LESSONS IN BUILDING COMMUNITY CAPACITY FOR MANAGING AGRICULTURAL PESTS: A SCIENCE POLICY EXPERIENCE IN IOWA

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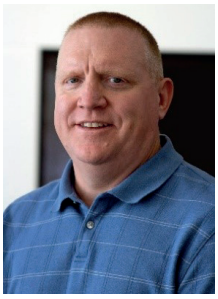

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Synopsis

The innate mobility of insects, pathogens, and weeds means that their management cannot be addressed fully by individuals acting independently (Patterson *et al*. 1999). Pests can spread quickly and widely via multiple channels (i.e. air movement, contaminated equipment, manure, irrigation, wildlife, grain movement, etc.) (Beckie *et al*. 2019; Ervin & Frisvold 2016; Patterson *et al*. 1999). For this reason, successful pest management initiatives commonly share a strong element of community coordination (Ervin & Frisvold 2016). However, fostering and coordinating these efforts is a highly complex and often difficult process. Drawing on the Center for Food Integrity's Trust Model (Sapp *et al*. 2009; CFI 2020) and literature on social dilemmas, the Weed Science Society of America and the Entomological Society of America organized a community coordination activity to address agricultural pest resistance issues. The Science Policy Experience took place in August 2019 at multiple sites across Iowa. The Experience was held in conjunction with the Iowa Pest Resistance Management Program and the Harrison County Iowa Herbicide Resistance Management Project. From this, we report lessons learned regarding the voluntary coordination of local community engagement and the need for broad stakeholder involvement as foundational requirements for successfully managing agricultural pests. Specifically, we address the critical elements that made the Experience successful, including the diversity of attendees, opportunities for relationship building, and the participation of community leaders and expert facilitators. We conclude with a list of suggested minimum requirements that future community coordination events should follow.

Keywords: Insecticide resistance, herbicide resistance, Trust Model, integrated pest management

Pest management is increasingly recognized as an area where socio-economic barriers exist that slow or prevent significant changes in adoption of new or integrated strategies, calling for a new thought paradigm for integrated pest management (IPM) (Dara 2019). Herbicide-resistant (HR) weed management, for instance, is now understood to be a collective problem, or social dilemma, which requires collaborative community engagement (Bagavathiannan *et al*. 2019). Herbicide-resistant weeds, like other pests, cannot be confined within an agricultural field, a farm, an agricultural region, or even a managed non-crop environment, meaning that neighboring farms, counties, or regions are highly connected to one another (Ervin & Frisvold 2016).

A recent successful example of the coordinated action of communities and broad stakeholder involvement to address a devastating insect pest was pink bollworm (*Pectinophora gossypiella*) management in Arizona (Tabashnik *et al*. 2019; Sims 2001). A second example is codling moth (*Cydia pomonella*) management in pears (Farrar *et al*. 2016); a third is the Palmer amaranth (*Amaranthus palmeri*) Zero Tolerance Program in Arkansas (Barber *et al*. 2015). One of the keys to success in all of these area-wide control programs was the use of diverse management tactics that were deployed in a socially organized and collective fashion, relying on multiple decision-making bodies operating across vertical and horizontal networks (Shaw *et al*. 2020). Extensive collaborations among

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private technology suppliers, growers, state and federal agencies created a new social construct for pest management for each example.

These examples, while encouraging, are relatively few and far between, demonstrating the limited extent of attempts to coordinate voluntary community-based efforts to manage resistant, mobile pests. There are multiple barriers that discourage community-based management; for instance, farmers have been found to be reluctant to collaborate on HR weed management for a variety of reasons including techno-optimism (the belief that new herbicides are being developed), values of individualism, frustration with neighbors who do not use best management practices, and more (Schroeder *et al*. 2018; Dentzman & Jussaume 2017). Additionally, critical stakeholders like industry and academia sometimes complicate community collaboration with inconsistent messaging.

