clean up waste after it is formed.
- *Atom economy:* Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.
- *Less hazardous synthesis:* Wherever practicable, synthetic methodologies should be designed to use and generate substances that possess little or no toxicity to human health and the environment.
- *Safer chemicals:* Chemical products should be designed to preserve efficacy of function while reducing toxicity.
- *Safer solvents and auxiliaries:* The use of auxiliary substances should be made unnecessary wherever possible and, innocuous when used.
- *Energy efficiency:* Energy requirements should be recognized for their environmental and economic impacts and should be minimized. Synthetic methods should be conducted at ambient temperature and pressure.
- *Renewable feedstocks:* A raw material of feedstock should be renewable rather than depleting wherever technically and economically practicable.
- *Reduce derivatives:* Unnecessary derivation should be avoided whenever possible.
- *Catalysis:* Catalytic reagents are superior to stoichiometric reagents.
- *Design for degradation:* Chemical products should be designed so that at the end of their function they do not persist in the environment and break down into innocuous degradation products.
- *Real-time analysis for pollution prevention:* Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.
- *Inherently safer chemistry for accident prevention:* Substances and the form of a substance used in a chemical process should be chosen so as to minimize the potential for chemical accidents, including releases, explosions, and fires. (Warner, Cannon & Dye, 2004)

Unlike traditional regulations, Green Chemistry principles couple innovation with economic drivers, challenging innovators to incorporate the use of matter and energy into their design so that there is maximum performance for minimal consumption while protecting human health and preserving the environment (Manley, Anastas, & Cue, 2008:743). Not simply a matter of environmental responsibility, adhering to Green Chemistry principles makes sense from an economic standpoint, as Hofmann recognized

as early as 1848, "In an ideal chemical factory there is, strictly speaking, no waste but only products. The better a real factory makes use of its waste, the closer it gets to its ideal, the bigger is the profit" (as quoted in Lancaster, 2010:23).

Green chemistry itself is not complicated, but more of a process, striving for perfection while realizing that those objectives can only be chased through continual incremental improvements supported by innovation (Anastas & Warner, 1998:11). When green chemistry is incorporated into industrial standards and regulations, a new level of complexity is added. "The wicked nature stems not only from their biophysical complexity but also from multiple stakeholders' perceptions of them and of potential trade-offs associated with problem solving. Identification of solutions becomes as much a social and political process as it is a scientific endeavor" (Kreuter et al 2004, as cited in Batie, 2008:1176). Box 2 below outlines a few of the characteristics of wicked problems.

Box 2: Characteristics of wicked problems (Allen 2013; Batie 2008; Rittel & Webber 1973)

- **Unstructured**: difficult to clearly define cause and effect, no clear solution, no immediate or ultimate test for a solution
- **Cross-cutting**: multiple stakeholders, varying perspectives, competing values, conflict potential, interdependencies
- **Relentless**: unstable, continuously evolving, no stopping rule

Despite the complexity, and while it is far from being universally employed, several states such as Michigan, Minnesota, California and Washington are establishing plans to support the incorporation of green chemistry principles (Lowell Center et al, 2014;

Mitchell & Initiative, 2009; Matus et al, 2010; Wilson et al, 2006; State of California et al, 2008; State of Washington et al, 2013).

In October 2010, the Oregon Environmental Council (OEC) and Zero Waste Alliance hosted a conference, Growing Green Chemistry in Oregon. The opening speaker, Dr. Paul Anastas, the founder of the field of green chemistry and at the time serving as the Assistant Administrator with the Office of Research and Development for the U.S. EPA, said, "Nowhere surpasses Oregon for its impact on green chemistry education, training of students, training of teachers, and advancing awareness of green chemistry" (OEC, n.d., Green Chemistry). The next year, a similar event, Advancing Sustainable Manufacturing in Oregon was held, where opportunities to save money and strengthen competitiveness through sustainability efforts were presented. Then in 2012, Oregon lawmakers developed a Healthy State Purchasing bill (HB 4151) that would have (1) added human health and environmental evaluation criteria to purchasing decisions made by state agencies, (2) increased transparency about the presence of chemicals of concern in products purchased by state agencies, and (3) allowed green chemistry innovators to highlight the benefits of safer, more sustainable products when being considered for state purchases (OEC, n.d., Fostering GC).

While the bill was denied a public hearing in the General Government and Consumer Protection Committee of the Oregon House of Representatives, it laid the groundwork for the successful signing of the 2012 executive order, (No. 12-05) *Fostering Environmentally-Friendly Purchasing and Product Design* and from it, the Green

Chemistry Innovation Initiative (Office of the Governor, 2012). The Executive Order aims to catalyze the development of innovative products and processes through green chemistry, and lays out four strategic areas displayed in Figure 1.

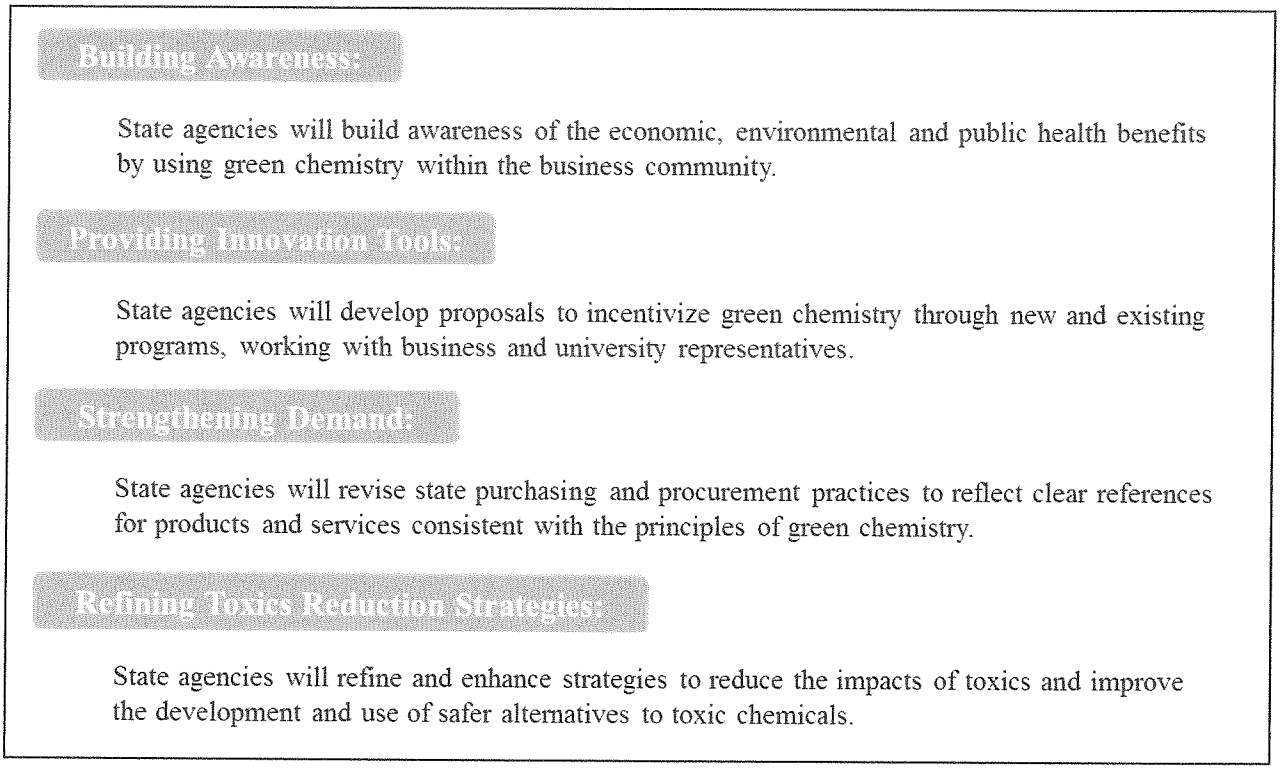


Figure 1. The four strategic areas where Oregon policies and programs can effectively foster innovation, from *Fostering Environmentally-friendly Purchasing and Product Design*, Oregon's Green Chemistry Executive Order.

The Executive Order clearly expresses the need for collaboration in order to be successful, saying:

> This Initiative will help ensure the long-term competitiveness of Oregon in the global market for greener technologies. To achieve this will require collaboration among agencies and businesses, universities and non-governmental organizations. The Initiative includes actions that represent the most effective

> and efficient ways for state government to foster this type of innovation (Office of the Governor, 2012:2).

From the Executive Order's call for collaboration came the Green Chemistry Executive Order Advisory Team, an advisory group consisting of agency officials, business and academic leaders, and policy advocates. The variety of perspectives enrich the discussion, as "It is necessary not only to have many disciplines involved, but also to have interaction with those whose resources and cooperation are indispensable for tackling the problem – that is, with stakeholders" (Bueren, Klijn, & Koppenjan 2003 as cited by Batie 2008:1179).

Wicked problems "require a broad systemic response, working across boundaries and engaging citizens and stakeholders in co-producing policy-making and implementation" (Ferlie et al, 2011:308). The Green Chemistry Executive Order Advisory Team, sitting at a crucial juncture of the boundaries between academia, industry, NGO, and government, has been tasked with facilitating the multi-sector collaboration. Boundary organizations facilitate collaboration and information or knowledge sharing between research and public policy spheres (Parker & Crona, 2012; Guston, 2001). This study aims to determine if the Green Chemistry Executive Order Advisory Team is acting as a boundary organization, by outlining the roles and objectives as described by members of the team, and examining recommendations made in Green Chemistry reports. By investigating major themes present in both sources to the boundary

organization criteria offered in the literature, the Advisory Team's characterization as a boundary organization and capacity for success can be better understood.

Literature Review

Schwarzman and Wilson (2009) identify the Toxic Substances Control Act (TSCA) of 1976 as a key cause, or jumping off point, in the barriers facing green chemistry. Figure 2 illustrates the three policy gaps discussed in much of the literature concerning the opportunities for Green Chemistry in policy (Allen 2013; Schwarzman & Wilson 2009a, 2009b; Wilson & Schwarzman 2009). The data gap concerns the lack of hazard information, either from the inadequate data generation via the producers or lack of transparency or access to the data for the consumers. The safety gap involves regulatory agencies such as the EPA lacking the authority to act on imminent hazards, and product lifecycle analysis being voluntary at best (Schwarzman & Wilson 2009a). The technology gap has multiple contributing factors, but can be considered a lack of capacity and innovation. There is not enough demand from consumers, considered a market weakness, which in turn does not motivate companies and researchers to invest the time and energy to innovate new technologies (Allen 2013). Similarly, there is a lack of education on the consumers end, as well as in the training of hard science disciplines to incorporate and strive for technologies that are not necessarily being demanded across industries.

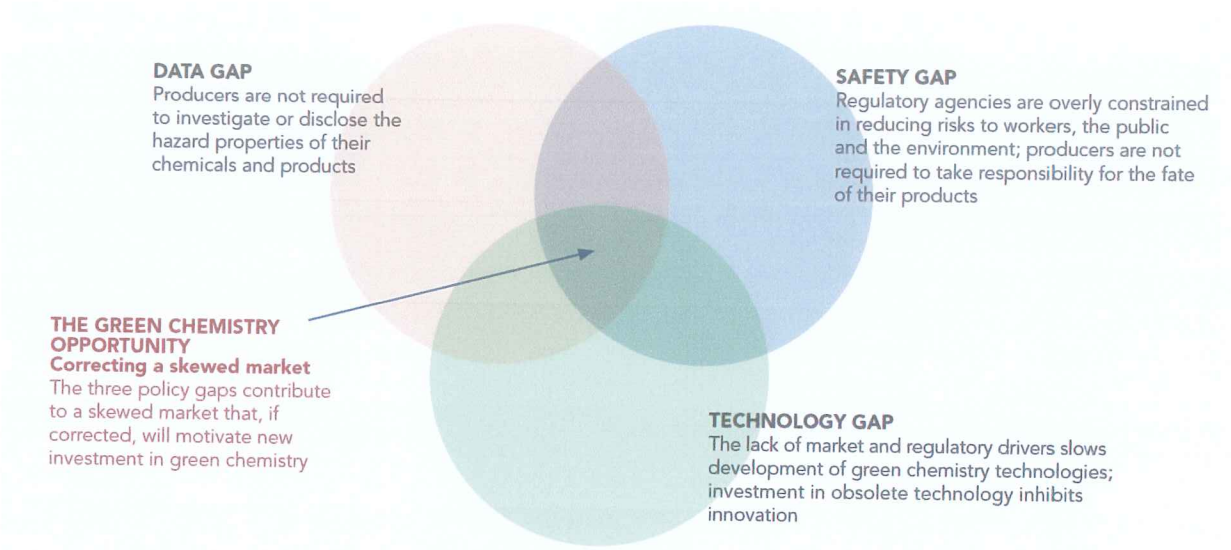


Figure 2. The policy gaps produce fundamental obstacles to green chemistry innovation; by correcting the three gaps, policies will lower these obstacles and open new opportunities for investment in green chemistry while also protecting human health and the environment (Wilson et al 2008:8).

