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Short communication

Using a team survey to improve team communication for enhanced delivery of agro-climate decision support tools

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ABSTRACT

In the Midwestern United States, where a third of the world's maize crop is grown, there are few decision support tools available to help farmers and their advisors plan for an uncertain climatic future. Developing tools that are actually useful and usable to agricultural decision makers necessitates an interdisciplinary team of climate scientists, agronomists, computer scientists, and social scientists. With such diversity come varying levels of engagement (e.g. co-project director, student, technician, etc.) and experience working with farmers and/or serving in an official Extension capacity. Therefore working together to address this challenging issue is not straightforward. This paper reviews how a survey of a large interdisciplinary team working on developing decision support tools to ensure resilient maize production in this region identified differences between team members and helped improve team functioning and communication. Specifically the team survey revealed some important differences in how team members perceive farmers' use of climate information, the types of decisions that should be addressed with a tool, and how such tools should function. These differences can be primarily explained by disciplinary background and project role and have provided valuable opportunities to learn from each other and build consensus on decision support tools developed. The survey as a feed-back tool complements other team communication approaches and reminds the team of the need for continuous communication and frequent discussion of assumptions.

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1. Introduction

> *"Interdisciplinary science entails the collaboration of scientists with largely nonoverlapping training and core expertise to solve a problem that lies outside the grasp of the individual scientists."* (Cech and Rubin, 2004, p. 1166)

Adapting agriculture to future changes in climate will require technical innovation, robust management strategies, and the integration of climate knowledge into decision making (Walthall et al., 2012). Commonly referred to as the Corn Belt, the North Central Region (NCR) of the United States accounts for about 88% of total U.S. corn production and provides nearly one-third of the global corn supply (United States Department of Agriculture – National Agricultural Statistics Service (USDA-NASS), 2011; United States Department of Agriculture – Foreign Agricultural Service (USDA-FAS), 2012). Though sufficient data are available to create better adaptive models for this region, there are gaps in our understanding of how different farm management decisions and practices can be used to increase resilience to climate variability and change while maintaining economic viability. Furthermore, currently available tools and models are not meeting producers' needs in the NCR, and little is known about the types of information farmers would like to access.

In order to develop tools that could address agricultural needs in the NCR, an interdisciplinary team was funded by the United States Department of Agriculture (USDA) Agriculture and Food Research Initiative (AFRI) in the spring of 2010. This 58 member team has now been working together on a project called "Useful to Usable (U2U): Transforming Climate Variability and Change Information for Cereal Crop Producers" for over three years in an intentionally interdisciplinary manner. This paper outlines how the team used a survey early in the project to identify and reconcile different opinions and beliefs about the project's trajectory. This survey, combined with frequent in-person and telephonic communication, served to ensure that a diverse and interdisciplinary team was able to facilitate achievement of common objectives which is not an easy task in interdisciplinary teams.

Interdisciplinary, multidisciplinary and transdisciplinary are all used in the literature to describe research that covers more than just one discipline. We follow Hicks et al. (2010) in using the term interdisciplinary as "the production of research which crosses disciplinary boundaries" thus covering all these forms (p. 465). The literature on interdisciplinary teams suggests that this type of work is not easy for a variety of reasons, including: publishing difficulties and concerns about the tenure and promotion system at universities (Daily and Ehrlich, 1999; McConnell et al., 2011), power imbalances (Campbell, 2005), lack of understanding of what different disciplines do (Campbell, 2005; Massey et al., 2006), and different language, terminology and research approaches (Jacobs and Frickel, 2009; Massey et al., 2006). Adding to these difficulties, stakeholder-driven research is particularly resource intensive (in terms of both time and money), difficult to sustain over long periods, and presents issues with the politicization of science (Dilling and Lemos, 2011). Notably, diverse team members may define problems differently which makes it difficult for a team to work cohesively together (Anders and Mueller, 1995; Hoogendoorn, 1998). Beyond these challenges of working across disciplines and with stakeholders, the size of a team is also an issue; the larger the team, the greater the differences in terms of roles, positions and experiences. As roles proliferate, hierarchical issues emerge between team members with different levels of seniority in the university setting (from full professors to students) (Müller, 1998).

