Crowdfunding Science: Sharing Research with an Extended Audience

Julie S. Hui
Segal Design Institute
Northwestern University
2133 Sheridan Rd., Evanston, IL 60208
juliehui@u.northwestern.edu

Elizabeth M. Gerber
Segal Design Institute
Northwestern University
2133 Sheridan Rd., Evanston, IL 60208
egerber@northwestern.edu

ABSTRACT
Crowdfunding is changing how, why, and which research projects are pursued. With the increasing number of crowdfunded research projects, it is important to understand what drives scientists to launch crowdfunding campaigns and how it affects their work. To better understand this recent phenomenon, we present a grounded theory of how and why scientists crowdfund. Through 27 semi-structured interviews, we find that scientists are motivated to crowdfund in order to share their work and engage the public in the research process in ways traditional science work has not offered. Scientists also perceive crowdfunding as a more accessible way to get funds quickly compared to existing fundraising mechanisms, such as grant applications. However, they must learn to use more accessible language to successfully communicate their research through social media to a broad audience of non-scientists and professional peers. Based on these findings, we discuss design implications to inform future crowdfunding platforms and support tools.

Author Keywords
Crowdfunding; Citizen Science; Computer Mediated Communication; Design

ACM Classification Keywords
H.5.3 [Group and Organization Interfaces]: Design

General Terms
Crowdsourcing, Design

INTRODUCTION
The Internet has radically changed how scientists work, from data collection to academic publishing [6]. Scientists archive data online to share with colleagues [4], use video chat to connect with collaborators across the globe [1,4], organize the crowd in online citizen science platforms to analyze data [48,49,57], and update their lab webpages to distribute recent publications to colleagues. Now, the Internet is changing how scientists interact not just with collaborators, but also with funders. Crowdfunding has become an increasingly popular way for scientists to solicit funds [55], and by running a crowdfunding campaign online, scientists can also communicate and connect with an extended network that they otherwise may not have reached.

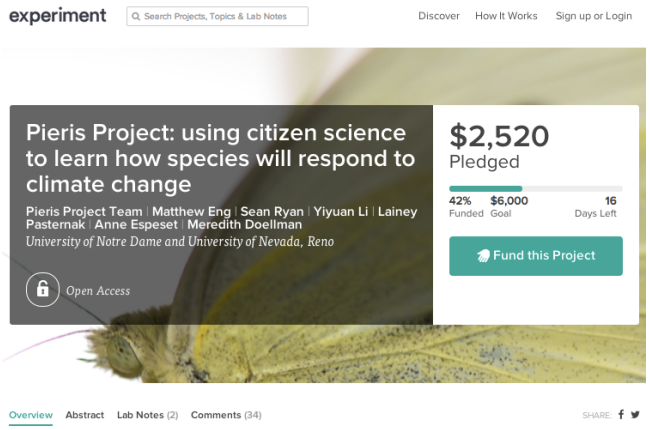

Figure 1: A crowdfunding science project page on a the crowdfunding platform, Experiment.

As the US continues to recover from research budget cuts [28], scientists search for new ways to fund their work. Crowdfunding science is the process of requesting financial resources from the crowd to support scientific research projects, often in exchange for a reward. Crowdfunding science differs from traditional science funding sources, such as grants and fellowships, because it 1) provides a way for scientists to share current research in an easy to understand format with the general public and 2) allows the public to influence future research directions by directly providing funds and ideas. In a mutually beneficial relationship, the public provides financial support, and in exchange, scientists participate in online discussions and share their work in a public-friendly manner, often through video and blog posts rather than journal articles and technical presentations.

CSCW '15, March 14 - 18, 2015, Vancouver, BC, Canada.

http://dx.doi.org/10.1145/2675133.2675188

For instance, one researcher raised over $10,000 to sequence DNA from ancient Roman skeletons. She posted a three-minute video explaining her research interests, goals, and funding request on a dedicated page within Rockethub, one of the top crowdfunding science platforms [60], and received donations from over 150 supporters. She used social media, such as Facebook and Twitter, to share the link to the crowdfunding page with her extended network. Shortly thereafter, a popular news blog noticed and disseminated the project video, helping surpass her funding goal by almost 70%. Like many others who crowdfund [30], she found that her supporters gave more than money: they sent messages of support through email, shared the project with their own social network, and asked her questions to learn more about her research. These interactions extend beyond science work in a way that the typical research grant writing process does not offer.

Crowdfunding science offers a novel area of study for CSCW researchers interested in designing tools to increase public engagement and broaden dissemination of scientific research. We initiate research in this emergent area with a qualitative study of 27 scientists who chose to crowdfund their research in order to understand how and why scientists use crowdfunding. Findings inform design principles to create and improve existing support tools.