The policy gaps overlap and cause problems that transcend boundaries, contributing to the wicked nature of Green Chemistry incorporation into policy. Single sectors do not house the capabilities to tackle boundary spanning issues, as the problems cover multiple disciplines, and often do not have a single answer or approach.

Collaboration & Advice

Problems that transcend the boundaries of single organizations must be addressed cooperatively, so processes and structures that bring together all stakeholders in a given problem domain "are the most promising response for all concerned" (Emery & Trist, 1965 as cited by Westly & Vredenburg, 1997:381). Multisectoral involvement is beneficial by reflecting the changing roles and relative importance among participants, bringing together diverse groups and resources, and

tackling problems that are outside the scope of any one group (deLeon & Varda, 2009). Green chemistry and the process of innovating for sustainability is multifaceted and multidimensional, with individual organizations often lacking the necessary resources to undertake the process alone. It is an area that is socially and institutionally embedded with multiple stakeholders, and requires interdisciplinary research and collaborative efforts to create an effective innovation environment (Sarkis, Cordeiro & Vazquez Brust, 2010). Savage et al. (2010:21) even uses green innovation as an example of collaboration, saying, "As an illustrative example, consider how the advent of 'green' and environmentally friendly products involves the collaboration of organizations across public and private sectors to develop new technologies for the benefit of society." Liroff (2010a, 2010b) goes on to identify the game plan for accelerating green chemistry as a collaborative effort on behalf of multiple sectors, including investment, policy, and education advancements.

Savage et al. (2010) lists the three general factors that motivate organizations to seek cross-sectoral partners through collaboration, (1) it allows an organization to achieve something that could not be accomplished in any other way, (2) it helps organizations tackle social or macro-environmental problems that cannot be solved by a single organization acting alone, and (3) it provides organizations an adaptive advantage. Seeking mutual-gain solutions or a win-win scenario is central to the nature of collaboration (Innes & Booher 2010; Head 2013). When organizations incorporate inter-organizational collaboration, they tap into more creative solutions that having

multiple contributors can offer; by bringing together different outlooks on a certain problem, they "constructively explore their differences and search for solutions that go beyond their own limited vision of what is possible" (Gray, 1989 as cited by Rod & Paliwoda, 2003:273). The stakeholders must be diverse in order to fully utilize the potential for creativity (Innes & Booher 2010), including industry, government, NGOs, academia, and the general public (Taylor 2006; Warner, Cannon & Dye 2004).

Bryson, Crosby and Stone (2006) point out the initial need for a convener, such as a mayor, CEO, or other powerful individual capable of bringing together stakeholders, and agreement on the problem definition as valuable linking mechanisms in the formation of collaborations. The Green Chemistry Executive Order called for the formation of such a group, and provided the problem definition and objectives.

In bringing together the stakeholders as outlined in the Green Chemistry Executive Order, the collaborative problem solving approach relies heavily on advice. As Roholt, Fink, and Baizeman (2014:186) describe it,

> Advice is primordial, socio-intellectual process – a system of soliciting and providing, of asking others for 'input' – perspective, technical 'know how,' thoughts, and meanings. And of deciding whether or not to use what is offered. Advice is a way to help correct one's limitations or a way to solicit support, a way to increase the likelihood that a study will meet its life purpose by being used in the everyday world in ways practical, useful, meaningful, and consequential.

Advisory groups are a method for attaining this advice, and are often employed by companies as a highly-effective strategy to identify potential opportunities and leverage existing organizational strength (Baynard & Burrell, 2012). They facilitate better information sharing (Ounanian & Hegland, 2012), allow for ongoing evaluation and feedback (Kvasnicka, Harris & Ytterberg, 1995), and provide a reality check by identifying existing or potential issues of concern (Parkins, 2002).

Similar to the way that an advisory board is chosen to reflect their customer base, an advisory team utilized in the policy sphere incorporates those affected by the policy. The National Institutes of Health (NIH) mentions their incorporation of advisory committees to advise on policy matters related to their mission responsibilities, make recommendations on program development, resource allocation, and regulation (1993). The advisory group is a way to seek outside assistance (Internet Advisory Group, 2012). When the problems become more complex, crossing sectors and disciplines, bringing outsiders in for negotiations between sectors is important. They bring in a fresh, informed perspective and can provide creativity and ingenuity that would otherwise be missed (Hightower, 2006; Jennings 1989). As Jasanoff (1990:249) pointed out "the advisory process seems increasingly important as a locus for negotiating scientific differences that carry political weight."

Boundary Organizations

The interaction of science and policy is not an example of two competing ideas, but indicative of a traditional boundary that has been difficult to cross or straddle.

Boundaries allow for clear distinctions in definitions and responsibilities, often dividing powers and functions throughout administrative processes (McGuire 2006). Wicked policy problems such as the incorporation of green chemistry principles into policies and industrial practices require a boundary spanning, collaborative approach. Such a tactic is supported throughout much of the literature (Gray & Wood 1991; Huxham & Vangen 2005; Baradach 1998) as groups with potentially different perspectives can constructively explore the problem at hand and construct solutions that go beyond their individual problem-solving capabilities, pointing towards better organizational performance (Thomson & Perry 2006:20). Organizations that collaborate must have interdependencies that are mutually beneficial and based on shared interests, in this case an appreciation and passion for an issue that goes beyond an individual group's mission (Thomson & Perry 2006:27), such as the multisector concept of Green Chemistry for the Executive Order's Advisory Team. This makes the Advisory Team a contender for the utilization of collaborative and advisory components, drawing from multiple disciplines across various boundaries, in a formal structure at the direction of the Green Chemistry Executive Order. This aligns well with the concept of a boundary organization, "Entities that bridge the gap between science (academicians) and policy (practitioners)" (Sternlieb et al. 2013:123). The interactions between science and policy is depicted in Figure 3, where the formation of the Advisory Team as a boundary organization is considered a formalized manifestation of boundary arrangements (Hoppe, Wesselink & Cairns 2013).

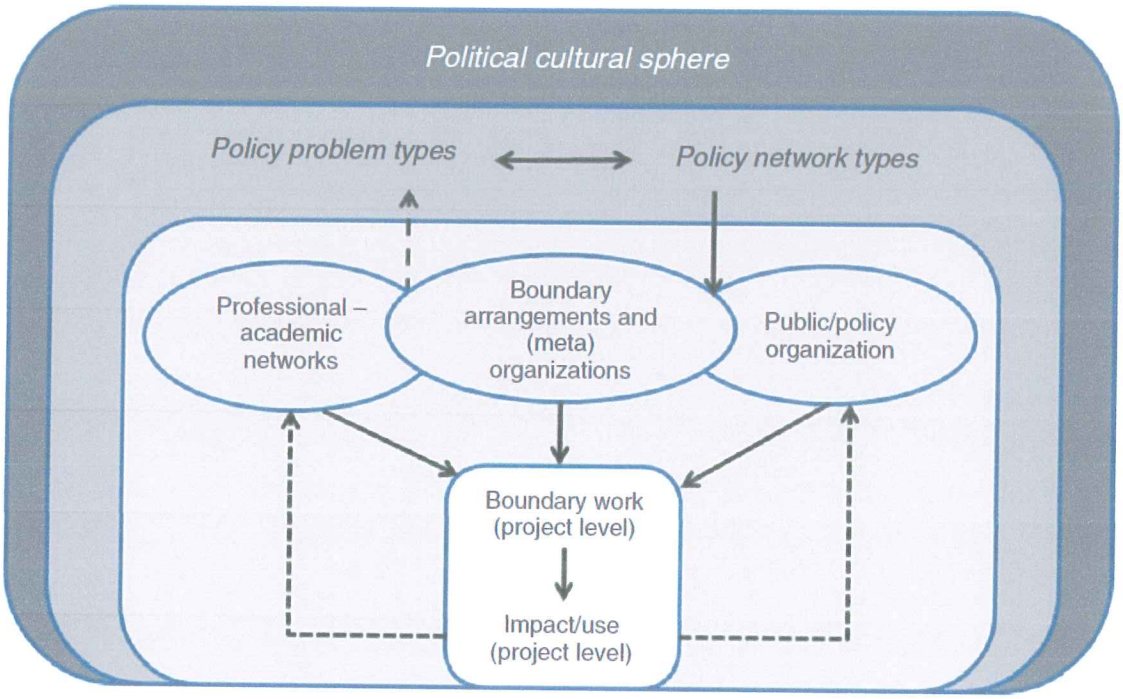


Figure 3. Multilevel conceptual framework for understanding science-policy interactions (Hoppe, Wesselink & Cairns 2013:285)

Meyer and Knight (2014) point out that scientist and decision-makers operate in different worlds, with different priorities, and at different paces, which can lead to opportunities being missed. Boundary organizations help to address these missed opportunities, by facilitating collaboration and information or knowledge sharing between research and public policy spheres (Parker & Crona, 2012; Guston, 2001). This can also be viewed as collaboration between knowledge producers and users, where the boundary organizations aim to facilitate mutually beneficial links between them (Meyer & Knight, 2014; Crona & Parker, 2011, 2012). Figure 4 demonstrates this structural relationship, where boundary organizations create the link for information flow.

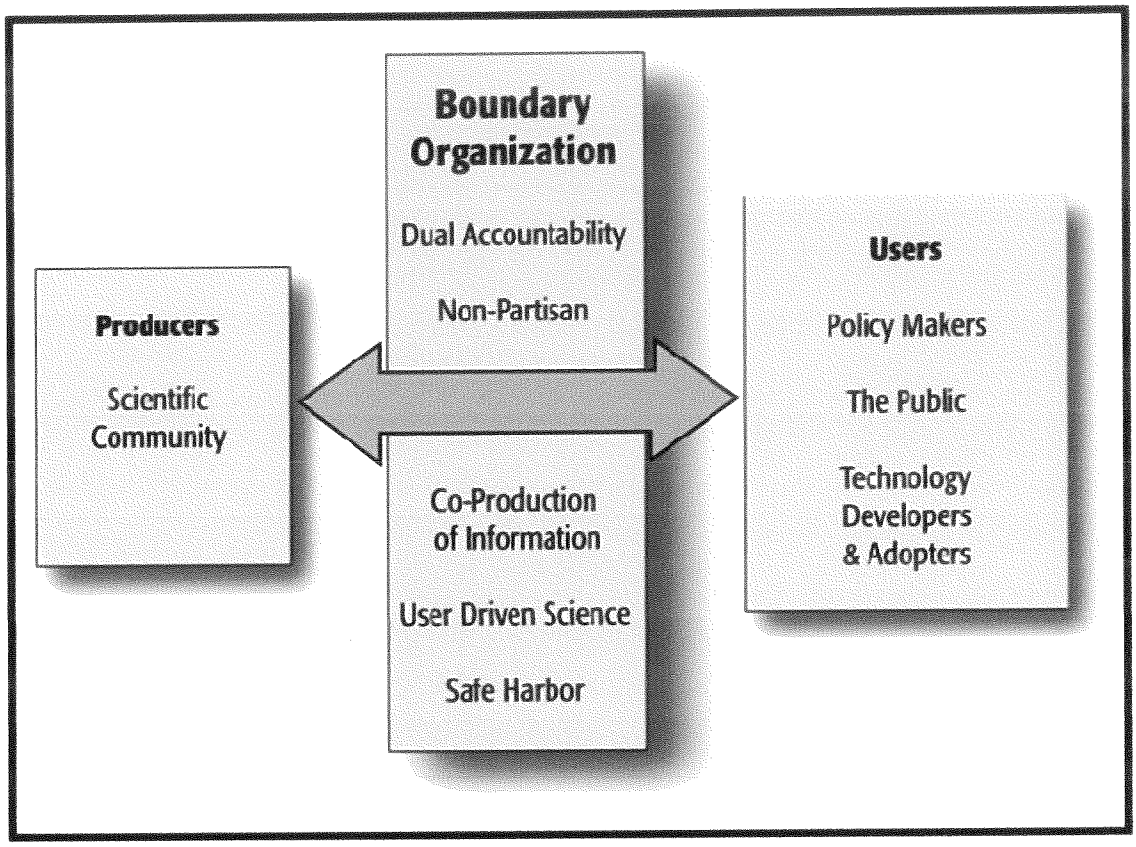


Figure 4. The positioning of a boundary organization in an end-to-end system. (Clark & Holliday, 2006)

One characteristic mentioned in Figure 4 is co-production, utilized in boundary organizations through facilitation of collaboration between scientists and nonscientists, creating combined scientific and social order (Guston, 2001). The inclusion of a plurality of sources of knowledge is an important aspect, as it provides new ways of integrating heterogeneous expertise (Halffman & Hoppe, 2005). It is clear that neither science nor politics has a monopoly on truth or power, so bridging them is a strengthening factor (Miller, 2001). A boundary organization draws stability by being accountable and responsive to opposing, external authorities rather than isolating itself (Guston, 2001).