While large interdisciplinary teams are somewhat new in the United States, they are not new in international development. The literature on international teams suggests that there is a need for teams to "mature" in order to work effectively together (Butler, 1998, p. 205), and it is difficult for team members to reach a shared understanding (Massey et al., 2006). Massey et al. (2006) discuss their experiences with a five person team and note that their first challenge was to identify and discuss differences; they did through an in-depth "talking through" (p. 136). In projects like U2U that are funded to accomplish a specific task, there is not time for this maturing to occur before work begins in earnest nor is it practical to engage in an in-depth conversation between over 50 team members to see what differences emerge. Another finding from this literature is that not only do disciplinary differences lead to communication difficulties; they also lead to different research interests and goals (Hoogendoorn, 1998; Müller, 1998). These findings suggest the urgency of resolving any fundamental differences in project purpose between team members early in a group process. We do not believe any other team has conducted a survey like ours (or if they did, they have not reported on it publically). However, Anders and Mueller (1995) report using the Analytic Hierarchical Process (AHP) to help structure discussions with an interdisciplinary team focused on cropping systems research. The purpose of this short communication is to highlight how the survey benefited the U2U team so other teams might benefit from a similar approach.

2. The project and process

In large interdisciplinary projects, the tendency is for people to compartmentalize by discipline to produce parts of the whole. The whole is cobbled together but is not necessarily enriched by the diversity of perspectives included in the entire project. In contrast, the Useful to Usable (U2U) project was intentionally designed to be integrated from the beginning. The overall goal of U2U is to have resilient and profitable farms in the NCR under an increasingly variable climate (see Fig. 1 for a map of the study area). This goal is being undertaken over a five year period with five objectives:

Objective 1: Conduct climate and crop modeling to determine where climate science can inform decision making;

Objective 2: Understand needs and interests of target audience, including both farmers and farm advisors;

Objective 3: Integrate climate modeling results with needs of target audience to develop decision support tools (DSTs) that they will find useful and usable;

Objective 4: Disseminate these tools across four pilot states and evaluate their uptake and effectiveness, with tool modifications as necessary; and

Objective 5: Disseminate tools and resources across the entire 12 state NCR.

Objective 1 is led by a group of climate scientists/climate modelers who are developing gridded crop models to look at the impact of climate and management scenarios on crop productivity and profitability. Objective 2 is led by social scientists who have conducted surveys of agricultural producers and their advisors (Arbuckle et al., 2013; Prokopy et al., 2013). This group has also conducted focus groups of both producers and advisors as tools are being developed to ensure their usefulness and usability. Objective 3 is jointly led by an agricultural economist and a climatologist with expertise in DST development. Objectives 1–3 working groups, though led by a majority of one discipline, each contain members of different disciplines and research/extension appointments. Objectives 4 and 5 have only started recently and are led by an agricultural economist with a substantial extension appointment.

The original project team comprised 22 co-project directors (co-PDs) located at 10 universities. As co-project directors added individuals to the project, it has now grown to 58 contributors as of June 2014, including 21 co-PDs, a project manager, technicians, graduate students, postdocs, and a 15-person advisory committee. Graduate students, staff and postdocs are all considered to be full team members and engage in team meetings, conference calls and email communications. Communication among all project participants is regular, frequent, and occurs in various formats. The full team and advisory committee