Regarding HR management, recent findings suggest community engagement increases farmers' use of Integrated Weed Management (IWM) practices (Dentzman 2018). As an example, the community-led Zero Tolerance Program in Arkansas made significant gains in a county plagued with HR Palmer amaranth (Barber *et al*. 2015). While there is little empirical research on the barriers and bridges to community HR weed management, a handful of articles draw on some general principles of community-based (CB) approaches to suggest the conditions necessary for such an approach to develop and succeed. There is some overlap in these suggestions and they can be grouped into nine general principles (Appendix A) based on recommendations from Shaw *et al*. (2020), Bagavathiannan *et al*. (2019), Ervin *et al*. (2019), Ervin & Frisvold (2016), Hurley & Frisvold (2016), and Lasley & Chase (2017). These principles include:

1. raising awareness of the need for community-based management
2. engaging diverse actors
3. setting clear community boundaries
4. recognizing farmer and community differences and needs
5. establishing shared goals/values through active communication
6. recognizing individual contributions and struggles
7. allowing the community to govern itself
8. starting simple with tangible targets
9. monitoring progress.

Taken together, this suite of design principles can aid in the establishment and utilization of CB pest resistance management initiatives.

The 2019 Science Policy Experience: Collaborative Approach to Resistance Management

(hereafter referred to as the 'Science Policy Experience' or 'Experience') was aimed primarily at developing four of these principles: #2 (involving a diverse set of actors), #3 (allowing community to lead itself), #4 (recognizing diverse needs by hearing everyone's voices), and #5 (establishing shared goals and values). In order to achieve this goal, the Center for Food Integrity (CFI)'s Trust Model (Sapp *et al*. 2009; CFI 2020) (Appendix A; Figure 1) and its implications for collaborative learning was utilized.

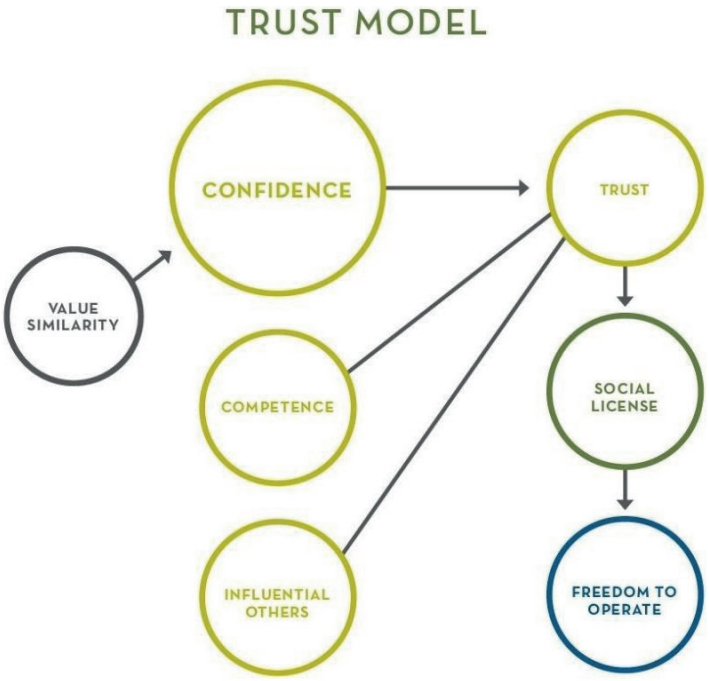

Figure 1. Center for Food Integrity (2020) Available at: https://www.foodintegrity.org/research/consumer-trust-research/trust-model/

The Trust Model describes three primary elements that build trust among groups of people and which can be translated into effective working partnerships. These elements are confidence (shared values and ethics), competence (skills and ability) and influential others (family, friends, and credible individuals). Confidence and building recognition of shared values are key to the Trust Model. Specifically, the Model posits that ethical questions are often more important to decision-making than fact-based questions about science and economics. Furthermore, it suggests that changing behaviors is fundamentally tied to building shared values through a process of listening, asking, and sharing.

In the Trust Model, the first key to behavior change is to listen without judgement. Second, you acknowledge what you have heard and ask questions that show you are open to conversation and will work to understand others' viewpoints. Finally, you may share your perspective through the lens of your shared values. Only then should you convey what you know (facts) about the issue at hand. This allows goals to be constructed collaboratively, among diverse groups, based on trust and shared values. Shaw *et al*. 2020 recently recommended that we need to build human management skills associated with pest technology stewardship. Their point is that, depending upon the pest control challenge, leadership within a community needs to consider the relevant socio-economic conditions and include important "trust relationships" in building a team.