BACKGROUND: CROWDFUNDING SCIENCE

Crowdfunding is defined as the online request for resources from a distributed audience to pursue a project [3,21]. Currently, the majority of science crowdfunding [1] is taking place on crowdfunding science-specific platforms rather than as a separate category on general crowdfunding platforms like Kickstarter. This may be due to the different nature of scientific research as compared to creating consumer products and services. Unlike with many traditional crowdfunding projects, crowdfunding scientists are raising funds with the end goal of furthering scientific knowledge, for which they must follow a specific process to collect data and validate their findings.

Crowdfunding could change how science work is performed by directly connecting fundraising with the need to interact with an extended audience of supporters outside their field of research. For these reasons, we focus specifically on scientists who use platforms where they maintain their own project page and interact directly with the public. We can then better understand how crowdfunding scientists are communicating and engaging with a wide range of people.

[1] Science crowdfunding platforms [61,62] use a variety of terms to describe participants and their projects including "science," "research," "project," "backers," "funders," and "creators." For consistency, we refer to *crowdfunding scientists* as the people who request funds through crowdfunding platforms, *supporters* as people who donate funds to projects through crowdfunding platforms, and *campaign* as the organization of online activity to achieve a the crowdfunding financial goal.

Scientists Who Crowdfund

The majority of scientists using crowdfunding may be novice rather than expert researchers, suggesting implications for supporting researchers with limited professional experience. While few people have published demographics on the crowdfunding science community, Experiment, one of the most popular crowdfunding science platforms, shared that the majority (58%) of their participants are post-doc, graduate and undergraduate researchers [31,61], most of whom have limited experience writing and producing research-related content for a general audience. The remaining 42% are made up of professors and industry professionals. Similar to other online populations, scientists' fluency with the Internet, social media, and multimedia technologies varies widely [26,38].

Platform Models

There are various types of crowdfunding platforms, such as using sites that specifically focus on research (i.e. Experiment [61]), sites run by universities (i.e. UCLA SPARK [63]), sites that host a variety of projects (i.e. Rockethub [60]), sites that broker the relationship between researchers and funders (i.e. Benefunder [64]), and sites that offer funder equity in the final product (i.e. MicroVentures [65]). Platforms follow an *all-or-nothing* or *keep-what-you-raise* funding model, or allow the project creator to choose between either. The former only lets scientists keep the funds if they meet their funding goal, while the later allows scientists to keep however much they raise whether or not they meet their goal.

Crowdfunding Work

As described in previous research [30], running a crowdfunding campaign includes activity not only on the crowdfunding platform, but also elsewhere such as on social and news media. Crowdfunding scientists prepare the campaign by choosing the duration of their campaign – typically between one and three months [61,66] and creating the campaign material, which includes a written description, short video, and often additional blogs and social media pages for visibility [30]. When supporters visit the live project page, they choose to pledge dollar amounts based on rewards specified by the crowdfunding scientist. After the campaign, scientists deliver the promised rewards as well as updates on the progress of their research.

RELATED WORK

Science crowdfunding combines elements of public engagement in science, peer collaboration in science, and crowdfunding. We examine related research to frame our theoretical expectations for *how* and *why* scientists crowdfund.

Public Engagement in Science

Public engagement in science is concerned with the ways scientific activities and research can be shared with the non-scientists [7]. The Internet is changing the way scientists do this through how they communicate and collaborate with the public [8,54].

Communicating Science to the Public

Traditionally, scientific work has been shared with the public through popular press articles or shows, which "translate" scientific terminology to more easily understandable language. Now, the Internet is allowing more scientists to engage directly with the public through written and video blogs, personal websites, and public online speeches like Ted Talks [67]. These new avenues of communication not only allow scientists to reach people outside their field [46], but also provides a way for scientists to grow an interested audience who can now receive online updates about their work, such as through YouTube or blogs.

Researchers studying public engagement in science find that scientists communicate with the public through one- and two-way interactions [8,53]. This could include open access journals [54] (one-way), or online discussion boards (two-way), which have allowed scientists and the public to work together to inform a research agenda and assist with the research process [44].

Consistent with motivational theory, scientists are motivated to connect with others as part of their work process [50]. Recent CSCW research found that science majors were motivated to share their knowledge on Wikipedia because it connected them with a large online audience [15]. Similarly, previous research on crowdfunding describes people's desire to share their work in order to connect with like-minded people [21]. Crowdfunding science builds on existing models of public engagement by allowing scientists an easy and direct way to communicate with the public in addition to collecting financial resources for their work. Inspired by motivational theory, we expect that sharing one's work publicly also builds a sense of mastery and competency, which supports self-confidence and desire to create high quality and more creative work [2,50].