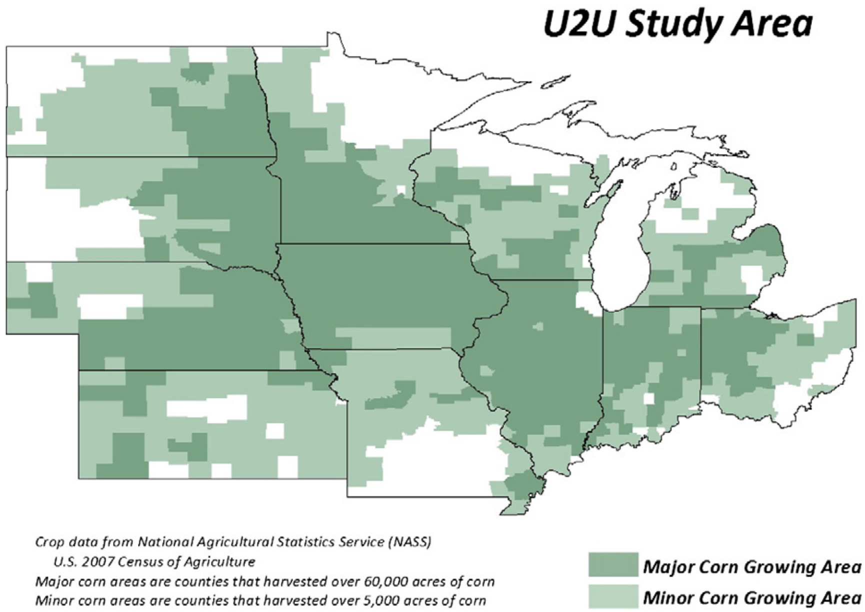

Fig. 1. Map of study area.

gather in person annually for a two day meeting to assess progress over the past year and plan work for the upcoming year. This meeting includes breakout sessions for objective working groups and facilitated full team discussions that allow different disciplinary perspectives to inform DST development. Objective working groups host an additional 1–3 in-person meetings throughout the year as needed. Objective working groups also hold separate monthly conference calls to advance their specific goals. Monthly full team conference calls provide an opportunity for working groups to coordinate and stay informed of each other's work. Additional conference calls with ad hoc subgroups and individual phone calls take place as needed. Email and web are also common methods used for communicating and sharing resources. Several listservs have been developed for easy access to working groups, the full team, and the advisory committee. An internal collaboration website has been developed using the “group” feature within the HUBzero™ platform (see http://www.hubzero.org).

Despite these attempts at frequent communication, we knew we could not do the type of open-ended in-depth communication about paradigms and team goals that smaller teams can do (see, e.g. Massey et al., 2006). In early phone calls, the project leader started worrying that perhaps the team did not all share the same thoughts about how tools developed in the project would be used. It seemed as if people were bringing their own disciplinary agenda and assumptions to the conversation and were not really listening to what others were saying. She knew that as a social scientist, she was certainly bringing her own disciplinary perspective to where she thought the team should go and she wanted to better understand others' perspectives in order to develop products that truly helped the agricultural community. She realized that it would be beneficial to understand this in order to promote a conversation about the project's direction. She decided to survey the team to see if we were all actually on the “same page” in regard to the overall direction of the project. This paper reviews the results of this survey and how differences between team members that were highlighted with the survey were used to foster improved communication and, hopefully, more meaningful and relevant DSTs. The research questions addressed with this survey are: (1) Were there significant differences among team members regarding project priorities and directions and (2) How can survey data be used to foster improved communication over time?

3. Methods

In May 2012 before the second annual full team meeting, an online survey of the full team and advisory committee (hereafter referred to as “team members”) was conducted. At the time the survey was conducted, no substantive efforts had been undertaken to do any cross-disciplinary communication although there had already been one annual meeting and numerous team conference calls. The survey was intended to serve as a baseline before efforts to develop decision support tools ramped up. The survey questions analyzed here asked team members for their beliefs about the influence of weather information on farm decisions, the usage of various weather-related tools by farmers, the types of information new DSTs should provide to farmers, and the amount of interactivity that should be built into new DSTs. Several of the survey questions were written by members of the U2U team for inclusion in surveys conducted with farmers and farm advisors for Objective 2 and were extensively pre-tested (Arbuckle et al., 2013; Prokopy et al., 2013), but additional questions were written by three social scientists (two of them agricultural economists) on the team for the express purpose of this team survey. These three social scientists spent considerable time both on email and phone discussing the form of the questions to ensure the collection of useful data (full text of the questionnaire is available in the supplementary material). It was not possible to pre-test the survey as there was no useful comparison group. The survey was built using Qualtrics software. A link to the survey was distributed by the project leader and project manager over email using team members who were asked on multiple occasions to complete it. Completion of the survey was voluntary and no individually addressed emails were sent. In total, 33 team members completed the survey (out of 59 people who received it). It is possible that some of the project members who were not involved in the day-to-day decisions chose not to take the survey as they did not believe these were their decisions to make. No attempts were made to check for non-response bias; despite the relatively low response rate, the survey results provided useful insights and the survey served its purpose in instigating communication. The degrees of freedom in estimating the statistical significance of the differences are limited. In many cases, there was broad agreement among team members, but there were several exceptions. For this discussion, we highlight differences at the 10% significance level.

