From Contests to Communities of Practice: Designing for Effective Feedback Exchange in Online Innovation Contests

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Abstract

Online innovation contests are an increasingly popular tool that organizations are using to find breakthrough solutions to problems in a variety of social, scientific, and business domains. By posting a specific challenge and a monetary prize on the internet, they attract large and diverse crowds of people to propose new ideas, in hopes of surfacing one or a few outstanding winners. However, prize-centered contest designs are inefficient at leveraging participant contributions and producing high-quality ideas. Competitive winner-takes-all systems inherently do not reward the majority of ideas, which discourages participants from contributing their earnest efforts, both during and after contests, especially if they lose or believe they may lose. The result is that most online innovation contests produce a disproportionately large number of low-quality ideas. As such, these inefficiencies demonstrate a need for new contest designs to better leverage participant contributions towards more effective innovation processes.

In this dissertation, I address these inefficiencies by exploring an alternative approach to designing online innovation contests as communities of practice, in which many participants are encouraged to contribute their efforts to help and learn from one another, while collectively raising the quality of ideas. To explore this, I introduce new design interventions for inducing different types of participants in online innovation communities to exchange feedback on one another's innovation ideas in contests. Through five field studies in real-world online innovation contests, I test and identify the conditions under which each intervention is effective at engaging and benefiting participants and improving project quality.

Specifically, I show that the introduction of new peer advisor programs, in which participants are explicitly invited and assigned to serve as feedback providers to specific project teams, elicits greater engagement between community members than standard collaboration mechanisms that are currently available on online innovation contest platforms. These successfully leverage more participant contributions by inducing a mutual exchange of benefits related to human capital development (e.g. learning, networking). However, meta-analyses across the five studies reveal that feedback only results in improvements to project quality when teams are matched with advisors who have relevant expertise in their project domains, and when feedback is exchanged during early stages in the contest process. In addition, helping feedback receivers process and incorporate feedback into project revisions also benefits project quality for participants who are not experts in their project domain.

In summary, this work contributes: (1) a new approach for designing online innovation contests as communities of practice: specifically, by inducing participants to exchange feedback with one another, and (2) a conceptual framework of conditions under which feedback interventions are effective at engaging and benefiting participants as well as improving project quality. These contributions provide practical guidance to organizations and researchers who are looking to advance innovation strategies and understandings of collaboration in online communities.

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Contents

Chapter 1: Introduction

Online innovation contests are a popular tool that organizations use to generate breakthrough ideas by attracting diverse crowds to propose new solutions to specific problems. In a typical online innovation contest, an organization posts a challenge on an online platform and offers a monetary prize to incentivize people to submit solution ideas. After a set period of time, the organization judges all submissions and awards the prize to one or a few winners that they deem worthy. For example, in 2010, the National Aeronautics and Space Administration (NASA) sponsored a $30,000 online contest to develop a new algorithm that could solve a long-standing challenge of predicting dangerous solar events that impede space exploration missions. Over 500 people from 53 countries answered the call, and the prize was eventually awarded to a retired engineer whose algorithm exceeded all of NASA's performance expectations [NASA]. Inspired by similar success stories, government agencies, nonprofits, and corporations have all been increasingly adopting online innovation contests to crowdsource solutions for a variety of purposes, including civic engagement, humanitarian causes, and new product development. To support this rising demand, numerous contest platform companies have sprung up to serve as intermediaries between organizations and online communities of potential solvers. In 2009, the online innovation contests industry was valued between $1 billion and $2 billion [McKinsey & Company 2009], and it has been rapidly expanding since.

The basic intuition behind online innovation contest designs is a game of odds: the more diverse participants that a contest prize incentivizes and the more ideas that they submit, the more likely it is that one of them will turn out to be a breakthrough innovation [Boudreau et al 2011; Jeppesen & Lakhani 2010; Terwiesch & Xu 2008; Terwiesch & Ulrich 2009]. While this prize-centered approach can be successful at surfacing one or a few outstanding winners, it is also inherently inefficient at leveraging participant contributions and generating high-quality ideas. These inefficiencies pose significant challenges that undermine the effectiveness of online innovation contests.

Specifically, prize-centered contest designs result in suboptimal participant contributions both during and after contests. During contests, participants make decisions about how much effort to contribute by weighing the potential costs vs. benefits of doing so: if they perceive the potential benefits to be low (e.g. due to a small prize value or low probability of winning against many competitors), then they are likely to reduce their contributions to the contest accordingly [Boudreau et al 2011; Che & Gale 2003; Dissanayake et al. 2018; Fullerton & McAfee 1999; Huang et al. 2012; Taylor 1995; Terwiesch & Xu 2008]. Similarly, most participants tend to stop contributing to online innovation contests and communities after submitting only one idea, especially if their idea was not selected as a winner [Bayus 2013; Hofstetter et al. 2017]. In the worst case scenarios, online innovation communities are even abandoned after a short period of time, as participants stop contributing to them entirely [von Briel & Recker 2017]. As such, not only do contest prizes not benefit the majority of participants, but they are also inefficient at inducing participants to contribute their earnest efforts and expertise to the community.

As a result, prize-centered contest designs are also inefficient at generating high-quality ideas. For example, an online innovation contest hosted by the software company SAP in 2008 invited users to submit radical innovations for their software, but only 12% of idea submissions were considered new or high-quality by the company, while the other 88% were already known or described as only minor improvements to current products [Blohm 2010]. Similarly, only 0.2-4% of idea submissions in online innovation communities hosted by multinational corporations Dell, Starbucks, Volvo Cars, and Renault were implemented [Bayus 2013, Hossain 2015a; Hossain 2015b; Elerud‐Tryde & Hooge 2014]. In the worst case scenarios, online innovation communities have failed to generate even one high-quality idea for their sponsoring company [von Briel & Recker 2017]. This inundation of low-quality ideas also incur heavy costs on organizations. For example, while an internal innovation contest hosted by the global technology company IBM in 2006 produced over 46,000 ideas, most of them were unoriginal or completely impractical, and dozens of senior executives at the company had to spend weeks filtering through tens of thousands of posts in order to find a few potentially promising ideas for future development [Bjelland & Wood 2008]. All together, these inefficiencies result in a significant waste of potential resources and demonstrate a need for new contest designs to better leverage participant contributions towards more effective innovation processes.

This dissertation addresses these inefficiencies by exploring an alternative approach to designing online innovation contests: rather than designing them as prize-centered competitions, in which only a few participants benefit and an excess of low-effort and low-quality ideas is produced, how can we design contests as communities of practice, in which many participants can contribute their efforts towards helping and learning from one another, while collectively raising the quality of ideas produced? This approach shifts the focus of participant benefits from the contest prize itself to other non-monetary benefits that participants can offer one another, and it shifts the focus of the innovation process from cherry-picking only one or a few of the best ideas to improving the quality of all ideas in a contest. In this way, community-centered contest designs have the potential to leverage more participants and ideas than purely prize-centered contest designs do.

To explore this approach, I introduce new design interventions for inducing different types of participants in online innovation communities to contribute their efforts and expertise by exchanging feedback on one another's innovation ideas in contests. Through five field studies in real-world online innovation contests, I test and identify the conditions under which feedback interventions are effective at engaging and benefiting participants as well as improving project quality. Specifically, I show that the introduction of new peer advisor programs, in which participants are explicitly invited and assigned to serve as feedback providers to specific project teams, elicits greater engagement between community members than standard collaboration mechanisms that are currently available on online innovation contest platforms. These successfully leverage more participant contributions by inducing a mutual exchange of benefits related to human capital development (e.g. learning, networking). However, meta-analyses across the five studies reveal that feedback only results in improvements to project quality when teams are matched with feedback providers who have relevant expertise in their project domains, and when feedback is exchanged during early stages in the contest process. In addition, helping feedback receivers process and incorporate feedback into project revisions also results in better quality for participants who are not experts in their project domain.

Overall, the contributions of this work are:

1. A new approach for designing online innovation contests as communities of practice: specifically, by inducing participants to connect and exchange feedback with each other.
2. A conceptual framework of conditions under which feedback interventions are effective at engaging and benefiting participants as well as improving project quality in online innovation contests.

These contributions provide practical guidance to organizations and researchers who are looking to advance collaborative innovation strategies as well as theoretical understandings of factors that influence the generation of innovative ideas.

Document Structure

The rest of this document is structured as follows:

Chapter 2: Background contextualizes this dissertation within current research and practice by summarizing related work on online innovation contests and feedback exchange, as well as introducing the online setting where the five research studies are conducted.

Chapter 3: Overview of Contributions presents a conceptual framework of conditions under which feedback interventions are effective in online innovation contests, and delineates how each of the five research studies contribute to it.

Chapters 4 - 8 detail the five research studies individually. Each chapter describes one field trial of a new design intervention for feedback in an online innovation contest, including its research goals, method, results, and implications. The title of each chapter corresponds to the new design intervention that is introduced in it: **Chapter 4**: Assigning Peers for Feedback, **Chapter 5**: Matching Peers for Feedback, **Chapter 6**: Early-Stage Peer Feedback, **Chapter 7**: Providing Expert Feedback, **Chapter 8**: Facilitating Feedback Incorporation.

Chapter 9: Meta-Analysis synthesizes the five studies through a set of meta-analyses on the effects of design interventions that are common among them.

Chapter 10: Discussion suggests how this work can be used to guide future online innovation contest designs and research on collaboration.

Chapter 11: Conclusion succinctly summarizes the key takeaways from this dissertation.

Chapter 2: Background

Collaboration in Online Innovation Contests

Previous online innovation contests have attempted to design communities of practice by enabling collaboration between participants in three different forms: collaboration within teams, collaboration between teams, and collaboration in open online communities. However, these contest designs have been met with mixed success at leveraging participant contributions and improving idea quality, and previous research does not provide an integrated framework for understanding the conditions under which design interventions are effective or ineffective.

Collaboration within teams

The most common form of collaboration that is enabled by online innovation contests is within private teams, as most contests allow participants to submit ideas as an individual or as a team [Adamczyk et al. 2012]. Contests in which the protection of intellectual property is a priority (e.g. for corporations seeking to commercialize winning innovations, for participants seeking to patent or publish their innovations) do not provide an explicit space for participants to publicly share ideas related to the challenge with one another, and the only form of collaboration tends to be with one's own teammates through communication channels outside of the contest platform. Examples of popular contest platforms where collaboration is currently limited to this form include the intermediaries InnoCentive[1] and NineSigma[2]. While these platforms have been successful at attracting hundreds of thousands of potential contributors, they fail to leverage them efficiently, as the lack of support for teams to benefit and learn from other teams leaves the majority of their potential efforts and expertise untapped.

Collaboration between teams

In addition to enabling collaboration within private teams, some online innovation contests also enable collaboration *between* teams, while still allowing participants to protect their ideas. To do so, they provide an explicit space for participants to publicly share ideas with others on the contest platform, but leave all decisions about whether and what to share to each team's own discretion. This approach is particularly common in online coding contests. For example, the media streaming service company Netflix launched a very high-profile contest in 2006, offering $1 million to the first individual or team to develop an algorithm that improves the accuracy of the company's movie recommendations by 10%[3]. To enable collaboration between teams, Netflix provided a dedicated online forum for participants to share ideas with one another during the contest. Similarly, examples of popular platforms that currently enable voluntary collaboration between teams include the coding contest intermediaries TopCoder[4] and Kaggle[5].

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[1] https://www.innocentive.com/
[2] https://www.ninesigma.com/
[3] https://www.netflixprize.com/
[4] https://www.topcoder.com/
[5] https://www.kaggle.com/

These contests show that providing an explicit space for voluntary idea sharing can indeed result in collaboration between teams and even winning solutions, but engagement between participants can be highly variable. For example, many teams in the Netflix Prize shared code, data, and insights with one another on the forum, explained their algorithmic approaches, and even combined their algorithms together to achieve better accuracy [Bennett & Lanning 2007]. In fact, the final winner was a merger of 3 competing teams in the USA, Austria, and Canada, while the runner-up was a merger of 23 competing teams who had all combined their work together during the contest [Bell 2010]. Similarly, an analysis of collaboration behaviors in 25 contests on Kaggle showed that participants who shared their code with other teams on the platform performed better in contests. However, unlike in the Netflix Prize, code sharing did not raise the average or top performance of solutions in the Kaggle contests, and only 10% of participants shared code, with larger teams and the highest performing teams being less likely to do so [Tausczik & Wang 2017]. These results illustrate the potential for contest designs that support voluntary collaboration to leverage more participant contributions and generate higher-quality ideas , but also indicate that they are not always effective at achieving these outcomes. Because prior research on such contest designs is limited to observational studies rather than experimental studies, they are unable to provide a causal model for understanding the conditions under which different design interventions are effective or ineffective.

Collaboration in open online communities

While idea sharing is voluntary in contests like the Netflix Prize and on Kaggle, idea sharing is *required* for participation in contests on open online communities. Open online communities are platforms that are intentionally designed for public collaboration, where all contest submissions are publicly shared for anyone to view. Additionally, site functionalities such as commenting, voting, and direct messaging between participants enable collaboration between anyone within teams, between teams, and even entirely outside of teams, as participants do not need to be actively competing with a submission of their own in order to browse or provide feedback on others' submissions. Examples of current contest platforms that are fully open online communities include OpenIDEO[6] and Climate CoLab[7]. Some open online communities award prizes for high-quality submissions to individual time-constrained contests, while others award prizes for high-quality submissions on a long-term rolling basis (e.g. Dell's IdeaStorm, LEGO Ideas, My Starbucks Idea).

Previous contests on open online communities show that they can indeed result in a flurry of collaborative behaviors on the platform, but only some participants proactively exchange comments with others, while the rest just focus on their own ideas or observe without engaging [Bullinger et al. 2010, Hutter et al. 2011]. Some community-based contests have been relatively successful at fostering collaboration. For example, over 90% of participants in a global LED light design contest hosted by German lighting company OSRAM in 2009 engaged in some form of

[6] https://www.openideo.com/
[7] https://www.climatecolab.org/

collaborative commenting activity, and comments included detailed constructive feedback, such as sharing experiences, asking questions, offering suggestions, and evaluating or critiquing ideas [Hutter et al. 2011]. Similarly, over 60% of participants in a global jewelry design contest hosted by Austrian jewelry company Swarovski in 2008 commented on others' ideas on the platform [Füller et al 2014].

However, other community-based contests have been less successful at fostering collaboration. For example, only 15% of participants commented on others' ideas in a global train interior design contest hosted by the transport manufacturing company Bombardier in 2010 [Kathan et al. 2015]. Similarly, a case study on IBM's internal innovation contest reports that "few contributors built constructively on each other's postings" and "it was rare to find suggestions that built on previously posted ideas." [Bjelland & Wood 2008]. These results show that even when collaboration functionalities are provided in open online communities, they are not always utilized by participants.

Previous contests also show mixed evidence as to whether collaboration actually leads to more innovative ideas in open online communities. Some contests show a positive effect of collaboration on innovation. For example, an analysis of submissions to SAP's community-based contest in 2008 shows that ideas generated collaboratively by multiple participants on the platform were higher quality than ideas generated independently by one participant [Blohm 2010]. Similarly, a randomized controlled experiment on TopCoder showed that a contest during which all submissions were required to be publicly shared between participants resulted in better performing code than a contest during which no collaboration was allowed between participants [Boudreau & Lakhani 2015].

However, other community-based contests show mixed and nuanced effects of collaboration on idea quality. For example, a university-based contest showed a U-shaped relationship, such that teams who exhibited very high or very low levels of commenting activity submitted more innovative ideas than teams who exhibited medium levels of commenting activity [Bullinger et al. 2010]. The authors speculate that this may be because teams with high levels of commenting activity benefited from integrating external knowledge, and teams with low levels of commenting activity benefited from focusing their efforts on the contest task itself under challenging time constraints, while teams with medium levels of commenting activity overstrained themselves by trying to do both at the same time. Similarly, another university-based contest showed different patterns of results for participants with high vs. low expertise in the challenge domain: amongst participants with *high* expertise, those who incorporated feedback from other participants submitted *lower* quality ideas than those who did not, but amongst participants with low expertise in the challenge domain, those who incorporated feedback from other participants submitted *higher* quality ideas than those who did not [Adamczyk et al. 2011]. Still other contests show that different types of feedback and different patterns of reciprocity between participants had different effects on idea quality [Kathan et al. 2015; Seeber et al. 2017; Wooten & Ulrich 2017; Zhu et al. 2019]. These results suggest that the effects of collaboration on innovation may be affected by many factors, such as the time constraints of contests, the expertise of participants, and how participants engage with feedback.

All together, these mixed results illustrate the potential for contest designs that support collaboration in open online communities to leverage more participant contributions and generate higher-quality ideas, but also indicate that they are not always effective at achieving these outcomes. These inconsistencies reveal both practical limitations of prior contest designs and theoretical limitations of prior research studies. A key practical limitation of prior contest designs is that their collaboration mechanisms rely on participants to self-initiate interactions with other community members. This lack of structure and direction provides no support to participants for identifying which individuals might have the most valuable expertise to exchange with them, when they should initiate interactions in the contest process to get effective feedback on their ideas, and how to process or incorporate feedback in productive ways. These limitations may explain why the design of existing open online communities resulted in different engagement behaviors and innovation outcomes for different participants.

In addition to these practical limitations, prior research on such contest designs are also limited in their ability to provide a causal model for understanding the conditions under which different design interventions are effective or ineffective in open online communities. Since most studies are observational studies on individual contests hosted in different open online communities, this makes it difficult to identify which design factors caused inconsistencies in their effects on engagement and innovation, since each contest is unique in a myriad of dimensions, including its challenge domain, its participants' expertise, its timing, its rules and instructions, as well as its online platform design. As such, the limitations of previous contest designs and previous research studies demonstrate a need to design more effective interventions for supporting participants during the collaboration process and to generate an integrated framework for understanding the effects of different interventions on whether participants engage with one another and generate better ideas.

Designing more effective collaboration interventions in online innovation contests

This dissertation addresses the limitations of prior work in two ways. First, it addresses the practical limitations of previous contest designs in supporting participants during the collaboration process by introducing a new approach to inducing and structuring interactions between participants during online innovation contests. Specifically, this approach differs from previous approaches in that instead of passively relying on participants to self-initiate interactions with others in the community, it actively directs participants to exchange feedback with specific people on their innovation ideas at specific times during a contest process. This approach has the potential to leverage more participant contributions and generate higher-quality ideas by helping participants identify individuals who may have valuable expertise to exchange with them and connecting them at moments when receiving feedback may be especially useful to their ideas.

In addition to addressing the practical limitations of prior contest designs, this work also addresses the theoretical limitations of prior research studies in understanding the effects of different design interventions on collaboration outcomes by experimentally testing multiple feedback interventions within and across different types of contests. Specifically, instead of conducting observational studies on individual contests, this work explicitly manipulates design factors, such as the matching between participants' expertise as well as the timing of feedback in the contest process, and compares their effects in five different online innovation contests. Through these experimental studies and meta-analyses across their results, this dissertation is able to generate an integrated framework of conditions under which feedback interventions are effective at engaging and benefiting participants as well as improving idea quality in online innovation contests.

Benefits of Feedback Exchange

The motivation behind designing interventions for *feedback exchang*e as the specific form of collaboration in online innovation contests comes from a large body of literature in other contexts showing that feedback exchange can be a mutually beneficial process for feedback providers and receivers. Specifically, studies in the contexts of education, design, and crowd work show that feedback exchange can contribute to the development of human capital as well as improvements to work quality for both parties. As such, online innovation contests have the potential to capitalize on these non-monetary benefits that participants can offer one another through feedback exchange in order to leverage more participant contributions and generate higher-quality ideas.

Human capital development

One of the most well-documented benefits of feedback exchange is the development of human capital. Human capital refers to the collection of knowledge, skills, and capabilities that people have, which contribute to their long-term productivity [Becker 1962; Schultz 1961]. For example, prior research in educational contexts shows that feedback exchange between students can improve learning outcomes for both feedback providers and feedback receivers [Bijami et al. 2013; Ertmer et al. 2007; Huisman et al. 2019; Kulkarni et al. 2015; Lundstrom & Baker 2009; Patchan & Schunn, 2016]. Specifically, feedback providers can benefit from gaining higher-level meta-cognitive skills, such as monitoring, evaluating, and regulating their own learning, reflecting critically on their own work, communicating their own views and ideas, as well as improving their own understanding of learned concepts [van Popta et al. 2017]. On the other hand, feedback receivers can benefit from leveraging their peers' criticisms, suggestions, and explanations to improve their skills, self-confidence, and motivation in the target domain, as well as building trusting relationships with peers, which can facilitate better communication and correction of their ignorance or misconceptions [Topping 2005]. As such, feedback exchange offers cognitive, social, and emotional benefits to the development of human capital that can be useful to participants' learning and networking in online innovation communities.

Work quality improvements

Beyond the development of human capital, another well-documented benefit of feedback exchange is the improvement of work quality. For example, prior research in the context of design work has shown that receiving crowdsourced feedback can improve the quality of designers' work by inducing both surface-level and deep-level changes to their graphic designs [Luther et al. 2015; Xu et al. 2015; Yen et al. 2017]. Similarly, research in the context of crowd work has shown that receiving external feedback can improve the quality of crowd workers' performance on writing tasks by inducing them to revise their work submissions [Dow et al. 2012; Nguyen et al. 2017]. On the other hand, another study showed that crowd workers who provided peer feedback on other crowd workers' work submissions subsequently exhibited significant improvements to the quality of their own work submissions [Zhu et al. 2014]. As such, both receiving feedback and providing feedback can improve work quality. This suggests that feedback exchange can be a promising mechanism for improving the quality of ideas in online innovation contests as well.

Challenges of Feedback Exchange

Even though feedback exchange has the potential to leverage more participant contributions and improve project quality in online innovation contests, design interventions need to address several challenges in the feedback process in order to effectively elicit these benefits. Specifically, prior literature on feedback exchange in the contexts of education, design, and crowd work shows that inducing engagement, inducing valuable feedback, and inducing feedback incorporation are three challenges in the feedback process. These three challenges are even more critical in the context of online innovation contests, and motivate the design interventions introduced in this work.

Inducing engagement

Research in the contexts of online tools for education and design reveals at least two barriers that prevent participants from engaging in feedback exchange. Specifically, many massive open online courses suffer from low rates of feedback exchange between participants due to a lack of clear incentives for contributing to such activities [Neubaum et al. 2014]. In addition, research on online creativity support tools shows that even when designers need help, not being able to identify who in the community has the right expertise to help can prevent them from reaching out to potential feedback providers [Lewis et al. 2015]. As such, a lack of clear incentives and a lack of support for identifying potentially valuable feedback providers make engagement a challenge to feedback exchange in online communities.

These challenges are even more critical in online innovation contests for two reasons. First, participants who are actively competing against one another or were not selected as winners have even less incentive to contribute their efforts and expertise to help one another than peers in online learning communities and on creativity support platforms. Second, the large and diverse nature of online contest communities can make it even more difficult for participants to search through and identify potentially valuable (and willing) feedback providers. To address these challenges, this dissertation introduces new design interventions that use the potential non-monetary benefits of feedback exchange to incentivize members of online innovation contest communities to provide feedback on others' innovation ideas. In addition, these design interventions support participants in identifying who to reach out to by explicitly assigning specific feedback providers to each innovation project in a contest.

Inducing valuable feedback

Beyond engagement, another challenge in the feedback process is that not all participants are able to provide equally valuable benefits to one another, especially in contexts where they have diverse expertise. For example, studies in the contexts of education, design, and crowd work show that feedback can be less helpful when feedback providers do not have sufficient expertise in a target domain, or when feedback does not contain constructive criticisms and suggestions that the receiver can implement to improve their performance in the target domain [Nelson & Schunn 2009; Patchan et al. 2016; Yuan et al. 2016]. Research on massive open online courses shows that this lack of expertise and inability to provide valuable feedback is even more pronounced in large online communities where many members can be non-experts in target domains [Suen 2014].

The challenge of matching participants who can exchange valuable feedback with one another is further complicated by two competing goals in the context of online innovation contest communities, where participants can have very diverse expertise and many are likely to be non-experts in one another's innovation project domains. One goal of feedback exchange in online contests is to help elicit more innovative ideas by matching participants with feedback providers who have different perspectives and domains of expertise to offer them. This suggests that even people who are working in different project domains can benefit from helping and learning from one another. However, the other goal of feedback exchange in online contests is to help elicit new ideas that are relevant to each innovation by matching participants with feedback providers who have expertise in similar domains. This suggests that people who have worked or are working in similar project domains can benefit more from one another. To address these competing goals, this dissertation introduces multiple approaches to designing interventions for matching participants with feedback providers, and examines their impacts on participant benefits and project quality.

Inducing feedback incorporation

Even when valuable feedback is exchanged, a subsequent challenge in the feedback process is that it may not be effectively incorporated into receivers' work. Prior research in the contexts of education, design, and crowd work show that feedback receivers often struggle with processing feedback and identifying productive ways of responding to it, resulting in them making ineffective revisions to their work or ignoring the feedback entirely [Carless & Boud 2018; Cook et al. 2020; Nguyen et al 2017]. In the context of creative work, two factors in particular pose challenges to feedback incorporation: fixation and feedback timing. Fixation is a well-documented cognitive phenomenon that traps people within a known space of ideas and prevents them from considering or adapting new ideas [Jansson & Smith 1991; Youmans & Arciszewski 2014]. For example, research in the context of engineering design has shown that receiving feedback can even increase designers' fixation on their initial ideas and result in less revisions than not receiving feedback at all [Kershaw et al 2011]. In addition, the timing of feedback within a designer's process has also been found to affect their ability to effectively incorporate feedback into their work. For example, feedback during early stages of a designer's process can be difficult to scope or structure, while feedback during later stages of a designer's process can leave little time or opportunity for receivers to iterate on their work [Crain & Bailey 2017; Kotturi & Kingston 2019; Ma et al. 2015].

These challenges are equally relevant in the context of online innovation contests, as participants can get fixated on their initial innovation ideas, and the time constraints of contests can leave limited windows of opportunity for participants to receive and effectively incorporate feedback on their innovations. To address fixation and feedback timing, this dissertation introduces multiple approaches to designing feedback interventions during early and late stages of contest processes, as well as an intervention for helping feedback receivers generate productive revision plans, and tests their respective impacts on participants' feedback incorporation behaviors and subsequent project quality.

Summary of challenges

In summary, prior research suggests that designing effective feedback interventions in online innovation contest communities requires addressing a number of challenges in the feedback process. Based on a review of existing literature and systems related to online feedback exchange, [Foong et al. 2017] proposes a framework of five user challenges that design interventions should consider in order to support effective feedback exchange: (1) Deciding to seek feedback, (2) Presenting work and asking for feedback in an effective way, (3) Incentivizing people to provide feedback, (4) Generating useful feedback on receivers' work, and (5) Processing and incorporating feedback into revisions. This dissertation builds on this framework by specifically exploring new design interventions for addressing the latter three challenges: Incentivizing people to provide feedback, Generating useful feedback on receivers' work, and Processing and incorporating feedback into revisions. In doing so, this work builds a conceptual framework around these three challenges by identifying which of them each design intervention is effective or ineffective at addressing in the context of online innovation contests.

Dissertation Research Setting

In order to test new feedback interventions in real-world online innovation contests, the five research studies in this dissertation were conducted in collaboration with Conservation X Labs (CXL)[8]. CXL is a technology and innovation company whose mission is to end human-induced extinction by applying open innovation processes to source, develop, and scale solutions to

[8] https://conservationxlabs.com/

environmental conservation problems. To achieve this mission, CXL hosts a variety of online innovation contests to attract and incentivize people from all around the world to propose new ideas. Below is a brief overview of CXL's existing contest practices and how this research builds upon them.

CXL uses different contest designs to address different scopes of conservation problems and innovations. One type of contest design is the Grand Challenge, which is a one-time open call for solutions in a specific conservation problem domain that is pre-defined by the sponsors (e.g. artisanal scale mining). It typically ends in the selection of one grand winner who receives a very large cash prize. Another type of contest design is the Con X Tech Prize, which is an annual call for solutions to any conservation problem of the participant's own choosing or within a broad challenge area that is pre-defined by the sponsors (e.g. conservation behavior change). In addition to addressing a diversity of problem areas, the Con X Tech Prize design also addresses different stages of innovation through two distinct phases: an ideation phase, followed by a prototyping phase. The ideation phase is an open call for written project proposals that ends in the selection of 20 finalists who each receive a small cash prize. The prototyping phase is a 12-week sprint in which the 20 finalists develop and submit a prototype of their proposed project idea, and it ends in the selection of a grand winner who receives a larger cash prize. Regardless of design, all CXL contests are open to applications from individuals and teams.

To promote collaboration between participants, CXL also seeks to build a community of practice around conservation technology and innovation by hosting an open online community where anyone in the world can join and contribute to projects. Currently, this platform consists of over 1000 members across a wide variety of disciplines, including biologists, biohackers, chemists, designers, engineers, entrepreneurs, scientists, technologists, and many other types of students and experts. Functionalities on this platform are similar to those of an online social network and discussion forum, as users can publicly post project ideas, view and comment on others' project ideas, and connect with others by browsing their personal profiles or sending them direct messages on the platform. However, prior to this research, CXL contests did not implement any explicit design interventions for inducing feedback on projects beyond these mechanisms for self-initiated feedback by participants on this open online community.

This dissertation builds upon CXL's practices by introducing new interventions for feedback into their existing online innovation contest designs and open online platform. Collaborating with CXL provided several key advantages to this research. First, the ability to co-design and administer real-world contests enabled the evaluation of new interventions with participants in the context of a real online innovation contest community with real stakes and incentives. This ensured the ecological validity of results from the five field studies. Second, the variety of contest designs that CXL uses enabled the exploration of new interventions during different phases within contest processes and with participants across a variety of expertise and project domains. This enabled us to test the effects of feedback interventions with different timing and different types of matching between participants' expertise. Third, the frequency of contests that CXL hosts enabled the iterative design of new interventions in consecutive studies. This enabled subsequent testing of new hypotheses that were generated based on the results of each study. Finally, the ability to test multiple contest designs within the same organizational context enabled meaningful comparisons and meta-analyses across the five studies. This expanded the insights that could be extracted beyond each independent study. As such, the affordances of our research setting provided a unique opportunity to generate new practical and empirical contributions to the online innovation contest literature.

At the same time, the field context of our research also imposed a few methodological tradeoffs. First, the sample size in each study was dictated by the number of participants or submissions in each contest. This limited the number of experimental conditions that could be tested in each study while still being able to make meaningful statistical comparisons, so tradeoffs had to be made in terms of which conditions were implemented in each study. Second, the timing of each study was dictated by CXL's business timeline for each contest cycle. This limited the types of interventions that could be tested to only those that could be implemented within the constraints of each contest timeline. Third, the design interventions that could be implemented in each study were dictated by practical and ethical constraints of CXL's real-world contests, including the organization's innovation goals, staff members' capabilities to program each intervention into their contest administration processes, and fairness to all contest participants. This limited the contrasts that could be conducted, as all interventions were intended to support the improvement of contest and community outcomes, and participants could not be forced to provide and/or receive feedback if they did not want to do so. However, these tradeoffs of our research setting were more than offset by its unique affordances.

Chapter 3: Overview of Contributions

Conceptual Framework of Conditions for Effective Feedback

A core contribution of this work is a conceptual framework of necessary conditions for effective feedback in online innovation contests and design interventions that help elicit those conditions (**Figure 3-1**). Specifically, based on quantitative and qualitative results across our five field experiments, we identify four key conditions that must be met in order for feedback interventions to effectively leverage participant contributions and improve project quality:

1. Participants must **engage** with one another by providing and/or receiving feedback.
2. Participants must provide **value** to one another through their feedback exchange.
3. Participants must **incorporate** new insights from feedback into their project.
4. Participants must incorporate feedback in ways that lead to **project improvements**.