Collaborating With the Public Through Citizen Science

Citizen science is an increasingly popular avenue for public engagement in science and demonstrates a trend to engage the public as research helpers. Rather than simply sharing information with the public, citizen science allows for research collaborations where members of the public participate in the scientific investigation [10,56], such as data collection and analysis.

Motivations to participate for scientists include desire to enhance their own research, collaborate with volunteers, educate others, and participate in open science, while motivations for citizen participants are more often intrinsic, such as desire to inform and be a part of the research agenda [43,47,49]. Deterrents for citizen science include variability in data quality [11,18], difficulty managing the hundreds or thousands of volunteers [57], and costs of running a citizen science platform [5].

CSCW researchers have identified design implications and built tools to improve participation and data quality on citizen science platforms. Sheppard and Terveen argue for including interactive tutorials and videos that teach data collection processes, applications that provide instant in situ feedback, and tools to allow citizens to explore data themselves [51]. Wiggins describes how improving information and communication technologies can support better project management [57]. Others describe ways platform features can support participant intrinsic motivation [43] as well as ways to increase project awareness and recruitment through social media strategies [48]. To help more scientists participate in citizen science, researchers have built mobile [34] and web [36] platforms to ease the onboarding process for mass data collection.

However, unlike citizen science, the focal contribution of science crowdfunding is money, not labor. Because funding is involved, scientists who crowdfund may feel more motivated than scientists of citizen science projects to take into consideration their supporters' opinions and suggestions.

Peer Collaboration in Science

While research has shown that scientists tend to collaborate with people who are physically close, email and other forms of online communication have made it easier to reach out and establish fruitful collaborations among distant research groups [17,58]. By working with others, scientists have been able to share large datasets [4] and gain access to financial resources, equipment and knowledge that they would otherwise not have been able to acquire easily [6]. Having access to the right tools supports a sense of autonomy [50], allowing people to work on projects that they are intrinsically motivated to pursue.

Furthermore, public partnerships, such as co-authoring papers [32], allow scientists to formally associate themselves with established researchers, thus building social capital [22] and a sense of relatedness with like-minded others [50]. Those who choose not to take advantage of their scientific network may be at risk of performing redundant research or having to spend more money on personal equipment [17]. Crowdfunding scientists have already begun to form such relationships with other crowdfunding scientists, which is why it is important to view crowdfunding science not only as a funding mechanism, but also as a peer collaboration support tool. Similar to research on crowdfunding motivations [21], we expect to see scientists motivated to connect with other scientists who could provide interesting ideas and new perspectives on their work.

Crowdfunding Science

Much of the discussion around crowdfunding science is still based in popular press [16,45], as few researchers have performed empirical studies of crowdfunding specifically in the context of science. Scientists speculate that a large audience, accessible and persuasive language, and outreach efforts are key factors to successfully raising funds [55]. These expectations are consistent with existing crowdfunding research, which describe the importance of building a support network [29,30], and using social media [40] and persuasive language [39].

From an initial qualitative study of 47 crowdfunding project creators, Hui et al. [30] found evidence that certain types of crowdfunding creators, such as visual artists or musicians, struggled less to communicate their message through social media compared to scientists and engineers. This suggests that scientists may overcome different communication barriers than non-scientists in order to explain their work effectively.

Muller et al. found that in crowdfunding within the enterprise, where employees crowdfund each other's projects, there was an increase in inter-departmental collaboration [41]. Because employees were given an opportunity to share their work with others, they were able to foster new professional connections. We expect to see similar motivations to connect with peers in crowdfunding science where the increased visibility of one's research will help scientists form collaborations and share ideas with people outside their immediate field of research.

However, no researchers have performed a qualitative study of this community of scientists who crowdfund to better understand why they are turning to crowdfunding and how these new practices could inform science work and crowdfunding overall.

METHODS

We took a grounded theory approach [52] to understand how and why scientists interact with their extended network during their crowdfunding campaign. We perform open qualitative data collection so as not to unnecessarily constrain the emergent framework.