Taken together, the literature on community-based management and the CFI's Trust Model suggest that communication is key to managing pest resistance, especially at the beginning stages of community formation. In particular, a diverse set of stakeholders must first be assembled. Inclusivity of stakeholders is critical to informing any CB pest management program (Shaw *et al*. 2020). The stakeholders must

Figure 2. Attendees at the Science Policy Experience pose for a picture in front of a field trial in Logan County, IA testing different herbicide resistance management practices.

listen to each other and ensure that everyone's voice is heard. Insightful questions based on mutual understandings should be asked and perspectives shared to create shared goals and values. We draw on these principles to evaluate the structure and outcomes of the 2019 Science Policy Experience as an early-stage effort to facilitate community-based formation and management of these "wicked problems"—that is, problems to which there are no definitive and objective solutions (Jussaume & Ervin 2016; Rittel & Weber 1973).

The Science Policy Experience grew out of the Science Policy Field Tour Concept, which was developed by the Entomological Society of America (ESA) in 2018 (Siebert *et al*. 2018). The goal of the Program was to be "a model for how a professional society can serve as a leader to create an unbiased platform for addressing issues and play an advocacy role when work done by scientists impacts issues affecting the public" (Siebert *et al*. 2018, p. 1). Based on this program and the CFI Trust Model (Sapp *et al*. 2009; CFI 2020), the Science Policy Experience was coordinated by the ESA, Weed Science Society of America (WSSA) and the United States Department of Agriculture (USDA) as an opportunity to address pesticide resistance in a dialogue including scientists, policy makers, and the public.

The Science Policy Experience took place August 6th–7th, 2019 in Harrison County and Ankeny, Iowa. It was held in partnership with the Iowa Pest Resistance Management Program (IPRMP) and the Harrison County Iowa Herbicide Resistance Management Pilot Project (Figure 2). The Experience was organized in a workshop format separated into morning and afternoon programs with presentations and participatory exercises on the community management of key pest organisms.

There were a total of 81 attendees from a diverse array of institutions, professions, and perspectives. Represented were farmers, commodity grain associations, industry, retailers/distributors, universities, local, state and federal government, non-governmental organizations (NGOs), and agricultural lenders (including land equity firms). Representation spanned local, regional, and national scales including local farmers from Harrison County and staff from the United States Department of Agriculture and Environmental Protection Agency from Washington DC. For a complete agenda see Appendix B.

The first day of the Experience focused on Local Community Learnings, beginning with an overview of the Harrison County community herbicide resistance management project, followed by a panel discussion with individuals involved in the project. A field tour (developed by the Harrison County community) brought participants to a demonstration plot showing various herbicide use best management practices. Over lunch, participants listened to a talk on Iowa land valuation (presented by the People's Company) that highlighted the economics of farmers' decision-making process.

For the afternoon exercise, breakout groups with at least one representative from each major category of participants were created. Each group was then asked to complete three tasks. First, each person listed all of their 'titles' –both professional and non-professional. Non-professional titles are those that friends and family use for individuals (e.g. dog lover, sports enthusiast, family mediator, comedian, mother, father, brother, or sister, for example). Second, each group was asked to share why they came to the Experience. Finally, members of each group collectively attempted to define why pesticide resistance is such a "wicked problem". The breakout groups then shared their results with the rest of the participants. At the end of the day, participants took a guided tour of Mr. Larry Buss' farm (Figure 3).

Figure 3. Mr. Larry Buss, a well-known farmer in the area and a key leader of the Harrison County Herbicide Resistance Management Program, shares his experiences and expertise.

Table 1. Day One-Breakout Group Summary.

Group #	# of Titles Identified		Why are you here?					Problem Definition			
	Professional	Personal – Non-professional*	Learn	Network, Bridge disciplines	Develop support for communities	Passion for the issue	Obligation	Anthro-pogenic	Agro-nomic	Chemical	All
1	13	32	✓	✓	✓			9	11	6	0
2	1	9		✓	✓		✓	6	4	1	1
3	30	15	**					7	3	1	0
4	12	17	**					9	5	6	0
5	4	13	✓	✓	✓		✓	4	2	1	0
6	11	23	✓	✓	✓	✓	✓	13	7	2	0
7	5	15	✓		✓	✓	✓	8	3	0	0
8	8	13	✓	✓	✓	✓	✓	39	9	1	3
Totals	84	137	5	5	6	3	5	95	44	18	4

* Non-professional titles included personal identities such as church leader, community gardener, dog lover, etc.