There are three criteria for boundary organizations: (1) providing opportunities and incentives for creating and using boundary objects, (2) involving participation by policymakers and researchers as well as professionals, and (3) existing between the science and policy communities while being accountable to both (Parker & Crona, 2012). These criteria provide a framework and definition against which the Green Chemistry Executive Order Advisory Team can be analyzed, as it provides a multidisciplinary, focused approach to providing recommendations to the Governor's office on the implementation of Green Chemistry policy.

Green chemistry is highly integrated and multidisciplinary, directly focusing on wicked problems and requires the engagement of stakeholders through institutions such as boundary organizations (Batie, 2008). Those engaged in boundary organizations come from various spheres, and provide a stronger perspective and approach by combining their strengths to overcome individual limitations.

Summary of Literature

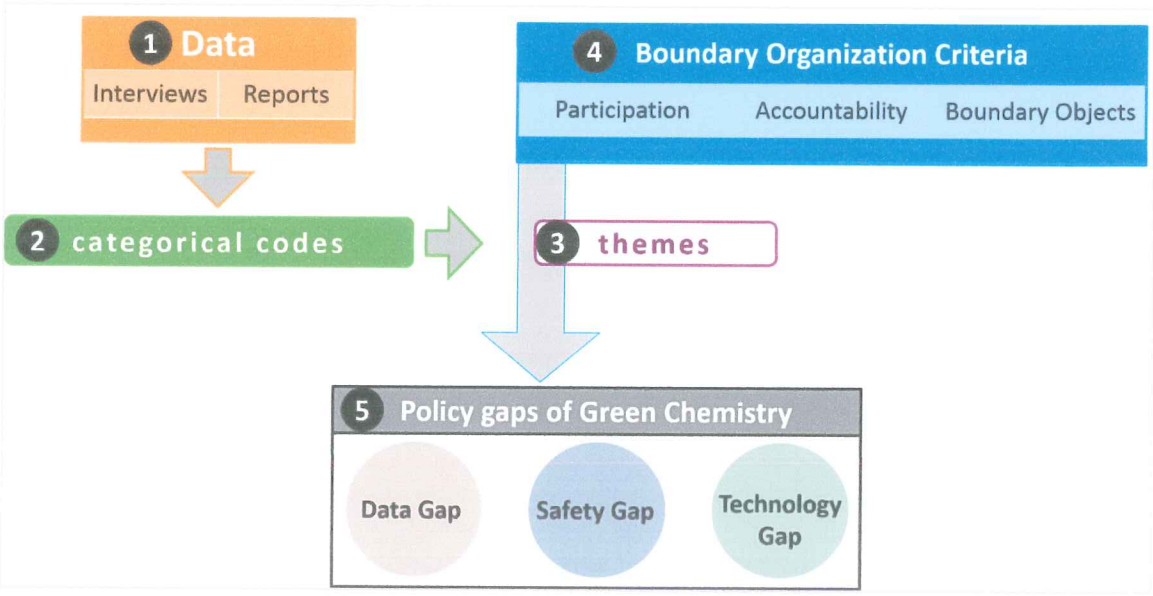
The literature highlights a few key concepts that will help guide the analysis of the Oregon Green Chemistry Executive Order Advisory Team interviews. The diversity of members is crucial to the quality and creativity of the policy solutions (Innes & Booher 2010; Taylor 2006; Warner, Cannon & Dye 2004), so seeking to understand the relevant work, discipline or sector, and prior experience with green chemistry of those involved will be useful. Identifying the role(s) of the members and group deliverables can be compared to those expected of boundary organizations and inform suggestions for

successful green chemistry guided policies. Collaborative efforts and an advisory role are foundational to addressing wicked problems and seeking policy solutions (Norris-Tirrell & Clay 2010; APSC 2007; Head 2013), and it is important to see if and how those qualities are represented in the Advisory Team. It is the objective of this study to ultimately compare the Advisory Team with Parker and Crona's (2012) three criteria for a boundary organization – participation, accountability, and boundary objects. Initially the interview data will be analyzed for emerging themes that can shed light on the characteristics represented and roles provided by the Advisory Team, alongside the recommended actors and courses of action provided in the Green Chemistry reports. The emergent themes will be inspected for relation to the boundary organization criteria, and applicability to the three policy gaps that present a major challenge for the success of Green Chemistry. This study intends to determine if the Advisory Team is acting as a boundary organization, and if the policy gaps can be addressed.

Methods

This study employed semi-structured qualitative interviewing with the members of Oregon's Green Chemistry Executive Order (GCEO) Advisory Team, and content analyses of Green Chemistry reports and recommendations. The data gathered from the interviews and policy reports, in conjunction with an extensive literature review of the proposed approaches, provided a more comprehensive depiction of the Advisory Team's role in relation to the Executive Order's directive, and interagency and cross-sectional collaboration. The methodological approach is represented in Figure 5.

Figure 5. Methodological approach. (1) Interview data transcribed and reports reviewed. (2) Categorical codes to structure data. (3) Themes emerg from the data. (4) The three boundary organization criteria are evaluated in relation to the themes. (5) Applicability to the three policy gaps facing Green Chemistry considered.



Sample Population and Participants

Tongco outlines the steps of purposive sampling, including starting with determining the type of information needed to answer the research problem (2007). It was concluded that in order to gain insight into the role of the Advisory Team, an important quality of the informant(s) would be participation in the Advisory Team. Purposive non-random sampling was implemented through in-depth interviews with those invited to participate on the Advisory Team. A total of five in-depth interviews were completed, of the eight individuals contacted, with the participants coming from academia, state agency, NGO, and industry. Table 1 is representative of the respondents. While the number of GCEO Advisory Team members is rather small, Wilmot points out that "with a purposive non-random sample the number of people interviewed is less important than the criteria used to select them" and the individual's characteristics are used as the basis of selection (2005:3). In this case, the individual's characteristic is membership on the GCEO Advisory Team.

Table 1. Respondents in GCEO Advisory Team interviews.

Respondent	Sector	Gender	Technical background*	GC focus
1	industry	F	2	regulation
2	academia	F	3	education
3	NGO	M	2	innovation
4	government	M	2	sustainability
5	academia	F	3	sustainability, innovation

* Technical background assigned based on experience and education specifically in a hard science such as chemistry, toxicology, environmental science, etc. 1=minimal (no undergraduate training); 2=strong (undergraduate degree or training); 3=advanced (advanced/graduate degree or training)

INTERVIEWS & REPORTS

A series of five semi-structured phone interviews were conducted with members of the GCEO Advisory Team. The semi-structured format was chosen in order to allow for questions to be prepared ahead of time, giving the interviewer clear discussion points that address the research problem, while allowing the participant the freedom to express unique perspectives and diverge from the interview guide (Stuckey, 2013:57). To gain insight into the Advisory Team's role, questions were asked concerning the individual's background in relation to Green Chemistry, the GCEO Advisory Team's mission/objectives, and the ways that the Advisory Team went about addressing their objectives. They were also asked to discuss the barriers and limitations of the Advisory Team's role and structure. The interview protocol is attached as Appendix A. All interviews were recorded using an Olympus VN-702PC digital voice recorder, and the interviewer simultaneously took hand written notes of key terms or phrases of particular interest. All five interviews were transcribed by the researcher using the Express Scribe program. This program was downloaded from the manufacturer's website onto the researcher's computer, and used to listen to the audio recordings[1].

To address the second objective of this report, identifying the main themes present in Green Chemistry reports and recommendations to address the Advisory Team's capacity for future success, nine green chemistry reports and/or policy recommendations were selected for content analysis. Table 2 represents a brief overview of the reports selected, and full bibliographic information can be found in

[1] The website used to download the Express Scribe program is http://www.nch.com.au/scribe/.

Appendix C. They were nonrandom, as reports were sought out that addressed the specific green chemistry incorporation into policy, recent initiatives, or opportunities in Oregon. The emerging nature of this topic limited the number of applicable reports, directing the sampling to purposive rather than random selection.

Table 2. Descriptive information on reports used in content analysis

Document	State	Year	Title
1	Oregon	2011	Leadership in sustainable chemicals policy: opportunities for Oregon
2	NY/EPA region 2	2012	Unleashing Green Chemistry and Engineering in Service of a Sustainable Future: Final Report
3	Michigan	2012	Advancing Green Chemistry: An Action Plan for Michigan Green Chemistry Research, Development, and Education
4	Multi/sector	2012	Collaboration across disciplines for sustainability: Green chemistry as an emerging multistakeholder community
5	Multi/sector	2006	Framing a safe chemicals future: Towards Safer Chemicals, Products, and Services
6	Minnesota	2009	The Green Chemistry Landscape in Minneapolis Saint Paul
7	Oregon	2010	Advancing Green Chemistry in Oregon: Recommendations from the Oregon Green Chemistry Advisory Group
8	California	2008	California Green Chemistry Initiative: Final Report
9	California	2008	Green chemistry: cornerstone to a sustainable California

ANALYSIS

Following Zhang and Wildemuth's steps of content analysis, the data were prepared through transcription, and individual themes were identified as the coding unit of analysis (2009:310). After transcription, interviews were coded using QSR International's NVivo 10 software[2]. Directed content analysis was elected for the coding strategy, as it allows the researcher to use existing theories to develop the initial coding scheme before analyzing the data (Kyngas & Vanhanen, 1999 as cited in Hsieh & Shannon, 2005:1286). As analysis continues, the initial coding scheme can be refined or revised as new codes emerge (Hseih & Shannon, 2005). The categorical codebook developed utilizing theory and data driven codes is shown in Table 3, which initially

[2] NVivo qualitative data analysis software; QSR International Pty Ltd. Version 10, 2012.

structured the data. Then, based on the three criterions of boundary organizations mentioned by Parker & Crona (2012), axial coding of the themes *boundary object*, *participation*, and *accountability* were done. Thematic coding was continued on the nine relevant Green Chemistry reports offering recommendations for the adoption of Green Chemistry, to further establish the presence of advisory groups as boundary organizations in the discussion of implementation strategy and innovation. The categorical codebook developed for the reports is shown in Table 4.

Table 3. Categories used to structure the interview data.

- Prior experience
  - The discipline; such as science, policy, business
  - Prior positions, jobs
  - Green Chemistry
    - Prior interactions with or knowledge of
- GCEOAT
  - Role
    - Mission, objectives
    - Advisory
      - recommendations or next steps
    - Expertise
      - Provide
      - Review of others
  - Structure
    - Members
      - Type of members/membership
- Collaboration
  - Communication
    - Methods of communication; facilitation of
    - Items communicated
  - Action
    - Meetings
    - Deadlines
- Future GC policy
  - Barriers to GC policy
  - GC policy necessities, improvements

Table 4. Categorical codebook used to structure reports

Scope	
	Scale of application, state or industry policies, industries targeted
Participants	
	Targeted groups, government roles, industry and community
Barriers	
	Obstacles to overcome, policy gaps
Solutions/Recommendations	
	Recommendation for action, structure, approach for green chemistry incorporation and success in policy

Results & Discussion

From the categorical coding of the interview data and reports surfaced five themes relevant to the objectives of this study. Figure 6 is an illustration of the categorical codes and emergent themes in relation to the methodological approach. The themes are multi-sector representation, networking capacity, knowledge sharing across sectors, boundary object creation, and lack of decision-making power.