Participants

In this study, we interviewed 27 (7 female) participants from Rockethub, Experiment, Petridish, and FundaGeek, over a yearlong period. We examined a diverse yet representative set of participants including scientists who were conducting research in biology (6), computer science (2), entomology (3), electrical engineering (2), anthropology (2), education (2), public health (1), neuroscience (1), ecology (3), applied science (1), nanotechnology (1), energy (1), bioengineering (1), and physics (1). 24 participants crowdfunded on science-specific platforms whereas the remainder used general platforms that supported science-related projects. Participants raised between $1,120 and $33,795. While some exceeded their fundraising goal, others just met a fraction of their goal. No informants relied on crowdfunding as their primary source of income, and all participants were US-based. Participants' employment statuses included high school student (1), undergraduate student (4), graduate student (13), professor (3), and researcher (6). We recruited participants through email and platform message systems aiming for a diverse range of participants. To understand if motivations or deterrents change over time, we interviewed scientists who were both currently crowdfunding and had finished crowdfunding. Scientists were not compensated for their participation.

Data Collection

We used semi-structured interviews to collect qualitative data. We began each interview with a description of our research method and explanation of our research interests in crowdfunding. We expressed our interest in understanding how scientists who crowdfund engage with an extended network and why they chose to crowdfunded in the first place. We concluded the interview with reassurance of anonymity of the data collection.

The average length of the interview was 30 minutes. All interviews were conducted over Skype, Google Hangouts, or phone because of the geographic distribution of participants. All interviews were audio-recorded and transcribed for analysis immediately following the interviews. We guaranteed anonymity by disguising informant's names, positions, and project titles.

Analysis

We employed selective coding and analysis [52] to understand 1) how scientists share their work with an extended audience through crowdfunding, and 2) why they are motivated to participate [21]. This framing allowed particular themes about scientific communication and engagement [8,37,42,54], scientific peer collaboration [17], and motivation [13,21] to emerge. As more data was gathered and analyzed, we simultaneously researched pertinent literature to understand existing theory related to these themes. Three coders began the process of selective coding by flagging each instance where participants communicated interacting with people outside their immediate academic circle. Instances were recorded using private Google Sheets. We identified 23 different themes, abandoning those for which there was insufficient data and clustered the remaining into groups based on frequency counts.

FINDINGS

The data describe three ways that scientists who crowdfund connect with an extended network of non-scientists and peer researchers. We then expand on initial motivations to crowdfund science research. Furthermore, we provide examples throughout of how existing online platforms and tools support this work and motivations to participate.

Engage Non-Experts Through the Research Process

The data show that scientists are motivated to achieve broader impact in line with the goals of the National Science Foundation of "promoting teaching, training, and learning" and "disseminating research broadly to enhance scientific and technological understanding" [68]. Crowdfunding scientists do this by describing their work in public forums and webpages, answering questions about their research area, and giving them an opportunity to impact the advancement of research through financial support. For instance, a professor studying cancer treatments described how he liked that crowdfunding allowed the public to see the research that goes into the project:

"It allows a form for people to engage in science…going through that product lifecycle, one gets to see where ideas come from, who's behind them and how do they plan to change the world with it."

Crowdfunding provides a way for people who are interested in science research to contribute and learn, motivations consistent with general crowdfunding supporters [21] and in citizen science [43,47]. A zoology PhD student described how her supporters not only funded her work, but also asked about how to perform data collection:

"I have been asked about the equipment I used to date my site. I've posted pictures of the equipment...and more information on the lab itself... Most of the times I get questions like that, they're from people who funded me, who are actually interested in paleo, but not working in the field."

By engaging non-scientists in the research endeavor, scientists see the process of crowdfunding as a more "direct" way to connect with the public and teach them about their research practices. The crowd aspect of crowdfunding allows scientists to reach a much wider audience compared to traditional funding where your application is only read by a handful of people. An entomologist described this difference:

"The fact that you're getting 1,000 views is 1,000 that you're touching and they're watching, and there are people that actually fund you, and they become part of your audience. They stick with you…You're able to blog just to those people and keep them in the loop, and communicate with them, so they can participate not just by funding, but you can actually bring them along for your research endeavor.

Similar to findings on crowdfunding work in general, the process of crowdfunding science also encompasses not just maintaining a crowdfunding project page, but also other forms of public engagement, such as creating a blog, writing popular press articles, and communicating with fans on social media [30]. Participants describe using a suite of social media platforms, including their personal Facebook Feed, creating a Facebook Group, Twitter, Google+, personal blogs, personal websites, and Reddit. The wide variety of outlets allows scientists to share their interests with a range of supporters outside of academia. An ecologist described how his job as a researcher did not require him to share his research in public avenues the way that running a crowdfunding project did:

"I view crowdfunding as a way to kind of share some of my passion about the work that I'm doing. There's a reason that I'm interested in the question that I'm asking. There's a reason that I keep studying the oceans and what's going on as they're confronted with climate change and all sorts of other impacts. I have very few opportunities to communicate that [in my job]."