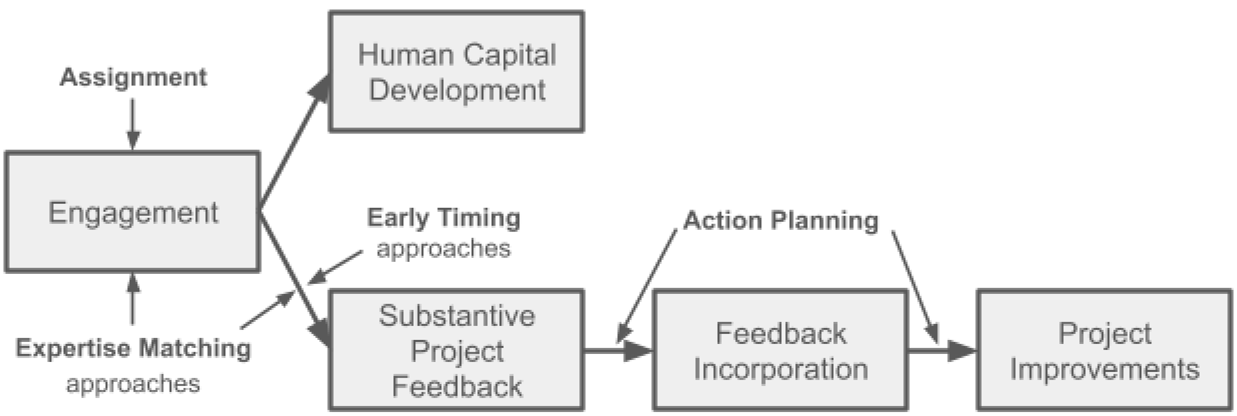

Figure 3-1. Conceptual framework of necessary conditions (labeled in gray boxes) and design interventions for effective feedback in online innovation contests.

Engagement

The first challenge to designing effective feedback in online innovation contests is inducing participants to engage with one another at all. As Chapter 4 and Chapter 6 show, without any intervention, very few if any participants may exchange feedback with one another, even when contests are hosted on a dedicated online community for collaboration. To address these challenges, we identify two types of design interventions for eliciting engagement:

1. **Assignment:** Chapter 4 and Chapter 6 show that explicitly inviting and assigning specific peers to provide feedback on specific projects elicits more engagement than only providing the standard collaboration mechanisms that are currently available on open online communities.

2. **Expertise matching**: Additionally, Chapter 6 shows that matching peers with relevant expertise (as measured by the similarity between their projects' problem domains) leads to more engagement than random assignment.

Value

The second challenge to designing effective feedback in online innovation contests is ensuring that participants who engage are able to offer some form of value to one another. We identify two different types of value that participants can offer one another in online innovation contests: human capital development and substantive project feedback.

- **Human capital development** refers to information and support that help expand participants' personal skills and opportunities, rather than the substance of their current projects per se. These include professional networking, learning, resources, and ideas that are potentially useful for future career development, as well as moral support and general feedback on project management or project presentation skills.
- **Substantive project feedback** refers to information and ideas that are specific to the content of participants' projects in each contest, such as technical advice on how to build or test their prototype, challenges that the project may need to consider in order to succeed, and alternative approaches for addressing the project's goals.

All five studies show that engagement results in human capital development. However, Chapter 4 and Chapter 5 show that not all engagement results in substantive project feedback. Key challenges to eliciting substantive project feedback include poor matching between the expertise of feedback providers and receivers (Chapter 4) and late timing of feedback within a contest process (Chapter 5). To address these challenges, we identify two types of design interventions for eliciting substantive project feedback:

1. **Expertise matching**: Chapter 5 shows that matching peers based on relevant expertise (as measured by the similarity or complementary between feedback providers' and receivers' expertise) results in substantive project feedback.
2. **Early timing**: Chapter 6 shows that inducing peers to exchange feedback on their projects prior to final proposal submission (e.g. during the ideation phase of contests) also results in substantive project feedback.

Feedback Incorporation

The third challenge to designing effective feedback in online innovation contests is inducing participants to incorporate new insights from feedback into the substance of their current project. Chapter 6 and Chapter 7 show that not all feedback is incorporated into projects. Key challenges to feedback incorporation include providers' lack of expertise in receivers' project domains as well as receiver fixation. To address these challenges, we identify two types of design interventions for eliciting feedback incorporation:

1. **Expertise matching:** Chapter 7 shows that matching projects with feedback providers who have expertise in their project domain results in greater incorporation due to the feedback provider's ability to offer substantive project feedback.
2. **Action planning**: Chapter 8 shows that prompting feedback receivers to generate specific ideas and revisions that they could implement in order to improve their projects based on the feedback also results in greater incorporation, specifically by participants who are non-experts in their project domain.

Project Improvements

The fourth challenge to designing effective feedback in online innovation contests is enabling participants to incorporate feedback in ways that actually improve their project quality. Chapter 4 underscores this challenge by demonstrating that when designed poorly, interventions for inducing feedback can even result in *worse* project quality than not inducing feedback. Additionally, Chapter 8 shows that even when feedback is incorporated into project revisions, not all revisions result in better project quality either. To address these challenges, we identify three types of design interventions for eliciting project improvements:

1. **Expertise matching**: Chapter 9 shows that when participants are matched with feedback providers who have relevant expertise for their project, receiving feedback results in better project quality than not receiving feedback.
2. **Early timing**: Chapter 9 also shows that when participants are induced to exchange feedback on their projects prior to final proposal submission (e.g. during the ideation phase of contests), receiving feedback results in better project quality than not receiving feedback.
3. **Action planning**: Chapter 8 shows that prompting feedback receivers to generate specific ideas and revisions that they could implement based on the feedback can also result in better project quality, specifically for participants who are non-experts in their project domain and incorporate feedback into substantive project changes.

Contributions of Each Study to the Conceptual Framework

Each of our five studies tests a new design intervention for feedback exchange and identifies conditions that it elicits effectively and ineffectively. The interventions in each study are designed to address the challenges identified in its preceding studies, and the results from each study also contribute to a set of meta-analyses at the end. Below is a brief overview of which design interventions and conditions each study introduces to the conceptual framework.

Chapter 4: Assigning Peers for Feedback

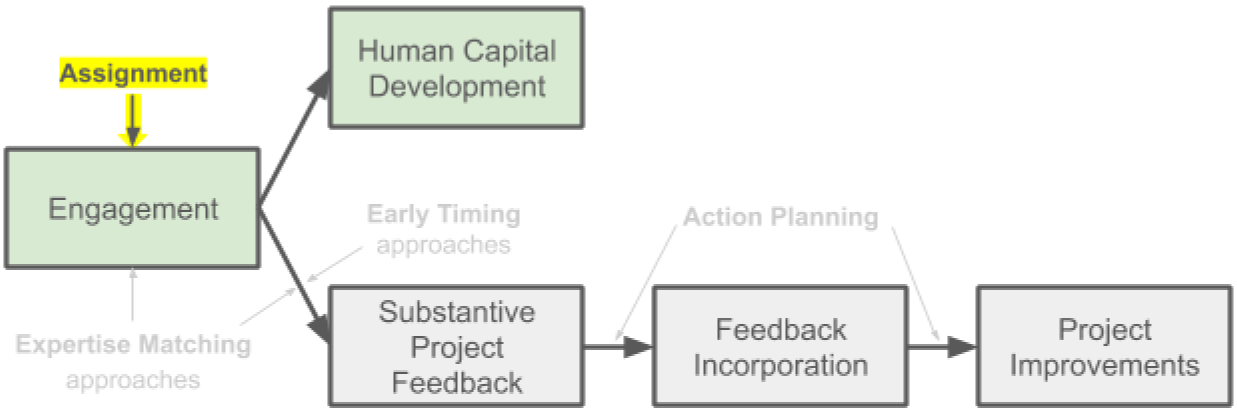

Figure 3-2. Contributions of Chapter 4 to the conceptual framework of conditions and design interventions for effective feedback in online innovation contests.

This study introduces the explicit assignment of specific peer advisors to specific projects as a design intervention for inducing feedback during the prototyping phase of a Con X Tech Prize. Results show that assignment elicited more engagement between participants, and engagement led to human capital development for both peer advisors and project teams. However, it did not elicit substantive project feedback, feedback incorporation, or project improvements, and projects that were assigned peer advisors actually resulted in worse quality than projects that were not assigned any peer advisors. A key challenge that prevented more effective feedback was poor matching between the expertise of peer advisors and projects.

Chapter 5: Matching Peers for Feedback

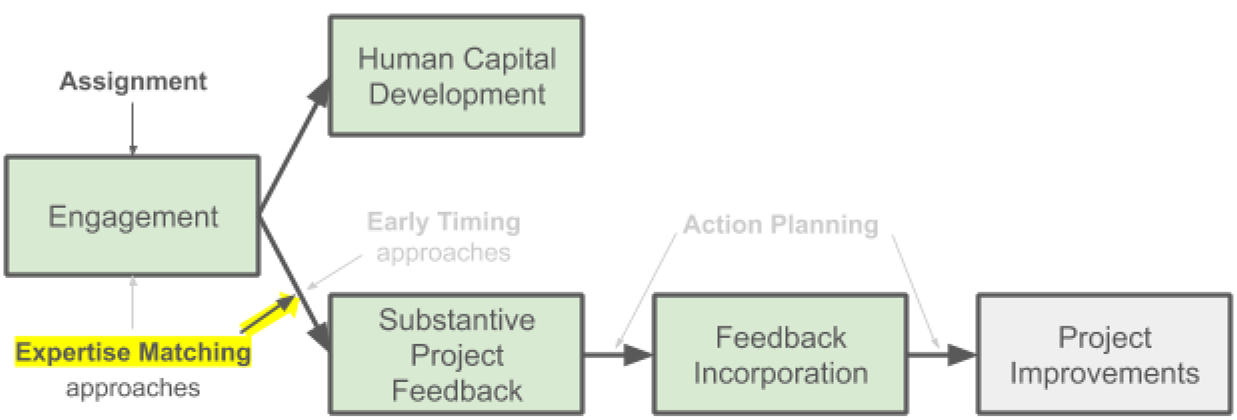

Figure 3-3. Contributions of Chapter 5 to the conceptual framework of conditions and design interventions for effective feedback in online innovation contests.

To address the challenges caused by poor matching from Chapter 4, this study introduces expertise matching as a new design intervention for assigning peer advisors to projects during the prototyping phase of a Con X Tech Prize. Specifically, peers advisors were matched with project teams with whom they had similar expertise or complementary expertise. New findings show that expertise matching was able to elicit substantive project feedback and its incorporation into project prototypes when peer advisors had more expertise than project teams in relevant domains. However, a key challenge that prevented more substantial project improvements was the late timing of feedback within the contest process, as constraints of the prototyping contest prevented more exploration and incorporation of novel ideas.

Chapter 6: Early-Stage Peer Feedback

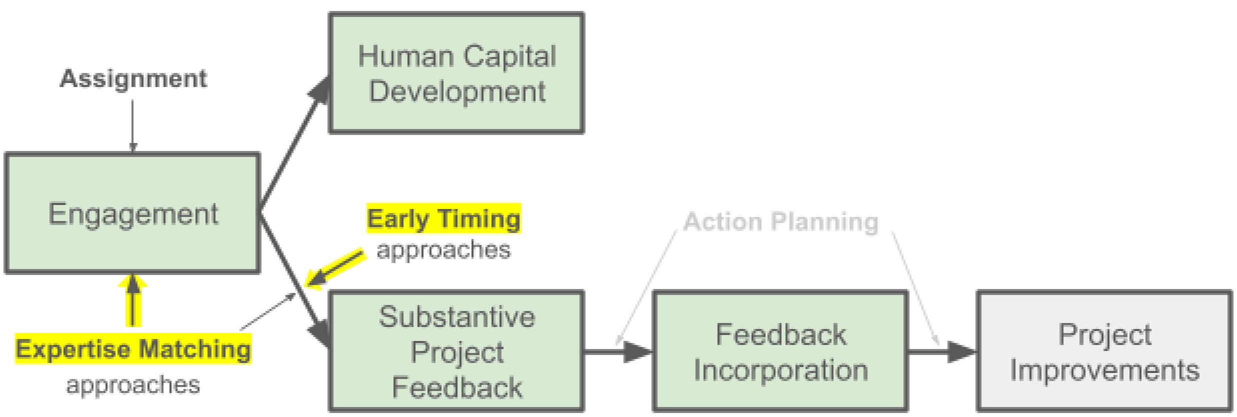

Figure 3-4. Contributions of Chapter 6 to the conceptual framework of conditions and design interventions for effective feedback in online innovation contests.

To address the challenges caused by late timing of feedback from Chapter 5, this study builds on the advantages of assignment and expertise matching while introducing early timing as a new design intervention. Specifically, participants were assigned to provide feedback on projects in similar problem domains as their own project prior to submitting their final proposals in the ideation phase of a Con X Tech Prize. New findings show that expertise matching elicited more engagement than random assignment, and that early timing was able to elicit substantive project feedback as well as its incorporation into projects. However, most incorporations were in the form of surface-level changes to projects' presentation. Key challenges that prevented more substantial project improvements were feedback providers' lack of expertise in receivers' project domain as well as receiver fixation.

Chapter 7: Providing Expert Feedback

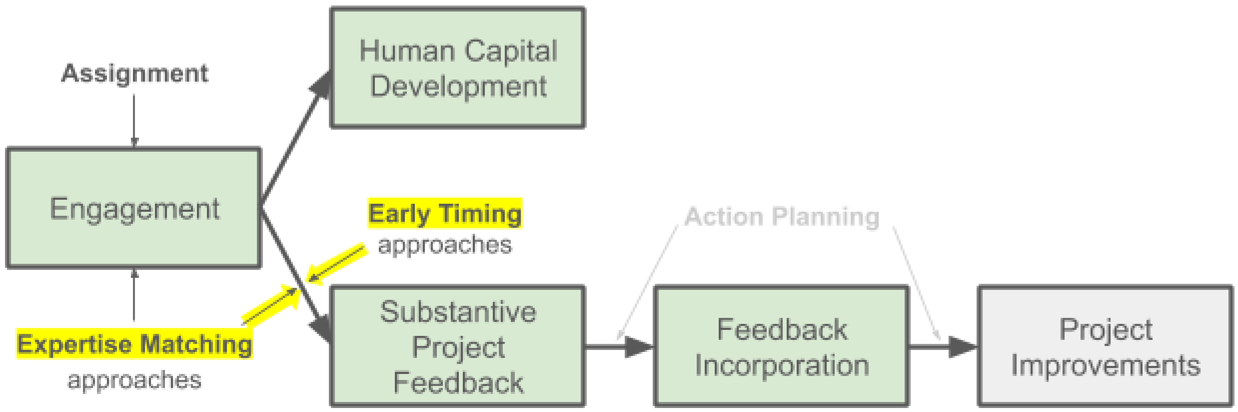

Figure 3-5. Contributions of Chapter 7 to the conceptual framework of conditions and design interventions for effective feedback in online innovation contests.

To address the challenges caused by feedback providers' lack of expertise and receiver fixation from Chapter 6, this study introduces new forms of expertise matching and early timing. Specifically, participants were assigned to receive feedback from peers and external professionals who have expertise in their project's specific problem domain during initial ideation. New findings show that expertise matching elicited more incorporation due to feedback providers' ability to offer substantive project feedback, and Early Timing elicited feedback incorporation in the form of conceptual changes to projects. However, receiver fixation remained a challenge to more significant project improvements for some participants.

Chapter 8: Facilitating Feedback Incorporation

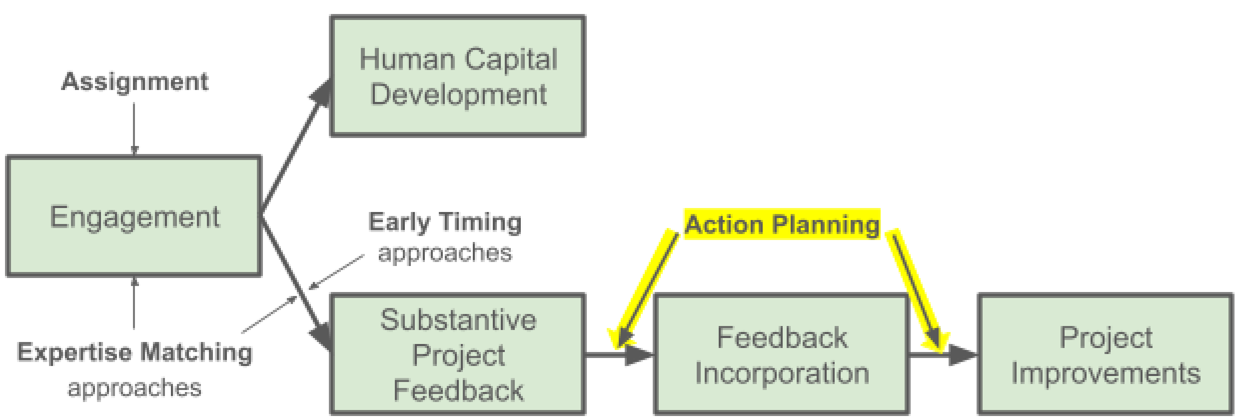

Figure 3-6. Contributions of Chapter 8 to the conceptual framework of conditions and design interventions for effective feedback in online innovation contests.

To address the challenges caused by receiver fixation from Chapter 6 and Chapter 7, this study introduces action planning as a new design intervention for inducing feedback receivers to think more deeply about incorporating feedback to improve their projects prior to submitting their final proposals to a Grand Challenge. New findings show that action planning elicited more feedback incorporation and helped those incorporations result in project improvements for feedback receivers who are non-experts in their project domain.

Summary of Design Interventions in Each Study

Table 3-1 provides detailed comparisons of the following feedback interventions in each study:

- **Assignment**: Were projects explicitly assigned to receive feedback from specific providers?
- **Expertise Matching**: Which type of expertise was used to assign or analyze the match between feedback providers and receivers?
- **Contest Timing**: At what stage of the contest process was feedback induced?
- **Action Planning**: Were feedback receivers explicitly instructed to generate action plans for incorporating ideas inspired by the feedback to improve their projects?

	Assignment	Expertise Matching	Contest Timing	Action Planning
Chapter 4: Assigning Peers for Feedback	Yes	None	Late-stage (During prototyping phase of Con X Tech Prize)	No
Chapter 5: Matching Peers for Feedback	Yes	Similarity or complementarity between self-reported expertise of peer advisors and project teams	Late-stage (During prototyping phase of Con X tech Prize)	No
Chapter 6: Early-Stage Peer Feedback	Yes	Similarity between problem statements in peer applications	Early-stage (Prior to final proposal submission in ideation phase of Con X Tech Prize)	No
Chapter 7: Providing Expert Feedback	Yes	Advisor's expertise in advisee project's problem domain	Early-stage (During initial ideation in ideation phase of Con X Tech Prize)	No
Chapter 8: Facilitating Feedback Incorporation	Yes	Advisor's and advisee's expertise in project's problem domain	Early-stage (Prior to final proposal submission during Grand Challenge)	Yes

Table 3-1. Comparison of feedback interventions across the five research studies.

Chapter 4: Assigning Peers for Feedback

Research Goals

One of the key inefficiencies with many prize-centered contest designs is that participants stop contributing after they have lost, as their efforts are not leveraged or rewarded by the prize. To address this inefficiency, the goal of this study is to explore whether a new community-centered design intervention could effectively re-engage those participants to continue contributing productively to innovations in the contest, even after they have lost. Specifically, we introduce a new peer advisor program, in which non-finalists from the ideation phase of a Con X Tech Prize are invited and assigned to help finalist teams during the subsequent prototyping phase of the contest by providing feedback on their projects.

From a prize-centered perspective, this approach may seem counterintuitive. After all, why would a participant want to continue contributing more effort to a contest after their project had just been rejected, and to help a competitor win a prize that they themselves are no longer even eligible to win anymore? However, research on participants' motivations for contributing to online contests and communities indicate that many are driven by both intrinsic and extrinsic incentives beyond the prize. For example, enjoyment, curiosity, personal achievement, learning, skill development, recognition, networking, passion, and feelings of pride and respect in the community have all been found to play important roles in motivating participants to contribute to online contests and communities [Boons et al. 2015; Hossain 2018; Kosonen et al 2012; Pellizzoni et al. 2015; Zhao & Zhu 2014; Zheng et al. 2011]. As such, a peer advisor program could tap into these existing motivations to induce non-finalists to continue contributing to the contest by offering such non-monetary benefits.

Even if non-finalists could be induced to contribute their efforts and expertise towards advising finalists in a contest, another question is whether their feedback would help improve the quality of finalists' projects. On one hand, research from the psychological and organizational sciences shows that collaboration and knowledge sharing between people with diverse expertise can have positive effects on creativity and innovation [Hargadon & Sutton 1997; Paulus & Nijstad 2003]. However, it is unclear whether non-finalists' expertise would be relevant or useful to the prototyping of finalist projects, especially if their own project was not high-quality enough to be awarded and they are asked to advise a different project. To explore these questions around the effectiveness of our new peer advisor program, we conduct a random-assignment experiment to examine its impact on participant engagement, the types of benefits and challenges that it raises for participants, as well as its impact on the quality of finalists' projects.

Method

Participants

To implement the peer advisor program, we recruited participants in two different roles: finalist project teams, and non-finalist individuals as peer advisors. Out of the 20 finalist project teams, 17 consented to sharing their data from the contest for this research. In addition, 13 project teams' leaders volunteered to participate in an interview for this research. To recruit peer advisors, the following invitation was sent to all 187 contestants from the ideation phase of the contest before finalists were announced:

> *“Conservation X Labs are recruiting an elect group of advisors who are passionate about advancing innovative conservation causes. As a project leader and CXTP applicant, we're extending an invite for you to join this advisory group. Being an advisor would involve approximately 2 hours of reading and providing feedback on a project idea per month, and leveraging your unique skills and experience to help them iterate on the solution. As an advisor, you'll be helping the global conservation effort, get valuable insight into how others approach conservation problems, and receive public recognition on the Conservation X Labs website and newsletter, as well as a Conservation X Labs t-shirt as a token of our appreciation. Would you be willing to serve as an advisor even if your submission is not selected as a finalist?”*

Out of the 100 respondents, 84 volunteered to serve as peer advisors, and 27 were ultimately assigned to a project team in the prototyping phase. In addition, five of the assigned peer advisors participated in an interview for this research, while another one sent their thoughts via email. Self-reported demographic information from the 100 respondents indicate that the participant pool is predominantly male (79 male, 21 female) and highly educated (20 doctorate degree, 30 master's or professional degree, 42 university or college degree, 3 high school diploma/G.E.D), with a diversity of ages (15 18-24 years, 39 25-34 years, 23 35-44 years, 13 45-54 years, 9 55-64 years, 1 65+ years).

Conditions

To compare the effect of our new intervention against the existing contest design, 9 project teams were randomly assigned to receive peer advisors during the prototyping phase (i.e. *Peer Advisor Program* condition), while the other 8 project teams were not (i.e. *No Peer Advisor Program* condition).

In the *No Peer Advisor Program* condition, project teams were not informed of the peer advisor program and only received the default communications that CXL staff sent to all project teams in the prototyping contest. These included reminder emails and check-in calls encouraging all project teams to post their project updates on the open online platform and reiterating information about final submission requirements.

In the *Peer Advisor Program* condition, each project team was assigned three peer advisors at the beginning of the prototyping phase, and sent periodic reminder emails from CXL staff encouraging them to connect with their peer advisors, in addition to receiving all the default communications. Since the goal of re-engaging non-finalists as peer advisors was to enable the exchange of useful expertise with project teams, we identified three broad areas of expertise that are relevant to the contest domain (i.e. conservation, technology, and business), and we vetted all volunteers to identify peer advisors who were most likely to have useful expertise to share in those three areas. To vet peer advisors, we used two criteria: volunteers' own application scores in the ideation phase of the contest, and volunteers' self-reported levels of expertise in each of the three relevant areas on the recruitment survey (Appendix A). Specifically, we identified volunteers who had relatively high-quality ideas by selecting those whose projects ranked in the top 75% of submissions during the ideation phase of the contest, and we identified volunteers with relatively high expertise by selecting those who self-reported an expertise level of 4 (advanced) or 5 (expert) on a 5-point Likert scale in at least one of the three relevant domains. The nine highest-ranking volunteers in each domain were then randomly assigned to the nine project teams until each project team had one conservation peer advisor, one technical peer advisor, and one business peer advisor. All remaining volunteers remained unassigned.

Procedure

Prototyping Phase

At the beginning of the prototyping phase, participants in the *Peer Advisor Program* condition were introduced to their assigned counterparts via email by CXL staff (Appendix C). Project teams were encouraged to introduce themselves, share their project proposal, and upload project updates to the open online platform at two suggested checkpoints during the prototyping phase to get feedback from peer advisors. Each project proposal included enough background information to help a reader understand the broad problem that the team is addressing (e.g. deaths from human-elephant conflict in Sri Lanka), and enough description about the team's proposed solution to help a reader understand their overall approach (e.g. an internet-based network of sensors to detect elephant movements and warn nearby people) without going into details about the exact implementation (e.g. the sensor models or the software system design; Appendix B).

Similarly, peer advisors were encouraged to introduce themselves, read their assigned team's project proposal and updates, and give feedback at each checkpoint through a structured online feedback form and optional phone/video calls with the team. To assist with feedback generation, peer advisors were provided a guide containing a list of suggested topics and questions (Appendix E) that were derived from prior interviews with expert conservation technologists about important considerations when prototyping (Appendix D). These included questions regarding the project's conservation approach, prototyping plan, feasibility/usability, and sustainability/scalability. The guide also encouraged peer advisors to be positive, constructive, and specific in their feedback, and to make their advice and recommendations as actionable as possible. Similarly, the online feedback form consisted of open-ended questions asking the peer advisor to summarize the project as they understand it, describe the project's strengths, and provide feedback or suggestions on the project's conservation approach, prototyping plan, feasibility/usability, and sustainability/scalability, as well as any other comments (Appendix F). An example of a peer advisor's completed feedback form can be found in Appendix G.

Semi-Structured Interviews

To collect data on participant engagement, benefits, and challenges, semi-structured interviews were conducted with participants at two different points during the prototyping phase: (1) mid-competition interviews were conducted independently with project teams and with peer advisors in the *Peer Advisor Program* condition who had completed the online feedback form by the first checkpoint, and (2) post-competition interviews were conducted independently with project teams in both conditions as well as with peer advisors after the prototyping phase had ended. Post-competition interviews were conducted before contest winners were announced so that participants' responses would not be biased by the contest outcome.

Each interview lasted between 20 to 60 minutes. In the *No Peer Advisor Program* condition, the interview with project teams consisted of questions about their prototyping process, their perceptions of any feedback or benefits that they may have received during the prototyping phase, and any suggestions that they may have for improving the contest process. In the *Peer Advisor Program* condition, the interview with project teams and peer advisors consisted of questions about their peer advising process, their perceptions of the feedback they exchanged, their perceptions of the relationship and match quality with their assigned counterpart(s), any benefits of the peer advisor program, and any suggestions that they may have for improving it. (A full copy of the interview guide can be found in Appendix H.)

All mid-competition and post-competition interview transcripts were qualitatively coded in two phases: the first phase involved open coding of behaviors, benefits, and challenges; the second involved thematic analysis of the open codes to identify groups and patterns among them.

Project Quality Evaluation

To evaluate the quality of finalists' projects at the end of the prototyping phase, each eligible project submission was evaluated by at least one and at most six independent CXL judges (who were blind to condition) along three contest criteria, each on a scale of 0 (Submission does not meet the criterion) to 9 (Submission exceeds the criterion): *Novelty and potential for a Transformative Solution*, *Proof-of-Concept / Prototype Success*, and *Strength of Value Proposition* (Appendix I). To adjust for potential biases between judges, all scores were z-scored within each judge. Each project's final quality score was computed as the average of z-scores from all its judges. Three out of the 17 project teams did not provide an eligible project submission, resulting in 14 project scores (7 per condition).

Results

Participant Engagement
We expect that introducing a new peer advisor program would induce more participants to continue engaging in a contest after they have lost. To test this, we first examine the number of non-finalists who engaged with project teams during the prototyping contest in each experimental condition. Results show that the peer advisor program was indeed effective at re-engaging non-finalists in ways that they otherwise would not participate in the contest, as the 9 project teams who were assigned peer advisors received feedback from significantly more non-finalists (M = 1.56, SD = 0.88) than the 8 project teams who were not assigned peer advisors did (M = 0, SD = 0), $t(16) = 4.97$, $p < .001$ (**Figure 4-1**).

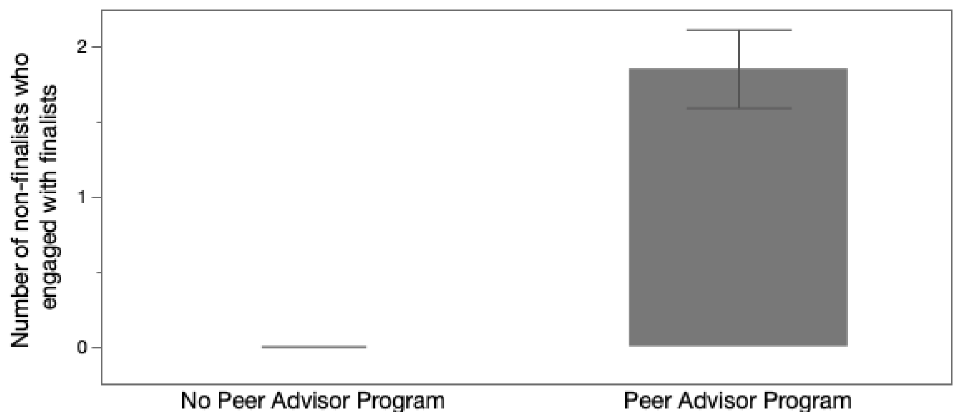

Figure 4-1. Effect of the peer advisor program on the average number of non-finalists who engaged with finalist project teams during the prototyping contest.

More specifically, none of the project teams in the *No Peer Advisor Program* condition reported engaging with any non-finalists during the prototyping phase. All interviewees in this condition only engaged with their internal team members or sought feedback from family, friends, and/or external colleagues who did not participate in the contest.

In contrast, 7 out of the 9 project teams in the *Peer Advisor Program* condition reported receiving feedback from at least one non-finalist. Two project teams had one main feedback exchange session with their peer advisor(s), while 5 project teams had multiple follow-up email communications with at least one peer advisor, in which they exchanged additional questions, information, resources, ideas, and/or updates throughout the prototyping phase. In total, 51% (14/27) of peer advisors provided feedback to their assigned project team, indicating that the peer advisor program can induce participants to re-engage in a contest after they have lost.

Participant Benefits
In addition to inducing participant re-engagement after a contest, another goal of the peer advisor program is to leverage non-finalists' contributions in ways that benefit themselves as

well as project teams in the contest. To explore the potential benefits of this intervention, we examine the types of benefits that participants who engaged with their assigned counterparts in the *Peer Advisor Program* condition received in this study. Results show that engagement led to benefits related to human capital development for both peer advisors and project teams.

Specifically, five peer advisor interviewees reported multiple aspects of human capital development, such as professional networking, learning from other project teams, gaining insights into CXL processes, and contributing to the greater good, as the most valuable benefits that they received from engaging with project teams. Two interviewees reported networking as valuable, because connecting with others who are interested in solving conservation problems can help them find and access valuable resources for one another's projects. For example, peer advisor P03 said, *"Getting to know interesting people and getting to know their interesting project… We're always working on improving ourselves and improving the world around us, and getting connected to people who have the same goals… will help us achieve that."* Similarly, one interviewee reported learning about new ideas, perspectives, and subject areas that could benefit projects of their own: *"Talking to [my assigned project team] has been useful information for me as well as for how I think about my projects… because [she] is very much an academic, and she's very much focused on the biological side, whereas I'm very much industry, very much engineering... so seeing the same problem viewed from two different viewpoints is quite illuminating. You see things that you maybe haven't thought about yourself"* (Advisor 5). The same peer advisor is also one of two interviewees who reported gaining insights into CXL processes as valuable, because they could help achieve their own project goals: *"In the future, I may be interested in submitting one of my projects for the Con X Tech challenges, so it gives me an inside view as well – what sort of deliverables are needed, how they're thinking, and stuff like that."* Beyond these extrinsic benefits, three interviewees also reported an intrinsic benefit of contributing their skills and passion towards the greater good. For example, peer advisor P02 said that the reason why they volunteered is *"because I'm a conservation scientist, and I really love saving wildlife, and saving species… is really the only priority of my life. For me to actively be involved and solving [conservation problems] would be a life goal."*

Similarly, five project team interviewees also reported multiple aspects of human capital development, such as professional networking, informational resources, advice on soft skills, and moral support, as the most valuable benefits that they received from engaging with peer advisors. Three interviewees reported networking as valuable, because it helps them find future collaborators, gain more credibility, access more knowledge, and access more people that they can consult about their projects' challenges. For example, Team 7 reported that one of their peer advisors had introduced them via email to a university research group that was working on a similar technology, which evolved into a *"back and forth email with one of the researchers that are trying to get more data for us to play around with [...] There's definitely some overlap in our goals, and there's like a possible future collaboration […] I think it gives us a little bit of credibility, just like with each group that we are reaching out to, they're like, 'Yes... we want to work with you.'"* Similarly, one interviewee reported a peer advisor providing information resources such as links to other relevant projects: *"They have sent me some other projects or* *similar projects which have been carried out in different parts of the world… the useful thing is I think I could be able to brainstorm more with the ideas"* (Team 11). In addition to these social and information capital, two interviewees also reported receiving advice on soft skills, such as project management and project presentation skills. For example, Team 10 received advice from a peer advisor on how to manage unexpected challenges during the prototyping process: *"I got to pick her brain a little bit on some coarse scale thinking… so she had a lot of useful advice… [on] the need to adapt and improvise… or just the general need to allow for maybe even much more time than you might initially think just to accomplish some of the very basics in the early stages. I think that is something that was really useful, and she shared some of her experiences with one or two of the campaigns that she was involved with."* Beyond these soft skills, two interviewees also reported moral support, such as encouragement and validation of their project ideas as valuable. For example, Team 8 said, *"The thing that was most helpful is his positivity, his encouragement… because… it can be a very frustrating process… We're kind of navigating these uncharted territories, and it's just helpful to have a voice saying, 'You're getting close.'"*

Project Quality

Besides developing human capital, another goal of the peer advisor program is to leverage non-finalists' efforts and expertise towards improving finalists' projects in the prototyping contest. Specifically, since the focus of the innovation process in community-centered contest designs is on raising the quality of all innovations, as opposed to the focus of the innovation process in purely prize-centered contest designs on cherry-picking only one or a few high-quality innovations, we examine whether the peer advisor program increased the average quality of projects. However, results show the opposite effect, as the 7 project teams who were assigned peer advisors received significantly *lower* project quality scores (M = -0.51, SD = 0.60) than the 7 project teams who were not assigned peer advisors did (M = 0.30, SD = 0.59), $t(13) = -2.53$, $p < .03$ (**Figure 4-2**).