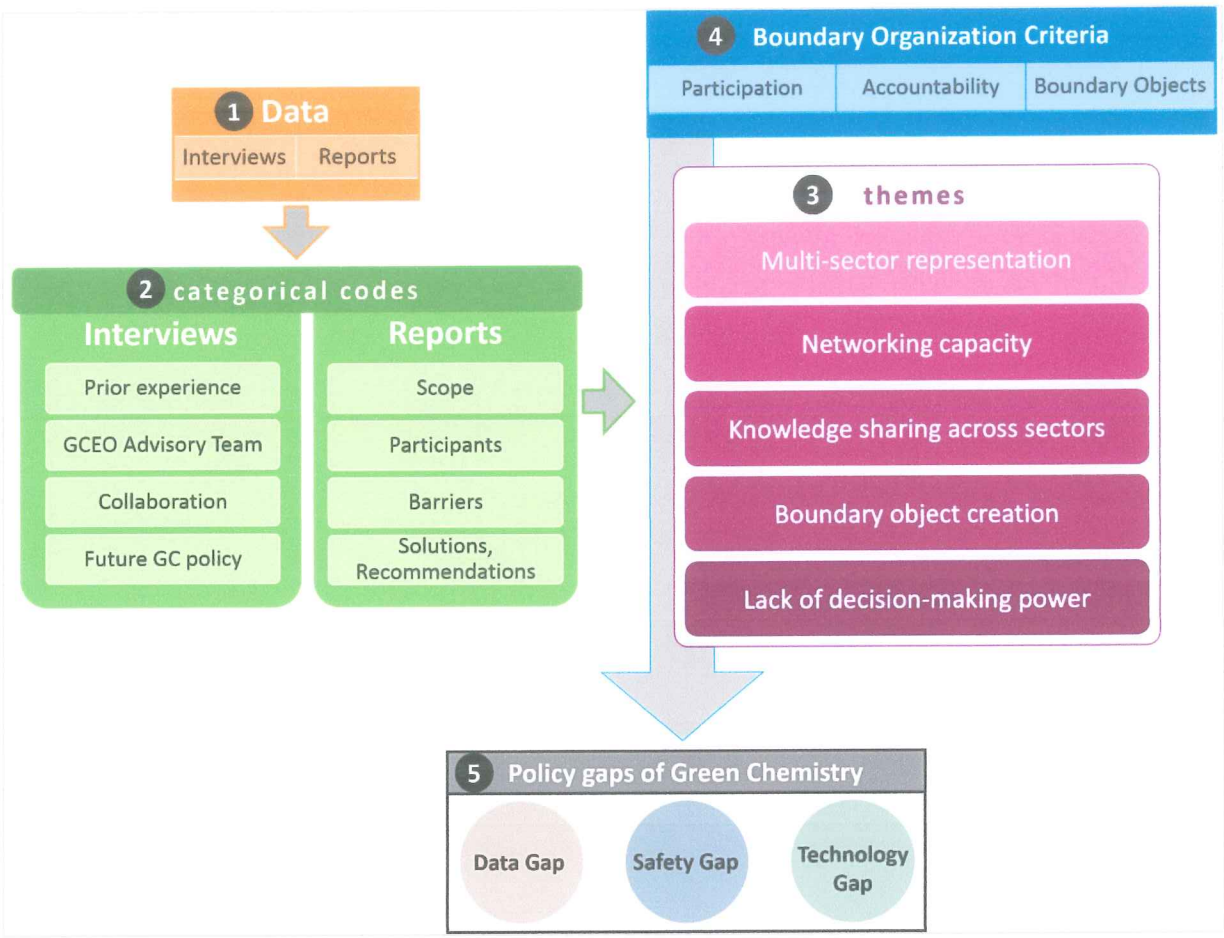


Figure 6. Methodological approach with categorical codes and emerging themes. (1) Interview data transcribed and reviewed reports. (2) Categorical codes provided initial structure from which the data were reviewed. (3) Five themes emerged from the data. (4) The three boundary organization criteria were evaluated in relation to the themes. (5) Applicability to the three policy gaps facing Green Chemistry was considered.

Multi-sector Representation

Participation of stakeholders requires multi-sector representation

Participation in the advisory team included many disciplines and experts with diverse backgrounds, representing many sectors. This was evident in discussing the structure and membership of the Advisory Team in the interviews. The use and importance of experts, and the types of people currently involved or necessary for future success was a discussion point. Respondent 4 mentioned the types of participants

outlined in the Executive Order, stating, "In the executive order we were advised to consult with universities, businesses, other interested parties as part of our work."

This was also reflected in discussing the prior experiences of the Advisory Team members, with multiple sectors and varying technical understandings being expressed. Government, industry, NGO, and academia were represented as indicated previously in Table 1, showing the participation of traditionally separated spheres in a collaborative, advisory group.

Expertise was also highly recognized and valued, mentioned by multiple respondents. For instance, in discussing the objective of the Advisory Team, Respondent 4 brought up "bringing experts in to cover the landscape." Respondent 3 continued with the way that ideas were "developed in ground truths by a broader set of experts." The expertise of the participants contributed in a collective manner, providing experience and knowledge of multiple, contributing areas to a single policy topic, in this case the utilization and implementation of Green Chemistry principles.

Respondents also discussed necessary qualities involved in the successful participation of stakeholders. Respondent 2 said, "[You] want some strategic people, you need a couple of leaders, you need some doers in addition to the talent pool and the expertise." The expertise was not the only contributing characteristic mentioned, as Respondent 2 later gave recognition to the value of local experts, stating:

> I think they provide a real world detailed information, context specific for people who are trying to develop policy, so one of the things that was really nice about this process is there were local experts, which I think is really important when you are trying to figure out how to set policy for a state or a city . . . by having people from the community, experts from the community, to participate you get a much more targeted conversation and it enables you to be creative and innovative in the appropriate context.

This provided insight into some of the difficulties in bringing outside experts into a local discussion, in that sometimes context can be lost, or there may be concerns in the direct application of a general concept to a specific situation. Including participants who provide specific context is valuable as they contribute to finding an appropriate scope for the discussion.

Respondents professed the value of diverse representation as a benefit or strength of the Advisory Team. Respondent 1 discussed the Advisory Team's participants, saying:

> Well, I think one of the strengths of our team is that it was diverse in backgrounds, we had some progressive industry stakeholders taking place, or taking part, in the conversation. We had a very diverse representation from the state government agencies, which was nice.

Respondent 2 made a similar comment in talking about the overall approach to participation, and the questions to which diverse perspectives can add depth, stating:

> The more diverse personalities that you can bring, that can help you anticipate and think about what is it that you are trying to accomplish and what tools are you using to accomplish that, and in what context are you trying to make that happen.

The respondents encouraged diverse perspectives throughout the interviews, realizing the value and benefit that it had in the Advisory Team, and that in future endeavors it would also add significance to the discussion in terms of applicability and context. When more disciplines contribute, the solutions and recommendations represent a more holistic and inclusive perspective, addressing concerns or conditions that may not be evident to a single expert or discipline.

The value of utilizing experts and diverse members was also a crucial point emphasized by Halffman and Hoppe (2005) in discussing boundary organization participation. Similarly, that value was also reflected in the reports, as they included a variety of suggested participants, outlining the future roles that education, industry, and government can play based on structures and resources. It was pointed out that education can bridge the policy gaps by creating opportunities for students to learn, and informing the public and future workforce. Industries can capitalize on the competitive advantage of green chemistry, push innovation, and create safer workplaces and communities. Report 2 demonstrates the role of government:

> "Governmental organizations and their policymakers have mechanisms in place that are fostering green chemistry research and education. At the local, state and federal levels these programs can play a key role in prioritizing and promoting green chemistry and sustainable technologies support through grants and funding, and generate incentives to encourage innovation and adoption" [pg. 9].

The necessary participants mentioned in the reports hailed from multiple sectors, supporting the need for a collaborative approach. The recommendations required efforts from all sectors, some relying more heavily on sector than another, such as the governmental organizations' role mentioned above, but no report identified one discipline or sector as the only critical participant. Other examples include Report 1 suggesting, "Given the number of chemical product manufacturers and their distribution across the United States, developing safer alternatives require collaboration between states and across agencies" (pg. 21), and Report 7 acknowledging, "Successful implementation of these recommendations will require collaboration between stakeholders from academia, industry, government and NGOs" (pg. 21).

The overall tone is very accepting to the idea that in order for the stakeholder to be involved in Green Chemistry discussions and present in advisory groups, specifically the Advisory Team, there needs to be multiple sectors represented. Advisory groups, whether looking to analyze their structure or contributions, or aiming to develop the most effective group, need multi-sector representation, as there are multiple

stakeholders that should be involved in the process in order to holistically reflect the knowledge and concerns of groups effected by the topic of discussion.

The selection of people able to contribute, who have the knowledge base and skills to help navigate science and policy concerns, and can provide or create an extended network to tap additional resources is paramount to the success of a collaborative effort. Without strong contributors that have an expertise and information to offer, and bring a willingness to engage the other participants, the collaboration is not providing value to members or effectively addressing the policy questions at hand. The relationships established in such collaboration provide the avenue for a continued dialogue, networking, and information sharing.

Networking capacity

Collaborative infrastructure supports improved networking capacity

The structure and nature of the Advisory Team encourages and facilitates improved networking between sectors through the relationships formed between participants. This is an avenue for discussion that can go beyond the structure or objectives of an advisory group like the GCEO Advisory Team, aligning resources and research priorities that may be currently out of scope, but could become a possibility. In discussing the structure of the team, Respondent 3 made a few good points concerning these relationships, saying "it was kind of natural for us to start that [advisory] process by building relationships." Later in the interview, adding:

> I think one of the key elements, strategically speaking, is that when you are able to forge strong relationships with individual businesses and with individual manufacturers and others in the private sector that can help neutralize some of that trade association or some other business opposition to those policies.

Respondent 4 echoed that sentiment of valuable relationships when asked about the benefits of the Advisory Team, mentioning "A secondary benefit has been some relationship building, so the ability to engage with new people on this topic has also been of benefit." Respondents discussed the outcomes of their collaboration in terms of relationships and networks built. Respondent 2 stated, "[You can] educate a community of experts, it builds bridges of trust and communication."

The diverse membership previously mentioned, allows for relationships to be made between individuals, agencies, or companies that might not otherwise be in contact or might not allow for communication of ideas. If a company's only interaction with a state agency is in a regulatory compliance manner, the sharing of innovative knowledge might not be encouraged, or even discouraged, for fear of compromising innovation capacity.

The reports encouraged networking in their recommendations, recognizing the need for partnerships and networking in order to push innovation forward. Networking increases the participants' innovative capacity (Pittaway et al. 2004), by pooling

resources and allowing for an increased long term knowledge base. For example, Report 1 suggests:

> In addition to supporting the Interstate Chemicals Clearinghouse's efforts in this area, Oregon may want to consider targeted stakeholder engagement (building on the work of the National Conversation on Public Health and Chemical Exposures); participation in developing scientific/technical collaboration networks to better leverage the capacities of different agencies to conduct certain types of scientific assessments; and development of an interagency federal-state task force (Tickner and Eliason 2011). [pg. 21]

Respondent 2 also recognized the value that networks provide, stating, "These types of collaborations help everyone to grow. And [are] especially catalytic if the people involved are experts and they have talents and they have networks." This demonstrates an understanding that through those networks, participants can reach out and incorporate additional perspectives and expertise if necessary, and can share those network connections with the collaborative infrastructure or advisory group – possibly enabling new, larger networks to be formed. So this initial collaboration provides a jumping off point to create further reaching networks. As Report 7 says:

> To ensure an integrated approach that maximizes the value of investment in green chemistry, we advocate for the formation of a statewide green chemistry resource "Hub". The Hub will build on the

existing work and partnerships in the state to help ensure Oregon's leadership in this emerging field. [pg. 21]

Report 3 recommends the formation of a conference, bringing in additional stakeholders to encourage the continued development of networks among Green Chemistry participants:

"A multi-stakeholder conference would educate a wide audience about the benefits of Green Chemistry; establish a venue for sharing successes, barriers, and strategies; and developing a network to support the Michigan Green Chemistry Program. The conference should highlight success stories uncovered in the development of the Green Chemistry resource clearinghouse and create opportunities for networking and leadership." [pg. 5]

Overall, the initial use of an advisory team provides a small scale network that can be built upon in future endeavors such as resource hubs, policy formation or implementation, or conferences. The structure of the group, that is the use of experts from multiple sectors in an open, dialogue-encouraging format, where they are asked to contribute to a group of diverse peers, is that initial foot in the door. The relationships built between participants can be utilized later, perhaps in an entirely different project or capacity, but it familiarizes those actors so that the burden of communication is lessened. Structures like this can be considered the introduction between sectors, where participants can leverage their personal networks in contributing additional

information, or bring in added perspectives that could not have been reached otherwise.