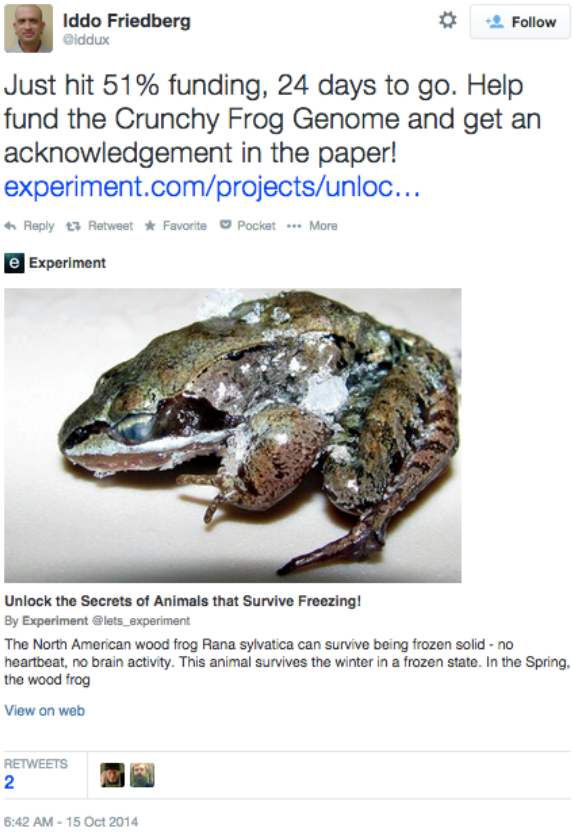

Figure 2: A crowdfunding scientist publicizes his project through Twitter.

Furthermore, in running their campaigns, crowdfunding scientists see themselves as science mentors to the general public:

"I would answer their questions about parasites…or they'd like ask about books that they like could read to follow up on something, and I would tell them about books… Hopefully they'll think of me in the future if they have a question."

Crowdfunding not only educates the public on research, but also allows the public to inform the research agenda as well. In the process of disseminating knowledge, a PhD student described how interacting with the crowd *"stimulated [her] thinking"* and *"sparked[ed] new ideas"* for future studies on parasites. Another crowdfunder described ideas exchanged between her and other crowdfunding scientists as *"cross pollination."* Sharing work with someone outside one's project team has been shown to support creativity and new ways of tackling problem solving [24,25].

By running a crowdfunding campaign, scientists are given the opportunity to not only receive funds, but also share what it's like to perform research from study design to field work. Crowdfunding scientists achieve this work using so-

cial technologies, such as maintaining public webpages and engaging in direct conversations on their crowdfunding project page. These public relationships last over time, which sets it apart from traditional funding transactions where scientists may receive funds from a grant officer who privately checks in once a year.

Communicate Research Using Accessible Language

Scientists also learn how to communicate their research using language that resonates with a broad audience. This stands in contrast to how scientists typically communicate – through lengthy written grants, papers or presentations to an expert scientific audience. Many participants describe how they were not initially skilled at communicating their work to non-scientists. A PhD student studying marine biology described how crowdfunding required a completely different skillset from his everyday research:

"As students, we are trained to research issues, write papers and submit grant proposals. But we are not trained to make videos and to reach out to the public."

Crowdfunding provides an avenue to build these skills, which participants describe as being useful when "go[ing] to an event" and "talking to every single person". An ecologist described how the crowdfunding process of making a video and writing a description helped him learn to explain his research succinctly:

"[Crowdfunding] helped me tremendously in putting together a message, my elevator speech if you will. It's helped me put together that 5 minute pitch of 'What do you do? Oh, well, I do x, y, and z.'"

Another PhD student in computer science said he learned to use *"shorter sentences that sound interesting"* in order to be more *"appealing to the outside world."*

In communicating with non-scientists, participants expressed their hope to still communicate the "deeper scientific purpose". Scholars who study science communication describe how converting scientific publications into public-friendly articles follows a process of removing complicated language and subtleties in order to reduce it to a simple set of facts [8]. However, some researchers find that scientists purposefully do not want to do this because they worry it may misrepresent their work [12].

In addition, they also learn to communicate through different media, such as video, blog articles (see Figure 3), and in-person. They see these as "cool ways" to describe their work outside of journal articles and conference presentations. One of the most difficult tasks of a crowdfunding campaign is creating a video [30]. While many participants had trouble with this aspect of the crowdfunding process, those that were able to learn video-making felt it was a valuable skill. A researcher of an anthropology project described her experience with videography:

"I've never made a video before for my research, and sort of trying to put that together in the style of you know History Channel documentary…it was really a lot of fun, so I really enjoyed that. It's definitely not something you would do for a grant like the National Science Foundation."