The survey was constructed to test four different dimensions that were hypothesized to have the potential to impact opinions about the project trajectory: (a) the individual's contact with farmers on climate information, (b) Extension versus non-Extension appointments, (c) the disciplines across the team, and (d) the role of the individual within the team. These four dimensions were chosen because they were hypothesized to have a bearing on team members' perspectives. Individuals having more contact with farmers and individuals with Extension appointments were expected to have more of an interest in topics with a practical application to farmers. The issue of Extension is especially interesting as USDA is strongly promoting "integrated" projects that include an extension component. Different disciplines were expected to demonstrate some disciplinary bias in answering questions, but were also expected to highlight strengths/weaknesses in current scientific knowledge and the gaps in knowledge among the disciplines. Co-Project Directors were expected to have more consistent viewpoints than newer team members such as students and technicians. Also, the survey provided guidance to the team, showing the differences between the advisory committee and other team members. This is especially important as a report from the advisory committee is one of the key measures USDA will use to determine the success of the project.

4. Results

Table 1 presents results for select survey questions where there were significant differences between team members across one of more of the distinguishing dimensions. A quick scan of the table shows that the majority of differences were across disciplines and role in the project. There are fewer differences based on whether the team member has experience talking with farmers about climate information and Extension role. There are a number of questions with high levels of 'don't know' answers as indicated by the sample size for each question. Below, the differences between the discipline and role in project dimensions are discussed; given the few differences with talking with farmers and Extension role we do not focus on those dimensions.

4.1. Discipline management (dimension 3)

Developing usable tools that actually get used requires the expertise of several disciplines. The following discussion highlights some of the differences within the team that fall along disciplinary lines. As noted in Table 2, not all disciplines have the same experience talking to

Table 1
Select questions from survey, means, and presence of significant differences across factors.

Survey question	Answer options	Mean (n)[h]	Significant differences at 0.10 level			
			Talk to farmers	Extension	Discipline	Role in Project
Please answer the following questions:	Ranked from definitely (1) to no (3)					
Should our tools allow a user to log in with their specific location information?		1.3 (33)				Y
Should our tools give users environmental implications of a variety of management scenarios?		1.2 (32)			Y	Y
Should our tools help farmers know when to apply nitrogen for maximum profits?		1.2 (32)			Y	
Should our tools help farmers make long-term investment decisions (e.g. tiling and irrigation)?		1.2 (31)			Y	
What short term decisions should we be helping farmers address?	Ranked from highest priority (1) to lowest (7)					
Nitrogen application		2.4 (31)		Y		Y
Planting dates		2.1 (31)			Y	
Crop insurance		3.7 (31)			Y	
Grain drying		5.0 (31)			Y	Y
What short term decisions are we actually able to help with?	Yes (1); No (0)					
Nitrogen application		0.88 (25)			Y	
Planting dates		0.88 (25)	Y		Y	
Variety selection		0.76 (25)			Y	
Crop insurance		0.44 (25)			Y	
Grain drying		0.64 (25)	Y		Y	
What long term investment decisions are we actually able to help with?	Yes (1); No (0)					
Tiling		0.88 (24)			Y	
Irrigation		0.88(24)			Y	
Equipment complement		0.54 (24)			Y	
What types of decisions can the climate models we're developing help with most reliably?	Short-term/single season (1); mid-term/2–3 years (2); long-term (3)	1.70 (23)	Y			Y
Which of the following management practices do you think our tools should allow users to test in different scenarios?	Yes (1); No (0)					
Crop rotations		0.77 (30)				Y
Tillage		0.63 (30)				Y
Use of irrigation		0.67 (30)			Y	
What climate-related information should our tools specifically address for the region?	Yes (1); No (0)					
Frost/freeze risk					Y	Y
Extreme heat risk					Y	
Growing degree days					Y	Y
Soil temperature				Y		Y
Soil moisture			Y			Y
Humidity				Y	Y	Y
How interactive should our decision support tools be?	Highly interactive (1); somewhat interactive (2); not interactive(3)	1.57 (33)		Y	Y	Y