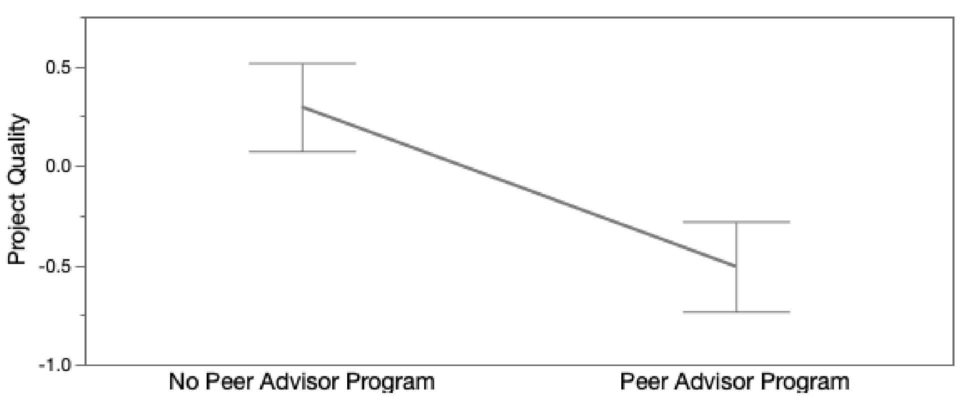

Figure 4-2. Effect of the peer advisor program on the average quality of finalists' project submissions in the prototyping contest.

To explore why the peer advisor program did not improve project quality, despite providing several benefits to project teams, we examine the challenges that participants who engaged with their assigned counterparts in the peer advisor program reported experiencing in this study. Interview results show that mismatches between peer advisors' expertise and project teams' needs prevented peer advisors from offering more useful assistance to projects during the prototyping contest. Specifically, six project teams and four peer advisors reported that their assigned counterparts were not a good fit for their specific needs or expertise. For example, when asked if their peer advisor's background was relevant to their project, Team 12 said, *"Not particularly. He [had] an… engineering background, and most of the problems we were having with our project were ecological in nature, so he wasn't really able to advise us on that aspect."* Similarly, when asked if their expertise matched their assigned project, Advisor 1, who is a biologist, said, *"Not particularly… the requirements that they need at the moment are more along the lines of AI coding and creating an algorithm, as well as more of the technical electrical engineering aspects of it. And [the only advice that I could] offer [was] just where it could be used and why, and just some of the applications… but outside of that, I do not think it was the most ideal of a match."* Not only did expertise mismatches prevent the provision of more useful feedback on projects, but it even resulted in some feedback that was actively distracting to project teams' immediate goals during the prototyping contest. For example, Team 7 reported, "*We're kind of just trying to do one thing at a time here, and everyone's like 'Wow, that's neat! You could totally do 1000 different things with that!' But that's what we call scope creep, and we're trying to avoid that just because we got enough on our plate*." Thus, even though project teams in the *Peer Advisor Program* condition received useful benefits that expanded their social and informational capital for future endeavors as well as their soft skills and moral support for persevering through the contest, they were not able to receive useful feedback on the most immediate and substantive problems that they needed help solving in order to accomplish their goals and improve their project quality under the time constraints of the prototyping contest.

Discussion

This study shows that a new design intervention for inducing feedback can be an effective approach to addressing inefficiencies in leveraging participant contributions after online innovation contests, specifically by engaging participants who have lost with participants who have won in order to exchange mutual benefits related to human capital development. However, it also reveals that additional conditions need to be met in order for feedback interventions to improve, rather than harm, the quality of resulting projects. All together, this study contributes evidence for the following pieces in our conceptual framework of conditions for effective feedback in online innovation contests:

1. **Assignment** of specific advisors to specific projects elicits **engagement** between participants.
2. **Engagement** between participants can result in **human capital development**.
3. **Engagement** without expertise matching does NOT result in **substantive project feedback, feedback incorporation,** or **project improvements**.

One limitation of this study is that the low number of finalists in the contest constrained the number of non-finalists that could be feasibly assigned, so only a small fraction of the 84 non-finalists who volunteered to serve as peer advisors actually benefited from the intervention in this study. However, these results serve as a proof-of-concept for this design approach and suggest that it is possible to reduce the inefficiencies associated with participant dropout after online innovation contests by expanding the peer advisor program to assign more non-finalists to peer advise other project teams. This can be further explored in future work by, for example, assigning non-finalists to peer advise other non-finalists and examining whether similar human capital development benefits can be exchanged in such contexts.

The finding that the peer advisor program resulted in significantly lower project quality is consistent with the mixed effects of collaboration that have been observed in prior online innovation contests (e.g. [Adamczyk et al. 2011, Bullinger et al. 2010]. [Bullinger et al. 2010] speculate that the reason why teams who exhibit medium levels of engagement with other teams may submit lower-quality projects is because they overstrain themselves by trying to integrate external knowledge while simultaneously focusing their efforts on the contest task under challenging time constraints. Given how time-constrained the prototyping phase of a Con X Tech Prize is, the teams in the *Peer Advisor Program* condition may have been similarly overstrained in this study, especially since the benefits exchanged did not directly assist in addressing the project teams' immediate prototyping needs in the contest.

The finding that mismatches between peer advisors' expertise and project teams' needs was a major barrier to eliciting more useful feedback on projects reveals a limitation to the peer assignment method in this study, and raises the follow-up question: Would improving the matching between peer advisors' expertise and project teams' needs lead to more useful feedback on projects during a prototyping contest? We address this question in the next study by introducing a new design intervention for expertise matching into the peer advisor program's assignment procedure.

Chapter 5: Matching Peers for Feedback

Research Goals

The goal of this study is to build on the benefits of a peer advisor program for leveraging participant contributions in online innovation contests, while introducing new matching approaches for assigning peer advisors with relevant expertise to project teams in order to elicit more useful feedback on projects' immediate needs. Specifically, we expand the peer advisor program beyond finalists and non-finalists in a contest, and further seek to leverage contributions from other community members who did not participate in the contest. This expansion could support better matching by increasing the breadth of expertise available and thus the likelihood of finding peer advisors who have relevant expertise for each project team.

Even if expanding the potential peer advisor pool yields more expertise, however, a challenge remains in determining what type of matching approach would elicit the most relevant feedback on projects. On one hand, peer advisors may need to have expertise in the same domain areas as the project team in order to deeply understand the project's constraints and be able to provide informed feedback on their specific needs. For example, it may be very difficult for someone to understand or provide relevant feedback on a project that involves developing a machine learning system for monitoring an environmental ecosystem if they do not have any expertise in machine learning or ecology. The potential downside of this approach, however, is that the peer advisor's expertise may be redundant with the project teams' own expertise and not provide any additional value to the team.

On the other hand, peer advisors may need to have expertise in complementary domain areas that the project team needs in order to supplement the team's existing domains of expertise rather than providing redundant expertise. For example, a team of conservation scientists who seek to apply a machine learning system to monitor an environmental ecosystem may not have enough technical experience to build the system themselves and need assistance from someone with more machine learning expertise. The potential downside of this approach, however, is that the peer advisor may not have enough expertise in the project team's own domains of expertise to deeply understand or take interest in their project.

As such, these two approaches to matching have opposite advantages and disadvantages. Since it is unclear which approach might be better than the other, we introduce both into a peer advisor program during the prototyping phase of a Con X Tech Prize, and we conduct a random-assignment experiment to compare their impact on participant engagement, the types of benefits and challenges that they raise for participants, as well as their impact on the quality of finalists' projects. Due to the limited sample size of finalist projects in the contest, we did not include an additional condition with no peer advisor program or with a peer advisor program without expertise matching, and only implemented conditions that we expected to improve practical outcomes in the contest and community.

Method

Participants

To implement the peer advisor program, we recruited participants in two different roles: finalist project teams and peer advisors. Out of the 20 finalist project teams, 19 consented to sharing their data from the contest for this research. In addition, 15 project teams' leaders completed a post-contest survey and 10 project teams' leaders participated in an interview for this research.

To recruit peer advisors, we expanded the pool of invitees beyond non-finalists from the ideation phase of the contest and additionally invited all finalists from the previous year's Con X Tech Prize as well as all other registered members in CXL's open online platform community. The invitation read: "*We are looking for volunteers to serve as Peer Advisors during the prototyping phase! This involves informally checking in with a Finalist team and providing feedback on their prototype about once a month between June - September. Previous Peer Advisors have found this to be a valuable opportunity for networking with other innovators, learning about new conservation technologies, making a meaningful impact with their expertise, and gaining useful insights into the competition process. Would you be interested in serving as a Peer Advisor during the Prototyping Phase?*"

In total, 77 people volunteered to serve as peer advisors, and 57 were ultimately assigned to project teams in the prototyping phase for this research. Out of the assigned peer advisors, 17 were non-finalists from the same contest, 3 were finalists from the previous year's Con X Tech Prize, and 37 were other community members who had never participated in a Con X Tech Prize. In addition, 28 of the assigned peer advisors completed a post-contest survey and 13 of them participated in an interview for this research. Self-reported demographic information from the 77 volunteers indicate that the participant pool is predominantly male (63 male, 13 female) and highly educated (27 doctorate degree, 16 master's or professional degree, 26 university or college degree, 6 high school diploma/G.E.D, 1 high school but no diploma), with a diversity of ages (18 18-29 years, 23 30-39 years, 17 40-49 years, 13 50-59 years, 3 60+ years).

Conditions

In order to compare the two matching approaches, 12 project teams were randomly assigned to receive peer advisors who have expertise in domains that are similar to their own domains of expertise (i.e. *Similar Expertise Matching* condition), while the other 7 project teams were assigned to receive peer advisors who have expertise in domains that are complementary to their own domains of expertise (i.e. *Complementary Expertise Matching* condition). In both conditions, each project team was assigned three peer advisors near the beginning of the prototyping phase via an email from a CXL staff member, encouraging them to introduce themselves to one another and reach out to one another as resources to help the project team during the contest.

Matching Procedure

Collecting Self-Reported Expertise Data

To implement the two matching approaches, we first needed to collect data on all peer advisors' and project teams' expertise. Peer advisors' expertise data were collected via a survey that asked all volunteers to rate their level of expertise on a scale of 1 to 5 in each of the following domains: conservation, technology, and business (Appendix J). In addition, the survey presented a checklist of 20 specific topic areas within each domain (e.g. fieldwork, human-wildlife conflict, sustainability within "conservation"; fabrication, sensors/cameras, AI development within "technology"; project management, growth/ commercialization, legal/IP within "business"), and asked volunteers to indicate the specific areas in which they felt comfortable peer advising. Any additional details or context that volunteers wanted to provide about their expertise were collected via an optional open-ended field. To maximize the likelihood that peer advisors had useful expertise to share with project teams, we only selected and assigned volunteers who self-reported high expertise (4 or 5 on a 5-point Likert scale) in least one of the three domains.

Project teams' expertise data were collected via a similar survey and checklist (Appendix K). In the *Similar Expertise Matching* condition, project teams were asked to rate their team's level of expertise on a scale of 1 to 5 in each of the three domains (i.e. conservation, technology, and business), and indicate the specific topics areas in which they had expertise within each domain via the checklist, as well as any additional details or context about their expertise via an optional open-ended field. In the *Complementary Expertise Matching* condition, project teams were asked to rate on a scale of 1 to 5 the extent to which their team needed a peer advisor with expertise in each of the three domains (i.e. conservation, technology, business), and indicate the specific topic areas in which they would like a peer advisor via the checklist, as well as any additional details or context about their needs via an optional open-ended field.

Calculating Similarity and Complementarity

To measure the similarity and complementarity between the expertise of peer advisors and project teams, we used word embedding approaches [Mikolov 2013] to create a separate vector representation for each participant's' self-reported expertise data in each of the three domains (i.e. conservation, technology, business). For each domain, we combined the specific topic labels from their checklist selections with their open-ended responses, and embedded them into 512-dimensional vectors using Universal Sentence Encoder (USE v.2)[9] [Cer et al. 2018], which is trained on a variety of data sources, such as Wikipedia, web news, web question-answer pages and discussion forums, and tasks, and encodes text input of varying lengths using a deep averaging network. Similarity in each domain was computed using the cosine similarity between the embedding vector of a peer advisor's expertise and the embedding vector of a project team's expertise in that domain, while complementarity in each domain was computed using the

[9] https://tfhub.dev/google/universal-sentence-encoder/2

cosine similarity between the embedding vector of a peer advisor's expertise and the embedding vector of a project team's needs in that domain.

Matching Algorithm

To ensure fairness across project teams, we randomized the order of project teams and assigned the best matching peer advisor to each in round-robin order until all project teams had three peer advisors. The first peer advisor was assigned based on the best match in the domain where the project team self-reported the highest expertise or need on a scale of 1 to 5. (If a team reported equally high expertise or need in multiple domains, one of them was randomly selected for the first assignment.) To reduce redundancy in the expertise of peers assigned to each project team, we reduced the rating of each project team's expertise or need in each domain by a factor proportional to the cosine similarity between that project team's expertise or need and the peer advisor's expertise before assigning the second peer advisor using the same approach, and repeating this procedure again for the third peer advisor. We designed the algorithm in this way because it completes the submodularity assumption needed to guarantee near-optimality of the algorithm [Nemhauser et al. 1978; Sviridenko 2004]: after a match has been assigned to a project team, the next match exhibits a diminishing return because it is likely that some of the expertise that this match has will overlap with those of the earlier matches for the team. This entire process was repeated a total of 1,000 times, and the run that produced the highest average similarity/complementarity between all matches was used to assign matches in this study.

To validate the performance of this algorithm, we conducted an evaluation using human judgements of similarity/complementarity to confirm that matches produced by this algorithm are significantly better than matches produced at random. The lead researcher and a conservation domain expert rated the similarity/complementarity between the expertise data for every possible domain match within a random sample of 5 project teams and 15 peer advisors (i.e. 5 teams X 15 peer advisors X 3 domains = 225 pairs), on a scale of 1 (No match) to 5 (Perfect match). Using the sum of the two human judgements as a "ground truth" for the quality of each match, we compared the performance of our embedding-based greedy matching algorithm versus the performance of a random assignment algorithm. Results from Welch's two-tailed t-tests show that our algorithm performs significantly better than the random assignment algorithm on all 3 types of domain matches ($t(73) = 11.95$, $p<.01$ for conservation matches; $t(73) = 4.54$, $p<.01$ for technology matches; $t(73) = 3.23$, $p<.01$ for business matches), supporting the construct validity of our experimental manipulations.

Data Collection Procedure

Survey and Semi-Structured Interviews

To collect data on peer advising behaviors, benefits, and challenges, we invited all project teams and peer advisors to complete a survey and participate in an interview after the prototyping contest ended. The survey included multiple-choice, Likert scale, and open-ended questions about if and how they engaged with each of their assigned counterparts, their perceptions of how useful each match was, any benefits that they received from the peer advisor program, and any suggestions that they may have for improving it, as well as an invitation to schedule an optional follow-up interview (Appendix L). The interview prompted participants to elaborate on their survey answers by describing specific examples of how or why each of their matches resulted in the behaviors, benefits, and challenges that they reported (Appendix M). All open-ended survey responses and interview transcripts were qualitatively coded in 2 phases: open coding of behaviors, benefits, and challenges, followed by thematic analysis of the open codes to identify groups and patterns among them.

Project Quality Evaluation

To evaluate the quality of finalists' projects at the end of the prototyping phase, each eligible project submission was evaluated by three independent CXL judges (who were blind to condition) on a scale of 1 (Project meets this criterion poorly or does not meet it at all) to 5 (Project meets this criterion well) along 10 contest criteria that were grouped into three categories: (1) Project Viability, (2) Value Proposition, and (3) Prototype Progress (Appendix N). To adjust for potential biases between judges, all scores were z-scored within each judge. Each project's final quality score was computed as the average of z-scores from all its judges. Two out of the 19 project teams did not provide an eligible project submission, resulting in 17 project scores (10 in the *Similar Expertise Matching* condition and 7 in the *Complementary Expertise Matching* condition).

Results

Participant Engagement

To explore whether similar or complementary expertise matching may be better for eliciting participant engagement, we examine the number of peer advisors from whom project teams in each condition received feedback during the prototyping contest. Results show that both matching approaches were equally effective at inducing engagement, as the number of peer advisors from whom the 12 project teams in the *Similar Expertise Matching* condition (M = 1.25, SD = 1.14) and the 7 project teams in the *Complementary Expertise Matching* condition (M = 1.43, SD = 1.34) received feedback were not significantly different, $t(18) = 0.33$, $p = .75$ (**Figure 5-1**). In the *Similar Expertise Matching* condition, 8 out of 12 project teams engaged with at least one peer advisor via email and/or phone/video call, while in the *Complementary Expertise Matching* condition, 6 out of 7 project teams did. In total, 25 out of 57 peer advisors (including non-finalists, previous finalists, and community members who had never participated in a Con X Tech Prize) engaged with their assigned project team, while an additional 5 reported reaching out to their team, indicating that the peer advisor program can induce contributions from an even broader population than the core competitors in a contest.

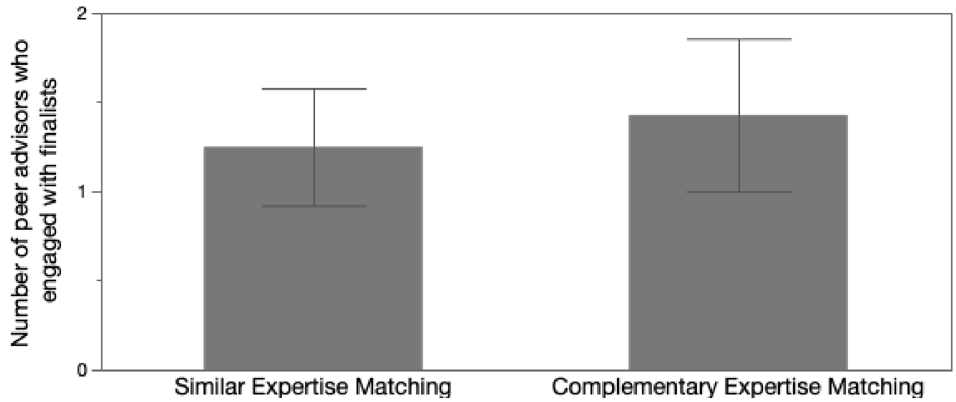

Figure 5-1. Effect of matching approach on the average number of peer advisors who engaged with each finalist during the prototyping contest.

Participant Benefits

To explore if and how similar and complementary expertise matching were successful at eliciting useful feedback on projects, we examine the benefits that participants who engaged with their assigned counterparts reported receiving in this study. Survey and interview results show that in addition to benefits related to human capital development, both matching approaches were also able to elicit useful feedback on project teams' immediate prototyping needs, especially when the peer advisor had more expertise than the project team in the area of need.

Human Capital Development

Peer advisors in both conditions reported multiple aspects of human capital development, such as professional networking, learning, building mentorship skills, and contributing to the greater good, as the most valuable benefits from engaging with their project teams. Three peer advisors reported establishing a foundation for long-term relationships with their assigned project team or other project teams in the CXL community in general as useful, because they could be helpful collaborators or feedback providers on their own work in the future as well. Similarly, four other peer advisors reported learning about different projects, problems, solutions, approaches, and opportunities in the conservation technology space as beneficial to their own thinking and career development. In addition, one peer advisor reported growing their own mentorship skills as a benefit of engaging with their assigned project team, and four peer advisors reported the intrinsic benefit of contributing to the greater good by helping with conservation.

Similarly, project teams in both conditions also reported multiple aspects of human capital development, such as professional networking, informational resources, advice on soft skills, and moral support, as the most valuable benefits from engaging with their peer advisors. Six project teams reported that their peer advisors offered useful professional contacts who could help them advance their project or career in the future. For example, Team 5 (*Similar* condition) reported "*[Our peer advisor] offered us introductions to relevant technology companies, and perhaps even additional funding.*" Similarly, four project teams reported receiving useful informational resources from their peer advisors, such as pointers to other relevant projects, grant opportunities, and application areas where their prototype could be used in the future. In addition to these social and informational capital, one project team also reported receiving useful advice on soft skills, such as how to pitch a new project to a potential investor, and another project team reported moral support as an important benefit in their entrepreneurship journey: "*[Our peer advisor] was influential in keeping our spirits up with regards to starting a company in general. He has previous experience starting companies of his own, and he helped level our expectations*" (Team 2, *Complementary* condition).

Substantive Project Feedback

In addition to human capital development, project teams in both conditions also reported receiving relevant and applicable feedback on their project's immediate prototyping needs (three project teams in the *Similar* condition and two project teams in the *Complementary* condition). In both conditions, project teams attributed these benefits to their peer advisors having more expertise than themselves in the domain area where they received help. For example, in the *Similar* condition, Team 3 reported that they are graduate students who were matched with one of their *"scientific role models"* as a peer advisor and *"[He] provided us with key literature on thermal drone imagery and gave us valuable insights into optimizing our flight time while in Galapagos. He further indicated consideration on weather and time of the day when flying as this affects the thermal properties of surfaces.*" Similarly, in the *Complementary* condition, Team 4's leader reported that they are a business executive who does not have much technical expertise and benefited greatly from having an experienced electrical engineer as a peer advisor to provide timely feedback on his prototype design: "*[He] was very helpful and spen[t] time revising our schematics. His feedback was very relevant in the decision on simplifying the device."* These findings suggest that not only is the similarity or complementary between the expertise of peer advisors and project teams an important condition for eliciting substantive feedback on projects, but the relative level of expertise in each domain is also important.

Project Quality

Ultimately, the goal of matching peer advisors to provide relevant feedback on project teams' needs during a contest is to improve the quality of projects in the contest. However, neither matching approach in this study was better than the other for improving project submissions, as the quality of the 10 projects in the *Similar Expertise Matching* condition (M = -0.04, SD = 0.54) and the 7 projects in the *Complementary Expertise Matching* condition (M = -0.06, SD = 0.83) were not significantly different, $t(16) = -0.06$, p = .95 (**Figure 5-2**).

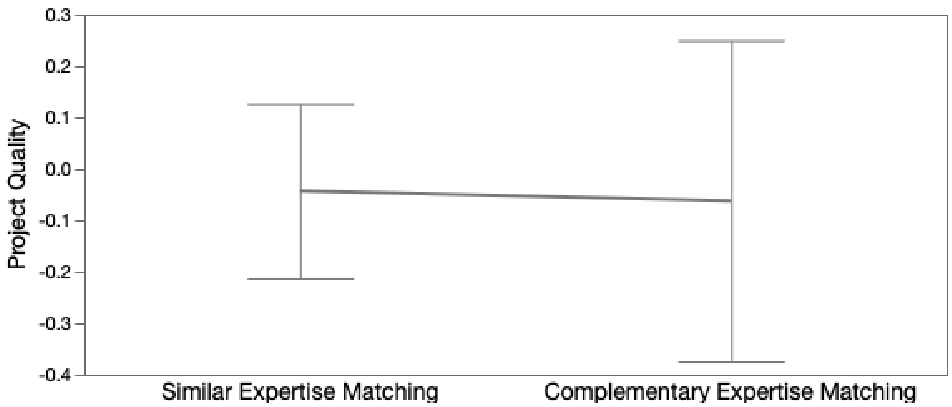

Figure 5-2. Effect of matching approach on the average quality of finalists' project submissions in the prototyping contest.

To understand why neither matching approach resulted in significantly better project quality than the other, we examine the challenges that participants reported with providing and incorporating feedback on projects during the prototyping contest. Survey and interview responses from four project teams and four peer advisors reveal that a key barrier to suggesting or implementing more substantial project improvements was the late timing of peer advising within the contest process, as project teams were already well on their way towards a specific prototype direction and time constraints of the contest prevented them from exploring more changes to their innovation. For example, Team 15 explained that the reason why their peer advisors' relevant feedback did not influence their project submission is because of "*...the short time that the prototyping period lasts. This makes incorporating the advice of advisors in the development of the prototype very difficult. We would love to have had more meetings with them and have had time to discuss and add their recommendations to our solution.*" Similarly, Team 10's peer advisor reported, "*Advice at an earlier stage in technology development might be more helpful to the projects.*" As such, even though the introduction of similar and complementary expertise matching into the peer advisor program was effective at eliciting more substantive feedback on projects, project teams were not able to apply all of the potential benefits of that feedback to improve their project quality under the constraints of the prototyping phase.

Discussion

This study corroborates and expands upon the implications from the prior study in multiple ways. First, it corroborates the prior study's implication that a design intervention for inducing feedback can be an effective approach to addressing inefficiencies in leveraging participant contributions during online innovation contests by engaging winners with other participants in order to exchange mutual benefits related to human capital development. In addition, this study expands on the prior study by demonstrating that not only can this approach work for leveraging contributions from participants who previously competed in the contest, but also participants who have not participated in the contest at all and/or have participated in other contests. This finding carries important implications for expanding the potential pool of contributors that an online innovation contest community can leverage beyond active competitors in a contest. Furthermore, this study expands on the prior study by demonstrating that matching peer advisors with similar or complementary expertise to project teams when assigning them can overcome some barriers to eliciting useful feedback on project teams' immediate needs during a prototyping contest. All together, this study contributes evidence for the following pieces in our conceptual framework of conditions for effective feedback in online innovation contests:

1. **Assignment** of specific advisors to specific projects elicits **engagement** between participants.
2. **Engagement** between participants can result in **human capital development**.
3. **Engagement** with **expertise matching** can result in **substantive project feedback**.

The finding that late timing of peer advising within the contest process was a barrier to more substantial project improvements reveals a key limitation to the design interventions in this study and the prior study, and raises the follow-up question: Would assigning peer advisors with relevant expertise to project teams during an earlier stage in the contest process enable feedback to improve the quality of projects?

In addition to the limitations of the design intervention, another limitation of this study is that it did not have a "control" condition in which finalist teams were not assigned any peer advisors. This is a constraint of the field context, as the low number of finalist teams in the contest inherently constrained the number of conditions that could be tested while still maintaining enough statistical power to make meaningful quantitative comparisons between them. The consequence is that this study does not allow conclusions to be drawn about whether assigning peer advisors with either matching approach would have a positive, negative, or no effect on the quality of projects, compared to assigning peer advisors without expertise matching or not assigning peer advisors at all.

In the next study, we remedy these two limitations related to the late timing of feedback and the study design constraints respectively, by shifting the peer advisor program to an earlier stage in the contest process and evaluating it with a study design that includes a "control" condition in which project teams are not assigned any peer advisors.

Chapter 6: Early-Stage Peer Feedback

Research Goals

The goal of this study is to explore whether introducing a peer advisor program during an early stage of an online innovation contest could be an effective approach to inducing competing project teams to engage and exchange useful benefits with one another, while leveraging peer feedback to improve the quality of projects in the contest. To do this, we shift the timing of peer feedback from the prototyping phase to the ideation phase of a Con X Tech Prize and add a dedicated time period for participants to exchange peer feedback and revise their project submissions before the ideation contest closes. By introducing feedback earlier in the contest process and extending the length of time for feedback incorporation, we aim to remove some of the constraints that prevented project teams from leveraging all the feedback they received to make more substantive improvements to their projects during later stages of contests in the prior two studies. In addition, introducing feedback prior to a contest submission deadline allows us to explore the potential for our design approach to induce more participation contributions from competing project teams *during* contests, as opposed to non-competing individuals *after* contests in the prior two studies.

Besides introducing early timing as a new design intervention, this study also builds on the benefits of expertise matching that were observed in the prior study and explores a new approach for assigning peer advisors to projects based on the similarity between their expertise. To do this, we draw on evidence-based strategies for leveraging external ideas to induce more creativity, especially during ideation tasks. Specifically, prior literature on approaches to analogical innovation have shown that introducing people to ideas, inspirations, and solutions from problem domains that are structurally similar to the problem that they are solving can help them generate more creative designs and solutions [Hope et al. 2017; Yu et al. 2014a; Yu et al. 2014b]. In this study, we adapt this approach of identifying analogical sources of inspiration into our interventions for inducing peer feedback in online innovation contests by matching project teams with peer advisors who submitted projects in similar problem domains as them. To test the effectiveness of this new expertise matching approach, we conduct a random-assignment experiment to compare the effects of assigning peer advisors with and without similar project matching on participant engagement, the types of benefits and challenges that they raise, as well as their impact on the quality of projects in the contest.

Method

Participants

To implement this new design of the peer advisor program, we recruited competing project teams in the ideation phase of a Con X Tech Prize. All 75 project teams that submitted an eligible project by the initial ideation phase deadline were invited and consented to share their data from the contest for this research. In addition, 48 project team leaders completed or partially completed a post-contest survey, and 13 of them participated in an interview for this research. Self-reported demographic information from the subset of project team leaders who volunteered it indicate that this participant pool is similar to those in the prior two studies: predominantly male (35 male, 9 female) and highly educated (10 doctoral degree, 16 master's degree, 10 bachelor's degree, 2 associate degree, 4 some college but no degree, 2 high school diploma or equivalent), with a diversity of ages (15 18-29 years, 11 30-39 years, 7 40-49 years, 7 50-59 years, 2 60-69 years, 2 70 years+).

Conditions

In order to compare the effects of assigning peer advisors with and without similar project matching on outcomes of early-stage feedback, each project team was randomly assigned to one of three conditions:

1. *No Assignment* - 25 project teams were not assigned to receive feedback from any specific peer teams in the contest.
2. *Random Assignment* - 25 project teams were assigned to receive feedback from 3 randomly selected peer teams in the contest.
3. *Similar Assignment* - 25 project teams were assigned to receive feedback from 3 peer teams in the contest who had submitted project proposals that are similar to their own.

Matching Procedure

To implement the *Random Assignment* and *Similar Assignment* conditions, we applied natural language processing techniques to calculate the similarity between all 50 project submissions in the two conditions and then algorithmically selected three peer advisors for each project, according to its experimental condition.

Calculating Similarity

To calculate the similarity between projects, we used word embedding approaches [Mikolov 2013] to represent each project as two distinct vectors – a “problem” vector and a “solution'” vector. Specifically, we used the problem and solution text descriptions provided in each project team's contest submission to represent the problem and solution vectors in a Symmetric Pattern embedding space [Schwartz et al. 2015]. This embedding was chosen for this study because it has been shown to perform well in encoding semantic relations among verbs, which are key aspects of projects’ problem descriptions (e.g. *remove* plastic from the ocean, *detect* wild animals, etc.). The problem and solution vectors were then used to compute the cosine similarity among project submissions.

Matching Algorithm

Using this similarity metric, we designed a greedy matching algorithm to assign peers to projects. The order of the 50 projects was randomized, and matches were assigned in round-robin order, with the most similar peer assigned to each project in the *Similar Assignment* condition and a random peer assigned to each project in the *Random Assignment* condition in each round, until all projects had exactly three peer advisors and three peer advisees. This process was repeated a total of 1,000 times, and the run that produced the highest average problem similarity between matches in the *Similar Assignment* condition was used to assign matches in this study.