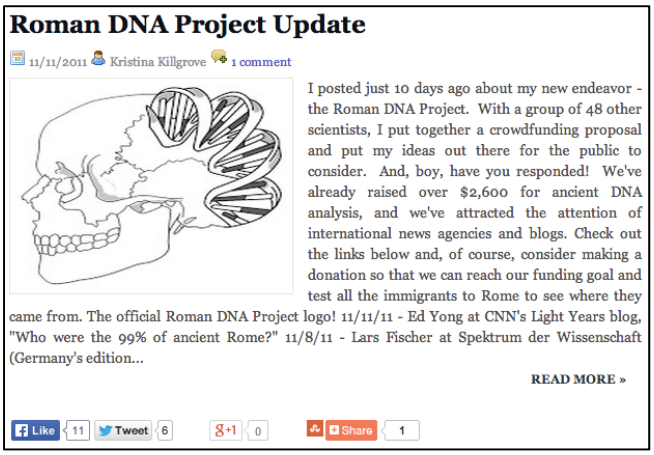

Figure 3: A crowdfunding scientist posts a blog entry on her research progress.

Participants also expressed improving their communication skills by soliciting and receiving feedback from peers and supporters. Being able to point to an online video and description of their project allowed scientists to easily communicate with other scientists about their work. Rockethub and Experiment scaffolded these interactions by setting up online communities where scientists could discuss topics and help each other before they went public with their campaign. A participant using Rockethub described how she found it useful to get feedback from other scientists launching projects:

"We had a wiki. We all put up our projects, and people would comment on them, so I got a lot of good feedback from the other people who were also putting up projects, and I commented on their projects."

The public process of communicating one's work forced participants to practice and receive feedback. A PhD student explained how the iterative process improved his communication skills:

"I got comments on the video and the kind of questions that people would ask in those comments or would ask when they sent me emails helped me figure out what I was explaining well and what I was explaining not well. And so I feel like I've been able to hone my explanation a bit because of that."

Participants see the benefits of learning to communicate with the public in more easy to understand terms because it increases public interest in science and improves their ability to succinctly explain the importance of their work, a skill necessary to succeed as a researcher. Participants learn to better communicate through frequent interaction and feedback in online community platforms like forums and social media sites.

Find Academic Peers through Campaign Publicity

Regular interactions in online forums and sharing work publicly help scientists who crowdfund create a community with other scientists. Scientists describe crowdfunding as a "public space" for making "connections" with other researchers.

Creating a crowdfunding page increases visibility for one's work, making it easier for other scientists to find researchers in the same field. A new assistant professor described how crowdfunding drew people interested in her research:

"Other scientists have seen [my campaign], and they've contacted me and talked to me about [research]."

They also use their project as a way to network with other scientists whom they have not met through traditional ways of connecting, such as through conferences:

"I've found them online through their Petri Dish [crowdfunding page] and gone, I didn't know you were doing that! That's really cool!"

Scientists use research connections to find people who can provide help on their research, such as feedback on an experimental setup or access to expensive equipment. A researcher described how the review process typically involves "hardcore physicists" giving feedback that is "very harsh." Therefore, he sees crowdfunding as a great way to meet others that may be able to provide their professional opinion in a more supportive rather than competitive atmosphere:

"Being crowdfunded, you expose yourself to a lot of other scientists. They really help us move forward and we really are craving for their feedback."

In addition to feedback, crowdfunding could support increased collaboration between scientists, which has shown to foster data [4] and idea [23] sharing for scientific progress:

"Another SciFund participant I got in touch with later…we actually ended up submitting a symposium proposal for a meeting."

Novice scientists see it as a great opportunity to locate mentors who are critical for professional development. A biology PhD student described how having a crowdfunding campaign gave her a reason to reach out to more experienced researchers:

"*One of the great things about the SciFund Challenge was that I had an excuse to contact people that I wanted to contact for a while, but didn't really have an excuse to contact."*

Similar to previous research on how expert crowdfunders contribute back to the community by giving advice on how to run a campaign [30], we find the similar interactions in the science space. One PhD studying parasites described how many professors approached him asking for advice on how to fund their own projects:

"Once I was funded…I've had a lot of people in my department of all ranges, from grad student to professors, just come and talk to me about advice and how they can do a crowdsourcing campaign."