The formation of advisory groups on smaller scale projects could be used as a tool for larger projects where a larger network of perspectives is desired. Similar to establishing a conference recommended in Report 3, the initial advisory group could be used as a recruiting tool, providing a jumping off point for participants that could then branch out to their personal networks. It allows for more people and sectors to be included, invited, or at least made aware.

The advisory team structure encourages improved networking, as it allows for additional relationships to be pursued, linking together resources and perspectives that may not otherwise be formed. The value of networking and forming relationships is clear to the participants, as it is seen as one of the benefits of participating in the Advisory Team.

Knowledge sharing across sectors

Knowledge sharing across sectors combats a lack of information, a major barrier to Green Chemistry

In discussing the diverse participants involved in stakeholder representation, the networking capabilities of the current Advisory Team, and the significance that those themes have in future endeavors, a third theme came out of the data – the importance of knowledge-sharing across sectors and boundaries. This theme was evident in two discussion points, mainly as a crucial part in effective communication, and as a way to overcome a major barrier to Green Chemistry, lack of information or education. The two

discussion points are interrelated, as communication is a method of battling lack of information, and faulty communication can lead to a lack of information.

The future of green chemistry in policy was discussed, and respondents were asked to elaborate on the barriers and necessities, or improvements, they saw relevant. Barriers involved a lack of education or general knowledge of green chemistry, with Respondent 4 pointing out, "There's still a knowledge gap about the nature of green chemistry and its potential and opportunities that exist." Information on the potential opportunities, and even the basic science behind some of the technologies is not readily accessible or being utilized by consumers and businesses. In order for there to be a demand for the technology, spurring innovation, and encouraging industries to adopt practices, there needs to be a level of understanding throughout all sectors.

The reports echoed this sentiment, as Report 6 mentions the lack of information relevant to consumers, saying:

> The primary barrier to consumer-led growth in green chemistry is lack of information. Recent studies show that consumers are optimistic about green efforts, such as recycling, but have little or no clear information about the products they use on a regular basis. [pg. 10]

Similarly, Report 7 addresses the industrial consumers and innovators, stating, "The misconception that green products and processes are not cost-effective or have a lower level of performance can deter investment in green chemistry solutions" (pg. 15). This demonstrates that a general knowledge of the workings, opportunities, hazards, and

benefits is necessary across sectors. Another example of the business sector lacking sufficient information or support is found in Report 1, describing:

> The absence of adequate decision support tools and technical assistance to help businesses identify or develop effective substitutes for chemicals of concern makes it difficult for businesses to explore safer alternatives unless they have a relatively high level of technical assessment capacity in-house. As a result, some businesses are concerned about the potential negative economic impact if chemicals are restricted or banned without effective alternatives in place. [pg. 15]

The lack of information generates resistance and fear towards policy change, producing a barrier to collaborative discussions as businesses may fear the outcomes of regulatory efforts or divulging their research efforts to the competition.

All of the documents identified lack of information as a barrier to Green Chemistry growth and policy success. Lack of information is a barrier that affects multiple sectors, so by facilitating the communication of knowledge, as toxicological data, feasibility concerns, or even policy ideas, the sectors are able to relate and coordinate efforts. This also educates additional, potential contributors, as Report 1 says, "A lack of information regarding chemical uses and flows across the state weakens agencies' ability to prioritize chemicals of concern and limits the ability of consumers to incorporate considerations about chemical impacts into their decision-making." The information provided educates agencies and consumers, so that the responsibility of risk

management is incorporated into the individual's practices. The consumer can decide what products to purchase, and the agencies have a chemical risk understanding when designing regulatory policy. The overall effect is raising the standard of understanding, that no information should be left out of context, and the knowledge users are provided with the most current data possible. It is with this information that efforts can be made to seek out the most appropriate course of action across the topic of Green Chemistry.

Tackling the lack of information by taking advantage of current networks and collaborations, such as professional societies and existing research partnerships, could bolster educational efforts. Report 3 discusses building awareness:

> Green Chemistry is not well known or understood, there is uncertainty as to what researchers and companies are working on or teaching in Green Chemistry, and there are no mechanisms to communicate Green Chemistry efforts to others. Therefore, it is important that the DEQ Advancing Green Chemistry: An Action Plan for Michigan 2 articulate a clear and consistent description of Green Chemistry and its objectives. However, the success of this initiative is dependent upon the engagement of key constituency groups in the state to lend their support and resources to communicate the benefits of Green Chemistry for public health and welfare, the environment, and the economy. [pg. 2]

Even within these current collaborations, effective communication across boundaries and between sectors is still a challenge. There is a disconnect between the natural

language and focus in the isolated context of individual disciplines, and when they attempt to convene in an interdisciplinary format or impart knowledge from one discipline to another. Table 6, taken from Report 4, demonstrates the research priorities of varying disciplines, and shows how direct transition from one to another could be difficult. Due in part to that diversity in research priorities and ways of approaching research questions, initial communication and understanding can be obstacles, as pointed out by Respondent 2:

> We all don't have the same background, so it's a little bit slow trying to communicate initially. But, once you have enough time together if there are solid participants, that goes away pretty quickly.

Coming from diverse disciplines with different focuses, interests, and ways to relay information presents a hurdle, but nothing that cannot be overcome by continuing to establish connections and working to understand and collaborate with the other members. Making communication and knowledge-sharing a priority among the group combats the initial disconnect presented by coming from different disciplines. One way to facilitate this collective approach between disciplines is through the process of creating boundary objects.

Table 5. Comparison of Disciplinary Research Priorities

Discipline	Basic Research	Development	Implementation	Evaluation
Chemistry	High	Moderate	Low	Moderate
Chemical Engineering	Moderate	High	High	Moderate
Toxicology	High	Low	Low	High
Environmental Science	High	Low	Moderate	High
Public Health	Moderate	Low	Moderate	High
Business	Low	Moderate	High	Moderate
Public Policy	Low	Moderate	High	High
Sociology	Moderate	Low	High	Moderate
Science and Technology Studies	Moderate	Low	High	High

Basic Research: Research aimed at the discovery of new quantifiable phenomena that could lead to technology development. **Development**: Research aimed at creating new technologies with specific outputs. **Implementation**: Research aimed at elucidating the drivers and barriers for the adoption of new technology in industrial and societal settings. **Evaluation**: Research aimed at determining the effects of new technology on society, health, and the environment (Iles & Mulvihill 2012:5644).

Boundary object creation

The process of boundary object creation facilitates collaboration

The Advisory Team had a strong sense of what the group was brought together to accomplish, that is, utilizing the collective knowledge of the members to provide options and information on a course of action in the implementation of the Green Chemistry Executive Order through creation of a recommendations report. Respondent 5 described the process, saying, "It was more providing ideas and sort of suggestions to what a strategy might look like in terms of outreach and prioritization, again, sort of strategies, metrics, things like that." Similarly, Respondent 1 stated that, "Our charter

was to make recommendations on what steps the governor's office could take to expedite the implementation process of the green chemistry executive order."

Generating a recommendation to the governor's office, one of the clear objectives of the Advisory Team, was representative of a *boundary object*. Useful to all disciplines involved, it provides information on how other sectors perceive the incorporation of Green Chemistry unfolding, as well as forging potential collaborations for future efforts outlined in the report.

In addition to this report, the networks and relationships brought about by participation in the Advisory Team, if maintained, can create effective avenues for future boundary objects. For example, maintaining contact with another sector might provide the opportunity for a collaborative metric or report on a unified goal. Additional advisory projects may be undertaken to produce white papers or research reports that would equally benefit both sectors individually.

The nine reports all represent boundary objects, as the information provided is relevant to multiple sectors and disciplines. The data and recommendations offered can be utilized by the sectors independently, so that it is not simply an informative report meant for one discipline and useless to the rest. The roles and responsibilities for all sectors are often discussed, allowing for the continued transparency and flow of knowledge. For example, Report 2 divides up the possible actions into the sectors of education, industry, and government, and then demonstrates possible actions that can be taken by each sector. The boundary object provides a way to acknowledge all

potential contributions that can aide in change, not linking responsibility to a single sector. The boundary objects assist in coordinating multiple, often differing, perspectives in a way that aligns objectives and efforts. Report 8 illustrates this point by generating six policy recommendations that include varying parts that can be contributed by a specific sector, and collaborative efforts that would equally benefit participants:

> Improved pollution prevention at participating California facilities protects neighboring communities from public health impacts, protects the environment and improves worker and consumer safety (for examples see illustration on page 16). California businesses that adopt green practices enhance revenue with increased consumer demand for cleaner products and substantially reduce costs through more efficient resource use, reduced energy consumption, reduced liability and insurance payments, reduced regulatory burdens and reduced hazardous waste management costs. [Report 8, pg. 13]

This demonstrates a way in which multiple disciplines are benefited by businesses investing in Green Chemistry, such as the safety and health impacts for the community, but also the reduced regulatory burdens and costs that directly affect the business.

The process of creating boundary objects, that is an effort among diverse disciplines and representatives from multiple sectors to create a meaningful metric or data that can be used by all participants, facilitates collaboration.

Barriers to successful interdisciplinary collaboration were discussed in the nine reports. The desired diversity encountered in bringing together individuals or groups from varying disciplines proves to be potential barrier:

> Two barriers to successful interdisciplinary collaboration are (1) the differences in cognitive models and problem-solving processes that various disciplines rely on because of their professional training and practice and (2) the divergent research and problem-solving priorities that these disciplines have when studying technology related fields. These barriers often inhibit effective communication and transfer of information from one discipline to another. This results in information being lost along the path from basic science to technology development and eventual societal adoption of new products and processes. [Report 4, pg. 5644]

When bringing together varying perspectives and different disciplines, the strategies and approaches generally accepted by one, may not be as readily accepted by another. Similarly, the established priorities that push one discipline to participate in collaborations may not even be on the agenda for another. The key is to create a meaningful, motivating goal that resonates across industries, disciplines, and expertise. The process of creating the recommendations report, or other boundary objects, is an example. A large part of this relies on communication, in finding that commonality of

goals, research priorities, and flow of knowledge – all things perpetuated by the process of boundary object creation.

A lack of decision-making power

Lack of decision-making power is not a major constraint to the collaborative, advisory process

The advisory role was heavily stressed throughout the interviews. Respondents all mentioned a lack of power or authority, in that the information provided was not a policy decision or had any direct impact, but was a recommendation. Respondent 2 illustrated this, stating, "We weren't a decision making body, we weren't going to be the ones determining the direction of implementation." Another example was when Respondent 3 described the Advisory Team, saying, "Yeah, it was not a decision making group, it was more of an advisory committee."

This brought up the question of authority, and how that was represented in the group, if at all. Respondents did not identify an authority, other than the parameters outlined in the Executive Order itself. Respondent 5 specified, "The Executive Order had its own parameters" and later elaborated, "I think it was fine that [the Executive Order] was constrained in that way, because it actually made sure that we focused on things that actually are doable . . . it was a limitation that was nevertheless realistic to work within."

The reports all provided information in a way that could be utilized by the sectors individually, or in a collaborative effort to address a boundary-spanning issue.

While there were acknowledgements that in some arenas, certain disciplines are given more power, such as government in regards to regulations, there was no attempt to identify one, ruling authority. Instead, it was based on the stance that the success of Green Chemistry will require efforts from many sectors, and they all have contributions and responsibilities related to their discipline.