To validate the performance of this algorithm, we conducted evaluations using both machine judgements and human judgements to confirm that matches produced in the *Similar Assignment* condition were indeed more similar than matches produced in the *Random Assignment* condition. The machine evaluation compared the average cosine distance between all assigned project pairs in the *Similar Assignment* condition vs. in the *Random Assignment* condition, and confirmed that project pairs in the *Similar Assignment* condition ($M = 0.44$, $SD = 0.11$) were significantly less distant (and thus more similar) than project pairs in the *Random Assignment* condition ($M = 0.68$, $SD = 0.11$), $t(148) = -13.05$, $p <.01$.

To further reinforce the validity of our machine evaluation, a conservation domain expert with multiple years of experience working in the field rated the similarity between the proposed problem descriptions in each assigned project pair on a scale of 1 (very different) to 5 (very similar), blind-to-condition. The domain expert's ratings were significantly correlated with the cosine similarity measures ($r = 0.36$, $p <.01$), supporting the criterion validity of our computational measures of similarity. Additionally, the domain expert's ratings of project similarity were higher on average for assigned pairs in the *Similar Assignment* condition ($M=2.28$, $SD=1.15$) than in the *Random Assignment* condition ($M=1.72$, $SD=1.05$), $d=.51$, $t(148) = -3.12$, $p < .01$, supporting the construct validity of the experimental manipulation.

Peer Advising Procedure

After the initial ideation phase was closed to new submissions, we implemented a new three-week peer feedback period, in which all participants were encouraged to exchange peer feedback by commenting on each other's projects, which were required to be publicly visible on CXL's open online platform. This was followed by a new one-week revision period, in which all participants were encouraged to respond to any feedback and revise their project before submissions were locked and official judging began. All 75 project teams' leaders were informed about the peer feedback and revision process via email by a CXL staff member, and provided a guide to assist with generating substantive feedback on projects (Appendix O). This guide included five sets of questions encouraging participants to: (1) Identify the core problem, (2) Identify important challenges, (3) Inspire novel solutions, (4) Challenge assumptions of the problem, and (5) Connect with other resources. In the *Random Assignment* and *Similar Assignment* conditions, project team leaders were additionally emailed a list of the three peer projects on which they were encouraged to provide feedback and the three peers who were encouraged to provide feedback on their project.

Data Collection Procedure

Survey and Semi-Structured Interviews

To collect data on peer advising behaviors, benefits, and challenges, we invited all project teams and peer advisors to complete a survey and participate in an interview after the peer feedback and revision period ended. The survey included multiple-choice, Likert scale, and open-ended questions about whether and with whom they exchanged peer feedback, their perceptions of any peer feedback they received and any peer projects they provided feedback on, any revisions they made to their project submission after the feedback period, any benefits they received from the peer advisor program, and any suggestions they may have for improving it, as well as an invitation to schedule an optional follow-up interview (Appendix P). The interview prompted participants to elaborate on their survey answers by describing specific examples of how or why providing and/or receiving feedback was beneficial or challenging (Appendix Q). All open-ended survey responses and interview transcripts were qualitatively coded in two phases: open coding of behaviors, benefits, and challenges, followed by thematic analysis of the open codes to identify groups and patterns among them.

Project Quality Evaluation

To evaluate the quality of finalists' projects at the end of the ideation phase, each eligible project submission was evaluated by three independent CXL judges (who were blind to condition) on a scale of 1 (Project meets this criterion very poorly, or does not meet it at all) to 7 (Project meets this criterion very well) along eight contest criteria: (1) Novelty, (2) Transformative Potential, (3) Conservation Impact, (4) Feasibility, (5) Culturally Appropriateness & Social Responsibility, (6) Environmental Sustainability, (7) Financial Sustainability, and (8) Scalability (Appendix R). To adjust for potential biases between judges, all scores were z-scored within each judge. Each project's final quality score was computed as the average of z-scores from all its judges. Four out of the 75 project teams did not provide an eligible project submission, resulting in 71 project scores (24 in the *No Assignment* condition, 22 in the *Random Assignment* condition, and 24 in the *Similar Assignment* condition).

Results

Participant Engagement

Based on results from the prior two studies, we expect that assignment and expertise matching will both induce engagement, but so far, we have not directly compared the effect of assignment with vs. without expertise matching. To deduce the independent effects of these two design interventions, we conduct two planned comparisons to examine how each one affected the number of peer advisors from whom project teams received feedback during the peer feedback period. Results show that assignment had a positive effect on engagement, as the 25 project teams in the *Random Assignment* condition received feedback from significantly more peers (M = 2.44, SD = 1.19) than the 25 project teams in the *No Assignment* condition (M = 0.48, SD = 0.71), $t(49) = 7.05$, $p < .001$. In addition, expertise matching had a positive effect on engagement beyond the effect of assignment, as the 25 project teams in the *Similar Assignment* condition received feedback from significantly more peers (M = 3.24, SD = 1.13) than the 25 project teams in the *Random Assignment* condition, $t(49) = 2.44$, $p < .02$ (**Figure 6-1**).

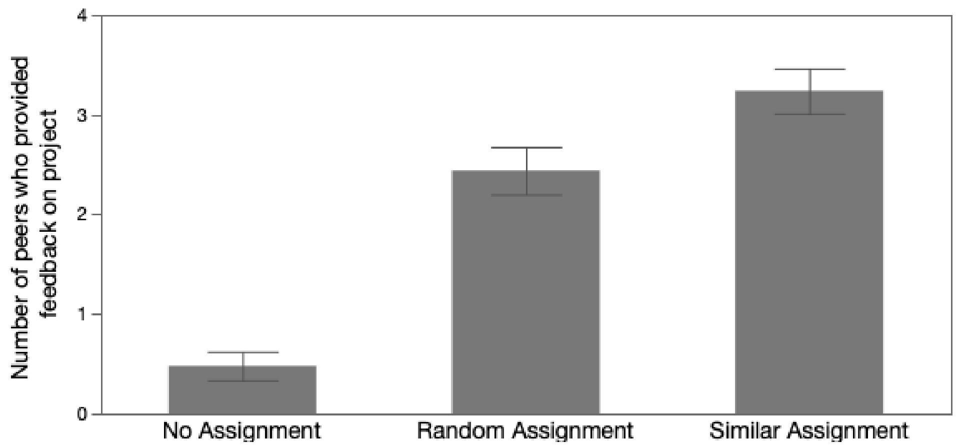

Figure 6-1. Effect of peer assignment method on the average number of peers from whom each project team received feedback on the open online platform during the peer feedback period.

Participant Benefits

The prior two studies show that during a late contest stage (i.e., prototyping), assignment of peer advisors without expertise matching only resulted in benefits related to human capital development, while assignment of peer advisors with expertise matching was able to elicit substantive project feedback. This study examines whether the same effects apply during an earlier contest stage. Interestingly, results show that early-stage peer feedback resulted in both human capital development and substantive project feedback, regardless of whether it was induced through assignment and/or expertise matching.

Human Capital Development

Peer advisors in all three conditions reported multiple aspects of human capital development, such as professional networking, learning, and contributing to the greater good, as valuable benefits from providing feedback on other projects. For example, three peer advisors reported networking with other people in the conservation technology community as useful, because it helps them build a mental directory of people whom they could reach out to in the future if they or someone they know ever needs help in a particular domain area. Similarly, 12 peer advisors reported learning from other project teams as useful, because it helps them build a general awareness of what others are thinking and doing around the conservation space, and reviewing other project proposals teaches them about technologies and new subject areas that could be useful for their own projects in the future. One peer advisor also reported that reviewing other project proposals helps them learn how to become a better writer, and four peer advisors reported the intrinsic benefit of helping others and contributing to conservation as a way of fulfilling their own values.

Similarly, project teams in all three conditions also reported multiple aspects of human capital development, such as informational resources and moral support, as valuable benefits from receiving peer feedback. For example, nine project teams reported receiving references to useful resources, such as names and links to relevant organizations, individuals, and literature that helped them think of new project ideas, identify gaps in their own research, and discover additional useful resources on their own. In addition, three project teams reported receiving external validation on their ideas as useful, because it increased their own confidence.

Substantive Project Feedback

In addition to human capital development, participants in all conditions also reported gaining benefits that they could apply to their project submissions by generating and/or receiving peer feedback. Two peer advisors reported that generating feedback on other projects helped them reflect back on their own project through a reviewer's lens and identify weaknesses that were similar to the weaknesses they identified in their peers' projects. For example, P13 said, *"When you write the feedback for the project, you also question your own project. It makes you also think on other limitations that your project might have, and thinking on solutions to overcome those limitations."* In addition, project teams reported receiving multiple types of substantive project feedback, such as suggestions for solution approaches to problems that they are facing and identification of important problems that their team had overlooked. Six project teams reported that their peer advisors suggested specific existing technologies they could use for their project or broad approaches that inspired them to brainstorm new ideas in other solution spaces. For example, P10 said, *"[he] made some comments on the question I actually opened at this time, and he proposed [to] me several ideas about some kind of technology you could use to vaporize gas in the hive. [...] [He] advised me to take a look at ultrasonic mist from fog fountains, and it actually worked!"* Similarly, three project teams reported that their peer advisors pointed out potential problems that could make their project fail, which helped them preemptively address risks. For example, P03 explained, *"One of the things he did point out, which potentially, I'm going to have to put into the risk management plan for the device, is about the potential contamination [...] I needed to actually write that in as a potential risk and make sure I mitigate that and then test for it."*

Project Quality

We expect that the benefits of early-stage feedback in addition to expertise matching could overcome the constraints that prevented project teams from leveraging feedback to improve project quality in the prior studies. To test this, we compared the quality of projects across the three conditions in this study. Results show that the average quality of projects in the *Similar Assignment* condition (M = 0.28, SD = 0.48) was higher than the average quality of projects in the *Random Assignment* condition (M = 0.06, SD = 0.68), which was higher than the average quality of projects in the *No Assignment* condition (M = 0.02, SD = 0.42), but the differences between these conditions was not statistically significant, $F(2, 68) = 1.64$, $p = .20$ (**Figure 6-2**). Pairwise comparisons also show no significant differences.

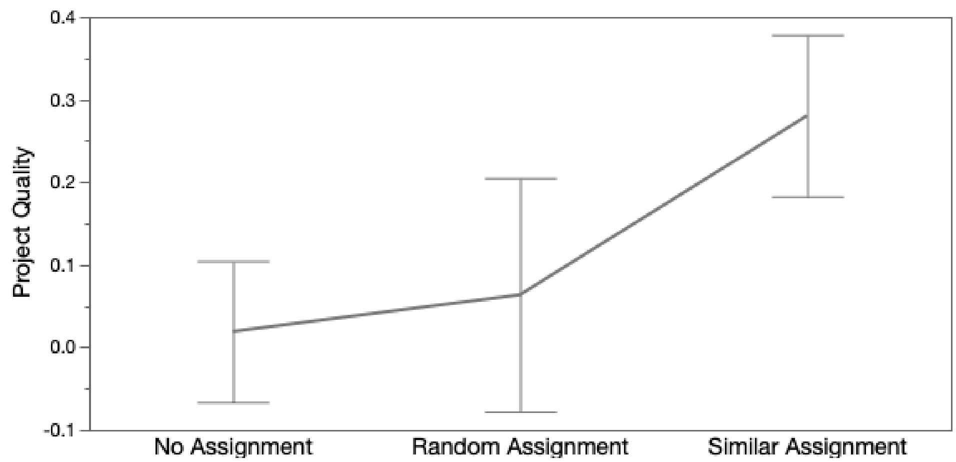

Figure 6-2. Effect of peer assignment method on the average quality of project submissions in the ideation contest.

To gain a deeper understanding of how early-stage feedback may have influenced project quality in this study, we examine the extent of revisions that participants reported in their survey and interview responses. Results show that in all conditions, most revisions were minor writing improvements to project submissions rather than substantive changes to project ideas. For example, on a scale of 1 (Not at all) to 7 (To a very large extent), the average extent to which survey respondents reported revising their project submission was only 2.86 in the *No Assignment* condition (N = 14, SD =1.96), 3.00 in the *Random Assignment* condition (N = 15, SD = 1.73), and 3.06 in the *Similar Assignment* condition (N = 16, SD = 1.69), indicating a minimal extent of revisions overall. Similarly, open-ended survey responses on the nature of revisions indicate that they were mainly clarifications or cosmetic, such as "*Changed some wording to try and communicate better*," "*Typos and grammar corrections*," and "*Better pictures*."

Further analysis on the challenges that participants reported across conditions reveal two types of barriers that may have prevented more substantive improvements to project quality: (1) lack of peer advisor expertise in project domains, and (2) receiver fixation. In total, 11 peer advisors reported not having enough expertise to provide useful feedback on their assigned projects, and six of them were assigned to projects in the *Similar Assignment* condition. Additionally, two peer advisors felt that project teams' responses to their feedback indicated a lack of willingness to genuinely engage with the issues that they had identified. For example, P05 said, *"the guy had the idea that he had to do it one way, so I gave very specific and pretty extensive responses… on his choice [...] Well, he came back, kind of doubling down on what he wanted to run with… I tried to walk him through what I thought was another way to look at the issue… [but] he didn't want to dive deeper with me. He kind of shut it off at the end."* These challenges suggest that even matching project teams with peer advisors who submitted similar project proposals in a contest may not be enough to produce the level of expertise needed for feedback providers to help make substantial improvements to projects, and that additional design interventions may also be needed to help receivers leverage feedback towards improving their projects.

Discussion

This study demonstrates the generalizability of our design approach for building a community of practice in online innovation contests in multiple ways. First, it demonstrates that not only can design interventions for inducing feedback effectively leverage more contributions from *non-competing* participants to exchange benefits with finalists in a contest, but it can also effectively leverage more contributions from *competing* participants to exchange benefits with one another in a contest. This approach could counteract inefficiencies with how prize systems induce competitors to reduce their efforts or contributions during a contest by instead inducing them to contribute more effort, not only to help themselves but to help others in the contest as well. Second, this study demonstrates that the benefits of assignment and expertise matching that were observed during prototyping contests are also applicable during an ideation contest, suggesting that these effects are generalizable across contest stages. All together, this study contributes evidence for the following pieces in our conceptual framework of conditions for effective feedback in online innovation contests:

1. **Assignment** of specific advisors to specific projects elicits **engagement**.
2. **Expertise matching** elicits more **engagement** between participants.
3. **Engagement** between participants can result in **human capital development.**
4. **Engagement** with **early timing** can result in **substantive project feedback**.

The finding that lack of peer advisor expertise in project domains and receiver fixation posed major barriers to more substantial improvements to project quality reveal two key limitations to this study design. First, since Con X Tech Prizes allow participants to submit projects in any problem domain of their choice, the diversity of projects within the limited number of submissions in this contest may have constrained the similarity between matches in the *Similar Assignment* condition, such that even the most similar project proposals were still quite different. This constraint may have limited the amount of relevant expertise or feedback that a peer advisor could provide on an assigned project. Second, even though we already shifted the timing of peer feedback to an earlier stage in the contest process by moving it prior to the prototyping phase, the fact that project teams had already decided on a specific project idea and submitted a complete proposal for it before the peer feedback period began may have led project teams to fixate on their idea. This timing may have limited the scope of changes that teams were willing to make to their projects after receiving peer feedback and thus undermined the potential benefits of feedback on project quality.

These challenges with lack of peer advisor expertise and receiver fixation raise the follow-up questions: Would matching project teams with feedback providers who have more targeted expertise in their project domain and doing so *prior* to them deciding on a specific proposal enable them to incorporate more substantive improvements to their project? We address this question in the next study by introducing feedback from project domain experts during the very initial phase of project teams' ideation process.

Chapter 7: Providing Expert Feedback

Research Goals

The goal of this study is to explore new design interventions for inducing the incorporation of feedback into substantive project improvements. Specifically, we introduce new approaches to expertise matching and early timing when inducing feedback on projects. First, we introduce advisors with specific expertise in advisees' project domains. Second, we shift the timing of feedback from *after* project teams' initial proposal submissions to an ideation contest to *before* project teams' initial proposal submissions to an ideation contest. Together, these two new design interventions aim to reduce some of the barriers that prevented project teams from being able to incorporate feedback into substantive project improvements in the prior study (i.e. lack of advisor expertise and receiver fixation). To test their effectiveness at achieving our goals, we host a Virtual Ideathon event prior to the ideation phase deadline of a Con X Tech Prize to kickstart project teams' initial ideation process, and we conduct a random-assignment experiment to compare the effects of different types of advisors (i.e. peers and experts) during the event on feedback incorporation and the quality of resulting project ideas.

Method

Participants
To implement the Virtual Ideathon event, we recruited attendees from a wide range of professional organizations and universities groups around the world with interests in the intersections of conservation, behavior change, technology, and/or entrepreneurship, through event advertisements on social media, email distribution lists, and word of mouth. A total of 110 individuals participated in the event, and assembled into 33 different teams, consisting of 2 to 5 members each. In addition, 76 attendees (from 28 different teams) completed a post-contest survey, and 27 of these attendees (from 23 different teams) participated in an interview for this research. Self-reported demographic information from attendees indicate that this participant pool is diverse in gender (44 male, 58 female, 1 non-binary), education (15 doctoral degree, 34 master's degree, 36 bachelor's degree, 14 some college but no degree, 4 high school diploma or equivalent), age (35 18-24 years, 41 25-34 years, 14 35-44 years, 10 45-54 years, 2 55-64 years, 1 65 years+), as well as expertise in conservation (78 self-reported 1-3 on a scale of 1=None to 5=Expert) and in behavior change (80 self-reported 1-3 on a scale of 1=None to 5=Expert).

To recruit expert advisors, we personally invited a shortlist of recognized professionals from universities, non-profits, and other organizations with practices in the domains of conservation and/or behavior change. A total of 17 expert advisors participated in the event, all of whom hold a university degree in a relevant field of study (6 doctoral degree, 6 master's degree, 5 bachelor's degree) and have multiple years of experience with teaching, researching, and solving conservation and/or behavior change problems in applied field contexts. In addition, 5 of these expert advisors participated in an interview for this research after the event.

Conditions

To examine how feedback from different sources influence projects, we assigned each team into one of three conditions:

1. *No Advisors* - 12 teams (with a total of 40 members) were not assigned to receive feedback from anyone outside of their own members while ideating during the event.
2. *Peer Advisors* - 8 teams (with a total of 29 members) were assigned to receive feedback from another team at two designated time points while ideating during the event. (The reason why there are fewer teams in this condition is because some pre-registered for the event but did not show up.)
3. *Expert Advisors* - 13 teams (with a total of 41 members) were assigned to receive feedback from one or two expert advisors in their project domain at two designated time points while ideating during the event.

Procedure

Virtual Ideathon Event

The Virtual Ideathon was a continuous six-hour event that was hosted through an online conferencing platform, and advertised as an opportunity for attendees to work with a team to generate a project idea for the ideation phase of the Con X Tech Prize. To ensure that expert advisors had expertise in advisees' project domains, we intentionally advertised and structured the event around a topic within the advisors' domains of expertise: conservation behavior change. At the beginning of the event, all attendees were oriented to this topic through a broadcast presentation created by a subset of the expert advisors. This ensured that all attendees had the same background information about behavior change strategies and how they have been applied to a wide range of conservation challenges in the past. After this presentation, each team was directed to their own virtual breakout room with audio, video, and textual chat functionalities, which served as a private work space for them to collaborate on a scheduled set of team ideation activities for the rest of the event. The schedule and instructions for these activities were provided through a private Google Doc for each team, and included four parts: (1) a 5-10 minute video recorded by one of the expert advisors about a conservation behavior change problem in their specific domain of expertise (e.g. overfishing, deforestation, pangolin trafficking, etc.), (2) problem formulation exercises, (3) solution ideation exercises, and (4) project evaluation and iteration exercises (Appendix S). Each team was assigned to tackle one specific conservation behavior change problem, based on their self-reported preferences amongst 8 different problems, and followed the activity instructions to generate one final project description with a defined problem and a defined solution by the end of the event.

The two designated time points at which teams in the *Peer Advisors* and *Expert Advisors* conditions received external feedback were: (1) after the problem formulation exercises, and (2) during the project evaluation and iteration exercises. In the *Peer Advisors* condition, each team was directed to get together with another team in a private breakout room and exchange feedback on one another's project ideas at each designated time point. In the *Expert Advisors* condition, each team's breakout room was visited by one or two expert advisors with expertise in their specific conservation problem and/or behavior change in general. Each feedback session lasted for about 30 minutes. To facilitate substantive feedback exchange, all teams received a list of suggested discussion questions for each session. In the *No Advisors* condition, each team was instructed to discuss these questions amongst themselves during the equivalent time period. To ensure that the procedures for each condition were executed as intended, each team's breakout room was periodically visited by an event staff member, who facilitated compliance with the activity schedule and instructions.

Survey and Semi-Structured Interviews

To collect data on feedback incorporation, all attendees were invited to complete a survey and participate in an interview after the event ended. The survey included multiple-choice, Likert scale, and open-ended questions about whether and from whom their team received feedback during the event, the extent to which discussions with each feedback source helped them change and improve their project over the course of the event, and why/how discussions with each feedback source was or was not beneficial to them, as well as an invitation to schedule an optional follow-up interview (Appendix T). The interview prompted participants to elaborate on specific examples of feedback from discussions with each source and why/how it influenced or did not influence specific parts of their team's project (Appendix U). To supplement attendees' perspectives, we also invited all expert advisors to participate in a similar interview to get their perspectives on the feedback they provided to teams and how it influenced or did not influence the teams' projects (Appendix V). All open-ended survey responses and interview transcripts were qualitatively coded in 2 phases: open coding of feedback incorporation behaviors and challenges, followed by thematic analysis of the open codes to identify groups and patterns among them.

Project Quality Evaluation

To evaluate the quality of all projects at the end of the event, each team's written project description was evaluated by two independent CXL judges (who did not participate in the event and were blind to condition) on a scale of 1 (not at all) to 5 (very) along three criteria: (1) Novel (unobvious and different from existing solutions), (2) Useful (impactful for addressing the larger conservation problem), and (3) Feasible (achievable with existing resources in the world) (Appendix W). To adjust for potential biases between judges, all scores were z-scored within each judge. Each project's final quality score was computed as the average of z-scores from both of its judges. Three out of the 33 teams did not generate a written problem description by the end of the event, and two other teams submitted two different solution ideas each, so we averaged the final score for both solution ideas to generate one project score per team, resulting in a total of 30 project scores.

Results

Feedback Incorporation
To understand how feedback from different sources gets incorporated into projects, we examine quantitative and qualitative reports on how feedback from team members, peer advisors, and expert advisors influenced teams' project ideas. Quantitatively, we compare participants' ratings of "the extent to which discussions with each feedback source helped them change and improve their project over the course of the event" on a scale of 1 (not at all) to 5 (to a large extent) by conducting a linear mixed effect regression with feedback source (i.e. team member vs. peer advisor vs. expert advisor) as a fixed effect and both participant ID and team ID as random effects. Results show a significant effect of feedback source, $F(2, 85.39) = 7.58$, $p<.001$, such that the extent to which feedback from expert advisors was incorporated ($M = 4.14$, $SD = 0.91$, $N = 35$ ratings) is greater than the extent to which feedback from peer advisors was incorporated ($M = 3.00$, $SD = 1.17$, $N = 17$ ratings), and rivals the extent to which feedback from team members was incorporated ($M = 4.13$, $SD = 0.95$, $N = 79$ ratings) (**Figure 7-1**).

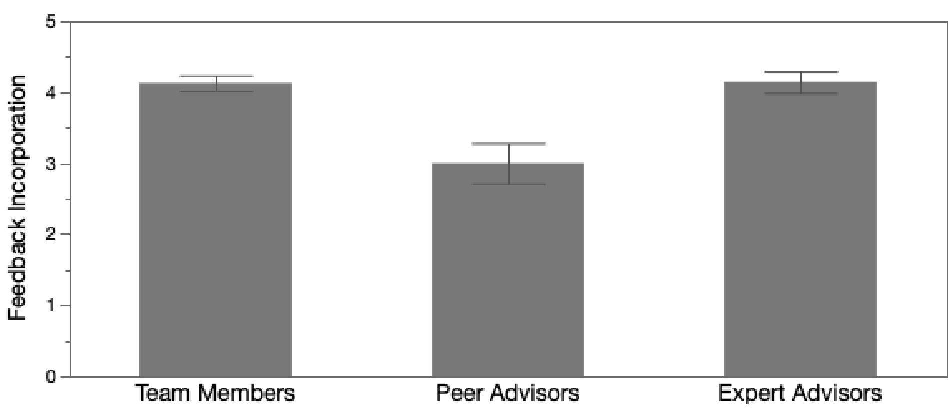

Figure 7-1. Project team members' ratings of the extent to which discussions with each feedback source helped them change and improve their project over the course of the event, on a scale of 1 (not at all) to 5 (to a large extent).

To understand why feedback from expert advisors was incorporated to a greater extent than feedback from peer advisors, we examine qualitative reports on how project teams incorporated feedback from each source. Open-ended survey and interview responses reveal two broad ways in which expert advisors influenced teams: (1) by directing their ideation *process*, and (2) by directing the content of their *project ideas*. Four participants reported that their expert advisors directed their ideation process in a Socratic-like method by guiding them through questions that they should ask themselves in order to pick, refine, and evaluate their problem formulation or solution ideas. For example, a member of Team 2 reported that their expert advisor "*asked us many critical questions, such as the goal of the project, how and why the target group would change their behavior*." Similarly, a member of Team 35 reported that their expert advisor “*brought up the question of how we would evaluate the success of our project. How would evaluation be set up? What would we measure? Over what time period?*” In addition, 23 participants reported that their expert advisors directed the content of their project ideas by providing additional context about stakeholders, challenges, and opportunities around the team’s project domain and about existing solutions in the field, as well as recommending alternative problem framings or solution approaches. For example, a member of Team 22 reported: “*Our expert mentor helped us identify a specific 'target market' for our solution (i.e. gorilla and orangutan tours) in the first round. He then returned to our group later in the process and - very critically - helped us select the most impactful idea from a handful of potential solutions that we were trying to choose between. This was very timely and important: he had seen many solutions work and not work in this space, and he validated that we were on to something with one of the ideas, so that's the one we decided to move forward with.*” Similarly, a member of Team 37 reported that their expert advisor “*gave real examples of where pushback would likely happen in hospitality and how he’d recommend us bypassing that by coming up with another approach.*” As such, feedback from expert advisors was incorporated to a great extent due to their ability to provide substantive feedback on ideation processes as well as real-world context around problems and solutions in the project domain.

On the other hand, the extent to which project teams incorporated feedback from peer advisors varied based on the peer advisors’ level of expertise in their project domain. Peer advisors with high levels of self-reported expertise (4-5 on a 5-point scale) in their advisee’s conservation problem and behavior change influenced project teams in a similar way that expert advisors did. Specifically, three participants who were assigned peer advisors with high expertise in their project domain reported that their peer advisors directed the content of their project ideas by providing additional context about stakeholders, challenges, and opportunities around their project domain and about existing solutions in the field. For example, a member of Team 40 said, “*we got to talk with the team from [a professional conservation behavior change organization] in the Philippines... they're out doing it in the field and they're working on this problem daily [...] They were pointing out that in their field and their situations, a lot of the individuals don't have access to even an SMS text phone [...] That showed us that it would be more useful if [our solution] was compatible with more basic cell phones that people would probably have, rather than smartphones if they're in a developing community.*” However, peer advisors with low levels of self-reported expertise (1-3 on a 5-point scale) in their advisee’s conservation problem and behavior change only influenced the way that project teams presented their idea, rather than the content of their idea, or did not influence their idea at all. Specifically, one participant (from Team 19) who was assigned peer advisors with low expertise in their project domain reported that “*The questions from the other team forced us to explain all of the details for our project, especially the methods*,” while seven other participants reported receiving benefits related to human capital development (i.e. networking, learning about other perspectives or solutions), rather than substantive feedback on their project. These results suggest that an advisor’s level of expertise in a project’s domain plays an important role in determining how much the advisee can incorporate their feedback into substantive project changes.

Project Quality
Given the advantages of expertise that have been observed in this study and in the prior studies, we expect feedback from expert advisors to be more effective than feedback from peer advisors at improving the quality of projects. However, results show that this is not necessarily the case, as the quality of the 14 teams' projects that received feedback from *Expert Advisors* (M = 0.06, SD = 0.66) and the 5 teams' projects that received feedback from *Peer Advisors* (M = 0.24, SD = 0.69) were both higher than the quality of the 11 teams' projects that received feedback from *No Advisors* (M = -0.23, SD = 0.71) (**Figure 7-2**). Differences between these conditions are not statistically significant, $F(2, 27) = 0.97$, $p = .39$, and pairwise comparisons also show no significant differences. These results suggest that while feedback from external experts may be more likely to get incorporated than feedback from peer teams, the feedback that gets incorporated from peer teams may be just as helpful for project quality as the feedback that gets incorporated from external experts.

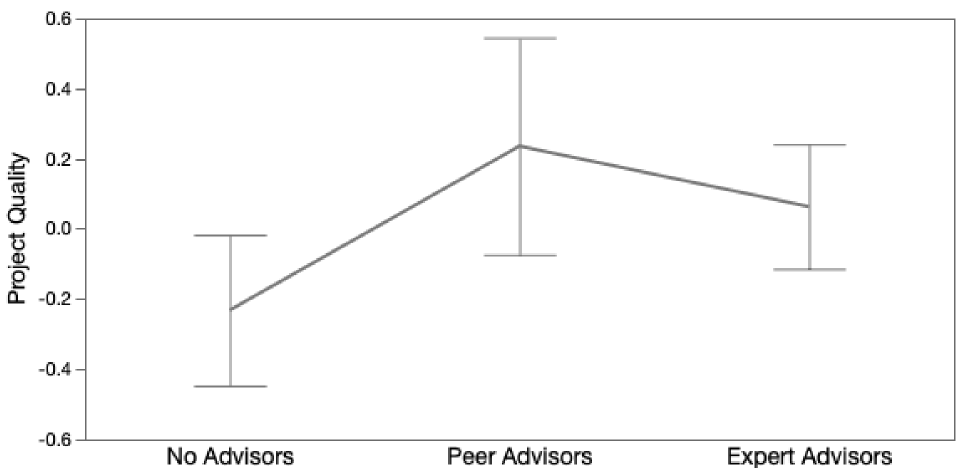

Figure 7-2. Effect of feedback source on project quality during the Virtual Ideathon.

To understand the discrepancy behind why expert advice was perceived as significantly more influential than peer advice but did not necessarily lead to significantly better project quality, we examine discrepancies between project teams' and expert advisors' perceptions on feedback incorporation. Survey and interview results show that while some project teams perceived expert advice to be highly influential to their project changes, their expert advisors did not necessarily perceive that their feedback was incorporated effectively into the advisees' projects. For example, members of Team 28 rated the extent to which discussions with their expert advisor influenced their project as a 5 on a 5-point scale, but their expert advisor reported via interview that they did not see their feedback reflected in the team's final project description: "*Initially they were talking about things that's been done by a lot of people everywhere… so that's where [I came in and told them] what the situation really is, what's been done, what has not been done, and why we're looking at it a little differently this time [...] But despite the fact that we talked about all that, they went back to the thing they initially discussed*." Similarly, members of Team 26 also rated the extent to which discussions with their expert advisors influenced their project as a 5 on a 5-point scale, but their expert advisor said via interview, "*I don't see much of the feedback that we gave the second time around being incorporated in there… it's just a summary of their original idea.*" These findings suggest that even when feedback is provided from advisors with relevant domain expertise, advisees are not always able to incorporate it effectively into their project ideas.

Discussion

By comparing the impact of different types of advisors on feedback incorporation and project quality during teams' initial ideation process, this study expands our understanding of how two types of design interventions influence feedback outcomes: expertise matching and early timing. While the prior two studies implemented expertise matching by measuring the relative similarity between peers and projects in an online innovation contest community, they were limited in that participants were all working in different project domains, so advisors may have had expertise in relatively similar but not identical domains as their advisees' project. This study expands on these prior approaches to expertise matching by identifying advisors who are working in or have expertise in the exact project domain that advisee teams are working in, and demonstrates that this more targeted approach to expertise matching is effective at inducing more substantive project feedback and its incorporation into projects.

In addition, this study also expands on the previous study's approach to introducing feedback during an early stage of a contest process. The previous study introduced a feedback intervention *after* participants had already decided on and submitted a project proposal to a contest, and found that the majority of feedback incorporations were in the form of minor changes to the presentation of projects. This study explored how feedback could induce more substantive changes to project ideas by introducing a feedback intervention *before* participants have decided on or submitted a project proposal to a contest. All together, this study contributes evidence for the following pieces in our conceptual framework of conditions for effective feedback in online innovation contests:

1. **Expertise matching** elicits more **substantive project feedback** and its **incorporation** into projects.
2. **Early timing** of feedback within a contest process can elicit **substantive project feedback** and its **incorporation** into projects.