Learning crowdfunding skills gives a way for novices in their scientific field to act as mentors to more senior researchers. Another participant described how crowdfunding "enlarged [her] community and overall interested group." Similarly, a high school student described how she looks forward to maintaining the relationships she made through crowdfunding in her future college research experiences

Participants described how their crowdfunding campaign served as conversation starter with peers and mentors in order to build useful, long lasting relationships in the future.

Motivations and Deterrents to Crowdfund Science

In addition to understanding how crowdfunding scientists connected with an extended audience, we also explored why they initially chose to crowdfund.

Motivations

Compared to traditional grantsmanship, scientists perceive that crowdfunding can help raise funds relatively quickly and that it provides a space to support riskier ideas that may not appeal to traditional funding agencies. While the work required to raise funds is considered difficult for scientists in terms of the skills, time, and attitude required to publicize on social media, scientists with an existing support network perceive the work as a monetization of their connections.

The immediacy of crowdfunding provides support when other funding sources are limited. Scientists explain that they may need extra funds in the middle of their study to buy laboratory materials or pay for data collection travel expenses. Many of these actions are time sensitive and running a month long campaign to raise funds for an immediate need is more desirable than writing a grant or fellowship application that may take months to process. A PhD student studying marine biology used crowdfunding to buy diving equipment for his upcoming research trip when his advisor was unable to provide him with the needed funds.

"With crowdfunding, it's been really cool to see all of this happening now, and to know that come January, I will be able to start this project. I don't have to wait six months to get my funding."

Scientists also like seeing funds trickle in every day as opposed to waiting to hear back months after submitting a grant proposal. They describe receiving news about supporter activity as "fun" and "exciting." A biology re

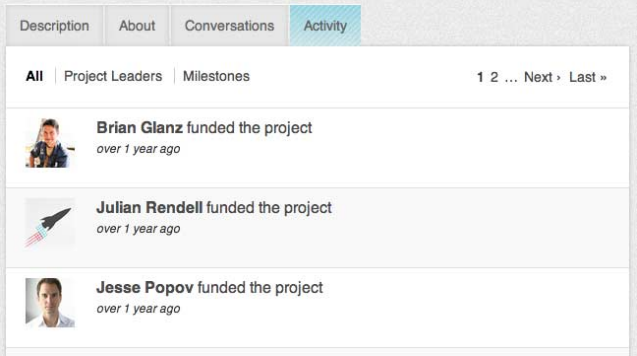

Figure 4: Rockethub provides a list of supporters as well as milestone notifications for when certain funding levels are reached.

searcher studying crustaceans described the emotional rush from getting notifications each day:

"It was highly emotional because you get the highs, you get the little rush when you actually see you know, 'So-and-so has funded your project,' and that comes into your email, it's like, 'Yay!' And that's a great feeling."

Involving the crowd in research funding has allowed scientists to see the people who support their work through the online list of supporters (see Figure 4). This stands in contrast to getting grant reviews back from a small panel of researchers through private communication channels. An undergraduate researcher of a computer science project described how she preferred being supported by the crowd compared to anonymous people in a funding agency:

"I haven't personally met most of the donors, but you know, being able to see a list of exactly who's contributing is a nifty change from just getting unmarked well, marked…with government dollars."

Scientists see crowdfunding as a way to encourage the work of novice scientists and the pursuit of unique research ideas. One participant studying zoology described how her work did not qualify for other forms of funding:

"Because of my status in a different program, I don't qualify for many of the same kinds of funding as a traditional paleontologist would…[My research] is not inexpensive, and I am a graduate student with tuition and all. [Crowdfunding] provided these means of funding my project and my research that I would otherwise not have access to."

With crowdfunding, scientists are judged less on their reputation and more on how their work appeals to the public. An entomologist who raised over $10,000 described his previous frustration with the NSF:

"It's getting so competitive. [The NSF] is becoming more conservative. It's not funding wild ideas that may be very good because they're too risky."

Some scientists are concerned projects will primarily be judged on scientists' salesmanship rather than research abilities [55]. However, this is not significantly different from grant applications, which also need to be written clearly and persuasively.

Participants also describe their desire to "bring democracy to the world of fundraising" in order to remove the "mysterious nature" of what and how research is funded. One participant lamented how there was no research version of the Grameen Bank, an organization that provides the ability to microfinance individuals in third world countries.

Deterrents

In addition to the outlined motivations to crowdfund science, scientists still identified many reasons why crowdfunding is not ideal, including overcoming institutional red tape, time and skills needed to publicize effectively online, risk of idea theft, and attitudes of asking for money online. For instance, because crowdfunding science has only recently started gaining attention, most research institutions lack infrastructure to foster crowdfunding easily.