Table2
Comparison of disciplines and talking to farmers.

Discipline	Talk with farmers re climate			
	Yes	No	No response	Total
Social scientist	2	8	1	11
Economist	3	1	0	4
Climate scientist	6	2	1	9
Crop modeler/Agronomist	2	3	0	5
Other	1	3	0	4

farmers. For instance, the majority of economists and climate scientists had talked with farmers about what they would like to know in terms of climate information. Though both discipline groups had talked with farmers, they had significant differences in their initial opinions on what the project should emphasize.

4.1.1. Social scientists versus economists

It should be noted the authors recognize that economics is a form of social science, but since the economists on the team have a unique role they are categorized separately in this analysis. The social scientists ranked a crop insurance tool much higher than the economists. The economists indicated a stronger belief that tools could be created for nitrogen application (100% versus 55%), variety selection (100% versus 36%) and irrigation (100% versus 55%). The social scientists provided more support of specific tools for historical humidity (45% versus 0%) and seasonal projected humidity (45% versus 0%). The social scientists were also much more supportive of highly interactive DSTs, where the economists favored somewhat interactive tools (Table 1).

4.1.2. Social scientists versus climate scientists

The climate scientists were much more optimistic than the social scientists that planting date (100% versus 45%) and grain drying (89% versus 27%) DSTs could be created. The climate scientists more strongly supported creating DSTs for long-term investments, such as irrigation and tiling. The climate scientists felt users should be allowed to examine various scenarios for irrigation (89% versus 27% of the social scientists). The social scientists indicated stronger support for seasonal projected frost/freeze risk DSTs (82% versus 22%), while the climate scientists indicated stronger support for DSTs focused on historical frost/freeze risk (89% versus 45%) and historical extreme heat risk (89% versus 36%) (Table 1).

4.1.3. Economists versus climate scientists

The economists placed a higher emphasis on the tools evaluating profit potential than the climate scientists. The climate scientists felt more strongly that specific tools should be developed for long-term projected frost/freeze risk (44% versus 0%), long-term projected growing degree days (44% versus 0%), and historical humidity (78% versus 0%). The climate scientists were also more supportive of more highly interactive DSTs (Table 1).

4.1.4. Climate scientists versus crop modelers/agronomists

The agronomists placed a higher emphasis on the tools evaluating profit potential. The climate scientists rated grain drying as a higher priority than the crop modelers did (Table 1).

4.2. Role management (dimension 4)

Project roles (e.g. co-project director, student, technician, etc.) come with varying levels of responsibility, engagement, and influence. Therefore, understanding differences due to role is essential for successfully building a common vision.

4.2.1. Co-PDs versus students/technicians

The co-PDs felt more strongly than students and technicians that tool users should log in with specific location information. The students and technicians felt more strongly that the tools should give users the environmental implications of various scenarios being analyzed by the DSTs. The co-PDs placed a higher priority on developing a nitrogen application DST and indicated a stronger belief that the project should help farmers with grain drying decisions (61% versus 25%). The co-PDs indicated a greater preference for developing a tool to specifically address long-term projected humidity (23% versus 0%). But the students and technicians were more supportive of highly interactive DSTs (Table 1).