** Groups 3 and 4 did not respond to the 'why are you here' question

The second day of the Experience, held in Ankeny Iowa, began with the WSSA and ESA presenting societal positions on resistance management. This was followed by a suite of case-study presentations describing four current examples of both herbicide and insecticide resistance successes and failures based on community responses to pest problems. Dr. Paul Lasley (Iowa State University) then made a presentation on "community structure". He explained that communities form and take action based on three key elements: 1) strong local leadership; 2) trust among group members, which leads to cooperation, and 3) recognition of the need to embrace change to improve the future. He then presented a "Model for Community Change" (Lasley & Chase 2017). The last presentation of the morning was by Roxi Beck of the CFI and she focused on the Trust Model described above. Following this presentation, Beck led the group in an exercise putting the Trust Model into practice.

The breakout groups from the previous day were reassembled and each represented a cross-section of specific stakeholder categories. Each individual group contained one member from 8 groups: University Scientists, Farmers, Industry/Manufacturing, Commodity Grain Groups, Government, NGOs, Local Community Groups, and Agricultural Retailers/Advisors. Each group was assigned a stakeholder category and asked to answer two main questions; 1) What values do you share with this stakeholder group? and 2) What do you want this stakeholder group to understand, believe, and do? They were then asked to identify three elements from their answers to question 2 that they believe are the most important to managing pest resistance moving forward. Again, each group answered each of these questions internally before sharing with the rest of the groups.

The participants were then reorganized into groups representing their stakeholder categories (e.g. all participants from universities were placed into a single group) to discuss and prioritize the three most important action items among the list of items identified by the earlier exercise. For instance, all participants from universities would assemble into a group and discuss the three most important action items identified for University stakeholders on a national scale. Each individual participant was then asked to create a personal action plan with specific steps for themselves and their stakeholder group. However, due to time constraints, this final process did not take place. Instead, each individual was asked to quickly write down a few actions they would take in the coming months. Participants also received a survey asking them to rank and provide feedback on each element of the Experience, describe what they liked the most, identify areas for improvement, and leave any other comments.

We first present the results of the exit survey, followed by the group activities on days one and two. According to the exit survey, attendees ranked the opportunities to dialogue across the diverse breadth of stakeholders as the most valuable portion of the Experience. The Harrison County project overview and Q&A session, Roxi Beck's presentation on the "Trust model", and the resource information in the packets also received high rankings by participants. The group breakouts and the field tour received the lowest marks, although these were still relatively high with an average rating of 4 on a 5-point scale.

When asked what they liked most about the Experience, the most common answers were the groups' diversity and the opportunity to communicate and share perspectives or ideas openly. Specifically, attendees mentioned camaraderie and collaboration, connecting with people outside of their immediate network, exchange of ideas, broad discussion across diverse groups, the formation of networks, open communication, stimulation of different thinking, comparison of regional problems, and hearing a diversity of ideas as their favorite elements of the Experience. Roxi Beck's presentation on the Trust Model was also cited several times as a highlight of the Experience.

Attendees were also asked how the Experience could be improved. Common responses included making the case-study presentations shorter, either eliminating or improving the field tour, and including more stakeholders from disciplines underrepresented in the Experience, such as producers and equipment manufacturers. Time management was also an issue – attendees particularly wanted more time at the end of the meeting for devising the action plan, and more unstruc-

Table 2. Day Two-Shared Values Summary.

	Profit/Economic Sustainability	Environmental Sustainability	Scientific Knowledge	Farmer Well-Being	Community Service	Additional Categories
University	✓		✓		✓	
Farmers	✓	✓	✓		✓	Independence
Industry/Manufacturing	✓		✓	✓		Seen as leader
Commodity Groups	✓	✓	✓	✓	✓	Seen as leader
Federal Government		✓		✓	✓	Practical application of laws
NGOs	✓	✓		✓		Safety/security of food system
Community Groups	✓	✓			✓	
Ag Retailers/Advisors	✓	✓		✓		

tured time between activities. This downtime was cited as necessary for unstructured open dialogue and networking.