The finding that some project teams were not able to effectively incorporate substantive project feedback from advisors in this study is consistent with the prior study's finding that some project teams experience challenges with fixation. Together, these studies suggest that beyond interventions for matching the right advisors to teams at the right time during a contest process to elicit useful feedback, some project teams may also need additional support in processing and incorporating feedback in more productive ways. We address this in the next study by introducing a new design intervention for encouraging project teams to identify actionable ways of incorporating feedback after receiving it on their contest submission, and examining what types of project teams benefit from it.

Chapter 8: Facilitating Feedback Incorporation

Research Goals

The goal of this study is to introduce a new design intervention for helping feedback receivers in an online innovation contest to process feedback in ways that facilitate its incorporation into productive project improvements. To this end, we draw on evidence-based strategies for facilitating feedback incorporation in analogous contexts where receivers often struggle to process and incorporate feedback in productive ways. Specifically, prior literature on strategies for supporting students' reception of feedback in learning contexts shows that forcing or encouraging feedback receivers to identify specific goals based on the feedback and to make clear action plans for working toward those goals can result in more productive learning outcomes [Winstone et al. 2017]. Similarly, research on strategies for supporting web-based workers' reception of feedback on their work performance shows that prompting feedback receivers to develop and write action plans based on the feedback can improve task performance more than receiving feedback alone [Anseel et al. 2009], and research on feedback reception in creative design contexts show that performing a similar reflection activity after receiving feedback yields higher quality designs [Yen et al. 2017]. In this study, we adapt this approach of "action planning" into the context of an online innovation contest by prompting project teams to identify specific actions that they can take in order to improve their project application based on the feedback they receive, and we test if and how it influences project teams' feedback incorporation behaviors and resulting project quality.

In addition to introducing action planning as a new design intervention, this study also explores how its effects may differ based on advisors' and advisees' level of expertise in a project domain. Results from our prior studies suggest that an advisor's expertise in a project domain can have a strong influence on whether and how their feedback gets incorporated into the advisee's project, but prior work on the role of expertise in fixation suggests that an advisee's expertise in a project domain can also have a strong influence on whether and how they incorporate external ideas. Specifically, experts have been shown to exhibit less flexibility and creativity in solving problems within their domain of expertise, due to their wealth of knowledge on existing and conventional solution approaches, which block their ability to consider or adapt new ideas [Frensch & Sternberg 1989; Jansson & Smith 1991; Marchant et al. 1991; Wiley 1998]. In addition, experts have been found to be more critical of feedback and feedback providers than non-experts are when the feedback they receive is inconsistent with their own knowledge or understanding in the project domain [Foong et al. 2017]. On one hand, these differences suggest that action planning may be more beneficial to non-experts than to experts in a project domain, due to non-experts' greater cognitive flexibility and receptivity to new ideas. On the other hand, if action planning can prompt experts to break through their initial fixation and take advantage of new ideas, then it may have a greater impact on them instead. To resolve these competing possibilities, this study examines how an action planning intervention influences the incorporation of feedback from and by experts vs. non-experts in a project domain, as well as how those incorporations affect the quality of projects in the contest.

To achieve these research goals, this study introduces a peer advisor program during a Grand Challenge, in which competing project teams are invited and assigned to exchange feedback on one another's written project proposals and given a dedicated period of time to revise their applications based on peer feedback before the contest closes. Unlike the Con X Tech Prizes in prior studies, which solicit project proposals for any conservation problem area of participants' own choosing, this Grand Challenge only solicits project proposals for one specific conservation problem area: artisanal scale mining. This enables us to capitalize on the advantages that we observed in prior studies of feedback exchange between peer advisors who work in the same project domain, and it allows us to make direct comparisons between feedback outcomes for experts vs. non-experts in the same project domain. In addition to examining the effect of receiving peer feedback on project quality, we also test the effect of action planning by manipulating whether project teams are instructed to perform action planning exercises or not after receiving peer feedback, and we trace its effect on project teams' feedback incorporation behaviors as well as the effect of those feedback incorporation behaviors on project quality.

Method

Participants

The data for this study is drawn from all 83 project teams who submitted an eligible application by the Grand Challenge's open call deadline. Each team consisted of 1-11 members, and self-reported demographic information from project team leaders indicate that this participant pool is predominantly male (57 male, 26 female) with mixed expertise in the contest's project domain (53 self-identified "experts" and 30 self-identified "non-experts," with a range of <1 year to 10+ years of experience in the project domain).

Conditions

Because applications to this Grand Challenge could contain confidential information and intellectual property, they were not made public, and all project teams were given the choice to share their application with other project teams in order to receive peer feedback and an opportunity to revise their submission before official contest judging began. This created two quasi-experimental conditions:

1. *Peer Feedback* - 66 project teams opted in to receive peer feedback and revise their application.
2. *No Peer Feedback* - 17 project teams opted out of receiving peer feedback and revising their application.

In addition, to examine the effect of an action planning intervention on feedback incorporation and project quality, each of the 66 project teams in the *Peer Feedback* condition were randomly assigned to one of two experimental conditions:

1. *Action Planning* - 33 project teams were instructed to generate and submit descriptions of specific ideas and revisions that they could implement in order to improve their application based on each peer's feedback.
2. *No Action Planning* - 33 project teams were instructed to complete an equivalent reflection task for each peer's feedback that did not necessarily involve generating action plans.

Procedure

After the Grand Challenge was closed to new submissions, we implemented a two-week peer feedback period, followed by a three-week revision period. During the peer feedback period, all project teams were required to provide feedback on specific peer applications that were assigned to them, but only applications in the *Peer Feedback* condition were assigned to receive peer feedback from three specific project teams each. To facilitate the feedback exchange process, each project team was given access to their assigned advisee projects through an online application portal, and instructed to provide written feedback on each via an online peer review form (Appendix X). Each peer review consisted of 5 open-ended prompts asking them to: (1) Identify the project's problem, (2) Identify important challenges, (3) Inspire novel solutions, (4) Connect with other resources, and (5) Provide other comments. Each project team was instructed to work as a team to submit one peer review for each assigned advisee project.

During the revision period, all project teams in the *Peer Feedback* condition were instructed to complete an online feedback evaluation form (Appendix Y), which prompted them to rate the quality of each peer review that they received on a scale of 1 (Very low quality) to 7 (Very high quality), followed by an open-ended prompt. In the *Action Planning* condition, the open-ended prompt was: "*Please brainstorm 3 new ideas or revisions that this feedback inspires you to think of. For each idea, specifically describe how you could use it to improve your project application.*" In the *No Action Planning* condition, the open-ended prompt was: "*Please provide 3 specific reasons why you gave this rating. For each reason, cite specific parts of the feedback that support this reason.*" Only project teams in the *Peer Feedback* condition were given the opportunity to revise their project application during this period.

After the revision period, all project teams were invited to complete a survey about the overall value of the peer feedback and revision program (Appendix Z). This survey included Likert scale questions about how much they improved their application during the revision period and how much the peer feedback they received helped them improve their application, as well as an open-ended question about any benefits that they gained through the peer feedback program.

Data Analysis

Feedback Incorporation

A total of 183 peer reviews were provided, and 173 of them were evaluated by their receiver. To examine how action planning affected project teams' incorporation of feedback from peer reviews, we collected and analyzed the textual data from each project team's pre- and post-revision applications, peer reviews, and open-ended responses in the feedback evaluation forms. By extracting objective differences between each project's pre- and post-revision application texts and correlating them with the text in each peer review as well as the receiver's open-ended responses to it, the revisions that were influenced by each peer review were coded as either changes to *project presentation* or to *project substance*. Changes to *project presentation* were defined as revisions that support or strengthen the communication of existing ideas in the application, such as copy edits, minor writing clarifications, and explanations or evidence for existing concepts in the proposal, that were incorporated in response to specific comments in each peer review. Changes to *project substance* were defined as revisions that added new concepts that expanded beyond existing ideas in the application, such as the proposal of new plans for testing, risk mitigation, or collaboration in the project, and pivots to entirely different approaches for addressing the overall challenge, that were incorporated in response to specific comments in each peer review.

To convert these qualitative codings into a quantitative measure of feedback incorporation, the extent to which each peer review influenced each project's revisions was coded on a 5-point scale:

1. No changes at all based on this peer review;
2. No conceptual changes in project substance, but small changes in project presentation based on this peer review (i.e. copyedits, minor writing clarifications to existing text);
3. No conceptual changes in project substance, but large changes in project presentation based on this peer review (i.e. added new evidence to support existing concepts);
4. Small conceptual changes in project substance based on this peer preview (i.e. added new plans for testing, risk mitigation, or collaboration to its existing solution);
5. Large conceptual changes in project substance based on this peer review (i.e. pivoted to a different approach for addressing the overall challenge).

This scale was developed through iterative rounds of coding and discussion between the lead researcher and a research assistant, and reflects the goal of feedback to stimulate new ideas by representing changes to *project substance* as greater extents of feedback incorporation than changes to *project presentation*.

To validate our codings, we confirmed that they are significantly correlated with feedback receivers' subjective self-reports of the extent to which peer reviews helped improve their project applications and with objective measures of the Levenshtein distance (i.e. number of character edits) between projects' pre- and post-revision application texts. Both alternative data sources provide useful signals to help check the validity of our codings, but are not strong enough on their own to serve as the primary measure of feedback incorporation in our analyses.

Subjective Self-Reports of Feedback Incorporation

Subjective self-reports of the extent to which project teams incorporated peer feedback into their project revisions were collected via the following question in a survey that was administered to all 66 project teams in the *Peer Feedback* condition after the revision period ended: "How much did the peer feedback you received help improve your application?" (rated on a scale of 1=Very little, to 5=Very much). At face value, we expect greater extents of feedback incorporation as represented in our codings to be reflected in greater extents of feedback incorporation as self-reported by project teams. To confirm this, we calculated the correlation between each project team's subjective rating and our coding of the maximum extent of feedback incorporation associated with all of its peer reviews. Results show that these two measures are indeed significantly correlated, $r = 0.56$, $p<.01$, supporting the face validity of our codings.

However, three major weaknesses of these subjective self-reports prevented us from using it as the primary measure of feedback incorporation in our analyses. First, 16 of the 66 project teams in the *Peer Feedback* condition did not complete the survey, so we were missing self-reported data from nearly 25% of project teams. Second, the survey question elicited a single rating for the impact of all peer feedback, but each project received peer reviews from up to 3 different project teams, so this data does not provide a separate measure of feedback incorporation for each individual peer review. Finally, we had already observed in the prior study that some project teams perceive feedback to be highly influential to their project, even when that feedback is not behaviorally reflected in their proposals. To reduce these discrepancies, we need a measure that reflects project teams' feedback incorporation behaviors, rather than relying on project teams' feedback incorporation perceptions. Our codings address all three of these weaknesses by having a human researcher code every peer review individually based on project teams' feedback incorporation behaviors that are reflected in their applications.

Objective Measures of Project Revisions

Objective measures of project revisions were computed using the Levenshtein distance (i.e. minimum number of character edits) between the textual components of project teams' pre- and post-revision applications. At face value, we expect greater extents of feedback incorporations as represented in our codings to be reflected in greater amounts of project revisions. To confirm this, we calculated the correlation between each project's Levenshtein distance and our coding of the maximum extent of incorporation associated with all of its peer reviews. Results show that these two measures are indeed significantly correlated, $r = 0.67$, $p<.01$, again supporting the face validity of our codings.

However, three major weaknesses of this machine-generated measure of project revisions prevented us from using it as the primary measure of feedback incorporation in our analyses. First, not all project revisions may have been based on incorporations of peer feedback, as project teams could also have made any changes that they thought of by themselves without input from their peers. While Levenshtein distance captures all project revisions, it does not differentiate between revisions that were vs. were not influenced by peer feedback. However, we specifically want to measure revisions that were influenced by peer feedback. Second, Levenshtein distance is only a measure of surface-level changes in a text (i.e. number of character differences), but it does not measure semantic changes in a text. However, we want a measure that is sensitive to the difference between surface-level changes to project presentation and semantic changes to project substance. Finally, Levenshtein distance is only able to capture changes in textual data, but contest applications also included graphical components such as charts and diagrams, and we want to be able to capture both textual and non-textual revisions that were influenced by peer feedback. Our codings address all three weaknesses of Levenshtein distance by having a human researcher make semantic judgements on the nature of textual and graphical differences between each project team's pre- and post-revision application, as well as their correlation with the semantic content of peer reviews.

Project Quality Evaluation

To evaluate the quality of all 83 projects at the end of the revision period, each application was evaluated by three to four independent CXL judges (who were blind to condition) on a scale of 0 (Does not meet the criteria) to 5 (Exceeds the criteria) along 16 contest criteria that were grouped into four categories: (1) Impact, (2) Design of the Innovation, (3) Adoption/Scalability, and (4) Business Viability (Appendix AA). To adjust for potential biases between judges, all scores were z-scored within each judge. Each project's final quality score was computed as the average of z-scores from both of its judges.

Results

Effects of Peer Feedback on Project Quality

Before diving into the nuances of how action planning affected feedback outcomes, we first explore whether giving project teams' the opportunity to receive peer feedback and revise their contest submissions at all improved the quality of projects in the contest. To do this, we compare the quality of projects that opted in to receive peer feedback vs. opted out of receiving peer feedback by conducting a linear regression with their quasi-experimental condition as the predictor (i.e. *No Peer Feedback* vs. *Peer Feedback*). Results show that the average quality of the 66 projects in the *Peer Feedback* condition (M = 0.04, SD = 0.74) was higher than the average quality of the 17 projects in the *No Peer Feedback* condition (M = -0.14, SD = 0.76), but this difference was not significant $t(82) = 0.95$, $p=.34$ (**Figure 8-1**). Adding the project domain expertise of application leaders (i.e. *Expert* vs. *Non-Expert*) and its interaction with quasi-experimental condition as predictors into the linear regression also resulted in non-significant effects of all terms. However, we expect that there are differences in project quality within the *Peer Feedback* condition, based on our action planning intervention and the feedback incorporation behaviors it elicits, so we explore these nuances next.

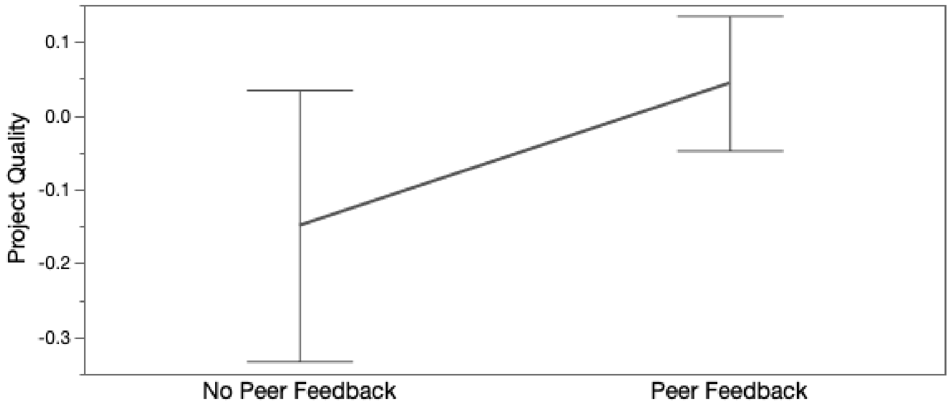

Figure 8-1. Effect of receiving peer feedback on project quality in the Grand Challenge.

Effects of Action Planning on Feedback Incorporation

To examine the effects of action planning on the incorporation of peer feedback, we conducted a linear mixed-effect regression on our quantitative measure of the extent to which each peer review influenced its project's revisions, with the experimental condition of each peer review as a fixed effect (i.e. *Action Planning* vs. *No Action Planning*) as well as the Team ID's of the peer review's provider and receiver as random effects. In addition, to explore if and how the effects of action planning may have differed based on participants' project domain expertise, we included two other fixed effects for advisors' and advisees' self-reported expertise (i.e. *Expert* vs. *Non-Expert*), as well as their interactions with action planning and with one another in the regression. Results show that action planning had opposite effects on expert vs. non-expert advisees (**Figure 8-2**): it led to a *lesser* extent of feedback incorporation for expert advisees, but a *greater* extent of feedback incorporation for non-expert advisees, regardless of the advisor's project domain expertise (**Table 8-1**). This is consistent with existing theories suggesting that experts exhibit greater cognitive inflexibility and resistance against feedback than non-experts do.

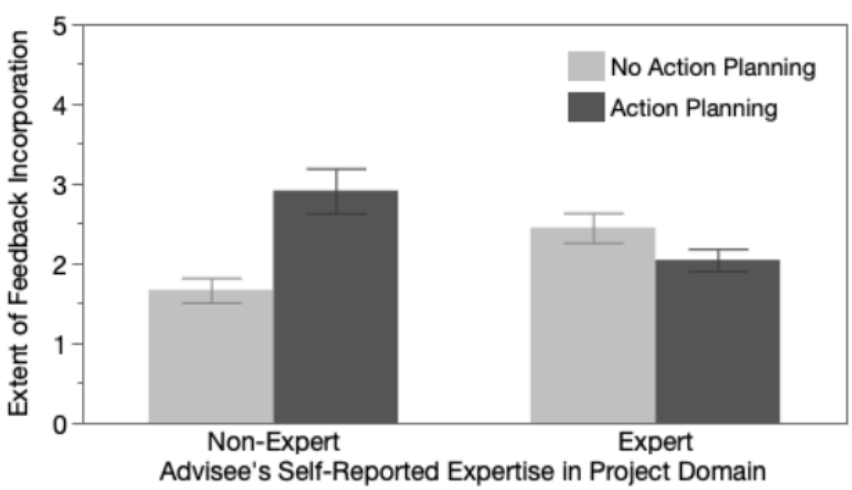

Figure 8-2. Two-way interaction between advisee's self-reported expertise in the project domain and action planning on the extent to which peer reviews influenced their project revisions on a scale of 1 (No changes at all) to 5 (Large conceptual changes in project substance).

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	2.25191	0.154502	72.19	14.58	<.0001*
Advisor's Project Domain Expertise	0.1087309	0.079375	68.63	1.37	0.1752
Advisee's Project Domain Expertise	-0.004938	0.14997	67.06	-0.03	0.9738
Action Planning	0.1944062	0.149273	66.07	1.30	0.1973
Advisor's Project Domain Expertise * Advisee's Project Domain Expertise	0.002589	0.070653	118.5	0.04	0.9708
Advisor's Project Domain Expertise * Action Planning	0.0095228	0.070398	120.7	0.14	0.8926
Advisee's Project Domain Expertise * Action Planning	**-0.410447**	**0.149042**	**65.8**	**-2.75**	**0.0076***
Advisor's Project Domain Expertise * Advisee's Project Domain Expertise * Action Planning	0.0682212	0.069778	115.1	0.98	0.3303

Table 8-1. Effects of action planning and project domain expertise on the extent of feedback incorporation. N = 176 peer reviews for which both advisor and advisee provided self-reported expertise data.

To further understand the nature of these differences, we examine the distribution of peer reviews that were incorporated through changes to *project presentation* vs. *project substance*. Results show that action planning affected both types of incorporations in different ways for experts vs. non-experts. For experts, action planning did not affect the percentage of peer reviews that were incorporated through changes to *project presentation* (49% without action planning vs. 48% with action planning), but decreased the percentage of peer reviews that were incorporated through changes to *project substance* (33% without action planning vs. 15% with action planning). For non-experts, action planning increased the percentage of peer reviews that were incorporated through changes to both *project presentation* (36% without action planning vs. 70% with action planning) and *project substance* (7% without action planning vs. 35% with action planning). Given that changes to *project presentation* focus on supporting existing ideas in an application, while changes to *project substance* focus on expanding beyond existing ideas in an application, these results suggest that action planning may make experts more critical of potential new ideas from peers, while making non-experts' more receptive to criticisms on their existing ideas as well as potential new ideas from peers.

Effects of Feedback Incorporation on Project Quality

The incorporation of feedback into project revisions is an important step to influencing project quality, but not all incorporations of feedback may have the same impact on project quality, as we expect that greater extents of revisions (i.e. changes to *project substance*) may have a stronger influence than lesser extents of revision (i.e. changes to *project presentation*). In addition, revisions made by experts and non-experts in a project domain may not be equally effective at improving project quality, as differences in their cognitive flexibility may influence how action planning facilitates their ability to identify productive ways of incorporating new ideas. Thus, we examine how different extents of feedback incorporation that were induced by action planning affected project quality for experts vs. non-experts by conducting a linear regression on project quality with the following three factors and their interactions as predictors: (1) the extent to which the project incorporated peer feedback (coded on our scale of 1=No changes at all, to 5=Large conceptual changes in project substance), (2) the project's experimental condition (i.e. *Action Planning* vs. *No Action Planning*), and (3) the project team leader's self-reported expertise in the project domain (i.e. *Expert* vs. *Non-Expert*).

Results show a significant three-way interaction, such that different extents of feedback incorporation that were induced by action planning affected project quality in different ways for experts vs. non-experts (**Table 8-2**). Specifically, greater extents of feedback incorporation that were induced by action planning led to significantly *higher* project quality for non-experts than for experts, while greater extents of feedback incorporation *without* action planning led to significantly *lower* project quality for non-experts than for experts (**Figure 8-3**), suggesting that action planning may have helped to redirect non-experts' feedback incorporation behaviors from counterproductive to productive revisions. Given that greater extents of feedback reflect changes to *project substance*, these results suggest that action planning may be most beneficial to project quality when it is used by non-experts in a project domain to incorporate feedback through new ideas or pivots to alternative project approaches.

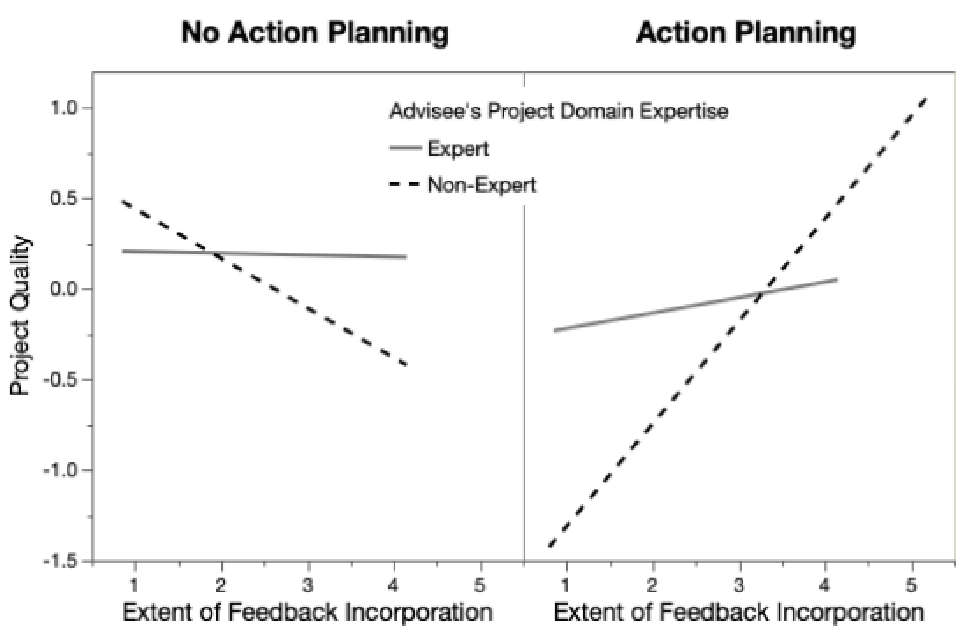

Figure 8-3. Three-way interaction between project domain expertise, action planning, and the extent of feedback incorporation on project quality.

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.313563	0.24216	-1.29	0.2005
Advisee's Project Domain Expertise	0.1305273	0.104213	1.25	0.2154
Action Planning	-0.183452	0.104213	-1.76	0.0836
Extent of Peer Feedback Incorporation	0.0921794	0.079739	1.16	0.2524
Advisee's Project Domain Expertise * Action Planning	0.0445617	0.104213	0.43	0.6705
Advisee's Project Domain Expertise * Extent of Peer Feedback Incorporation	-0.054366	0.079739	-0.68	0.4981
Action Planning * Extent of Peer Feedback Incorporation	**0.2341705**	**0.079739**	**2.94**	**0.0048***
Advisee's Project Domain Expertise * Action Planning * Extent of Peer Feedback Incorporation	**-0.186529**	**0.079739**	**-2.34**	**0.0228***

Table 8-2. Effects of project domain expertise, action planning, and the extent of feedback incorporation on project quality. N = 66 projects in the *Peer Feedback* condition.

Discussion

This study expands on the prior studies by demonstrating that not only is it important to match the right advisors to the right advisees at the right times within a contest process in order to elicit substantive feedback on projects, but it is also important to help advisees process and incorporate the feedback in a productive way in order for it to improve project quality. In addition, it shows that design interventions for supporting feedback incorporation can have different effects on advisees with different levels of expertise in the project domain. Specifically, prompting advisees who are not experts in their project domain to brainstorm specific actions they can take in order to incorporate peer feedback into project improvements (i.e. action planning) appeared to overcome some of the barriers to feedback incorporation that were observed in prior studies (i.e. receiver fixation) by inducing those non-experts to make more revisions to their project presentation and project substance. In turn, these revisions to project substance improved project quality for those non-experts who were prompted to perform action planning. Overall, this study contributes evidence for the following pieces in our conceptual framework of conditions for effective feedback in online innovation contests:

1. **Action planning** elicits greater extents of **feedback incorporation** for receivers who are non-experts in their project domain (but lesser extents of feedback incorporation for receivers who are experts in their project domain).
2. **Action planning** results in **project improvements** for feedback receivers who are non-experts in their project domain and incorporate feedback to a great extent.

The fact that we did not find a significant effect of peer advisors' project domain expertise on the extent to which their feedback was incorporated by advisee project teams in this study may seem inconsistent with the prior study's finding that feedback from peer advisors with more project domain expertise was incorporated into advisee projects more than feedback from advisors with less project domain expertise. However, this may be explained by an overall difference in the project domain expertise of participants across the two studies: the majority of participants in the Virtual Ideathon self-reported low levels of expertise in the event's project domain (i.e. conservation behavior change) and many were working in their assigned project domain for the first time during the event, while the majority of participants in the Grand Challenge self-reported high levels of expertise in the = contest's project domain (i.e. artisanal scale mining), and all of them already had experience with either working directly in the project domain or developing a project proposal in this domain (i.e. for this Grand Challenge). Thus, the project domain expertise of peer advisors in this study may have already been sufficient enough to provide substantive feedback on projects in this domain (even if they self-identify as "non-experts" in it).

However, this study still provides inconclusive evidence for a critical question underlying this dissertation's approach to inducing feedback in online innovation contests: Does receiving external feedback actually result in better project quality than not receiving external feedback? This study's finding that receiving external feedback had a positive but non-significant effect on project quality is consistent with findings from the prior two studies in Chapter 6 and Chapter 7, which also show positive but non-significant effects of receiving external feedback on project quality. However, these findings are contrary to findings from the study in Chapter 4, which show a significant negative effect of receiving external feedback on project quality. Several limitations prevent us from being able to draw strong conclusions about the effect of receiving external feedback on project quality from these findings. One limitation is the low statistical power of each study, which was constrained by the number of projects in each contest. This makes it difficult to interpret whether non-significant differences between the quality of projects in conditions that received vs. did not receive feedback mean that feedback truly did not have an effect on project quality, or that we were just not able to reliably detect an existing effect. Another limitation is that the feedback in each study was induced under different design interventions (i.e. with vs. without expertise matching; at late vs. early stages in the contest process). This makes it difficult to make direct comparisons between the effect of feedback across the studies. We address these limitations in the next chapter by conducting meta-analyses across the results from the five studies to examine how feedback that was induced under different design interventions affected project quality.

Chapter 9: Meta-Analysis

Research Goals

One of the fundamental assumptions underlying our overall approach of inducing feedback on projects in online innovation contests is that receiving feedback can help improve the quality of projects. However, limitations to the design of our five studies provide inconclusive evidence for whether receiving feedback indeed leads to better project quality than not receiving feedback, and under what conditions it does so, when each study is analyzed independently. To overcome these limitations, we conduct meta-analyses across the results from our five studies to examine how receiving feedback under different design interventions affected project quality.

In addition to examining the overall effect of receiving feedback on project quality, we also examine the effects of two types of design interventions that we had observed qualitative but inconclusive quantitative evidence for potentially improving project quality in the five independent studies: expertise matching and early timing. Since assigning advisors to advisees without taking into account the match between their specific expertise and specific projects only resulted in benefits related to human capital development (i.e. Chapter 4), while matching advisors to advisees with expertise in similar or complementary project domains resulted in more substantive feedback on projects (i.e. Chapters 5-8), we expect that receiving feedback with expertise matching led to better project quality than not receiving feedback. In addition, since constraints during later stages of contest processes limited the extent to which project teams could incorporate changes to their projects (i.e. during the prototyping phase in Chapters 4-5), while project teams had more flexibility and opportunity to incorporate feedback during earlier stages of contest processes (i.e. prior to final proposal submissions in Chapters 6-8), we also expect that receiving feedback with early timing led to better project quality than not receiving feedback. We explore whether these two design interventions demonstrated these expected effects across our studies through a set of five meta-analyses.

Method

To examine the effects of receiving feedback under different design interventions, we code the "condition" of each project from the five studies based on whether the project team actually received feedback from peer/expert advisors or not. This results in two overall conditions:

1. ***Feedback*** - A total of 160 projects received feedback, either because they were experimentally forced to receive feedback or because the project team voluntarily chose to engage with advisors (7 from Chapter 4, 14 from Chapter 5, 54 from Chapter 6, 19 from Chapter 7, and 66 from Chapter 8).
2. ***No Feedback*** - A total of 54 projects did not receive feedback, either because they were not experimentally assigned to receive feedback, or because they were assigned to receive feedback but the project team did not actually engage with any advisors (6 from

Chapter 4, 3 from Chapter 5, 17 from Chapter 6, 11 from Chapter 7, and 17 from Chapter 8).

Additionally, to examine the effects of receiving feedback under different design interventions, we code each project in the ***Feedback*** condition based on whether the feedback received was induced with or without expertise matching and early timing. Expertise matching was defined by whether the feedback was induced from advisors in the study who had similar domains of expertise as them, complementary domains of expertise as them, or were working in similar project domains as them. Early timing was defined by whether the feedback was induced prior to final proposal submissions and prototyping during the contest process. This results in four subgroups:

1. **Feedback *with* Expertise Matching** - 123 projects.
2. **Feedback *without* Expertise Matching** - 37 projects.
3. **Feedback *with* Early Timing** - 139 projects.
4. **Feedback *without* Early Timing** - 21 projects.

Table 9-1 summarizes the exact studies and experimental conditions that projects in each subgroup came from.

	Feedback *with* Expertise Matching (N = 123 projects)	**Feedback *without* Expertise Matching** (N = 37 projects)
Feedback *with* Early Timing (N = 139 projects)	**Chapter 6** (24 *Similar Assignment*) **Chapter 7** (5 *Peer Advisors*, 14 *Expert Advisors*) **Chapter 8** (66 *Peer Feedback*)	**Chapter 6** (9 *No Assignment*, 21 *Random Assignment*)
Feedback *without* Early Timing (N = 21 projects)	**Chapter 5** (8 *Similar Expertise Matching*, 6 *Complementary Expertise Matching*)	**Chapter 4** (7 *peer advisor program*)

Table 9-1. Studies and experimental conditions that projects in each meta-analysis subgroup came from.

Using these codings, five fixed-effects model meta-analyses were conducted to compare the average quality of projects that did vs. did not receive feedback overall and within each of the four subgroups, using the *metacont* function in the *meta* package for the statistical software R. The fixed-effects model assumes that all studies stem from a single homogeneous population, and pools their effect sizes to get one overall effect size estimate by computing a weighted average of all effect sizes. Greater weight is given to studies with greater precision, i.e. studies with a larger N, which leads to a smaller standard error of their effect size estimate. As such, these meta-analyses enable us to estimate the overall effects of receiving feedback across our multiple studies.

Results

Effect of receiving any feedback

A meta-analysis on the effect of receiving any feedback across all five studies shows no significant effect on project quality ($z = 1.31$, $p = .19$, **Table 9-2**). However, measures of heterogeneity show moderate heterogeneity between the five studies ($I^2 = 52\%$, $\tau^2 = 0.06$, $p = .08$), indicating that there may be distinct subgroups of studies with distinct effects. These results suggest that feedback induced under different design interventions may have had different effects on project quality.