4.2.2. Students/technicians versus advisory committee members

The students and technicians rated grain drying higher as a target for a DST than did advisory committee members. And advisory committee members rated nitrogen application higher than the students/technicians. The students/technicians felt more reliable tools could be developed for mid-term (2–3 years) issues, while the advisory members had more reliability in short-term (single season) DSTs. As with the co-PDs, advisory committee members also indicated a stronger desire to allow users to test various scenarios in crop rotations (100% versus 67%) and tillage practices (100% versus 50%) within the DSTs. The students/technicians felt stronger about developing a specific tool for historical soil temperature (50% versus 0%) and that the DSTs should be highly interactive. The students differed from both the co-PDs and advisory committee members on the interactivity of the tools and the choice to develop a tool for the nitrogen application decision (Table 1).

4.2.3. Co-PDs versus advisory committee members

The advisory committee members felt the most reliable tools would be short-term (single season), whereas the co-PDs indicated more reliability in mid-term (2–3 years) DSTs. Advisory committee members also indicated a stronger desire to allow users to test various scenarios in crop rotations (100% versus 69%) and tillage practices (100% versus 46%) within the DSTs (Table 1).

There were considerable differences between the co-PDs and advisory committee members on a specific target for DSTs. The co-PDs rated grain drying higher than did advisory committee members. Thirty-one percent of the co-PDs indicated the need for a long-term projected frost/freeze risk tool, whereas none of the advisory committee members did. Seventy-seven percent of the co-PDs indicated the need for a historical soil temperature tool. Again, none of the advisory members supported this. Specific tools for historical soil moisture and atmospheric humidity were supported by 69% of the co-PDs, but only 17% of the advisory members (Table 1).

5. Discussion

For a project like U2U that has team members with many disciplines, roles and appointments, a key to success is to understand the viewpoints of each team member (Hoogendoorn, 1998). The survey was taken near the beginning of the project and revealed several differences of perspective across all four dimensions, but primarily around discipline and role in project. Being aware of these differences enabled subsequent team discussions during annual full team meetings and objective-specific meetings to highlight and reconcile these differences. It is also worth noting that the number of team members who were willing to admit they “didn't know” an answer to a question indicates both the range of skills and backgrounds in a project like this and also team members' willingness to defer to others on topics about which they do not have a lot of experience. It is also important to point out that the survey results were anonymous and so no one person was made to publicly feel that they were “wrong” in their beliefs and this further enabled an open discussion around the topics.

At the annual team meeting immediately following the survey, the survey results were presented and differences were discussed not only during that portion of the meeting but in additional portions focused on direction and tool development. At that meeting, the team reached consensus that immediate efforts should focus on short-term decisions: nitrogen application and variety selection. The team has also moved forward with tools designed to assist famers with planting date decisions – a topic for which only one discipline (Other) suggested a different opinion than the rest of the disciplines.

The team decided not to focus on crop insurance and marketing tools that are affected by weather information. While other disciplines tended to rank crop insurance a high priority, all of the economists ranked it as low priority. This led to a helpful discussion in which the economists explained to the rest of the team members that crop insurance is already widely used across the Corn Belt. Therefore, insurance-related decisions are not likely to be meaningfully affected by new DSTs since most producers have already made what would be considered the most appropriate risk management decision (purchasing insurance). After this explanation the rest of the team was convinced not to focus on crop insurance. It is fair to say that before this explanation, the non-economist team members believed they understood crop insurance more than they actually did. After realizing how much they did not know, the non-economist team members asked to learn more and shortly following the annual meeting, one of the agricultural economists conducted a webinar about crop insurance for the entire team which further broadened everyone's understanding.

A final consideration in deciding tool development priority is confidence in the team's ability to successfully create tools that will make a difference. The Objective 3 team chose to work on those short-term decisions that most of the full team and the advisory committee believed were achievable. Note that while the team survey helped to determine the project trajectory, we also conducted extensive survey and focus group work with farmers and their advisors. This also helped to determine the course of the project within the confines of what the team felt it could actually accomplish in a meaningful way.