The first day's breakout groups answered three questions: what are your titles, why are you here, and why is pesticide resistance a problem (Appendix A; Table 1)? Each breakout group listed an average of 49 titles, with 62% of those unrelated to their profession - -i.e. titles such as church member, parent, dog lover, etc. The main reasons listed for attendance were to develop support for constituents; learn, network and bridge disciplines; and develop their community. Some also mentioned that they attended the Experience because of their passion about the issue or because they felt obligated to attend. Relevant to this last point, all participants from the various stakeholder groups received personal invitations to attend (except the graduate students, who applied to their societies for attendance). There were three broad categories of causes identified for pesticide resistance - anthropogenic, agronomic, and chemical. 59% of all listed causes were anthropogenic, while 27% were agronomic, and 11% chemical. A few groups also listed the interaction of these domains as a fundamental cause of pesticide resistance.

The second day's breakout groups answered two main questions about their assigned stakeholder category (Appendix A; Tables 2 and 3), the first of which was 1) What values do you share with this stakeholder group? Across all groups, Profit/Economic Sustainability was the most frequently mentioned shared value, followed by Environmental Sustainability. By grouping responses thematically, we identified an additional three value categories: Scientific Knowledge, Farmer Well-Being, and Community Service (see Table 1 for a breakdown). Additional shared values that did not fit into these categories included practical application of laws, safety/security of the food system, independence, and being seen as a leader.

After identifying these shared values, groups answered question 2) What do you want this stakeholder group to understand, believe, and do? They then ranked their answers, identifying the top three most important elements (Table 3). Common themes included increasing collaboration and communication across diverse networks, being involved with and supporting community-led efforts, being open to continual learning, and acting on/researching solutions for resistant pest management. Unfortunately, time ran out before stakeholders from each category could reconvene to give input on the most important actions for their own stakeholder community. All stakeholder groups, however, have heard the recommendations and many have since acted on the advice given.

According to feedback from attendees, there were several critical elements that made the 2019 Science Policy Experience successful. These elements could be used in designing future events aimed at early-stage community formation (Appendix A; Table 4). They included 1) the diversity of stakeholders present, 2) the opportunity to network, exchange ideas, and build relationships, and 3) the presence of community leaders and expert facilitators. This indicates that all four community management design principles the Experience was focused on developing (involving a diverse set of actors, allowing the community to lead itself, recognizing diverse needs by hearing everyone's voices, and establishing shared goals and values) were seen as important and considered useful by attendees. These principles also contributed to building shared values and ethics, a central component of the CFI's Trust Model. Below, we review each of the critical components identified by attendees along with suggestions to facilitate their inclusion in event planning.

Table 3. Day Two- Top Stakeholder Priorities

	Priority #1	Priority #2	Priority #3
University	Modernize/give more resources to extension	Collaborate across disciplines and stakeholder groups	Improve relationship with industry and government
Farmers	Advocate/be involved	Keep learning	Implement BMP's/diversify IPM
Industry/Manufacturing	Open communication	Research	Prioritize issue over competition
Commodity Groups	Survey membership about pest resistance management (knowledge, concerns, BMPs)	Act as liaisons between universities and groups	Play critical role in community-based resistance management
Federal Government	Be involved/be part of the community	Enable/encourage locally led groups	Provide funds
NGOs	Involve external groups in planning	Tell us if we aren't practicing what we preach	Don't just focus on problem - work on/propose possible solutions
Community Groups	Attend field days, share their knowledge	Participate, partner, and listen	Use their network to share/spread the resistance management message
Ag Retailers/Advisors	Identify early warning signs	Offer alternative approaches for pest management	Develop stewardship enabling programs

Table 4. Critical Elements of the Success of the 2019 Science Policy Experience

Element	Key Actions	Relevant Community-Based Management Principle(s)
Diversity of attending stakeholders	• Plan event with diversity in mind • Involve diverse planners in the early stages • Draw on planners' existing social networks and relationships • Poll potential attendees on what groups should be there	2 (Engage diverse actors), 4 (Be aware of farmer/community differences and needs/actors)
Opportunities to network, exchange ideas, and build relationships	• Assigned seating to create diverse discussion groups • Planned group activities based on identifying shared values/goals • Unstructured time to network	2 (Engage diverse actors), 5 (Establish shared goals/values through active communication/communicators)
Engage community leaders and expert facilitators	• Recruit local farmers/others with experience in community engagement • Design interaction, Q&A with local experts • Recruit experienced facilitators to encourage networking • Limit academic-oriented presentations	2 (Engage diverse actors), 3 (Allow community to lead/govern itself)