	Feedback			*No Feedback*					
Study	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**Mean Difference**	**95% Confidence Interval**	**Weight**
Chapter 4	7	-0.46	0.61	6	0.20	0.50	-0.67	[-1.27; -0.06]	9.8%
Chapter 5	14	-0.09	0.64	3	0.13	0.78	-0.22	[-1.16; 0.73]	3.9%
Chapter 6	54	0.17	0.56	17	-0.04	0.46	0.22	[-0.05; 0.48]	51.1%
Chapter 7	19	0.11	0.66	11	-0.23	0.71	0.34	[-0.17; 0.86]	13.4%
Chapter 8	66	0.04	0.74	17	-0.15	0.76	0.19	[-0.21; 0.60]	21.9%
Fixed effects model	**160**			**54**			**0.13**	**[-0.06; 0.31]**	**100.0%**

Table 9-2. Fixed-effects model meta-analysis on the effect of receiving feedback on project quality.

Effect of receiving feedback *with* expertise matching

A meta-analysis on the effect of receiving feedback with expertise matching across the four studies in this subgroup shows a significant positive effect on project quality ($z = 2.49$, $p = .01$, **Table 9-3**). Measures of heterogeneity show no heterogeneity between the studies ($I^2 = 0\%$, $\tau^2 = 0$, $p = .72$), indicating that this effect is consistent across these four studies. These results support our hypothesis that feedback improves project quality when advisors are matched to advisees based on their specific expertise and specific projects.

	Feedback with Experist Matching			*No Feedback*					
Study	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**Mean Difference**	**95% Confidence Interval**	**Weight**
Chapter 4	-	-	-	-	-	-	-	-	-
Chapter 5	14	-0.09	0.64	3	0.13	0.78	-0.22	[-1.16; 0.73]	4.8%
Chapter 6	24	0.28	0.48	17	-0.04	0.46	0.32	[0.03; 0.61]	51.8%
Chapter 7	19	0.11	0.66	11	-0.23	0.71	0.34	[-0.17; 0.86]	16.4%
Chapter 8	66	0.04	0.74	17	-0.15	0.76	0.19	[-0.21; 0.60]	26.9%
Fixed effects model	**123**			**54**			**0.27**	**[0.06; 0.47]**	**100.0%**

Table 9-3. Fixed-effects model meta-analysis on the effect of receiving feedback with expertise matching on project quality.

Effect of receiving feedback *without* expertise matching

A meta-analysis on the effect of receiving feedback without expertise matching across the two studies in this subgroup shows no significant effect on project quality (z = -0.23, p = .82, **Table 9-4**). However, measures of heterogeneity show substantial heterogeneity between the two studies (I^2 = 81%, τ^2 = 0.26, p = .02), indicating that their feedback interventions had distinct effects. Since one study was conducted during a later stage of a contest process (i.e. during the prototyping phase of a Con X Tech Prize), while the other study was conducted during an earlier stage of a contest process (i.e. prior to final proposal submission in the ideation phase of a Con X Tech Prize), these results suggest that feedback without expertise matching may have had different effects on project quality when induced at different times.

	Feedback without Expertise Matching			*No Feedback*					
Study	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**Mean Difference**	**95% Confidence Interval**	**Weight**
Chapter 4	7	-0.46	0.61	6	0.20	0.50	-0.67	[-1.27; -0.06]	20.6%
Chapter 5	-	-	-	-	-	-	-	-	-
Chapter 6	30	0.09	0.61	17	-0.04	0.46	0.13	[-0.17; 0.44]	79.4%
Chapter 7	-	-	-	-	-	-	-	-	-
Chapter 8	-	-	-	-	-	-	-	-	-
Fixed effects model	**37**			**54**			**-0.03**	**[-0.31; 0.24]**	**100.0%**

Table 9-4. Fixed-effects model meta-analysis on the effect of receiving feedback without expertise matching on project quality.

Effect of receiving feedback *with* early timing

A meta-analysis on the effect of receiving feedback with early timing across the three studies in this subgroup shows a significant positive effect on project quality (z = 2.23, p < .03, **Table 9-5**). Measures of heterogeneity show no heterogeneity between the studies (I^2 = 0%, τ^2 = 0, p = .90), indicating that this effect is consistent across these three studies. These results support our hypothesis that feedback improves project quality when it is induced during contest periods when project teams still have the flexibility and opportunity to incorporate external ideas into changes to their project submission.

	Feedback with Early Timing			*No Feedback*					
Study	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**Mean Difference**	**95% Confidence Interval**	**Weight**
Chapter 4	-	-	-	-	-	-	-	-	-
Chapter 5	-	-	-	-	-	-	-	-	-
Chapter 6	54	0.17	0.56	17	-0.04	0.46	0.22	[-0.05; 0.48]	59.2%
Chapter 7	19	0.11	0.66	11	-0.23	0.71	0.34	[-0.17; 0.86]	15.5%
Chapter 8	66	0.04	0.74	17	-0.15	0.76	0.19	[-0.21; 0.60]	25.3%
Fixed effects model	**139**			**54**			**0.23**	**[0.03; 0.43]**	**100.0%**

Table 9-5. Fixed-effects model meta-analysis on the effect of receiving feedback with early timing on project quality.

Effect of receiving feedback *without* early timing
A meta-analysis on the effect of receiving feedback without early timing across the two studies in this subgroup shows a significant negative effect on project quality (z = -2.07, p < .04, **Table 9-6**). Measures of heterogeneity show no heterogeneity between the studies (I^2 = 0%, τ^2 = 0, p = .43), indicating that this effect is consistent across these two studies. These results suggest that feedback interventions need to be designed carefully in order to avoid inducing inadvertent negative effects on project quality.

	Feedback without Early Timing			*No Feedback*					
Study	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**Mean Difference**	**95% Confidence Interval**	**Weight**
Chapter 4	7	-0.46	0.61	6	0.20	0.50	-0.67	[-1.27; -0.06]	71.2%
Chapter 5	14	-0.09	0.64	3	0.13	0.78	-0.22	[-1.16; 0.73]	28.8%
Chapter 6	-	-	-	-	-	-	-	-	-
Chapter 7	-	-	-	-	-	-	-	-	-
Chapter 8	-	-	-	-	-	-	-	-	-
Fixed effects model	**21**			**54**			**-0.54**	**[-1.05; -0.03]**	**100.0%**

Table 9-6. Fixed-effects model meta-analysis on the effect of receiving feedback without early timing on project quality.

Discussion

These meta-analyses expand on the independent results from our five studies by revealing consistent quantitative evidence to support the qualitative and descriptive trends that were observed in the five studies. Specifically, they provide more conclusive evidence on the benefits of two types of design interventions for inducing feedback: expertise matching and early timing. These results suggest that feedback improves project quality when advisors are matched to advisees based on their specific expertise and specific projects, and when it is induced during contest periods when project teams still have the flexibility and opportunity to incorporate external ideas into changes to their project submission. Overall, these meta-analyses contribute evidence for the following pieces in our conceptual framework of conditions for effective feedback in online innovation contests:

1. Engagement with **expertise matching** results in **project improvements**.
2. Engagement with **early timing** results in **project improvements**.

While these meta-analyses address some limitations from our five independent studies, they are not without limitations of their own. First, analyzing projects based on whether they actually received feedback or not rather than by their assigned experimental conditions means that the effect of receiving feedback in these meta-analyses could be confounded with other factors, such as motivation, that may have influenced whether a project team actually received feedback or not. However, receiving feedback was experimentally forced in two of the five studies (Chapters 6-7), and the effects observed in these two studies are consistent with the effects observed in the other three studies where project teams had a choice in deciding whether or not to engage with assigned advisors and receive feedback (Chapter 4-5 and 8). This suggests that the effects observed in these meta-analyses are at least in part due to receiving feedback and not purely due to confounds.

In addition, another limitation of these meta-analyses is that expertise matching and early timing are confounded in some studies which implemented both design interventions at the same time (i.e. Chapters 6-8). If there were multiple studies that implemented one design intervention without the other, then further subgroup analyses could examine their interaction effect, but we only have one study with expertise matching without early timing, and only one study without expertise matching with early timing. Thus, it is impossible to tease apart the independent effects of these two interventions with meta-analyses on the present five studies, as a portion of the effect of expertise matching may have been due to early timing and vice versa.

Possible solutions to addressing these limitations include expanding the sample size represented in the meta-analyses (e.g. by repeating the present studies in multiple future contests), as well as leveraging a different research design, in which expertise matching and early timing are both experimentally manipulated within the same study rather than between different studies. Both of these solutions were not able to be implemented in the present work due to the nature and constraints of contests in our field setting. However, the results of this work provide a motivating foundation for future work to further examine the independent effects of different design interventions on feedback’s potential to improve project quality.

Chapter 10: Discussion

In summary, this dissertation addresses key inefficiencies in online innovation contests by exploring a new approach to designing them as communities of practice. Specifically, we introduce new design interventions for inducing effective feedback exchange with participants and non-participants in online innovation communities, both during and after contests. Through five empirical studies and meta-analyses across their results, we demonstrate a conceptual framework of conditions under which these feedback interventions are successful at leveraging participant contributions to benefit one another and improve the quality of projects. Below, we discuss how researchers and practitioners can use this design approach and framework to inform future interventions in online innovation contests and other contexts.

Designing Feedback to Leverage Participant Contributions

One of the key challenges that this work addresses is how online innovation contests are inefficient at inducing participants to contribute their efforts and expertise towards innovation challenges, as the majority of their ideas are unrewarded and unused by contest prizes. Our introduction of new peer advisor programs that explicitly invite and assign community members to provide feedback on specific projects demonstrates that these inefficiencies can be overcome by creating additional opportunities for people to gain non-monetary benefits in exchange for contributing their efforts and expertise to contest projects. Specifically, we show that setting up explicit processes and targets for feedback exchange can even overcome a lack of participant engagement in collaboration during contests as well as a lack of participant engagement after contests that many previous online innovation contest communities have faced.

Our findings carry several practical implications for managing the growth and success of online innovation communities. First, the fact that our peer advisor programs successfully induced non-finalists, non-competitors, and previous finalists in Con X Tech Prizes to contribute to and benefit from contests without having to participate as active competitors suggests alternative pathways for attracting and retaining contributors in online innovation communities. Prior research in other types of online communities for peer learning and peer production have shown that "legitimate peripheral participation," or engagement in non-critical but helpful tasks, is a common pathway through which newcomers become socialized and further integrated into a community [Fiesler et al. 2017; Lave & Wenger 1991; Mugar et al. 2014; Preece & Schneiderman 2009]. For example, newcomers in Wikipedia perform peripheral tasks such as noting or correcting mistakes in articles [Bryant et al. 2005; Halfaker et al. 2013], while newcomers in open source software communities perform peripheral tasks such as submitting bug reports or feature requests [Gasson & Purcell 2018; von Krogh et al. 2003]. Similarly, the creation and assignment of tasks for non-competitors in contests (e.g. peer advising) can serve as a form of legitimate peripheral participation that removes the barrier of having to submit a contest proposal and broadens the potential range of members who contribute and stay in online innovation communities. This is especially relevant for organizations and contest platforms that seek to build a persistent community of participants to draw upon for multiple innovation contests over time.

Additionally, our findings provide practical guidance for helping members in online innovation communities to gain the types of benefits that are appropriate for their needs at any given time. Specifically, the fact that different types of matching and timing of feedback led to different types of value for participants in our peer advisor programs suggests that feedback interventions can be tailored based on whether community members are seeking general benefits related to human capital development or seeking substantive feedback on their projects. For example, newcomers who do not have a specific project of their own but are interested in networking with other members or learning about other project domains can be randomly matched with other members to do so. On the other hand, members who are actively working on a specific project can be matched with other members who have relevant expertise in their project domain to get feedback during their ideation sessions or on their initial project proposals. As such, supporting community members' articulation of their expertise or needs through mechanisms such as user profiles and project description fields, as well as implementing intelligent matching systems that can dynamically adapt to members' changing needs throughout their tenure in the community could further engage and benefit a broader range of participants over time.

Designing Feedback to Improve Project Quality

Another key challenge that this work addresses is how online innovation contests are inefficient at generating high-quality ideas, as they often produce a disproportionate number of low-quality ideas that remain unused. Our introduction of new design interventions for inducing feedback exchange demonstrates that these inefficiencies can be overcome by leveraging the efforts and expertise of members in an online innovation community to collaboratively improve the quality of ideas in contests. Specifically, this work also shows the importance of strategically matching specific advisors to project teams during strategic times within contest processes in order to realize the benefits of feedback on project quality.

Our findings carry several practical implications for managing the quality of ideas in online innovation contests. First, the fact that expertise matching played an important role in eliciting substantive project feedback and its incorporation into project improvements suggests that contest platforms should explore different approaches for collecting and analyzing data on participants' expertise and projects in order to facilitate such matching. This dissertation demonstrated three different approaches to expertise matching: (1) matching based on self-reported expertise (Chapter 5), (2) matching based on project submissions (Chapter 6), and (3) matching within a contest challenge domain (Chapter 7 & Chapter 8). The first two approaches demonstrate the potential of using machine learning to generate matches in a systematic and scalable manner in contests with large numbers of diverse submissions, while the third approach demonstrates that it is also possible to facilitate effective matching by restricting the scope of projects in each contest. More generally, our interventions represent a broad design space of potential expertise matching approaches that could be further explored in order to improve project quality. For example, more sophisticated matching algorithms can be explored for identifying potentially useful yet non-obvious sources of expertise by extracting analogical relationships between participants' expertise and projects or contest domains.

In addition, the fact that early timing of feedback within contest processes also played an important role in enabling project improvements suggests that contest platforms should explore different approaches for building more explicit feedback processes into the early stages of contest timelines. This dissertation demonstrated two different approaches to early timing: (1) dedicated feedback and revision periods prior to final proposal submission (Chapter 6 & Chapter 8), and (2) dedicated feedback sessions during initial project ideation (Chapter 7). While we only implemented one round of interventions during each contest, our results suggest that feedback may be beneficial to projects at multiple points within the early stages of contest processes, and open up a broader design space of approaches that could be further explored in order to improve project quality. For example, more iterative rounds of feedback interventions can be explored for eliciting different types of feedback that may be useful for projects at different levels of maturity, and building a culture of iteration rather than one-time submissions.

Finally, the fact that action planning played an important role in facilitating the benefits of feedback for participants who are non-experts in a contest domain suggests that contest platforms should explore different approaches for supporting not only the exchange of feedback but also the effective incorporation of feedback for project teams. Given that the goal of many online innovation contests is to open up the pool of potential solvers beyond those who would typically work on a target challenge, it is likely that many participants will be non-experts in the challenge domain and thus likely to benefit from such interventions. As such, exploring new approaches to facilitating explicit reflection sessions for project teams after they receive feedback can help overcome some of the challenges that have prevented collaboration from improving project quality in prior contests on open online communities.

Beyond Online Innovation Contests

While our conceptual framework is developed from empirical studies of online innovation contests, it could also apply to other contexts in which collaborative creativity is central to a community's practice. For example, for start-up incubators seeking to support teams in developing their human capital and innovations, this framework underlines the benefits of assigning peer start-up teams to exchange ideas and resources with one another in between periods of development work, as well as assigning external mentors with relevant expertise to provide feedback on teams' projects during dedicated times prior to prototyping. Similarly, for design firms and R&D teams seeking to support their internal innovation practices, this framework underlines the benefits of facilitating explicit opportunities for knowledge and resource sharing between diverse project teams, and keeping up-to-date databases of employees' expertise and projects to help identify the most relevant feedback providers for each project team. In addition, it highlights the importance of facilitating explicit reflection sessions after dedicated feedback sessions to help teams with less expertise in their project domains to better process and apply external feedback towards improving their project.

Beyond its applications to existing organizational practices, this work also opens up a new approach to designing crowdsourcing systems for large-scale collaborative ideation. Prior approaches in HCI research focus on identifying specific ideas within a large corpus to show people as inspirations during ideation tasks. For example, many approaches involve techniques for identifying diverse or analogical ideas from crowdsourced submissions or existing repositories [Chan et al. 2018; Hope et al. 2017; Siangliulue et al. 2015; Siangliulue et al. 2016; Yu et al. 2014]. Our work demonstrates a complementary approach of connecting people with other people within a large community who have relevant expertise to induce idea sharing and collaboration. Since people have many forms of implicit knowledge from experiences and expertise that are not explicitly expressed in idea submissions, this approach of matching people to one another for feedback exchange may facilitate more knowledge elaboration and transfer than presenting a static idea submission. Additionally, given that the transfer of solutions from one domain to another often requires some degree of adaptation and modification in order to fit the unique constraints of each problem context [Holyoak et al. 1994], such opportunities for elaboration have the potential to facilitate more effective integrations of novel ideas. However, feedback exchange inherently incurs greater costs than presenting static ideas in terms of participant time and coordination, so each approach may be more suitable in different contexts. As such, future crowdsourcing systems for large-scale collaborative ideation can expand their sources of inspiration to include people in addition to ideas and flexibly switch between the two according to task constraints.

Chapter 11: Conclusion

Online innovation contests are quickly becoming the go-to tool for organizations in almost every sector around the world, from government agencies and nonprofits to corporations, for solving pressing scientific, technological, and societal problems that are going to shape the future of humanity. This dissertation advances a vision towards a future in which online innovation contests are not just prize competitions where only a few winning participants benefit and the majority of submissions are low-quality ideas, but vibrant communities of practice where many diverse participants can contribute and exchange valuable benefits with one another while collaboratively generating more high-quality ideas. To this end, this dissertation contributes two new advancements in the state of research and practice around online innovation contests:

1. **A new approach to designing online innovation contests as communities of practice**: specifically, by inducing participants to connect and exchange effective feedback with one another around their project ideas.

2. **A conceptual framework of conditions under which feedback benefits participants and improves project quality in online innovation contests**: specifically, 4 necessary conditions (i.e. engagement, value, feedback incorporation, and project improvements), and 4 evidence-based design interventions for eliciting those conditions (i.e. assignment, expertise matching, early timing, and action planning).

I invite researchers and practitioners to build on this design approach and conceptual framework by applying them to manage future online innovation contests, and by exploring other conditions or interventions for improving the outcomes of collaboration.

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Appendix

Appendix A. Self-reported expertise survey for peer advisors in Study 1

Please rate your skills and experience with solving CONSERVATION problems (e.g., problems involving environmental pollution, wildlife monitoring and management, habitat preservation).

None	Basic	Intermediate	Advanced	Expert

Please rate your skills and experience with solving TECHNICAL problems (e.g., problems involving engineering, scientific analysis, computing, and mathematics).

None	Basic	Intermediate	Advanced	Expert

Please rate your skills and experience with solving BUSINESS problems (e.g., problems involving marketing, finance, project management, manufacturing, business models, and leadership).

None	Basic	Intermediate	Advanced	Expert

Appendix B. Example of a finalist's project proposal in Study 1

EleSense - IoT to prevent HEC

Alerting humans when wild elephants are intruding into villages

The Problem

In Sri Lanka, annually more than 200 elephant deaths and more than 80 human deaths attributed for Human Elephant conflict. In 2016, 279 elephant deaths and 88 human deaths had been reported in Sri Lanka according to the Department of Wildlife conservation. Sri Lanka has the highest density of Asian elephants per square kilometer amongst countries in the Asian region, and as a result there has been frequent HECs. Different mitigation methods were used since 1980s but nothing seems to be effective and successful in preventing HEC as Elephant deaths and human deaths are increasing annually. So, there are opportunities exists for innovative technological solutions to prevent HECs saving lives of these threatened umbrella species as well as saving lives of humans and preventing property damages.

Our Proposal

Main reasons for HECs in Sri Lanka are unexpected confrontation of elephants by villagers, and humans confront with elephants intrude into croplands, paddy fields & villages. If a network of sensors could detect and track movement of elephants close to villages, and alert villagers with information on where the elephants are dwelling or moving, it could definitely prevent humans from unexpected confrontations with elephants. It could also provide necessary information for wildlife officers and guards, so that they can take measures to prevent elephants entering villages. An IoT based network of sensors coupled with a software system will be designed to accomplish this task. The sensor network will have an array of seismic sensors such as geophone sensors, which can detect movements of large animals like elephants. The effectiveness of the sensor network can be improved by integrating additional sensors which can detect elephants and their movements. The software system will receive telemetry data from the sensor network and detect possible elephant intrusions. It will then send alerts via mobile networks to subscribers and trigger buzzers/alarms positioned in the target area. It will also enable wildlife officers and guards to receive information on elephant movements so that they can chase elephants away.

We Assume that...

1. Target village and its population has access to a mobile phone network, so that they can receive SMS alerts.
2. Target area has access to electricity.
3. Government and local authority permissions are granted.
4. A volunteer team from the target area will carryout maintenance work.
5. The system and its components will be safeguarded by the community.

Constraints to Overcome

Current HEC mitigation methods lack the ability to detect elephant movements accurately and the ability to provide information on such elephant intrusions timely to villagers. This solution will overcome such barriers and let villagers take informed decisions, which will in turn prevent and reduce human - elephant confrontations.

Current Work

1. Establish a prototype of the system in a target area in 2018.
2. Get more than 50 people to use the system in 2018.
3. Launch the system in large scale in an area where HECs are frequent.
4. Get more than 60% of people in that area to use the system.
5. Reduce number of human-elephant conflicts in that area by considerable number.

Current Needs

1. Equipment (Sensors, prototyping equipment, etc).
2. Acquiring technical expertise on related technologies.
3. Funding for field research and purchase of equipment.
4. Community support to improve the product.

Appendix C. Introduction email from CXL staff member to finalists and peer advisors in Study 1

Subject: Digital Makerspace: Introducing Peer Advisor *[insert peer advisor's name]* to *[insert finalist project's title]* Project Team

Dear *[insert finalist project team leader's name]* + *[insert peer advisor's name]*:

Per my previous email, I am writing to introduce *[insert finalist project team leader's name]* of *[insert finalist project's title]* to Peer Advisor *[insert peer advisor's name]*. We hope that the Peer Advisor program will be rewarding and useful for all as the Con X Tech Prize Finalist teams work through the prototyping period. This is an optional program, so if you have any concerns, please let me know.

Please remember the suggested timeline (included below). We encourage the following as next steps:

1. **Introduce yourselves!** A quick hello to explain your interests and background.

2. **Peer Advisors should get to know the Project**: As a start, Peer Advisors should review the project profile on the Digital Makerspace. With the permission of the Project Instigators, I am sharing the full project application with Peer Advisors. Project Instigators can share their goals and performance metrics for the prototyping period, as well as any project plans, leads for research, questions, needs for contacts or technical support.

3. **Peer Advisors review Documentation & give Feedback:** Peer Advisors may request to join the Project on the Digital Makerspace and will review the provided project documentation. They will use this form to provide feedback to the Project Team. Conservation X Labs will help deliver this feedback to the Project Team.

4. **Project Teams digest Feedback and seek further Discussion**: The Project Team will review the Peer Advisor feedback and may choose to reach out to the Peer Advisor for clarification, advice, or a phone call to discuss further.

We will ask Peer Advisors to provide feedback twice during the prototyping period. Peer Advisors are asked to keep all information confidential, and it is up to Project Instigators to decide how much detail to share or if any additional confidentiality agreement is warranted. I'm happy to answer any questions! We hope this peer advising opportunity is collaborative, rewarding, and productive for everyone involved.

Kind regards, *[insert name of CXL staff member]*

Proposed Timeline

Step	Requirement
Project Documentation & Application Sharing ***As soon as possible***	The Project Team will share their project documentation with the Peer Advisor to provide additional detail, planning, and context beyond their project profile on the DMS. CXL can make the full DMS project application available to the Peer Advisor with the Project Team's permission.
First Check-In Suggested timeframe for first check-in **Sept 10 - Sept 21**	Peer Advisors' should review project documentation and provide written feedback and ideas for the project team to consider during the first few weeks of the prototyping period. Peer Advisors will deliver written feedback using this form. As a complement to this written feedback, Project Teams & Peer Advisors may choose to have a followup phone call or video conference to discuss project design, plan, and written feedback with the Project Team.
Second Check-In Suggested timeframe for second check-in **Oct 14 - Oct 24**	The Project Team will provide Peer Advisors with an update (via teleconference, written documentation on the Digital Makerspace, and/or an email) on their project progress. Peer Advisors will again provide written feedback on the team's progress and suggestions for improvement.
Other CheckIns	Peer advisors are a resource for project teams! Consult one another as mutually agreed upon and depending on availability.

Appendix D. Interview guide for conservation technology experts in Study 1

SPECIFIC EXAMPLE WALKTHROUGHS:

- Can you tell me a little about your past experiences with mentoring or providing feedback to maker teams and conservation projects?
    - E.g., What was the process like?

- Can you think of a specific example of a maker team or conservation project that you've mentored in the past, and walk me through your thought process as your evaluated it:
    - What was the idea?
    - What aspects of it immediately jumped out to you?
    - What aspects of it did you think were really good?
    - What aspects of it did you think could have used some improvement?
    - What kind of feedback did you provide to the team?

- Think of an example of a *successful* conservation tech prototype/solution and an example of an *unsuccessful* conservation tech prototype/solution that you've seen in the past.
    - What characteristics of their prototyping process or product made them successful or unsuccessful?
    - What were some key differences between them?s

GENERAL QUESTIONS: Based on your experience…

- What are some important considerations that teams of *engineers* tend to overlook when building conservation tech solution prototypes?

- What are some important considerations that teams of *non-engineers* tend to overlook when building conservation tech solution prototypes?

- What are some important considerations that are specific to *conservation tech solutions* that innovators from other fields might not think of when developing their prototypes?

- What are the most common mistakes or oversights that cause a prototype to fail?

- Anything else I haven't asked about yet that you think is important for us to know while developing our feedback processes for the conservation tech competition?

Appendix E. Feedback guide for peer advisors in Study 1 & 2

CON X TECH PRIZE

GUIDE FOR PEER ADVISORS

Thank you for volunteering to provide feedback on a Conservation Technology prototype!

To help you get started, below are some topics and questions that conservation technology experts suggest are important to consider when providing feedback on solution prototypes. Feel free to use any of them that you think are applicable to the prototype you are evaluating. You are also encouraged to ask your own questions that you think might help improve the prototype.

Please try to be positive, constructive, and specific in your feedback, and make your advice and recommendations as actionable as possible.

PROTOTYPING PROCESS / PRIORITIES:

- What's the essential conservation problem that this technology is intended to solve?
    - Is this prototype focused on solving that conservation problem, or is it getting caught up with an unnecessary engineering problem?
    - If it's getting caught up with an engineering problem, what might be easier/faster ways for this prototype to achieve the same conservation goal?

- Successful prototypes typically start small, test frequently, and grow step by step.
    - Is this prototype testing after every step and demonstrating that it works before building on to the next step?
    - If not, what might be some useful ways to test this prototype at this point?
    - Is there a way to create prototype device consistently in an economical way?

- What are the capabilities of your team?
    - Does your team need to ask for help for particular tasks within the project?
    - What is the the timeline for implementation given the amount of time each member can give to the project?

- What other products/resources can be used in the development of the product?
    - Are there libraries/breakout boards/databases/design files etc. that provide stepping stones in prototyping?
    - Is there someone that has developed something similar before that is willing to help where necessary?

- Successful prototypes typically prioritize functionality first before working on aesthetics.
    - Is this prototype focused on getting the key functionalities to work, or is it getting caught up with making things look pretty?
    - If it's getting caught up with aesthetics, what functionalities might still be needed and prioritized instead at this point?
    - Is there a different technology that isn't as aesthetically pleasing that creates a better result?

FEASIBILITY / USABILITY:

Will this technology work in the context of the location/community where its intended to be implemented? What are some assumptions that this prototype is built upon that might not be true in the intended location/community of use? (Examples listed below.)

- Does this prototype require **power** and/or **internet connectivity**?
    - If so, are power/wi-fi readily available and affordable in the intended location of use? How will it get power/wi-fi there?

- What **materials** is this prototype made of?
    - Are these materials available and affordable in the intended location of use?
    - If not, what alternative materials might be more available and affordable?

- Can this prototype work in the **environment** in the intended location of use?
    - If this prototype is intended for use in oceans, would salt water (which conducts electricity) corrode or kill it?
    - How might we design this prototype to resist harsh environmental conditions (think dust/biofouling/mud/angry animals)?
    - How will skeptical/opposing members of the community react to your product? Will they destroy/tamper or steal?

- Can this prototype be properly **maintained** in the intended location/community of use?
    - How might this prototype break down over time?
    - How might we build in mechanisms for addressing those breakdowns?

- Is this prototype **culturally relevant** to people in the intended community of use? (Will they even want to use it?)
    - What are important cultural values and norms in that community?
    - Is this prototype consistent with all of those cultural values and norms?
    - If not, how might we design this prototype to be more culturally relevant?

- Is this prototype **understandable** to people in the intended community of use? (Will they know how to use it?)
    - What are the intended users' education levels? languages?
    - How might intended users be confused by this prototype's interface?
    - How could the prototype be made more familiar or build on existing systems in the intended community?
    - How might intended users misuse this prototype?

- Does this prototype incorporate direct **feedback and buy-in** from end users and stakeholders in the intended community of use?
    - Does this prototype work against their natural behaviors? If so, how might we design it to harness them instead?
    - How might we go about getting feedback and buy-in from end users and stakeholders on this prototype at this point in an effective way?

SCALABILITY / SUSTAINABILITY:

- Is this technology manufacturable and implementable at scale?
    - How might we design this prototype to be replicable in an affordable and efficient way?
    - How might we design this prototype to be applicable across multiple ecosystems or cultures?
    - How might we design a core prototype that is easily adaptable and/or modular?
    - Is there a secondary market that can provide scale until need in conservation is realized?

- Will this technology perpetuate future environmental or social problems when manufactured and implemented at scale?
    - What unexpected problems might arise as a consequence in other ecosystems?
    - How might we design this prototype to mitigate those potential negative effects?
    - Are there problems other than environmental (such as cultural, social, political, or humanitarian) that may be caused by the solution? Could this tool inadvertently be used to manipulate biodiversity and how could you safeguard against this?

- How might this technology's complexity and impact change over time?
    - How might we make this prototype easier to use over time?
    - How might we amplify this prototype's power or benefits over time?
    - Are there reasonable assumptions we could make about changes in material cost, technological, social, and/or regulatory barriers that will make this technology more feasible in the near to medium future?
    - Is the technology built/coded to enable feature upgrades?

OTHER CONSIDERATIONS:

- What other problems or questions might help improve this prototype?

Appendix F. Online feedback form for peer advisors in Study 1

Peer Advisor - Check-In

Thank you again for your commitment to conservation and willingness to serve as a Peer Advisor.

Remember to be thoughtful, positive, constructive, and specific in your feedback and make your advice and recommendations as actionable as possible.

Your goal is to improve the Project Team's approach and prototype.

* 1. Your Full Name

* 2. The name of the Project Team you are advising

* 3. Date

MM/DD/YYYY

* 4. This is Peer Advising Check-In Number:

- ○ 1
- ○ 2
- ○ Additional Check-In

5. Description of Documentation provided by your Project Team

6. In 2 to 3 sentences, summarize the project as you understand it.

7. Describe what you think is good, well-thought-out, and well designed about the project or progress they've made in the last few weeks.

8. Following along the Guide for Peer Advisors, what feedback and suggestions do you have regarding the conservation approach and prototyping process and plan?

9. Following along the Guide for Peer Advisors, what feedback and suggestions do you have regarding the feasibility and usability of the prototype?

10. Following along the Guide for Peer Advisors, what feedback and suggestions do you have regarding sustainability and scalability of the project?

11. Do you have any other comments or suggestions for your Project Team?

Appendix G. Example of peer feedback from Study 1

Your Full Name
[anonymized for data privacy]

The name of the Project Team you are advising
[anonymized for data privacy]

Date
09/20/2018

This is Peer Advising Check-In Number:
1

Description of Documentation provided by your Project Team
The team provided me with their conservation xlabs tech application along with a powerpoint presentation outlining the overall project.

In 2 to 3 sentences, summarize the project as you understand it.
[Finalist project name] is a project that utilizes AI and machine learning to identify invasive species (specifically cats at the moment) in the field using remote camera traps. They're creating algorithms that use training sets to increase the accuracy of identification over time along with intuitive user interfaces for potential clients to work with. They eventually plan to develop hardware that can link remote traps together wirelessly so that clients can download and analyze their data in real time.