The strength of collaboration comes from the diversity of perspectives and experiences, culminating into a holistic, win-win approach. Collaboration and networking bring value to participants, as Report 7 exhibits, "Collaboration helps identify synergies, coordinate efforts, build resources and expertise, bridge gaps, identify needs and opportunities, and facilitate implementation" (pg. 16). While negotiations must happen in terms of fusing priorities, all participants are contributing and have something of value to offer. The lack of authority in terms of deciding power will not necessarily result in a failed collaboration. The collective approach to aligning resources and needs, identifying opportunities, and providing transparent information to the sectors alike can still successfully occur. A report or boundary object that suggests a certain approach does not automatically become policy, as it lacks the authority. Instead, the information can be utilized by individual sectors over areas where they have authority, or it can simply remain a collective recommendation that is used to encourage action. One such example is seen in Report 5:

> The non-profit sector has launched efforts to change public policy and encourage firms to transition to safer chemicals. The successful Health

> Care without Harm Campaign, a coalition of more than 400 environmental advocates, health professionals, and hospital organizations has worked with medical device manufacturers, hospitals, and purchasing agencies to encourage the substitution of potentially problematic chemicals used in the medical sector. [pg 7]

The non-profit sector does not have the authority to mandate the chemical substitution, but rather is utilizing the chemical information and collaborative network to encourage the change. The lack of authority does not negate the information, collaboration, or approach. It does not seem to be a greatly disrupting factor overall.

Boundary organization criteria represented in themes

The three criteria of a boundary organization are participation, accountability, and boundary object creation. In comparison to the emerging themes developed from the interview and report data, the criteria and themes share many similarities and overlaps. For instance, the multi-sector representation, networking capacity, and knowledge-sharing across sectors address the criteria for participation from multiple sectors. The accountability to both sectors, or all involved sectors, is evident in the improved networking capacity and lack of decision-making power themes. This is due to participants relying on their reputation and respected expertise to be involved in networks and form relationships with other participants. Also, despite the lack of decision-making power, participants are still providing information representative of

themselves and their sector, and are accountable to the sectors relying on their information. Boundary objects are represented in the collaborative recommendations report generated from advisory groups, and even the established dialogue avenue where information is imparted to multiple sectors and can be utilized by the individually or collectively.

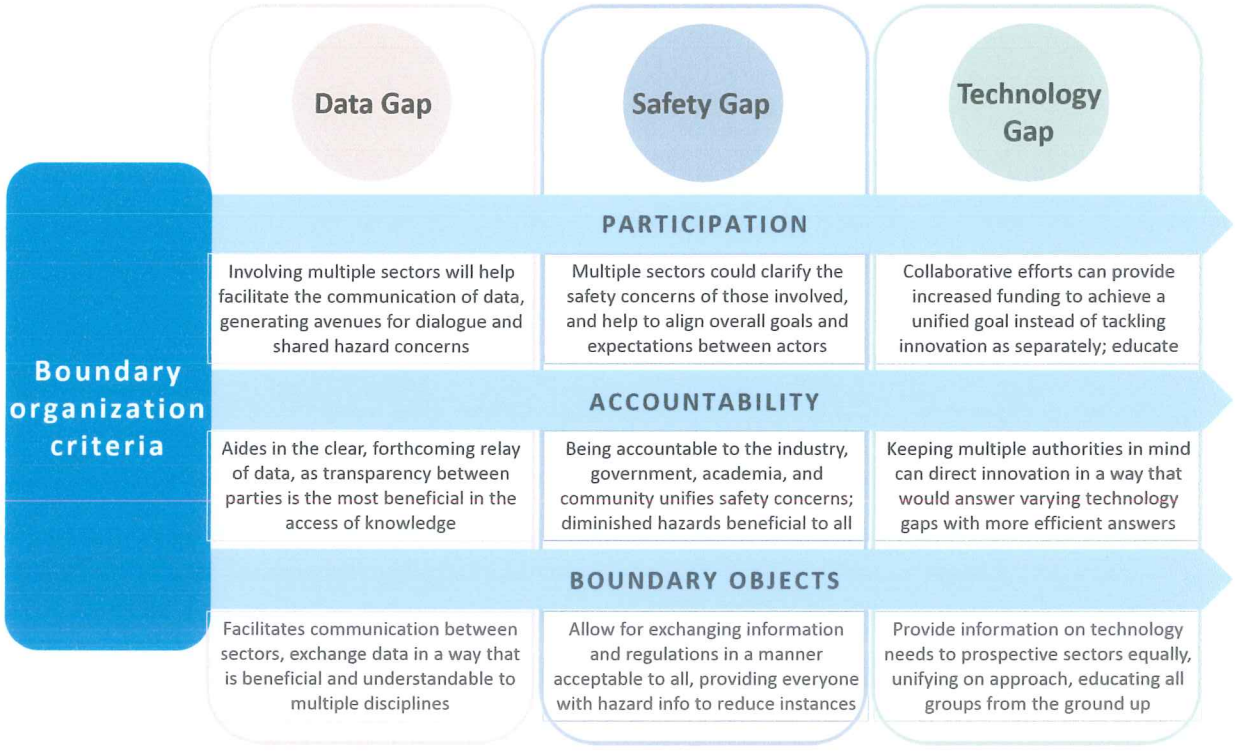
Conclusion

The aim of this study was to determine if the Green Chemistry Executive Order Advisory Team is acting as a boundary organization. By utilizing the three criteria of participation, accountability, and boundary objects put forth by Parker and Crona (2013), the Advisory Team was analyzed as a boundary organization by outlining the roles and objectives as described by members of the team along with the recommendations of the green chemistry reports. The Advisory Team meets the three boundary organization criteria, despite limitations in decision-making responsibilities and authority. The Advisory Team described the boundary organization characteristics in discussing objectives, roles, and structure, as there was participation from multiple sectors, accountability to the varying sectors, and production of boundary objects. Similarly, the Green Chemistry reports reflected similar sentiments that led to the five emerging themes in discussing the participants and recommended approaches to addressing Green Chemistry. The reports provided information on suggested participants, foreseen barriers, and solutions and recommendations. Additionally, the boundary organization criteria of participation, accountability, and boundary objects

were applied to the emerging themes, and found the concept of a boundary organization to be present as a means to achieving the recommended solutions.

Figure 7 demonstrates how the three boundary organization criteria can address the three policy gaps indicated as problems for the incorporation and implementation of Green Chemistry principles. The participation of multiple sectors can pool informative and safety data, improving understanding across boundaries, and spurring innovation to address the technology gap. Accountability generates higher efficiency in addressing the policy gaps, from transparency in data sharing, incorporation of the safety concerns of multiple sectors, and aligning innovative endeavors to address opportunities sought by multiple sectors. Lastly, the creation of boundary objects generates data, safety information, and innovative inspiration that is equally valuable and useful to all participants, demonstrating the capacity for many contributing efforts in attempting to meet Green Chemistry efforts. This aligns the structure and capacity of the Advisory Team with the recommended approaches set forth by the various Green Chemistry reports, suggesting the Advisory Team houses the potential for success in addressing the incorporation of Green Chemistry into policy.

Figure 7. Boundary organization criteria applied to the policy gaps facing Green Chemistry



By utilizing the structure and characteristics of a boundary organization, this and future advisory teams will have a common structure and role that will allow for better comparison and assessment of the policy needs and areas for improvement. The general expectations of a boundary organization doesn't restrict it to a certain discipline, and in fact encourages the involvement of multiple sectors. A boundary organization provides the necessary participation from multiple sectors, directed focus via creation of a boundary object, and the expertise expected from participants held accountable to the collaborative process necessary to address Green Chemistry incorporation.

RECOMMENDATIONS

Based on the themes that surfaced from the data, and the relevancy of the boundary organization criteria, several general recommendations are offered for consideration in furthering the successful incorporation of Green Chemistry into policy. In forming these recommendations, the main focus was to address some of the weaknesses evident in the three boundary organization criteria; that is, participation, accountability, and boundary objects.

First, the multi-sector participation was evident as government, industry, NGO, and academia were all represented in the interviews. Similarly, the reports identified the need for multiple sectors to provide input as there are many stakeholders of Green Chemistry. Bryson, Crosby and Stone (2006) mention the need for a facilitator within the

boundary organization to bring together the stakeholders and facilitate a dialogue between members. This was weakly provided through the initial creation of the Executive Order and identification of possible members, and then more informally carried out by a participating governmental agency member in spurring conversations between group members. In order to strengthen the implementation capacity, utilizing the stakeholder responsible for implementation, such as the Governor's Office, to act as a facilitator within the group and to provide feasibility on implementation processes is recommended. The inclusion of the implementers is also discussed in Bramwell and Sharman (1999):

> Gray contends that Acceptance of any solution is enhanced when those who must abide by it are included in designing the solution (Gray 1989:64). If the implementers are not involved, then the collaboration may be by-passed by other policy arenas (Reed 1997). In addition, the people who will implement a policy often provide valuable information about the likely practical issues of implementation. [pg. 396]

Including the implementers in the discussion, among the stakeholder groups, provides real-time feedback on practicality that can ultimately strengthen the applicability of the resulting boundary object or recommendations report.

In addition to the boundary organization members that are included in the meetings and discussions, employing a survey of the stakeholders prior to meeting could provide additional input without complicating the discussions of the boundary

organization by inviting a large number of people, possibly skewed in representation. The surveys could produce initial discussion topics, and allow for an understanding of where sectors overlap and disagree on certain stances pertaining to the policy question. The survey data could also provide a verification, or disprove, the information being provided by the boundary organization members. This would also address the accountability of members to the sectors and boundary organization.

The dual accountability required in a boundary organization, that is the accountability to both the individual's respective sector and to the boundary organization, could be improved upon in this Advisory Team. While it was addressed through the acknowledgement of relationship-building among members, the Advisory Team could benefit from increasing accountability through balancing expectations and aligning task performance (Huse 2005). Drawing from the suggested survey approach, the expectations of the stakeholders can be more prominent in discussions, and can better align with the tasks outlined in the Executive Order as well as the creation of a boundary object. This is through increased communication that develops more realistic expectations of the boundary organization, and holds the members accountable to both the individual sectors and the boundary organization (Parker & Crona 2012).

Another way to bolster accountability is through the continued formation and support of relationships. As DeLeon and Varda (2009) point out, "network ties will tend to form, regardless of the similarities among the participants; that is, the emergence of ties will be based on the policy topic at hand, with a tendency to draw together a

diverse group of stakeholders" (pg. 60). This demonstrates the capacity of a diverse group to form relationships based on the policy topic at hand, that is, Green Chemistry. Through this unified interest in the topic, not necessarily sharing the same perspective, a group can form relationships that will increase accountability to the other members, and through that, to the boundary organization as a whole. To support this relationship building, the facilitator could guide discussions in an inclusive format, allowing all members to share on the topic, which would provide an open dialogue and therefore foster equality between sectors and their perspective knowledge. Also, holding meetings regularly would provide interactions between members that could strengthen the relationships rather than maintaining just a stagnant point of contact. The continuous interactions could provide a familiarity that strengthens the relationships, and thus the accountability.

The boundary object of the Advisory Team, mainly the recommendations report, could be submitted for external review in order to gain perspective on the data from the respective sectors. This could be done through focus groups in the individual sectors, and providing insight into the stances of the Advisory Team's members. This process could allow for any initial concerns to be brought up and addressed in the group, and provide an avenue for knowledge-sharing across the sector boundaries. The sectors could provide additional comments on the approaches outlined in the boundary organization, as well as sharing the report information to the sectors in a way that provides a reactions time – they would be familiar with the overall direction and

information being provided, and could voice concerns in a manner that would allow the boundary organization time to react, and potentially edit the boundary object. This would also increase the accountability of the boundary organization member to their respective sector, as the sectors would be aware of missing input or incorrect information.

Limitations

Little prior research has been done on the advisory groups responsible for assisting in the development and implementation of policies concerning new technological advancements and potential regulations. The focus has a duality to it, as the question is limited in scope to Green Chemistry in Oregon as seen, or addressed, by one advisory group under the Green Chemistry Executive Order, but has much larger implications for the necessary groups and approaches in addressing wicked policy problems. The sample was very limited, and randomization was not feasible. Incorporating a case study approach for similar advisory groups' structures and outcomes would provide a more robust analysis.

Future Research

This project is poised at an exciting juncture, as the application of Green Chemistry principles through innovation and technological developments are still very new and will be a continued effort, and policy development is still in its infancy. As policies concerning Green Chemistry become more prevalent and have time to develop into boundary work projects, evaluation of quality and success could become a focus.