It is impossible to know what would have happened to the team without the survey as there is clearly no comparison group. However, evidence from internal evaluations conducted in the two years since the team survey reveal that team functioning is still high with little conflict. In April 2013 and January 2014, the project evaluator interviewed 22 and 29 team members, respectively. In both rounds, the two most common responses regarding how the project was going overall were (1) praising the project's leadership and (2) praising the team (over half of team members interviewed proactively discussed this). Quotes that embody the team praise include “There is good camaraderie and the team is very engaged.” and “I really like the environment and think this group in particular has done really well interacting, because it's not easy when you have a multidisciplinary group like this that looks at the world differently.” In the second round, all but three team members interviewed gave very positive or positive ratings regarding how the project was going overall. Nearly one-third proactively commented positively about project communication. One team member said, “I've always been interested in how well the social scientists and climatologists have worked together on this project. I've been on other multidisciplinary projects where things haven't gone so smoothly. This will be one of the standout features of this project when it's done – that we have close connection between physical and social scientists not seen on other projects.” As the survey, and subsequent discussions, led to increased synergy in goals across these different disciplinary groups, it is highly likely that these outcomes would not have been achieved without it.

6. Conclusion

As discussed earlier in this paper, a number of issues make interdisciplinary work difficult. Conducting a survey of team members early on in the project helped the U2U project avoid some of these issues by enhancing opportunities for communication around what different disciplines do (Campbell, 2005) and different language, terminology and research approaches (Jacobs and Frickel, 2009). We believe that conducting the survey and using it as a means to foster discussion has made interdisciplinary communication more sustainable over the long-term and thus addresses one of the concerns of stakeholder-driven research articulated by Dilling and Lemos (2011). Surveys like this could be used to address other issues associated with interdisciplinary projects such as differences in promotion and tenure requirements and power imbalances.

This particular survey revealed some interesting differences among the team members on this large interdisciplinary project. Despite many efforts to facilitate communication and build rapport, these differences only emerged through an online survey. It is quite possible that if this survey had not been done, work would have progressed with different team members working toward different (unstated) ends which would lead to less than maximally effective outcomes. It is very difficult in these types of projects to ascertain whether team members are or are not on the same page with regard to the overall end product when each individual is working just on their piece of the puzzle the majority of the time. The results from this survey reveal the importance of taking stock of a large diverse team periodically to assess whether everyone has the same vision – when the same vision is not held, communication around this is essential.

A survey by itself, of course, is not enough for successful team functioning. In the case of U2U, the survey was just the beginning of opening lines of communication that has made discussions around different perspectives straightforward and non-confrontational. The survey enabled this ongoing discussion because team members realized we could not just assume that others necessarily agreed with them. Large interdisciplinary projects such as U2U need frequent communication that includes some amount of “face time” to build collegiality. This is especially important as teams grow and transform over time.

At the beginning of the project, before much work had been done, it was a reasonable assumption that team members would have shared similar goals (as many of these were outlined in the grant proposal) and yet the survey showed we did not. As the project evolved and the team changed over time, it is clearly important to continuously and explicitly revisit project goals and overall direction especially as team composition changes over time. For U2U, this is done by revisiting the project's overarching logic model at each annual meeting and modifying this as necessary. The results of the team survey reinforced the need to continue doing this even though it is not necessarily the most stimulating discussion. The team survey was not sufficient to replace frequent team meetings and communication as advocated by Hoogendoorn (1998) but it did help to direct those team communications in more useful avenues.

In conclusion, large interdisciplinary teams can benefit from being very purposeful in their intra-team communication and to never assume that everyone shares a collective vision. Revisiting the vision and desired goals frequently is beneficial. Furthermore, doing a survey or some other means of data collection (such as in-depth interviews or using Analytic Hierarchical Process) can be an excellent way to assess where differences of opinion exist that might not be otherwise discernible until products are developed that do not meet everyone's expected outcomes.

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Appendix. Supplementary material

Supplementary data to this article can be found online at doi:10.1016/j.agsy.2015.05.002.

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