Describe what you think is good, well-thought-out, and well designed about the project or progress they've made in the last few weeks.
This project uses well established AI methods for photo identification in a novel situation where there is likely a very high demand (wildlife conservation). Whether used to identify invasive species, individuals of a species of interest, or monitoring wildlife communities in general, this tech has a broad range of applications. The team has already made significant progress in training their classifier, but requires field data to continue the process. Each of the members also has a very applicable skillset with respect to this project, along with additional resources that can help them create a successful product.

Following along the Guide for Peer Advisors, what feedback and suggestions do you have regarding the conservation approach and prototyping process and plan?
The team has a well defined problem to solve using a common approach (image classification) developed in other fields. They are testing it in conjunction with potential clients so that user feedback can be incorporated into the prototyping process. However, the team should take

some time to explore whether or not this technology is currently being developed or has already been deployed to solve similar problems. Establishing these connections could lead to potential collaborations as well as access to important information to speed up the process or avoid mistakes. As a peer advisor, I can offer connections in my own network to facilitate this process.

Following along the Guide for Peer Advisors, what feedback and suggestions do you have regarding the feasibility and usability of the prototype?
The team is creating their prototype with usability as a main priority and have past experience with potential clients that provide them with an understanding of what sorts of user constraints they might encounter, which they can address during their design process. With respect to the software side of things, there shouldn't be many usability issues given their approach, but the hardware aspects may provide a different set of challenges.

Following along the Guide for Peer Advisors, what feedback and suggestions do you have regarding sustainability and scalability of the project?
This prototype, at least the software portion of it, can easily be scaled up and applied to a wide variety of problems across a broad range of clients. The biggest roadblock to scalability is the availability of training imagery for the software to use, which in many situations involving wildlife, there may not exist enough photos to properly train the program. However, there are still ways to overcome this challenge. The hardware portion of the project might be more difficult to scale, depending on a number of factors including costs and longevity. As the team is working on this project, I would advise them to keep in mind potential applications outside of the initial first client that could be useful in guiding design decisions.

Do you have any other comments or suggestions for your Project Team?
In general, I think that they have a great idea with a lot of potential applications so I would stress that they keep this in mind during their design work. And I would suggest that they begin building up a network of professionals working in these fields to help generate and facilitate their growth, which they've already begun simply by applying to this contest.

Appendix H. Interview guide for participants in Study 1

Prototyping Process

*[For Finalists in the **No Peer Advisor Program** condition]*

- To start off, can you walk me through what the prototyping process was like for your team, starting from September up until the end of the competition?

- What was the biggest challenge that your team ran into during the prototyping process?
    - What made this a challenge?
    - How did you try to solve it?
    - What types of resources/support do you think would have helped make it easier?
        - Do you think there's anything that the people in the Conservation X community could have provided to help make it easier?
- Besides that, what other challenges did you run into during the prototyping process?
    - *[repeat above follow-up questions]*

Feedback

*[For Finalists in the **No Peer Advisor Program** condition]*

- Did you receive any feedback on your project posts from other community members in the Conservation X Labs Digital Makerspace during the prototyping process?
    - *[If yes]*
        - Can you tell me a little more about that?
            - Did you request it? Were you expecting it?
            - What did you think about that feedback?
            - Was it useful? Why or why not?
        - Is there any other kind of feedback that you would have liked to receive but didn't?
            - What kind of feedback?
            - Why?
    - *[If no]*
        - Would you have liked to receive any kind of help or feedback from other people in the Digital Makerspace community?
            - Can you explain a little more about why / why not?
            - *[if yes]* What kind of feedback?
                - Why? How would that be useful to you?

- What could Conservation X do to make it easier for you to get the kind of help or feedback that you need while prototyping?

Peer Advising Process

*[For all Finalists and Peer Advisors in the **Peer Advisor Program** condition]*

- To start off, can you walk me through what the peer advising process was like for you, starting from September up until the end of the competition?

    - Who reached out to who first?

    - How did you communicate?
        - What tools?
        - How often?
        - How did it change (if at all) between Check-In #1 and Check-In #2?

    - What information did you share with them?
    - What information did they share with you?
        - *[Peer Advisors]*
            - How clear or understandable was it to you?
            - Did you feel like you got enough information to give feedback? Or would you have liked more?
                - *[If "more"]* What other information would you have liked to help you give feedback?

    - Did you experience any challenges in your communication with each other?
        - Why/How?
        - How do you think the Peer Advisor Program could be improved to make this better?

Feedback Quality

*[For Finalists in the **Peer Advisor Program** condition]*

- What kind of feedback did you receive from your Peer Advisor(s)?
    - Specific example?
    - What did you think about it?
    - How useful was this feedback to you?
        - Why or why not?
    - Did you apply this feedback?
        - Why or why not?

- Did you receive any other feedback from your Peer Advisors?
    - *[repeat above follow-up questions]*

- Which piece of feedback (if any) do you think was…

    - the MOST useful? Specific example? Why?
    - the LEAST useful? Specific example? Why?

- If you could have received any kind of advising or feedback in the world during the prototyping process, what would you have wanted?
    - Why?

- What was the biggest challenge that your team ran into during the prototyping process?
    - What made this a challenge?
    - Were your Peer Advisor(s) able to help you solve this?
        - Why or why not?
        - *[If yes]* How?
    - What types of resources/support do you think would have helped make it easier?
        - Do you think there's anything that the people in the Conservation X community could have provided to help make it easier?
- Besides that, what other challenges did you run into during the prototyping process?
    - *[repeat above follow-up questions]*

Feedback Giving

*[For Peer Advisors in the **Peer Advisor Program** condition]*

- How easy or difficult was it to come up with feedback for your Project Team?
    - What made it easy / difficult?
    - *[If difficult]* What do you think would help make it easier for you?

- Do you remember if Conservation X provided any kind of "Guide for Peer Advising"?
    - *[If Yes]* What did you think about it?
        - Was it useful to you?
            - Why or why not?
        - Did you use it?
            - Why or why not?
    - *[If No]* Would you have liked to get more guidance on peer advising?
        - Why or why not?
        - *[If Yes]* What kind of guidance would you have liked?

- Do you think your Project Team used the feedback that you gave them?
    - Why or why not?
    - How does that make you feel?
    - [If "don't know"] Would you have liked a little more feedback from your Project Team about whether they found your feedback useful?

Relationship / Matching

*[For **Finalists** in the **Peer Advisor Program** condition]*

- How well do you think Your Peer Advisors' expertises matched your project's needs?
    - Why? How?
    - Did your Peer Advisor have any advice or skills that were useful but you didn't know you needed?
- If you could have gotten any Peer Advisor in the world during the prototyping process, what would your ideal Peer Advisor be like?

*[For **Peer Advisors** in the **Peer Advisor Program** condition]*

- What did you think about the project that you got assigned to?
    - How well did it match your personal interests?
        - Why/How?
        - *[If Good]* Do you think you would have gotten involved with this project anyway if you weren't part of the Peer Advisor Program?
        - *[If Bad]* What types of projects would you have been more interested in peer advising?
    - How well did it match your expertise?
        - Why/How?
        - *[If Good]* Do you think you would have gotten involved with this project anyway if you weren't part of the Peer Advisor Program?
        - *[If Bad]* What types of projects would you have been more suited to your expertise?

- How much visibility did you have into the project team's prototyping process?
    - [*If yes]* How did you get visibility?
        - How do you think it affected your experience?
    - [*If no]* Would you have liked to have more visibility into it?
        - Why or why not?

*[For all Finalists and Peer Advisors in the **Peer Advisor Program** condition]*

- Did you experience any specific challenges in your relationship with your [Project Team / Peer Advisor(s)]?
    - Why/How?
    - How do you think the Peer Advisor Program could be improved to make this better?

- Are you interested in continuing your relationship with your [Project Team / Peer Advisor(s)] now that the competition is over?
    - Why or why not?
    - *[If yes]* How could you benefit from a continued relationship with them?

Overall Benefits

[For all Finalists and Peer Advisors]

- Overall, what do you think is the most useful benefit that you've personally gotten out of participating in the [Peer Advisor Program / prototyping competition]?
    - Why/How has that been useful to you?
    - Why/How is that important to you?

- Are there any other benefits that you've gotten out of the [Peer Advisor Program / prototyping competition]?
    - *[repeat above follow-up questions]*

*[For all Finalists and Peer Advisors in the **Peer Advisor Program** condition]*

- Based on your experiences so far, would you be interested in being a Peer Advisor in a future competition?
    - Why or why not?

- Based on your experiences so far, would you be interested in getting Peer Advisor(s) if you were a Finalist in a future competition?
    - Why or why not?

Overall Improvements

[For all Finalists and Peer Advisors]

- Is there anything else that you would have liked to get out of the [Peer Advisor Program / prototyping competition] that you don't feel like you were able to get?
    - Can you explain that a little more?
    - Why is this important to you?
    - How do you think Conservation X could improve the [Peer Advisor Program / prototyping competition] to help you get this?

- Is there anything else that you think Conservation X could do to improve the [Peer Advisor Program / prototyping process] for you?

Appendix I. Project quality evaluation rubric in Study 1

Scale

0 - Submission does not meet the criterion
3 - Submission partially meets the criterion
6 - Submission fully meets the criterion
9 - Submission exceeds the criterion

Criteria

Novelty and potential for a Transformative Solution	Proof-of-Concept / Prototype Success	Strength of Value Proposition
How revolutionary is the proposed solution? Would this solution be ‘ground-breaking,’ with the potential to shift the context of the conservation challenge? How different is it from existing solutions on the market?	Demonstrated functionality of proof-of-concept and successfully meeting the team's proposed performance metrics	Including financial sustainability, scalability and usability by proposed customer or audience

Appendix J. Self-reported expertise survey for peer advisors in Study 2

Want to be a Peer Advisor in the Con X Tech Prize?

We are looking for volunteers to serve as Peer Advisors during the Prototyping Phase! This involves informally checking in with a Finalist team and providing feedback on their prototype about once a month between June - September. Previous Peer Advisors have found this to be a valuable opportunity for networking with other innovators, learning about new conservation technologies, making a meaningful impact with their expertise, and gaining useful insights into the competition process.

Would you be interested in serving as a Peer Advisor during the Prototyping Phase?
- Yes
- No

[The following pages were shown to respondents who indicated "Yes" above.]

Conservation Expertise

We'll use your answers to the following questions about your expertise as the basis for suggesting projects for you to peer advise that are relevant to your interests and expertise.

Please rate your level of expertise in conservation.

○ None ○ Basic ○ Intermediate ○ Advanced ○ Expert

On the following checklist, please indicate which areas of expertise within conservation you are comfortable advising other project teams on.

- ❏ Scientific inquiry / research methodology & design
- ❏ Fieldwork (monitoring, research, restoration, invasive removal, etc)
- ❏ Protected Zone / Park Management / Governance
- ❏ Environmental law / justice / policy
- ❏ Environmental advocacy
- ❏ Social science
- ❏ Human & community development / Human-Wildlife Conflict

- ❏ Wildlife rehabilitation or veterinary services
- ❏ Enforcement
- ❏ Ecotourism
- ❏ EIA / LCA development
- ❏ Education
- ❏ Behavior change / value systems
- ❏ Ecosystem services / environmental economics
- ❏ Ecotoxicology / environmental chemistry
- ❏ Wildlife videography / photography
- ❏ Biology / zoology (individuals)
- ❏ Ecology / population biology
- ❏ Biospheric sciences (atmospheric, cryospheric, etc.)
- ❏ Sustainability / sustainability science

Please include any details to add context to your selections above, or add any areas of expertise not listed.

Technology Expertise

We'll use your answers to the following questions about your expertise as the basis for suggesting projects for you to peer advise that are relevant to your interests and expertise.

Please rate your level of expertise in technology.

○	○	○	○	○
None	Basic	Intermediate	Advanced	Expert

On the following checklist, please indicate which areas of expertise within technology you are comfortable advising other project teams on.

- ❏ GIS / geospatial / remote sensing
- ❏ Software / product development
- ❏ Firmware / embedded systems development
- ❏ Hardware development – electrical engineering (PCB / Circuit design)
- ❏ Hardware development – fabrication
- ❏ Manufacturing / Design for manufacture

- ❏ Genetics / synthetic biology
- ❏ Sensor / camera / video use & development
- ❏ AI development (NNs, ML, CV, etc)
- ❏ Materials science & development
- ❏ Analytical chemistry / chemical development
- ❏ RF and wireless communications systems
- ❏ Blockchain / cryptocurrencies
- ❏ Marine tech
- ❏ Aerial / atmospheric tech
- ❏ Data science / statistical modeling
- ❏ Control Systems engineering
- ❏ Software architecture / database management
- ❏ Quality Control and Quality Assurance / Failure Analysis
- ❏ Biochemistry / Biomaterials

Please include any details to add context to your selections above, or add any areas of expertise not listed.

Business Expertise

We'll use your answers to the following questions about your expertise as the basis for suggesting projects for you to peer advise that are relevant to your interests and expertise.

Please rate your level of expertise in business.

○	○	○	○	○
None	Basic	Intermediate	Advanced	Expert

On the following checklist, please indicate which areas of expertise within business you are comfortable advising other project teams on.

- ❏ Operations
- ❏ Marketing (digital or traditional)
- ❏ Supply Chain Management
- ❏ Finance – Public Markets
- ❏ Finance – Private Markets (Private equity, venture capital, etc)

- ❏ B2B or B2C sales
- ❏ Entrepreneurship / startup management
- ❏ Growth / commercialization / scale
- ❏ Innovation / design thinking
- ❏ Project / product management
- ❏ Business management / leadership
- ❏ Retail / customer service
- ❏ HR / Recruiting / people management
- ❏ Accounting / financial modelling
- ❏ Business intelligence / analytics
- ❏ Business strategy
- ❏ Legal / IP
- ❏ Branding / design / UX
- ❏ Impact strategy
- ❏ PR / comms / media management

Please include any details to add context to your selections above, or add any areas of expertise not listed.

Personal Info

Your name

Your email address

Your gender

- Female
- Male
- Prefer not to say
- Other

Your age

- 18-29
- 30-39
- 40-49
- 50-59
- 60-69
- 70 or older
- Prefer not to say

Your highest level of completed education

- Some high school but no diploma
- High school degree or equivalent (e.g., GED)
- Some college but no degree
- Associate degree
- Bachelor’s degree
- Master’s degree
- Doctoral degree (e.g., JD, MD, PhD)
- Prefer not to say

Appendix K. Self-reported expertise and needs survey for finalist teams in Study 2

The following sections will ask about your project team's conservation, technical, and business needs. We'll use your answers to the following questions to help suggest peer advisors who are relevant to your project team. The more detail you give, the better we will be able to generate a list of relevant matches for you.

Your project will NOT be judged based on the Peer Advising process, or any of the information you give in the Peer Advising section. This information will not be made available to judges.

Conservation Expertise

Complementary Expertise Matching condition	*Similar Expertise Matching condition*
To what extent does your team need a Peer Advisor with expertise in conservation? 1. Not at all 2. To a small extent 3. To some extent 4. To a moderate extent 5. To a large extent	**Please rate your team's level of expertise in conservation.** 1. None 2. Basic 3. Intermediate 4. Advanced 5. Expert
On the following checklist, please indicate which areas of expertise within conservation your team would like a peer advisor to have expertise in. The list is provided as a broad overview. If you require an area of expertise that is not listed, please include it in the open field below.	**On the following checklist, please indicate which topic areas within conservation you and your team members have expertise in.** It's fine to only have expertise in one or two. The list is provided as a broad overview. If you have an area of expertise that is not listed, please include it in the open field below.

- ❏ Scientific inquiry / research methodology & design
- ❏ Fieldwork (monitoring, research, restoration, invasive removal, etc)
- ❏ Protected Zone / Park Management / Governance
- ❏ Environmental law / justice / policy
- ❏ Environmental advocacy

- ❏ Social science
- ❏ Human & community development / Human-Wildlife Conflict
- ❏ Wildlife rehabilitation or veterinary services
- ❏ Enforcement
- ❏ Ecotourism
- ❏ EIA / LCA development
- ❏ Education
- ❏ Behavior change / value systems
- ❏ Ecosystem services / environmental economics
- ❏ Ecotoxicology / environmental chemistry
- ❏ Wildlife videography / photography
- ❏ Biology / zoology (individuals)
- ❏ Ecology / population biology
- ❏ Biospheric sciences (atmospheric, cryospheric, etc.)
- ❏ Sustainability / sustainability science

Please include any details to add context to your project's CONSERVATION needs during the 10-week prototyping period, specifically that you would like a Peer Advisor to have expertise in. (Such as methodology design, fieldwork experience, or expertise with a specific biome.)	**Please include any details to add context to your selections above, or add any areas of expertise not listed.**

Technology Expertise

Complementary Expertise Matching condition **To what extent does your team need a Peer Advisor with expertise in technology?** 1. Not at all 2. To a small extent	*Similar Expertise Matching condition* **Please rate your team's level of expertise in technology.** 1. None 2. Basic 3. Intermediate

3. To some extent
4. To a moderate extent
5. To a large extent

4. Advanced
5. Expert

On the following checklist, please indicate which areas of expertise within technology you are comfortable advising other project teams on.
The list is provided as a broad overview. If you require an area of expertise that is not listed, please include it in the open field below.

On the following checklist, please indicate which topic areas within technology you and your team members have expertise in.
It's fine to only have expertise in one or two. The list is provided as a broad overview. If you have an area of expertise that is not listed, please include it in the open field below.

- ❏ GIS / geospatial / remote sensing
- ❏ Software / product development
- ❏ Firmware / embedded systems development
- ❏ Hardware development – electrical engineering
- ❏ Hardware development – fabrication
- ❏ Manufacturing / Design for manufacture
- ❏ Genetics / synthetic biology
- ❏ Sensor / camera / video use & development
- ❏ AI development (NNs, ML, CV, etc)
- ❏ Materials science & development
- ❏ Analytical chemistry / chemical development
- ❏ RF and wireless communications systems
- ❏ Blockchain / cryptocurrencies
- ❏ Marine tech
- ❏ Aerial / atmospheric tech
- ❏ Data science / statistical modeling
- ❏ Control Systems engineering
- ❏ PCB / Circuit design
- ❏ Software architecture / database management
- ❏ Quality Control and Quality Assurance / Failure Analysis
- ❏ Biochemistry / Biomaterials

Please include any details to add context to your project's TECHNOLOGY needs during the 10-week prototyping period, specifically that you would like a Peer Advisor to have expertise in? (Such as AI algorithm expertise, hardware design for

Please include any details to add context to your selections above, or add any areas of expertise not listed.

manufacturing, or software development expertise.)	

Business Expertise

Complementary Expertise Matching condition	*Similar Expertise Matching condition*
To what extent does your team need a Peer Advisor with expertise in business? 1. Not at all 2. To a small extent 3. To some extent 4. To a moderate extent 5. To a large extent	**Please rate your team's level of expertise in business.** 1. None 2. Basic 3. Intermediate 4. Advanced 5. Expert
On the following checklist, please indicate which areas of expertise within business your team would like a peer advisor to have expertise in. The list is provided as a broad overview. If you require an area of expertise that is not listed, please include it in the open field below.	**On the following checklist, please indicate which topic areas within business you and your team members have expertise in.** It's fine to only have expertise in one or two. The list is provided as a broad overview. If you have an area of expertise that is not listed, please include it in the open field below.

❏ Operations
❏ Marketing (digital or traditional)
❏ Supply Chain Management
❏ Finance – Public Markets
❏ Finance – Private Markets (Private equity, venture capital, etc)
❏ B2B or B2C sales
❏ Entrepreneurship / startup management
❏ Growth / commercialization / scale
❏ Innovation / design thinking
❏ Project / product management
❏ Business management / leadership
❏ Retail / customer service

- ❏ HR / Recruiting / people management
- ❏ Accounting / financial modelling
- ❏ Business intelligence / analytics
- ❏ Business strategy
- ❏ Legal / IP
- ❏ Branding / design / UX
- ❏ Impact strategy
- ❏ PR / comms / media management

Please include any details to add context to your project's BUSINESS needs during the 10-week prototyping period, specifically that you would like a Peer Advisor to have expertise in? (Such as supply chain expertise, legal expertise, or business intelligence / data analytics.)	**Please include any details to add context to your selections above, or add any areas of expertise not listed.**

Appendix L. Post-contest survey for participants in Study 2

Con X Tech Prize: Peer Advisor Program Evaluation

This year, we implemented a Peer Advisor Program during the Prototyping Phase of the Con X Tech Prize, and we need YOUR honest opinions to help evaluate and improve it. Regardless of whether you participated or not, **please complete this survey by October 12, 2019**. It should take no longer than **5-10 minutes**.

Your responses will be used for research purposes only and will NOT affect your standing or anyone else's standing in the competition. All identifiable information will be kept confidential.

[For Finalists ONLY]

Did you receive any feedback from your Peer Advisor, [insert Name], during the Prototyping Phase?

◯ Yes
◯ No

[For Finalists who indicated "Yes" above]

How did your project team communicate with [insert Name] during the Prototyping Phase? (Check all that apply.)

☐ Email
☐ Phone call
☐ Video calls
☐ Other [Please specify: _____]

How many times did your project team communicate with [insert Name] during the Prototyping Phase? (including messages, emails, calls, etc.)

◯ 1
◯ 2
◯ 3
◯ 4
◯ 5
◯ More than 5

How helpful was [insert Name]'s feedback to your project team?

1	2	3	4	5	6	7
Extremely unhelpful	Moderately unhelpful	Slightly unhelpful	Neither helpful nor unhelpful	Slightly helpful	Moderately helpful	Extremely helpful

Why was or wasn't [insert Name]'s feedback helpful to your project team?

[For Peer Advisors ONLY]

Did you provide any feedback to the "[insert Project name]" team during the Prototyping Phase?

◯ Yes
◯ No

[For Peer Advisors who indicated "Yes" above]

How did you communicate with the "[insert Project name]" team during the Prototyping Phase? (Check all that apply.)

☐ Email
☐ Phone call
☐ Video call
☐ Other [Please specify: __________]

How many times did you communicate with the "[insert Project name]" team during the Prototyping Phase? (including messages, emails, calls, etc.)

◯ 1
◯ 2
◯ 3
◯ 4
◯ 5
◯ More than 5

How valuable was the experience of peer advising the "[insert Project name]" project to YOU?

1	2	3	4	5	6	7
Extremely unvaluable	Moderately unvaluable	Slightly unvaluable	Neither valuable nor unvaluable	Slightly valuable	Moderately valuable	Extremely valuable

Why or why wasn't the experience of peer advising the "[insert Project name]" project valuable to YOU?

[For all Finalists AND Peer Advisors]

What other benefits (if any) did you experience through the Peer Advisor Program?

Any other comments on your experience with the Peer Advisor Program?

We'd love to follow up with you to understand more details about your experience with the Peer Advisor Program!

Would you be willing to participate in a 40-minute phone or video interview at a time convenient to you in October? If so, we'll email you to schedule one.

- ◯ Yes
- ◯ No

Appendix M. Interview guide for participants in Study 2

Communication Process

- To start off, can you walk me through what the Peer Advising Process was like for you, starting from July up until now?

    - How did you feel about the Conservation X Labs staff's communications with you about the Peer Advising Program?

    - Who reached out to who first?

    - How did you communicate?
        - What tools?
        - How often?
        - Were they responsive to you?

    - What information did you share with them?
    - What information did they share with you?

    - Did you experience any challenges in your communication with each other?
        - Why/How? (e.g., time zone differences?)
        - How do you think the Peer Advisor Program could be improved to make this better?

Feedback Quality

*[For **Finalists** only]*

- What kind of **feedback** did you receive from your Peer Advisor(s)?
    - Specific example?
    - What did you think about it?
    - How useful was this feedback to you?
        - Why or why not?
    - Did you apply this feedback?
        - Why or why not?

- Did you receive any other feedback from your Peer Advisors?
    - *[repeat above follow-up questions]*

- If you could have received any kind of advising or feedback in the world during the prototyping process, what would you have wanted? Why?

- What was the biggest **challenge** that your team ran into during the prototyping process?
    - What made this a challenge?
    - Were your Peer Advisor(s) able to help you solve this?
        - Why or why not?
        - *[If yes]* How?
    - What types of resources/support do you think would have helped make it easier?
        - Do you think there's anything that the people in the Conservation X community could have provided to help make it easier?

- Besides that, did you run into any other challenges during the prototyping process?
    - *[repeat above follow-up questions]*

Matching

*[For **Finalists** only]*

- What did you think about the Peer Advisors that you got assigned?
    - How much visibility did you get into their expertise?
        - Why/Why weren't you able to get visibility into their expertise?
    - How well do you think your Peer Advisors matched your project's needs?
        - Why? How?

- If you could have gotten any Peer Advisor in the world during the prototyping process, what would your ideal Peer Advisor have been like?

- How would you compare the type of support you get from your Peer Advisors vs. the type of support you get from your project team members?

*[For **Peer Advisors** only]*

- What did you think about the project that you got assigned to?

    - How much visibility did you get into the project team's needs?
        - Why/Why weren't you able to get visibility into their needs?
    - How well did it match your personal interests?
        - Why/How?
        - *[If Bad]* What types of projects would you have been more interested in peer advising?
    - How well did it match your expertise?
        - Why/How?
        - *[If Bad]* What types of projects would you have been more suited to your expertise?

[For all participants]

- Did you experience any specific challenges in your relationship with your [Project Team / Peer Advisor(s)]?
    - Why/How?
    - How do you think the Peer Advisor Program could be improved to make this better?

Overall Benefits

*[For **Peer Advisors** only]*

- What initially motivated you to volunteer as a Peer Advisor?

[For all participants]

- Overall, what do you think is the most useful benefit that you've personally gotten out of the Peer Advisor Program?
    - Why/How has that been useful to you?
    - Why/How is that important to you?

- Are there any other benefits that you've gotten out of the Peer Advisor Program?
    - *[repeat above follow-up questions]*

Overall Improvements

[For all participants]

- Is there anything else that you would have liked to get out of the Peer Advisor Program that you don't feel like you were able to get?
    - Can you give me a specific example?
    - Why is this important to you? / How would this help you?
    - How do you think Conservation X could improve the Peer Advisor Program to help you get this?

- Is there anything else that you think Conservation X could do to improve the Peer Advisor Program for you?

Appendix N. Project quality evaluation rubric in Study 2

Instructions: Please rate each project based on the criteria to the right.

The rating scale is as follows:

1 - Project meets this criterion poorly, or does not meet it at all.
2 - Project meets this criterion somewhat poorly.
3 - Project meets this criterion neither poorly nor well.
4 - Project meets this criterion somewhat well.
5 - Project meets this criterion well.

Project Viability		
Transformative impact for conservation	**Financially sustainable & Scalable**	**Culturally, socially, & environmentally responsible**
Would this solution be ground-breaking, with the potential to radically shift the paradigm of the conservation challenge? How likely is the proposed solution to achieve tangible, real- world outcomes that dramatically and positively affect the conservation problem at hand?	Are there potential channels for revenue? Does the idea retain potential if it were widely scaled up from the prototype/pilot studies? Is there potential for this idea to work in a variety of different contexts (i.e. geographies, cultures, biomes, or markets)?	Does the proposed project cause any undue harm to a specific group or population? Does the solution idea result in a significant net positive environmental outcome (when considering its direct and indirect impacts)? Are any associated environmental costs worth taking the risk on for the expected benefits?

Value Proposition			
Fit of solution to the problem	**Team's understanding of user needs**	**Team's understanding of solution / market landscape**	**Future outlook**
Does the proposed solution seem like an appropriate fit to the problem described? Is the solution a good fit for the environmental, cultural, political, or social context in which it will be deployed?	Has the team identified the key users of their projects? Do they understand the needs, desires, pain points, and preferences of their key users?	Has the team displayed an understanding of the other solutions that are currently available for this project? Have they explained how their solution is unique or different to what currently exists?	How compelling are the next steps put forward by the team? Are they appropriate for the stage of development of the project? Are they ambitious? Are they a good use of funds?

Prototype Progress		
Progress against goals	**Ambitiousness of goals**	**Overall prototype progress**
Has the team achieved the goals that they set for themselves at the beginning of the period? How well did they complete those goals?	How ambitious were the goals? Were each of them appropriate and necessary to reach the final prototype?	Has the team successfully developed a prototype that demonstrates their proposed idea? How well does that prototype prove their concept? Have any pivots improved the overall quality of the idea?

Appendix O. Peer feedback instructions in Study 3

For Feedback Providers

Email Subject: ACTION ITEM - Share your feedback on these 3 Con X Tech Prize projects! (Due: April 12)

Hi *[insert name]*!

As part of the Con X Tech Prize's Peer Feedback Phase, we encourage all project teams to review and comment on any other project in the competition. (Here's the link to the Youtube explainer if that doesn't sound familiar.)

In addition, to help each project get the most value out of this phase, we've assigned 3 peer projects from the Con X Tech Prize for you to provide feedback on, and 3 different peers to provide feedback on yours.

Please provide your feedback on the following projects by April 12:

1. *[insert URL-linked name of project #1]*
2. *[insert URL-linked name of project #2]*
3. *[insert URL-linked name of project #3]*

INSTRUCTIONS: Copy and paste the following questions into a new comment in the "Discussion and Tasks" of each project page, and answer them as appropriate.

- **Identify the core problem:** What is the core problem that this project is trying to solve?
- **Identify important challenges:** Based on your expertise and experience, what are some important challenges that this project might run into?
- **Inspire novel solutions:** How could ideas, technologies, or solutions from your expertise area be adapted to help solve this project's core problem or important challenges?
- **Challenge assumptions of the problem:** How could ideas, technologies, or solutions from your expertise area inspire new ways of thinking about this project's problem?
- **Connect with other resources:** What other ideas, media, people, or organizations might be useful to this project team?

The 3 peers who are assigned to provide feedback on YOUR project are **[Name 1]**, **[Name 2]**, and **[Name 3]**. Let them know what type of feedback you're looking for by posting a comment about it on your project page!

As always, feel free to reach out if you have any questions!

For Feedback Receivers

To be sent immediately after the Peer Feedback Phase ends (i.e., on April 13)

Email Subject: Con X Tech Prize: Final Project Revisions due April 21!

Hi *[insert name]*,

Starting today, we're giving all Con X Tech Prize applicants **one more week to revise project submissions** on the Digital Makerspace before official judging begins. This is a great chance to respond to any peers who commented on your project during the Peer Feedback Phase and to strengthen your project submission. To help you get the most out of this opportunity, below are some best practices for improving projects based on feedback:

- **Identify useful ideas or resources:** What ideas or resources from this feedback could be useful for improving my project?

- **Adapt useful ideas to your project's context:** How might I incorporate this feedback to improve my project? If it seems irrelevant or infeasible, how might I adapt or modify it to fit my project's context?

- **Inspire new ideas or questions:** What other solution approaches or questions does this feedback inspire me to think of that could help improve my project?

All final project submissions are due at **11:59 PM EDT on Sunday, April 21**.

As always, feel free to reach out if you have any questions. Good luck!

Appendix P. Post-contest survey for participants in Study 3

Con X Tech Prize: Peer Feedback Phase Survey

This year, we implemented a new Peer Feedback program during the Ideation Phase of the Con X Tech Prize, and we need YOUR honest opinions to help evaluate and improve it. Regardless of whether you provided/received peer feedback or not, **please complete this survey by May 5, 2019**. It should take about **10-15 minutes**.

Your responses will be used for research purposes only and will NOT affect your standing or anyone else's standing in the competition. All identifiable information will be kept confidential.

The following questions were only shown to people who RECEIVED peer feedback.

Here's a link to feedback that you received from **Insert Peer Name** on your project **"Insert Project Name"**: Insert hyperlink

Please answer the following questions about this feedback.

How helpful was this feedback?

1	2	3	4	5	6	7
Extremely unhelpful	Moderately unhelpful	Slightly unhelpful	Neither helpful nor unhelpful	Slightly helpful	Moderately helpful	Extremely helpful

Why or why wasn't this feedback helpful?

The following questions were only shown to people who PROVIDED peer feedback.

Please answer the following questions about the project **"Insert Project Name"** (Insert hyperlink), which you provided feedback on.

How much value did you get out of reviewing this project?

1	2	3	4	5	6	7
None	A very small amount	A small amount	Some	A moderate amount	A large amount	A very large amount

Why or why wasn't the experience of reviewing this project valuable to you?

The following questions were shown to EVERYONE.

To what extent did you revise your project submission between the pre-feedback deadline (March 20) and the post-feedback deadline (April 21)?

1	2	3	4	5	6	7
Not at all	To a very small extent	To a small extent	To some extent	To a moderate extent	To a large extent	To a very large extent

What are the 3 biggest changes (if any) that you made to your project submission between the pre-feedback deadline (March 20) and the post-feedback deadline (April 21)?