Hoppe, Wesselink and Cairns (2013) suggest "the quality of boundary work projects for policy makers can be evaluated by the degree to which criteria of *credibility* [emphasis in original] (technically adequate in handling of evidence), *legitimacy* (fair, unbiased, respectful of all stakeholders), and *salience* (relevant to the decision or policy) are simultaneously achieved for relevant stakeholders to the extent possible" (pg. 284).

Upon a more complete view of the Advisory Team's efforts and resulting recommendations report, comparison to other organization with similar structures and then similar objectives could provide insight in to the effectiveness of the Advisory Team's structure and approach. This could then be applied to other governmental settings, such as comparing the state to federal level effectiveness, and to other boundary-spanning policy problems.

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Appendix A: Interview question outline

Background in relation to green chemistry, and how you came to be on the Advisory team?

Describe the team's mission or main objectives?

Could you talk about what the Advisory Team is doing to make the mission/objectives happen? Perhaps projects?

What role does the Advisory Team play in the policy process, or where does it fit in the policy scheme/structure? Coordination with anyone? Do you report to anyone?

Are there any limitations that the Advisory Team faces?
Does the structure or organization of the Advisory Team hinder or limit their capabilities?

What do you think are some of the biggest barriers for a successful Green Chemistry policy, and what role does the Advisory Team play in overcoming those?

Appendix B: Email sent to potential interviewees

Dear _____,

I am a masters candidate in the Master of Public Policy program at Oregon State University's School of Public Policy. I am in the process of writing my master's thesis and am collecting data for that purpose. I had the pleasure of interning with Hewlett-Packard, and was afforded the opportunity to attend one of the Green Chemistry Advisory meetings this last year. That experience piqued my interest in Green Chemistry policy, and ultimately helped to formulate my thesis topic. I am interested in exploring the policy process surrounding Green Chemistry in Oregon, particularly the role of a group like the Green Chemistry Executive Order Advisory Team.

As a member of the Advisory Team and a professional well versed in the challenges facing Green Chemistry policy, I would appreciate the opportunity to talk with you in order to gain insight into the Advisory Team. The interview would be approximately 45-60 minutes in length, and if convenient for you, could be conducted over the phone.

If you have any questions or concerns, I am more than happy to discuss this further. My contact information is listed below. I am working with Dr. Denise Lach, Director of the School of Public Policy on this project. You may contact her directly with any questions at denise.lach@oregonstate.edu.

Please let me know if you are available to assist me with this project. I greatly appreciate your time and look forward to hearing from you.

Sincerely,

Anna Sherman

Appendix C: Bibliographic information of documents selected for content analysis

Allen J.H., & Dinno, A. (2011). Leadership in sustainable chemicals policy: opportunities for Oregon. Portland State University. http://www.pdx.edu/sites/www.pdx.edu.sustainability/files/media_assets/Chemical_Leadership.pdf

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Appendix D: Broad coding of interview data

	terms, "quotes" examples
Prior experience	
The discipline; such as science, policy, business	(regulatory) policy, government science, chemistry, environmental corporation marketing
Prior positions, jobs	researcher, director strategist
Green Chemistry	white paper sustainability green chemistry education
Prior interactions with or knowledge of Green Chemistry	
GCEOAT	
Role	"came and listened and said what we thought and just engaged fully in the process"
Mission, objectives	"to help inform the implementation process" "guide the work that the steering committee is doing, and that some agencies are doing" "to consult with universities, businesses, other interested parties" "the overall deliverable was a recommendation to the governor office of what steps to take next in the implementation of the green chemistry executive order"
Advisory	"it was not a decision making group, it was more of an advisory committee"
Make recommendations or next steps	"to make recommendations on what steps the governor's office could take to expedite the implementation process" "a recommendation to the governor office of what steps to take next in the implementation of the green chemistry executive order"
Lack of power	"we weren't a decision making body, we weren't going to be the ones determining the direction of implementation" "it was not a decision making group"
Expertise	
Provide	"so bringing experts in to cover the landscape"
Review of others	"providing that external perspective" "we serve as a sounding board "
Structure	
Members	
Type of members/membership	"there were local experts" "by having people from the community, experts from the community, to participate you get a much more targeted conversation and it enables you to be creative and innovative in the appropriate context" "bringing in a targeted group of people" "want some strategic people, you need a couple of leaders, you need some doers in addition to the talent pool and the expertise" "broader set of experts and so we convened this advisory group"

Authority, in charge	"the executive order had its own parameters" "more of a collaboration" "that it was constrained in that way, because it actually made sure that we focused on things that actually are doable"
Limitations	"lack of familiarity or education with each other's work" "we don't all speak the same language" "time to meet" "it was a limitation that was nevertheless realistic to work within"
Advantages/benefits	"one of the main benefits was [the team] has allowed the agencies to get the feedback in real time and not operate in a vacuum" "these type of collaborations help everyone to grow" "one of the strengths of our team is that it was diverse backgrounds" "the ability to engage with new people on this topic"
Collaboration	
Communication	
Methods of communication; facilitation of	Discussion dialogue "met face to face" "to start that process by building relationships"
Items communicated	"so we got everybody to get the same picture in their head of what we wanted the outcome to be"
Action	
Meetings	meetings phone calls "we had several brain storming meetings"
Deadlines	**
Outcomes	"able to forge strong relationships " "it enables you to be creative and innovative in the appropriate context" "educate a community of experts, but it builds bridges and trust and communication" "these types of collaborations help everyone to grow. And especially catalytic if the people involved are experts and they have talents and they have networks"
Future GC policy	
Barriers to GC policy	"there's also still a knowledge gap about the nature of green chemistry and its potential and opportunities that exist" "how do we tap that talent? How do we incentivize? How do we inspire?"
GC policy necessities, improvements	"identify an individual that understands the process and is willing to engage and help to teach and guide and collaborate with the group" "especially catalytic if the people involved are experts and they have talents and they have networks"

Appendix E. Boundary organization criteria codes applied to interview data

	Boundary Organization		
	Participation (policy, expert, multi-sector)	Accountability (to "both" sides, equally)	Boundary object (recommendations report)
Prior experience	exemplifies the diverse background of those participating multiple disciplines, sectors	rationale for joining, vested interest avenue for desired change or outcome voiced expertise, given experience collaborative	
The discipline; such as science, policy, business			
Prior positions, jobs			
Green Chemistry			
Prior interactions with or knowledge of			
GCEOAT			inform, consult and guide the implementation process; a recommendation [in the form of a report] to the govenor
Role			
Mission, objectives	and other organizations is indicative of		
Advisory			
recommendations or next steps			
Expertise	Experts, external perspective, people from the community, a broad set of experts/expertise not all of the same discipline		
Provide			
Review of others			
Structure			
Members			
Type of members/membership			
Collaboration		Communication of priorities, meetings to discuss and build relationships or networks. Networks based on interests and resources, members bring expectations from their agency/business/university positions which is equally important as they are accountable to their position as well as the advisory team reliant on their expertise.	
Communication			
Methods of communication; facilitation of			
Items communicated			
Action			
Meetings			
Deadlines			
Future GC policy			
Barriers to GC policy			
GC policy necessities, improvements	Diversity in participation		facilitates information equally

Appendix F: Data initially presented and discussed in categorical codes

INTERVIEWS

Prior experience

Interviewees were asked to state their current positions or titles, discuss their background and how they have been involved with or interacted with green chemistry. Each respondent had unique answers, meaning no one person had the same response or experience or expertise. This provided confirmation of a diverse membership, with varying expertise and interests. Disciplines or sectors represented included government and policy, scientific endeavors via industry positions or research and teaching, and marketing and regulatory positions within corporations.

All respondents had interactions, experience, or prior knowledge of green chemistry and green chemistry principles. Examples included authorship of or exposure to related publications, research in environmental sciences and chemistry, sustainability efforts within a company or through broader policy design, and seeking out a competitive advantage in an industry market through use and application of the green chemistry principles.

While there were responses indicating knowledge of the principles, the levels and sources of knowledge varied. Some were knowledgeable in the technical applications, such as product design and chemicals to avoid, while others were familiar with the policy efforts surrounding green chemistry-related topics like Design for the Environment (DfE), product life cycle assessments, and labeling regulations.

Green Chemistry Executive Order Advisory Team (GCEOAT)

To investigate the role of the Green Chemistry Executive Order Advisory Team, respondents were asked to describe the mission and/or objective(s) of the Advisory Team. The responses aligned in understanding of what the group was tasked with and aimed to accomplish. For instance, Respondent 3 described the mission in terms of providing information on possible courses of action, replying, "To help inform the implementation process." Similarly, Respondent 1 stated that:

> Our charter was to make recommendations on what steps the governor's office could take to expedite the implementation process of the green chemistry executive order.

The Advisory Team had a strong sense of what the group was brought together to accomplish, that is, utilizing the collective knowledge of the members to provide options and information on courses of action in the implementation of the Green Chemistry Executive Order. Respondent 2 and Respondent 3 both used "sounding board" as a description of the role of the Advisory Team.

All members mentioned the utilization or value of experts in the Advisory Team, culminating into a common understanding that expertise plays a significant role in the structure and objectives. Examples include:

Bringing experts in to cover the landscape. [Respondent 4]

[Ideas] developed in ground truths by a broader set of experts. [Respondent 3]

The use and importance of experts led to the discussion of overall membership, and the types of people currently involved or necessary. Respondent 4 mentioned the types of participants outlined in the Executive Order, stating:

> In the executive we were advised to consult with universities, businesses, other interested parties as part of our work.

In support of this, Respondent 2 mentioned:

> [You] want some strategic people, you need a couple of leaders, you need some doers in addition to the talent pool and the expertise.

A diverse group of individuals, with various expertise clearly adds value to the structure and capabilities of the Advisory Team according to its members. This provides criteria against which other group memberships can be judged, such that a group representing multiple sectors could provide a broader, perhaps more impactful evaluation and recommendation that a single sector.

An advisory role was also heavily stressed throughout the interviews. Respondents all mentioned a lack of power or authority, in that the information provided was not a policy decision or had any direct impact, but was a recommendation. Examples include Respondent 2 stating:

> We weren't a decision making body, we weren't going to be the ones determining the direction of implementation.

And Respondent 3, when describing the Advisory Team:

> Yeah, it was not a decision making group, it was more of an advisory committee.

This brought up the question of authority, and how that was represented in the group, if at all. Respondents did not identify an authority, other than the parameters outlined in the Executive Order itself. Respondent 5 specifies, "The Executive Order had its own parameters" and later elaborates:

> I think it was fine that it was it [the Executive Order] was constrained in that way, because it actually made sure that we focused on things that actually are doable.

The parameters of the Executive Order, mainly the focus on an advisory role rather than any decision-making power and the specificity of implementing the Green Chemistry Executive Order, provided the closest authority for the group.

The interviewees were asked if there were any limitations in relation to the Advisory Team. Two of the respondents acknowledged that the Executive Order parameters were a type of constraint, but in a beneficial way. Respondent 5 recognized, "it was a limitation that was nevertheless realistic to work within."

Another limitation of the team was due in part to the diversity of the membership, creating an obstacle in initial communication and understanding. This stems from diverse backgrounds and differing expertise

"We all don't have the same background, so it's a little bit slow trying to communicate initially. But, once you have enough time together if there are solid participants that goes away pretty quickly." [Respondent 2]

Coming from diverse disciplines with different focuses, interests, and ways to relay information presents a hurdle, but nothing that cannot be overcome by continuing to establish connections and working to understand and collaborate with the other members.

Following the limitations of the Advisory Team, respondents were asked what benefits or advantages there were within the structure. Participants viewed the collaborative structure and engaging with people as an advantage of the Advisory Team:

"These type of collaborations help everyone to grow." [Respondent 2]

"The ability to engage with new people on this topic." [Respondent 1]

One respondent even mentioned the efficiency with which agencies were able to get feedback, from people outside of a potentially closed off network, or in a manner that allows for additional, removed perspectives:

"One of the main benefits was [the team] has allowed the agencies to get the feedback in real time and not operate in a vacuum." [Respondent 3]

The advantages of the Advisory Team's structure are founded in the collaborative nature, engaging participants from varying disciplines and creating networks for knowledge sharing and flow of information. Bringing together a group where members are interested in hearing the expertise of another in order to add context and depth to their understanding.