First, the diversity of stakeholders in attendance was greatly appreciated by the participants and central to the success of the event. Obtaining a commitment to attend from these stakeholders was a function of significant outreach and planning on the part of the organizers. Existing social networks and relationships were also imperative, as demonstrated by the remarkably common refrain of "[Name] invited me, so I felt obligated to come". Having a diverse planning committee with strong positive community relationships should therefore be considered a critical element to planning future community management events. It will also be necessary to initiate planning with a diversity of attendees in mind as a central goal. Considering attendees' feedback on the underrepresentation of certain stakeholder groups, such as equipment manufacturers and a wider breadth of agricultural producers, it may be useful to poll potential attendees ahead of the meeting to ascertain what stakeholder groups they feel should be in attendance. This recommendation reflects that of Shaw *et al*. (2020) who recommended engaging "...inclusive stakeholder groups that might have a vested interest in the outcome of any community stewardship developments". The heterogeneity of crop production situations may alter the composition of stakeholders based on locally diverse production, environmental, and socio-economic conditions (Shaw *et al*. 2020).

Second, networking among diverse stakeholder groups was key to the attendee's enjoyment and sense of utility of the Experience. Strategically assigned seating to create groupings of diverse stakeholders functioned well to facilitate these interactions. Additionally, the first-day group activity acted as an icebreaker, demonstrating to attendees that they have many common identities and values. In particular, the elicitation of non-work identities (community gardener, nature lover, etc.) acted to draw together individuals with diverse and sometimes conflicting professional interests. Providing additional opportunities for networking in a less structured way was one of the main suggestions for improving future events. Therefore, we suggest that a combination of structured networking and opportunities for unstructured communication are necessary for a successful community development event.

Third, attendees identified presentations, workshops, and Q&A sessions with community leaders and expert facilitators as a highlight of the Experience. In particular, attendees listed hearing from farmers involved in the Harrison County Project - especially the leader Larry Buss - as highly valuable for understanding the importance of community-based management. They also cited Roxi Beck's presentation on the Trust Model as one of the most useful and interesting elements of the Experience. The case studies on historical and current pest resistance problems rated slightly lower, with recommendations to reduce the length of the examples. The "scientific analyses" were not well received by the broader set of stakeholders. Rather, hearing from local, on-the-ground experts with experience in coordinating community action should be prioritized when available. Additionally, enrolling experts in facilitating respectful dialogue and stakeholder communication appears to be vital. Overly jargonistic academic presentations, however, may not be as highly valued and should be kept to a minimum.

Finally, one key component intertwined with the above three elements is to provide a mechanism to break down the barriers between stakeholder groups by creating a personal identity for each group. We especially recommend describing and introducing the Trust Model in each and every event so that all participants may recognize that they share common values. A quote from Theodore Roosevelt, "No one cares how much you know, until they know how much you care", was shared during the workshop and drives home the core meaning of the Trust Model. Once a community recognizes that they share common values, common goals can be developed and create action toward a common purpose. Roxi Beck emphasized that we need to stop persuading, correcting, and educating and start listening, asking, and sharing. Fiduciary responsibilities (i.e., ethical relationships built on shared values) have been found to be 3 times more important in building trust than sharing facts or demonstrating competence/expertise (Sapp 2009). Indeed, Experience participants clearly felt that the root cause of pest resistance development is more anthropogenic than technical (agronomic or chemical based) in nature (Table 1), highlighting the need to address human relationships as key to pest management.

The success of the Science Policy Experience was the result of significant effort and planning. We hope that the principles identified and expanded upon in this paper will streamline the planning process for future community pest management development efforts. In particular, the lessons drawn from the Experience are applicable to early-stage community formation events. Key elements include the diversity of attendees, structured and unstructured opportunities for dialogue and networking, and the inclusion of local experts and facilitators. These are directly related to principles for community development we identified from academic literature on this topic; specifically, principles #2 (involving a diverse set of actors), #3 (allowing community to lead itself), #4 (recognizing diverse needs by hearing everyone's voices), and #5 (establishing shared goals and values). The relevance of these principles suggests that 1) there is an order of operations to the nine management principles we identified (Appendix A), with communication and relationship building occurring early on, and 2) the principles not in operation at the Experience will become relevant as community management initiatives mature and evolve. Therefore, while we emphasize design principles for beginning community management development, additional principles may be more applicable depending on where specific communities are in their process.

Notes

Appendices A and B are available from the corresponding author.

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