Who or what inspired the changes that you made (if any)? (e.g., specific peers, specific feedback you received, specific projects you read, discussions with your project team, additional research you did, your own thoughts, etc.)

What other benefits (if any) did you experience through the Peer Feedback Phase?

Any other comments on your experience during the Peer Feedback Phase?

We’d love to follow up with you to understand more details about your experience during the Peer Feedback Phase!

Would you be willing to participate in a follow-up phone interview at a time convenient to you before May 11? If so, we'll email you to schedule one.

- Yes
- No

Your Gender

- Male
- Female
- Other (Please specify)

Your Age

- 18 - 29
- 30 - 39
- 40 - 49
- 50 - 59
- 60 - 69
- 70 or older

Your Highest Level of Completed Education

- Some high school but no diploma
- High school degree or equivalent (e.g., GED)
- Some college but no degree
- Associate degree
- Bachelor’s degree - Please specify major/department.
- Master’s degree - Please specify major/department.
- Doctoral degree (e.g., JD, MD, PhD) - Please specify major/department.

Appendix Q. Interview guide for participants in Study 3

Project Context

To start off, can you log into the Conservation X Labs Digital Makerspace, and go to your own project page? (If you submitted multiple projects to the Con X Tech Prize, then can you go to the one that you received the most feedback on?)

- Before we talk about the peer feedback, can you give me a little context about the stage of development that this project was in when you submitted it to this Con X Tech Prize? (i.e., was it in the very early ideation stage, or had you already done some work on it?)

- Were you pretty set on your ideas for this project when you submitted it to the Con X Tech Prize, or were you still open to new ideas at that point?
    - *[If open]* What kinds of new ideas were you open to?

- What were the biggest challenges that you faced with this project during the Ideation Phase of this Con X Tech Prize?
    - Did you face any challenges with thinking of novel or innovative idea for it?
    - *[If yes]* What do you mean by that? Can you describe an example?

Receiving Feedback

Now that I have a little more background on your project, I'm wondering if you can click on one of the specific peer comments that you received and walk me through your thought process as you read it?

- What was your reaction to this feedback?

- What did it make you think of?

- Was it helpful to you?
    - Why/How or why not?

- Did this feedback inspire you in any way?
    - *[If yes]* What ideas did it inspire?
    - Did it influence any changes to your project submission?
    - Did it spark any follow-up discussions with this peer?

- Do you see any value in potentially keeping in touch with this peer in the future?

    - Why or why not?
    - *[If yes]* What value do you see in keeping in touch with them?

Can you click into another peer comment that you received, and walk me through your thought process on that one as well?

- *[Repeat above follow-up questions]*

Overall, what was the *most* helpful feedback that you received?

- Why was this the most helpful feedback?

Overall, what was the *least* helpful feedback that you received?

- Why was this the least helpful feedback?

Is there any other feedback that you would have liked to receive, but didn't receive?

- Can you give me a specific example?
- Why? How would you benefit from that feedback?
- What types of expertise would you have liked in your peer feedback providers?

Providing Feedback

Can you go to one of the other project pages that YOU commented on during the Peer Feedback Phase, and walk me through your thought process as you were reviewing it?

- Why did you decide to provide feedback on this project?
    - *[If assigned]* Do you think you would have commented on this project if it hadn't been assigned to you?

- Were you personally interested in this project?
    - Why or why not?
    - [*If no]* What other types of projects would you have been more interested in?

- Did you think your expertise was relevant to this project?
    - Why or why not?
    - [*If no]* What other types of projects would be more relevant to your expertise?

- Do you think reviewing this project was beneficial to YOU in any way?
    - Why or why not?
    - Did it inspire any new ideas for you?
        - If so, what ideas?
        - Did these influence any changes to your project submission?

- Do you see any value in potentially keeping up with this project in the future?

    - Why or why not?
    - Do you see any value in staying in touch with the project team members?

Can you click into a different project that you commented on, and walk me through your thought process on that one as well?

- *[Repeat above follow-up questions]*

Overall Benefits & Improvements

- Overall, what do you think is the most useful benefit that you personally got out of the Peer Feedback Phase?
    - Why/How has that been useful to you?
    - Why/How is that important to you?

- Are there any other benefits that you got out of the Peer Feedback Phase?
    - *[Repeat above follow-up questions]*

- Is there anything else that you would have liked to get out of the Peer Feedback Phase but didn't get this time?
    - If so, what?
    - Why is this important to you? / How would this help you?

Appendix R. Project quality evaluation rubric in Study 3

Instructions: Please rate each project based on the following 8 criteria.

The rating scale is as follows:

1 - Project meets this criterion very poorly, or does not meet it at all.
2 - Project meets this criterion quite poorly.
3 - Project meets this criterion somewhat poorly.
4 - Project is neutral on this criterion, or, meets it neither poorly nor well.
5 - Project meets this criterion somewhat well.
6 - Project meets this criterion quite well.
7 - Project meets this criterion very well.

Transformative Potential	How revolutionary is the proposed solution? Would this solution be ground-breaking, with the potential to radically shift the paradigm of the conservation challenge? Is it a 'quantum leap' from existing approaches?
Conservation Impact	Does the idea demonstrate a thorough understanding of the specific conservation need for which the solution is designed? How likely is the proposed solution to achieve tangible, real-world outcomes that dramatically and positively affect the conservation problem at hand?
Financial Sustainability	Does the idea respond to a critical conservation need, market, or demand? Has the applicant considered customers or users of the product? Are there potential channels for revenue? Are costs realistic? Has the problem & market been sized appropriately, or overestimated?
Environmental Sustainability	Does the solution idea result in a significant net positive environmental outcome (when considering its direct and indirect impacts)? Are any associated environmental costs worth taking the risk on for the expected benefits?
Culturally Appropriateness & Social Responsibility	Does the proposed project cause any undue harm to a specific group or population? Is it appropriately sensitive and give due credit to different cultures? Does it benefit the public good and not unfairly promote or discriminate against a population?
Feasibility	Is the proposed solution technologically, culturally, and economically realistic, with an acceptable degree of risk, from idea to deployment? Does it rely on existing or emerging approaches, information, or technology, or does it require an entirely new technology to be invented and proven?
Novelty	How different is it from existing solutions on the market? Has anyone ever tried this before, or is currently trying it? Is this approach a unique take on a solution to the problem?
Scalability	Does the idea retain potential if it were widely scaled up from the prototype/pilot studies? Is there potential for this idea to work in a variety of different contexts (i.e. geographies, cultures, biomes, or markets)?

Appendix S. Team ideation exercises for participants in Study 4

CONSERVATION X LABS

Virtual Ideathon
Team Ideation Activities

This document includes the schedule, instructions, and worksheets for all team activities in the Virtual Ideathon. Please work with your team to complete each section during its scheduled time in the event.

Team Name: *{{TeamName}}*

Your Conservation Problem: *{{ConservationProblem}}*

	Name (First and Last)	Email Address
Team Member #1	{{MemberName1}}	{{MemberEmail1}}
Team Member #2	{{MemberName2}}	{{MemberEmail2}}
Team Member #3	{{MemberName3}}	{{MemberEmail3}}
Team Member #4	{{MemberName4}}	{{MemberEmail4}}

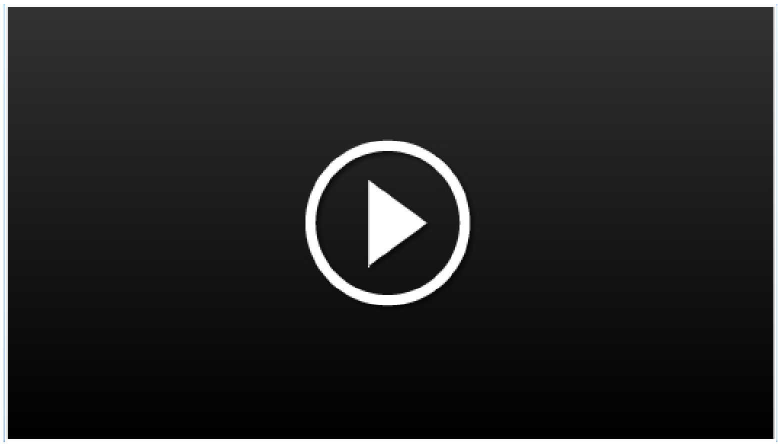
Today's Team Ideation Activity Schedule

Please follow this schedule as closely as possible in order to stay on track with all other teams during the event. At the end of these Team Ideation Activities, all teams will have a chance to share their final project ideas at the same time and join a networking hour to meet each other!

Click on an activity title to skip to that section in this worksheet.

(1:30 - 2:00 EDT) Learn About Your Conservation Problem (30 min total)

To help you gather background information about your selected conservation problem, an expert has personally curated and provided the following resources for your team.



Please watch the above video at this link: *{{ ProblemVideoLink }}*

{{ ProblemArticleLinks }}

Using the resources above, discuss the following information with your team:

- **What's the current state of the world?**
    - Describe the conservation problem.
    - Identify the actors who are contributed/involved in the problem.
    - Describe the behaviors that contribute to the problem.

- **What are previous solutions?**
    - What have people tried to do to address this problem?
    - Why haven't those solutions worked?

- **What are the next steps?**
    - What more needs to be done to address this problem?
    - What areas of innovation are people in this field excited about?

(2:00 - 3:30 EDT) PROBLEM FORMULATION (90 min total)

The following activity is adapted from the Center for Behavior & the Environment at Rare.

(2:00- 2:30 EDT) Step 1 of 4. Create a Problem-Actor-Behavior map. (30 min)

Complete the table on the next page to develop a deeper understanding of the conservation problem that your team is trying to solve. Moving from left to right…

1. State what the **conservation problem** is (E.g., climate change, food waste, high energy use, etc.)
2. Name **actors/people** who are responsible for or contributing to this problem,
3. List the **behaviors** that these actors are doing/not doing now that contributes to the problem,
4. Identify the **desired behaviors** of what you want them to do.

Below is an example table:

What is the **conservation problem**?	Who is contributing to the problem? (Who are the **actors?**)	What are they doing or not doing? (What is their **behavior?**)	What do you want them to do? (What is the **desired behavior?**)
Food waste	*Households*	*Throwing away leftovers*	*Eating leftovers*
		Buying too much food	*Buying less food*
	Restaurants	*Serving large portions*	*Serving smaller portions*
	Grocery stores	*Selling only perfect produce*	*Selling imperfect produce*
		Throwing away food past 'sell by' date	*Donating food past 'sell by' date*

Finish your own Problem-Actor-Behavior Map on the next page by 2:30 EDT.

Your Group's Problem-Actor-Behavior Map:

Use the expert-provided resources above and search online for any other relevant resources to help you identify as many actors and behaviors as you can. Feel free to create more or less rows as needed.

<table>
<tr><th>What is the conservation problem?</th><th>Who is contributing to the problem?
(Who are the actors?)</th><th>What are they doing or not doing?
(What is their behavior?)</th><th>What do you want them to do?
(What is the desired behavior?)</th></tr>
<tr><td rowspan="18">{{ConservationProblem}}</td><td rowspan="3"></td><td></td><td></td></tr>
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<tr><td rowspan="3"></td><td></td><td></td></tr>
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</table>

(2:30 - 3:05 EDT) Step 2 of 4. Discuss your Problem-Actor-Behavior Map. (35 min)

No Advisors condition	*Peer Advisors condition*	*Expert Advisors condition*
Take turns discussing the following questions with your team members to identify gaps, strengths, and weaknesses in your Problem-Actor -Behavior Map.	**At 2:30 EDT, your facilitator will introduce you to a peer team to help you complete the following discussion activity.** Once you are in the same room as your peer team... 1. Introduce yourselves to each other. 2. Share the link to this Google Doc with your peer team through the Session Chat. 3. Take turns discussing the following questions with your peer team to identify gaps, strengths, and weaknesses in your Problem-Actor-Behavior Map.	**At 2:30 EDT, your facilitator will introduce you to an expert mentor to help you complete the following discussion activity.** Once you are in the same room as your expert mentor... 1. Introduce yourselves to each other. 2. Share the link to this Google Doc with your expert mentor through the Session Chat. 3. Take turns discussing the following questions with your expert mentor to identify gaps, strengths, and weaknesses in your Problem-Actor-Behavior Map.

Assign 1 person to be a "notetaker" for your team during your discussion, and record your discussion notes in the table below.

QUESTION	ANSWER	NEXT STEPS: How can we incorporate these ideas into our project's problem formulation?
What are some unobvious actors and/or behaviors that are missing from your table? Describe how those unobvious actors and/or behaviors are contributing to the problem.	[type answer here]	[type next steps here]
Which actors and behaviors are most impactful for addressing	[type answer here]	[type next steps here]

the larger conservation problem? Explain why and how they are most impactful.		
Where are there synergies between behaviors or actors? Describe which combinations of behaviors and actors can interact to produce the largest effects.	[type answer here]	[type next steps here]
Where are existing solutions already working and where are there gaps? Describe how your new project can differ from existing solutions and address important gaps.	[type answer here]	[type next steps here]
Record any other notes from your discussion here:	[type answer here]	[type next steps here]

(3:05 - 3:20 EDT) Step 3 of 4. Reflect on Your Discussion. (15 min)

As a team, take 15 minutes to reflect on your discussion. Go back to the table above and...

1. Finish filling out any boxes that you did not get to fill out during the discussion.
2. Bold the **most important ideas** that your team gained from your discussion.
3. Then decide on an audience/actor and behavior to focus on for your team's project.

(3:20 - 3:30 EDT) Step 4 of 4. Write a Problem Statement. (10 min)

Once your team has selected a behavior and actor/audience(s) for the conservation challenge that you want to solve, write a clear and concise paragraph (4 - 6 sentences) to communicate the following below:

- State what the **problem** is.
- Specify the **actor(s)** whom you want to target.
- Describe the **behavior** of these actor(s) that you want to change.
- Describe the **desired behavior** of what you want them to do.
- Describe **why** this is a significant and impactful problem.

(3:30 - 4:40 EDT) SOLUTION IDEATION (70 min total)

(3:30 - 3:45 EDT) Step 1 of 3. Independent Brainstorming (15 min)

Set a timer for 15 minutes. *Without looking at each other's work*, each team member should *independently* brainstorm as many **new tools or products** as possible to address the problem statement within 15 minutes. On the pages below, each team member should record at least 1 idea per "lever for behavior change":

How might we design new tools or products that leverage…

- Emotional appeals to relate to people's values, goals, concerns, interests, and feelings?
- Social influences to make behaviors observable, increase social expectations, eliminate excuses?
- Choice Architecture to direct attention, simplify decisions, use timely moments and prompts?
- Information to provide step-by-step instructions for a behavior, build awareness/understanding?
- Material Incentives to make a behavior easy (or the alternative hard), give rewards or penalties?
- Rules & Regulations to prohibit or mandate a behavior?

Tips:

- Focus on *quantity*, NOT quality. (Aim for 15 ideas in 15 minutes.)
- Encourage crazy / wild ideas!
- Don't judge yourself or your ideas.
- Record ALL ideas, not just good ones.

Each team member should record their own ideas on a SEPARATE PAGE BELOW.

Team Member #1's ideas for new tools or products:

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.

Don't limit yourself – We encourage you to brainstorm more than 15 ideas if you can!

Team Member #2's ideas for new tools or products:

1.
2.
3.
4.
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10.
11.
12.
13.
14.

Don't limit yourself – We encourage you to brainstorm more than 15 ideas if you can!

Team Member #3's ideas for new tools or products:

1.
2.
3.
4.
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14.
15.

Don't limit yourself – We encourage you to brainstorm more than 15 ideas if you can!

Team Member #4's ideas for new tools or products:

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.

Don't limit yourself – We encourage you to brainstorm more than 15 ideas if you can!

(3:45 - 4:15 EDT) Step 2 of 3. Group Sharing & Brainstorming (30 min)

Take turns sharing 1 idea at a time with your teammates. For each idea, all team members should contribute to brainstorming new ways that the idea could be used, adapted, and/or combined with another idea to solve the problem.

Tips:

- One idea/speaker at a time. (Respect and pay attention to others.)
- Build on each other's ideas. (Start each comment with "Yes, and..." instead of "No.")
- Don't criticize your teammates or their ideas.
- Record ALL ideas / comments, not just good ones.

Assign 1 person to be a "notetaker" for your team during your discussion, and record your discussion notes below.

Your Group's Discussion Notes:

-
-
-
-
-
-
-

(4:15 - 4:40 EDT) Step 3 of 3. Select your best solution ideas. (25 min)

As a team, select the 2 best solution ideas that you might like to develop into a conservation project. For each selected idea, write a clear and concise paragraph (5-10 sentences) to communicate the following below:

- Briefly describe **what** the solution idea is.
- **Who** is the target for the change in behavior? **Who** is the target user? (May be the same person.)
- **Which** lever/strategy for behavior change does the solution use?
- **Where** would it be implemented?
- **When** would it be implemented?
- **How** would it be implemented?
- How would you measure whether it is **successful**?

Finish writing your top 2 solution ideas below by 4:40 EDT.

Solution Idea #1:

Solution Idea #2:

(4:40 - 6:00 EDT) PROJECT DISCUSSION + ITERATION (80 min total)

(4:40 - 5:20 EDT) Step 1 of 4. Evaluate your project ideas. (40 min)

No advisors condition	*Peer advisors condition*	*Expert advisors condition*
Take turns discussing the following questions with your team members to identify gaps, strengths, and weaknesses in your top 2 solution ideas.	**At 2:30 EDT, your facilitator will introduce you to a peer team to help you complete the following discussion activity.** Once you are in the same room as your peer team… 1. Introduce yourselves to each other. 2. Share the link to this Google Doc with your peer team through the Session Chat. 3. Take turns discussing the following questions with your peer team to identify gaps, strengths, and weaknesses in your top 2 solution ideas.	**At 2:30 EDT, your facilitator will introduce you to an expert mentor to help you complete the following discussion activity.** Once you are in the same room as your expert mentor… 1. Introduce yourselves to each other. 2. Share the link to this Google Doc with your expert mentor through the Session Chat. 3. Take turns discussing the following questions with your expert mentor to identify gaps, strengths, and weaknesses in your top 2 solution ideas.

Assign 1 person to be a "notetaker" for your team during your discussion, and record your discussion notes in the table below.

QUESTION	ANSWER	NEXT STEPS: How can we incorporate these ideas to improve our project?
What ASSUMPTIONS are being made about the actors and behaviors in the problem? What would happen to our idea if those assumptions were not validated?s	[type answer here]	[type next steps here]

What **IMPACT** would this solution have on the larger conservation goal? ● How many **people's behavior** would it change? ● What **environmental effect** would it have? How large? ● How is the impact **better** than or **different** from existing solutions? ● How can the behavioral and environmental impact of this solution be **increased**?	[type answer here]	[type next steps here]
What **CHALLENGES** might this solution run into: ● Imagine that 6 months from now, this solution failed. What are the biggest reasons why it might have failed? ● How can these risks be mitigated?	[type answer here]	[type next steps here]
How might we ensure that the solution is… ● **socially / culturally acceptable** to the target actors/ audience?	[type answer here]	[type next steps here]
● **technically / logistically feasible?** (e.g., What tools, tech, and/or materials are needed?)	[type answer here]	[type next steps here]
● **financially feasible?** (e.g., minimize costs / maximize profits)	[type answer here]	[type next steps here]
● **scalable?** (e.g., reach many actors and/or places)	[type answer here]	[type next steps here]
● **sustainable?** (e.g., 2 years from now? 10 yrs? 20 yrs?)	[type answer here]	[type next steps here]

What **RESOURCES, people, or organizations** might be able to help improve or implement this solution?	[type answer here]	[type next steps here]
Record any other notes from your discussion here:	[type answer here]	[type next steps here]

(5:20 - 5:40 EDT) Step 2 of 4. Reflect on your discussion. (20 min)

As a team, take 20 minutes to reflect on your discussion. Go back to the table above and…

1. Finish filling out any boxes that you did not get to fill out during the discussion.
2. Bold the **most important ideas** that your team gained from your discussion.

(5:40 - 6:00 EDT) Step 3 of 4. Refine and iterate on your project idea. (20 min)

Based on your discussion above, choose the best idea that your team might like to develop into a project. Then write a revised Problem Statement and Solution Statement below.

Finish writing your Revised Statements below by 6:00 EDT, and share it in the link below.

Revised Problem Statement:

Revised Solution Statement:

(6:00 EDT) Step 4 of 4. Share your work with the event community!

At 6:00 EDT, share your Revised Problem Statement and Revised Solution Statement via this form: **https://airtable.com/shrq8mg3g6gYgJB1g**. Once you share your own project, you'll be able to view other teams' projects from this event too!

Then head back to the main Stage on Hopin for a Wrap Up presentation and to network with other teams!

Appendix T. Post-event survey for participants in Study 4

Conservation X Labs - Virtual Ideathon Participant Feedback Survey

Thanks so much for participating in our event! Please complete this survey to help us understand your experience and improve future events. It should take **less than 10 minutes** to complete.

About Your Project

Which Conservation Problem did your team work on during the Virtual Ideathon?

- Animal-human disease transmission
- Deforestation
- Food waste and consumption (less & better meat and dairy)
- Human-elephant conflict
- Human-predator conflict
- Overfishing
- Pangolin trade and trafficking
- Single-use plastics in hospitality
- Other (Please specify) ___________________

How much expertise did you have in your team's Conservation Problem before the Virtual Ideathon?

1	2	3	4	5
None (No knowledge or real-world projects)	**Basic** (Some knowledge, but no real-world projects)	**Intermediate** (Some real-world projects)	**Advanced** (Many real-world projects, but not a professional)	**Expert** (Recognized professional with many real-world projects)

About Your Team Discussions

During the Team Ideation Activities, which of the following people did you have live discussions with? (Check all that apply.)

- ❏ My own team members

- ❏ Peers from other teams
- ❏ Expert mentor(s) at the event

About Your Project

[The following 2 questions were shown to participants who indicated “My own team members.”]

To what extent did discussions with **your team members** help you change and improve your project over the course of the event?

1	**2**	**3**	**4**	**5**
Not at all	To a small extent	To some extent	To a moderate extent	To a large extent

Please describe an example of the most valuable benefit that you received from discussions with **your team members**.

[The following 2 questions were shown to participants who indicated “Peers from other teams.”]

To what extent did discussions with **<u>peers from other teams</u>** help you change and improve your project over the course of the event?

1	**2**	**3**	**4**	**5**
Not at all	To a small extent	To some extent	To a moderate extent	To a large extent

Please describe an example of the most valuable benefit that you received from discussions with **<u>peers from other teams.</u>**

[The following 2 questions were shown to participants who indicated “Expert mentor(s) at the event.”]

To what extent did discussions with your **<u>expert mentor(s) at the event</u>** help you change and improve your project over the course of the event?

1	**2**	**3**	**4**	**5**
Not at all	To a small extent	To some extent	To a moderate extent	To a large extent

Please describe an example of the most valuable benefit that you received from discussions with your **<u>expert mentor(s) at the event.</u>**

[The following questions were shown to all participants.]

Final Thoughts

Any other thoughts you'd like to share with us about the event?

Would you be willing to participate in a 30-minute follow-up interview to share more about your experience in the Virtual Ideathon? (If so, we'll email you to schedule one!)

- Yes
- No

Appendix U. Interview guide for participants in Study 4

To ground participants' responses in specific examples from their experiences during the event, each interview was conducted while showing the participant an exact copy of their team's ideation activity Google Doc from the end of the event.

Let's start with the first activity: "Learn About Your Conservation Problem"
What did you think about the information in this video? Was it useful or not useful?

- How did it affect your thinking about a potential project? Which parts?
- Did it help you fill out the Problem Actor Behavior map? If so, how? Which parts?

Let's move on to the next section: "Problem Formulation"
Tell me about how your team filled out the Problem Actor Behavior map.

- Where did you find the information to fill it out?
    - Video? Other online resources? Own knowledge? Etc.
    - Can you give me an example of each?
- Did you get to talk to anyone outside of your team members?
    - What did you talk about with them?
    - What kinds of feedback did they give you?
    - What did you think about their ideas? Were they useful to you or not? Why?
    - Did they bring up any ideas that you wouldn't have thought of on your own? If so, what?
    - Did your conversation with them influence your project ideas in any way? If so, how?
    - How did your ideas change from before you talked to them to after you talked to them?
    - Did you have any questions or problems that you felt your [team / peer team / expert mentor] was NOT able to help you address? If so, what and how?

Let's move on to the next section: "Solution Ideation"
Tell me about your team's solution ideation process.

- Did you do individual ideation, and then group ideation? Or did you do it all together?
- How did you decide on which ideas to move forward with?

Did you have time to do the next section: "Project Discussion + Iteration"?
Tell me about your group's discussion and iteration process.

- Did you get to talk to anyone outside of your team members?
    - What did you talk about with them?
    - What kinds of feedback did they give you?
    - What did you think about their ideas? Were they useful to you or not? Why?
    - Did they bring up any ideas that you wouldn't have thought of on your own? If so, what?

    - Did your conversation with them influence your project ideas in any way? If so, how?
    - How did your ideas change from before you talked to them to after you talked to them?
    - Did you have any questions or problems that you felt your [team / peer team / expert mentor] was NOT able to help you address? If so, what and how?

Overall, which activities or resources do you think had the BIGGEST influence on your final project idea? How? Example?

Is there anything else that you'd like to share with me about your experience in this event?

Appendix V. Interview guide for expert mentors in Study 4

To ground expert mentors' responses in specific examples from their experiences during the event, each interview was conducted while showing the expert mentor an exact copy of their assigned team's ideation activity Google Doc from the end of the event.

First Mentoring Session

What do you remember about the status of the team's ideas when you came into their room?

What type of feedback or discussion did you have with them?

- Can you remember an example of what you shared with them?

What type of help or support do you think they needed in order to develop a good project idea at this point?

- Can you give me an example?

What did you think about the problem statement that they decided on?

- Do you feel like it was a good problem to focus on?
- Can you tell if they incorporated any of the feedback you gave them?
    - If so, did they incorporate it well? Or is there something they were still missing?

Second Mentoring Session

What was the status of the team's ideas when you came into their room the second time?

What did you think about their solution ideas?

- Do you feel like they were good solution ideas to further develop?
- Did they have any ideas that you were particularly surprised or impressed by?
    - If so, what?

What type of feedback or discussion did you have with them?

- Can you remember an example of what you shared with them?

What type of help or support do you think they needed in order to develop a good project idea at this point?

- Can you give me an example?

Looking at their Revised Problem Statement and Revised Solution Statement at the bottom, can you tell if they incorporated any of the feedback that you gave them?

- If so, did they incorporate it well? Or is there something they were still missing?

Is there anything else that you think we could do to improve the ideation or mentoring process?

Appendix W. Project quality evaluation rubric in Study 4

Instructions: Please evaluate each project on the following dimensions.

The rating scale is as follows:

1 - Not at all
2 - Slightly
3 - Somewhat
4 - Moderately
5 - Very

Novelty	How novel is this project idea? (A novel idea should be unobvious and different from existing solutions.)
Usefulness	How useful is this project idea? (A useful idea should be impactful for addressing the larger conservation problem.)
Feasibility	(A feasible idea should be achievable with existing resources (such as technologies and human capital) in the world.)

Appendix X. Online feedback form for peer advisors in Study 5

Please provide feedback on the following peer's application:

[insert link to peer contest submission]

Your feedback should be **thoughtful, constructive,** and **provide helpful insights** to improve the application's quality around the four key criteria:

1. **Impact** (Biodiversity Conservation; Water Quality, Quantity, and Hydrology Human Security; No Inadvertent Impacts)
2. **Design of the Innovation** (Transformative; Novel; Creative; Technical Feasibility)
3. **Adoption and Scalability** (Adoption; Adaptability)
4. **Business Viability** (Financial Sustainability)

Anyone who is listed as a collaborator (co-author) on your application may provide the feedback. The feedback is not anonymous, and your peers will be scoring the quality of your feedback. **The quality of your feedback will be worth 5% of your total application score**, so it is in your interest to make your best efforts to help others.

Identify the project's goal: Based on your understanding of the application, what is the specific problem that this project is trying to solve?

Identify important challenges: Based on your expertise and experience, what are some important challenges that this project might encounter? Please be specific about why these are important challenges.

Inspire novel solutions: Please brainstorm 3 different ideas, technologies, or solutions that can help address this project's goal or important challenges that you identified above. For each idea, describe specific actions or revisions that the project team can do to incorporate the idea into their application over the next 10 days.

1.
2.
3.

Connect with other resources: What other ideas, media, people, or organizations might be useful to this project team in the long run?

Other comments: (Optional)

Appendix Y. Online form for feedback receivers in Study 5

Please answer the questions on this page about the following peer feedback.

Identify the project's goal:
[insert feedback text]

Identify important challenges:
[insert feedback text]

Inspire novel solutions:
[insert feedback text]

Connect with other resources:
[insert feedback text]

Other comments:
[insert feedback text]

Please rate the quality of this feedback. High-quality feedback is ***thoughtful***, ***constructive***, and provides ***helpful insights***. Be as honest and fair as possible, because your rating will affect your peer's application score in the contest.

1	2	3	4	5	6	7
Very low quality	Low quality	Somewhat low quality	Average quality	Somewhat high quality	High quality	Very high quality

*[The following question was only shown to participants in the **No Action Planning** condition]*

Please provide 3 reasons why you gave this rating.

1.
2.
3.

*[The following question was only shown to participants in the **Action Planning** condition]*

Please brainstorm 3 new ideas or revisions that this feedback inspires you to think of.
For each idea, specifically describe how you could use it to improve your project application.

1.

2.

3.

Appendix Z. Post-contest survey for participants in Study 5

Did you choose to receive peer feedback on your application?

- Yes, I chose to receive peer feedback on my application.
- No, I chose NOT to receive peer feedback on my application.

[The following questions were shown to participants who indicated "Yes" above.]

How much did you improve your application during the "Revision" phase?

Very little ○ ○ ○ ○ ○ Very much

How much did the peer feedback you received help improve your application?

Very little ○ ○ ○ ○ ○ Very much

What was the most useful benefit (if any) that you gained from providing and/or receiving peer feedback in the ASM Challenge?

Appendix AA. Project quality evaluation rubric in Study 5

External reviewers and judges will assign point values (on a scale of 0 to 5) for the statements associated with the four Technical Submission Criteria (Impact; Innovation Design; Adoption and Scalability; Business and Financial Viability). Each Technical Submission Criteria topic will receive a total of 20 points.

0	1	2	3	4	5
Does not meet the criteria	Meets few of the criteria	Meets some of the criteria	Meets most of the criteria	Meets all of the criteria	Exceeds the criteria

Technical Submission Criteria	Score Weighting
Impact	20 points
Innovative Design	20 points
Adoption and Scalability	20 points
Business and Financial Viability	20 points

Impact

A. The innovation will have a tangible, net-positive impact on biodiversity conservation, including at a species, community, and/or ecosystem scale. 5 points

B. The innovation will have a tangible, net-positive impact on water resources, including water quality, quantity, and hydrology. 5 points

C. The innovation will have a tangible, net-positive impact on human security* including human health. 5 points

D. The innovation minimizes any inadvertent impacts that will negatively impact environmental** or human* security. 5 points

Innovation Design

A. The innovation has the potential to transform at least one aspect of the ASM industry. 5 points

B. The innovation is sufficiently different from existing solutions that are currently deployed in the field. 5 points

C. The innovation is creative in the way it addresses the described need or problem. 5 points

D. The innovation is technically feasible, and the applicant has provided sufficient evidence to demonstrate feasibility. 5 points

Adoption and Scalability

A. The applicant has gathered user/customer input to inform the design of the innovation so that it will be adopted in the field. 5 points

B. The applicant has shown sufficient evidence to indicate that users/customers will use the innovation instead of existing solutions. 5 points

C. The applicant has demonstrated an understanding of any modifications in behaviors or practices that will be required for users/customers to adopt the innovation instead of existing solutions. 5 points

D. The applicant has clearly articulated how the innovation is designed for widespread adoption and use (including articulation of any needed adaptation for widespread use.) 5 points

Business and Financial Viability

A. The applicant has provided detailed descriptions of existing users/customers and revenue (if available) and/or has sufficiently described a plan to acquire new users/customers and generate future revenue. 5 points

B. The applicant has provided a well-defined and realistic plan to get funding for further development and deployment of the innovation. 5 points

C. The applicant has provided convincing evidence that users/customers are willing to pay for and use the innovation. 5 points

D. The applicant demonstrated a clear understanding of risks that may impact the feasibility and long-term viability of the innovation and provided a realistic plan to mitigate or reduce the identified risks. 5 points