The interviews provided insight into the role, structure, limitations and advantages of the Green Chemistry Executive Order Advisory Team. The role of the Advisory Team was established in discussing the objectives with members, mainly to inform the implementation process, supplying their given expertise, and providing advice without making decisions. The diverse membership brought with it the ability to generate creative solutions that otherwise might not be realized. The parameters outlined in the Executive Order provided both guidelines and slight limitations, but allowed for a focused approach. The benefit of the Advisory Team was the collaborative nature, allowing for members to interact with and be exposed to other sectors and expertise.

Collaboration

In the interviews, respondents discussed the collaborative nature of the Advisory Team. They were coded as methods and items communicated, and action items indicative of collaboration. For instance, Respondent 1 mentioned that the group "had several brain storming meetings, we met face to face as much as possible, or if we couldn't meet face to face some folks were always on the phone." Respondents discussed the outcomes of their collaboration in terms of relationships and networks built. Respondent 2 stated, "[You can] educate a community of experts, it builds bridges of trust and communication." Respondent 3 echoed the sentiment when they mentioned, "You are able to forge strong relationships" in discussing the opportunities that collaboration provided.

Future GC Policy

The future of green chemistry in policy was discussed, and respondents were asked to elaborate on the barriers and necessities, or improvements, they saw relevant. Barriers involved a lack of education or general knowledge on the topic of green chemistry, with Respondent 4 pointing out, "There's still a knowledge gap about the nature of green chemistry and its potential and opportunities that exist." Information on the potential opportunities, and even the basic science behind some of the technologies is not readily accessible or being utilized by consumers and businesses. In order for there to be a demand for the technology, spurring innovation, and encouraging industries to adopt practices, there needs to be a level of understanding throughout all sectors.

Other concerns dealt with the mobilization and functionality of continuing green chemistry application. Respondent 2 posed questions that motivate some of the Advisory Team's discussions, saying, "How do we tap that talent? How do we incentivize? How do we inspire?" Recognition of the types of people necessary to further the collaborative efforts and generate successful incorporation of Green Chemistry into policy was stemmed from those concerns, and became a common theme in the interviews. Respondent 2 continued, highlighting a need to "identify an individual that understands the process and is willing to engage and help to teach and guide and collaborate with the group."

The selection of people able to contribute, who have the knowledge base and skills to help navigate science and policy concerns, and can provide or create an extended network to tap additional resources is paramount to the success of a collaborative effort. Without strong contributors that have an expertise and information to offer, and bring a willingness to engage the other participants, the collaboration is not providing value to members or effectively addressing the policy questions at hand. The relationships established provide the avenue for a continued dialogue and information sharing.

Boundary Organization

Axial coding of the themes *participation, accountability,* and *boundary object* from the three criteria of a boundary organization, is represented by general themes presented in Table 5. *Participation* in the advisory team included many disciplines and experts with diverse backgrounds, representing many sectors. *Participation* was evident in discussing the structure and membership of the Advisory Team in the interviews. For instance, Respondent 2 said:

> By having people from the community, experts from the community, to participate you get a much more targeted conversation and it enables you to be creative and innovative in the appropriate context.

The value of utilizing experts and diverse members was recognized by the Advisory Team, and is a crucial point emphasized by Halffman and Hoppe (2005) in discussing boundary organization participation.

The importance of diverse participation was reflected in discussing the prior experiences of the Advisory Team members, with multiple sectors and varying technical understandings being expressed. Government, industry, and academia were represented as indicated previously in Table 1, showing the participation of traditionally separated spheres in a collaborative, advisory group.

Related to the boundary organization criteria of *accountability*, one aspect brought up in the interviews was the lack of clear leadership or authority. When discussing the limitations of the Advisory Team, Respondent 3 pointed out the potential for more apparent expectations, saying:

> I think there was also a leadership vacuum, that the advisory team could have been a lot more effective with a very clear charge and some very clear expectations and tasks from the governor's office.

This provides a jumping off point in creating future advisory groups, as delegating a clear authority or more precise expectations may strengthen the accountability between sectors. *Accountability* was also demonstrated in driving the respondents to participate in the Advisory Team, as there was a benefit to their prospective sectors, as well as contributing to the collaborative effort. This established accountability across sectors, and not to a single entity. In comparison to *participation* and *boundary objects*, the boundary organization criteria of *accountability* was not as clearly demonstrated in the interviews. The notion was more inferred in the way that participants are incorporated from a certain sector, and expected to engage and participate within the collaborative group, making themselves accountable to that unit as well.

Generating a recommendation to the governor's office, one of the clear objectives of the Advisory Team, was representative of a *boundary object*. Useful to all disciplines involved, it provides information on how other sectors perceive the incorporation of Green Chemistry unfolding, as well as forging potential collaborations for future efforts outlined in the report.

REPORTS

Scope

The scope of the reports chosen included state-specific applications (Oregon, Michigan, California, Minnesota), multi-state presentations (EPA Region 2), and broad industry considerations (chemical industry). Reports included policies, state directives, and green chemistry workshops as foundational in the assessments or initial formations. For instance, Report 8 references two such laws signed in California:

> Governor Arnold Schwarzenegger demonstrated his leadership on green chemistry policy by signing groundbreaking laws that will put into place two of the six recommendations in this report. AB 1879 (Chapter 559, Statutes of 2008) by Assemblymembers Mike Feuer, Sam Blakeslee and Jared Huffman requires DTSC to adopt regulations by January 1, 2011 to identify and prioritize chemicals of concern, to evaluate alternatives, and to specify regulatory responses where chemicals of concern are found in products. SB 509 (Chapter 560, Statutes of 2008) by Senators Joe Simitian and Ron Calderon requires an online, public Toxics Information Clearinghouse to be created that includes science-based information on the toxicity and hazard traits of chemicals used in daily life.
>
> A critical foundation for green chemistry policy has been established by the enactment of these important laws. [pg. ii]

The documents identified current, pending, and even potential policies or initiatives that provided the basis for the report, or could further the recommendations outlined within them. An example is seen in Report 5, highlighting progress in the European Union:

> The European Union is currently finalizing a new chemicals policy called REACH (Registration, Evaluation and Authorization of Chemicals), which will require data submission for most chemicals in commerce and restrictions for those of highest concern.

The acknowledgement of international regulations and policies shows the breadth of application when it comes to Green Chemistry, and how the regulations are adapting to account for hazardous chemicals.

Participants

Common across the reports is identification of necessary participants and players in order to achieve the objectives or recommendations. Indicative of this, Report 1 lays out the opportunities for Oregon to become a leading reformer in chemicals policy, then points out that, "Such an approach will take focused effort on the part of state

agencies and industry leaders,"[pg. 3] and later expresses the necessity of engaging "state agencies, universities, nongovernmental organizations, industries and the public" (pg. 16). Report 5 offers another example of a necessary participant, stating, "Advocacy coalitions are working within specific sectors to influence industrial and government policy towards safer materials" (pg. 7).

The reports included a variety of suggested participants, outlining the future roles that education, industry, and government can play based on structures and resources. It was pointed out that education can bridge the policy gaps by creating opportunities for students to learn, and informing the public and future workforce. Industries can capitalize on the competitive advantage of green chemistry, push innovation, and create safer workplaces and communities. Report 2 demonstrates the role of government:

> "Governmental organizations and their policymakers have mechanisms in place that are fostering green chemistry research and education. At the local, state and federal levels these programs can play a key role in prioritizing and promoting green chemistry and sustainable technologies support through grants and funding, and generate incentives to encourage innovation and adoption" [pg. 9].

The necessary participants mentioned in the reports hailed from multiple sectors, supporting the need for a collaborative approach. The recommendations required efforts from all sectors, some relying more heavily on one than another, such as the governmental organizations' role mentioned above, but no report identified one discipline or sector as the only critical participant.

Barriers

All of the documents identified lack of information as a barrier to Green Chemistry growth and policy success. Lack of information is a barrier that affects multiple sectors. Report 6 mentions the lack of information relevant to consumers, saying:

> The primary barrier to consumer-led growth in green chemistry is lack of information. Recent studies show that consumers are optimistic about green efforts, such as recycling, but have little or no clear information about the products they use on a regular basis. [pg. 10]

Similarly, Report 7 addresses the industrial consumers and innovators, stating, "The misconception that green products and processes are not cost-effective or have a lower level of performance can deter investment in green chemistry solutions" (pg. 15). This demonstrates that a general knowledge of the workings, opportunities, hazards, and benefits is necessary across sectors. Another example of the business sector lacking sufficient information or support is found in Report 1, describing:

> The absence of adequate decision support tools and technical assistance to help businesses identify or develop effective substitutes for chemicals of concern makes it difficult for businesses to explore safer alternatives unless they have a relatively high level of technical assessment capacity in-house. As a result, some businesses are concerned about the potential negative economic impact if chemicals are restricted or banned without effective alternatives in place. [pg. 15]

The lack of information generates resistance and fear towards policy change, producing a barrier to collaborative discussions as businesses may fear the outcomes of regulatory efforts.

Along those lines, barriers to successful interdisciplinary collaboration as a whole were discussed in the reports. The diversity housed in bringing together individuals or groups from varying disciplines proves to be potential barrier:

> Two barriers to successful interdisciplinary collaboration are (1) the differences in cognitive models and problem-solving processes that various disciplines rely on because of their professional training and practice and (2) the divergent research and problem-solving priorities that these disciplines have when studying technology related fields. These barriers often inhibit effective communication and transfer of information from one discipline to another. This results in information being lost along the path from basic science to technology development and eventual societal adoption of new products and processes. [Report 4, pg. 5644]

When bringing together varying perspectives and different disciplines, the strategies and approaches generally accepted by one, may not be as readily accepted by another. Similarly, the established priorities that push one discipline to participate in a collaboration may not even be on the agenda for another. There is a disconnect between the natural language and focus in the isolated context of individual disciplines, and when they attempt to convene in an interdisciplinary format. Table 6, taken from Report 4, demonstrates the research priorities of varying disciplines, and shows how direct transition from one to another could be difficult. The key is to create a meaningful, motivating goal that resonates across industries, disciplines, and expertise. A large part of this relies on communication, in finding that commonality of goals, research priorities, and flow of knowledge – all things perpetuated by the process of boundary object creation.

Solutions, Recommendations

The recommendations and proposed solutions for the incorporation and success of green chemistry had overlapping tones throughout the reports. Capitalizing on the diversity participants, forming collaborations across disciplines, and coordinating efforts and priorities were general themes represented. Report 1 demonstrates this, stating:

> Oregon can best leverage its limited resources, address priority areas of concern and advance the state's economic competitiveness by taking an integrated approach that engages government agencies, industry, nonprofits and individuals around a set of shared goals. Such an approach will require coordination that enables entities to share information about chemical use, hazard and exposure. It would also require clear mandates, authorities and resources to enable state agencies to implement key strategies and actions. Most important, Oregon has the opportunity to harness innovation and improve its economic competitiveness by engaging in cooperation and partnerships. [pg. 15]

The call for cooperation and partnerships was echoed in Report 7, which says, "Collaboration helps identify synergies, coordinate efforts, build resources and expertise, bridge gaps, identify needs and opportunities, and facilitate implementation" (pg. 16).

Tackling the lack of information was also suggested throughout the reports. Taking advantage of current networks and collaborations, such as professional societies and existing research partnerships, could bolster educational efforts. Report 3 discusses building awareness:

> Green Chemistry is not well known or understood, there is uncertainty as to what researchers and companies are working on or teaching in Green Chemistry, and there are no mechanisms to communicate Green Chemistry efforts to others. Therefore, it is important that the DEQ Advancing Green Chemistry: An Action Plan for Michigan 2 articulate a clear and consistent description of Green Chemistry and its objectives. However, the success of this initiative is dependent upon the engagement of key constituency groups in the state to lend their support and resources to communicate the benefits of Green Chemistry for public health and welfare, the environment, and the economy. [pg. 2]

Uniting varying sectors provides a collective hub for knowledge-sharing and distributing information across boundaries. Utilizing dialogue-encouraging events such as research grants, research seminars, conferences and workshops will generate networks and relationships that will provide additional avenues for the flow of knowledge to further combat lack of information. Furthermore, cross sector efforts can unite goals, identifying needs and opportunities that can benefit all interested parties, and push forward in seeking out win-win scenarios.