Participants describe how their institutions are confused about opening an account for researchers to receive public donations and have been asked to contact every individual supporter with necessary paperwork. A participant described how her financial office had trouble understanding the nature of crowdfunding donations:

"Does it count as one large donation or does it count as many small donations? Each individual contributor needs to be contacted by the university and confirm with the university that they know that the donation was not tax deductible…Accounting offices at universities are not set up yet for this kind of funding structure."

Similar to other ways of securing funding, it still requires hard work. For people who have full time jobs as researchers—writing papers, taking or teaching classes, and performing studies—running a crowdfunding campaign can be overwhelming. A PhD student at a midwestern university described the stress of running a crowdfunding campaign:

"The fundraising should have been a fulltime job…and web development, as well, was a fulltime job. So, I was basically doing three fulltime jobs at the same time. And I'm also doing a PhD and I'm also teaching at a university, so I have like basically, 5 official titles. So that was definitely hard."

Despite the workload, novice researchers have expressed feeling more secure about their ability to crowdfund compared to getting a research grant. Another participant thought the crowdfunding was "much less stressful" because she didn't have to fill out "all the applications." An anthropologist studying breastfeeding described how she felt the work more likely would pay off:

"It was a lot of work, but I felt like all of the work was worthwhile, whereas when you write a normal grant, you can maybe put a ton of effort in, and then all you hear back is no."

However, while crowdfunding a certain amount seems more certain, scientists who choose to use an All-or-Nothing platform express worries that their network is not strong enough to meet the funding goal. One participant described how her advice to a friend considering crowdfunding deterred her from the experience:

"I told her my experience and she did not decide to pursue [crowdfunding] because, as she put it, 'If it's mostly people you know, no one I know has that kind of money to give me.'"

Furthermore, although participants were motivated to engage a broader audience, they also take into consideration the risk of sharing their research openly. While sharing one's research with other scientists can help with research collaborations or mentorship relationships, it also puts one at risk of idea theft. Although none of the scientists that we interviewed reported having their ideas stolen, many expressed concerns. For instance, a university professor of an applied science project explained how crowdfunding may not be ideal for beginning researchers:

"Early stage people that have new findings, and they haven't protected it, should stay away [from crowdfunding]…If you make it public, you can't patent it or you have a very limited amount of time to file a provisional [patent]…The ideal time to do crowdfunding is when the technology is in a mature enough stage."

However, data from beginning researchers with limited capital suggest that they are willing to put up with this risk in order to receive immediate funds because they have few other choices.

In addition, while creators appreciate interacting with people to receive feedback, they feel uncomfortable asking for monetary help. The persistent and ongoing face-to-face and computer mediated communication is critical to achieving funding success, but can feel uncomfortable because it breaks certain social norms. One scientist described it as *"hounding."* Another participant who reached his funding goal expressed his extreme discomfort:

"[Requesting funds] was the biggest challenge because you have to do it. You have to send emails to your friends… you feel like a beggar, a glorified beggar."

Overall, scientists are motivated to seek funds through crowdfunding for a variety of reasons including speed, freedom from large funding agencies, being more democratic, and being funded by many people. However, they are deterred because of the time commitment, bureaucratic red tape, possible idea theft, and discomfort asking for money.

DISCUSSION

Crowdfunding allows scientists to share their work with the public, connect with research peers, and solicit resources outside traditional funding mechanisms. These opportunities allow scientists to feel *competence* in their work through acting as an expert in their field, *relatedness* with others by establishing connections to people with similar interests, and *autonomy* by having access to financial resources without having to apply to traditional funding sources that can take months of effort with no reward. The combination of competence, relatedness, and autonomy, form the groundwork of self-determination theory, which describes how people are more likely to be self-motivated and produce higher quality work [50].

Competence through Public Engagement and Communication

As crowdfunding becomes a more popular and accepted way to fund scientific research [55], it shows how the Internet is changing established work practices and what is needed to build professional expertise. Unlike other popular crowdfunding categories, such as art or product design, showing or explaining one's work to a general audience has not been a common form of fundraising for individual scientists. Science foundations and societies have long sought donations for research, but until crowdfunding, scientists have rarely taken it upon themselves to solicit resources by publicizing their work to a extended network of friends, family, and beyond. Other forms of promoting public awareness of science, such as through popular press, have involved hiring a science journalist to translate research.

Crowdfunding builds on the more recent ways scientists are engaging with the public, such as through blogs and social media [44,46], by providing an opportunity to use these to both seek needed resources and build a sense of competence. Our data gave examples of how scientists are viewed as experts and mentors to people interested in their work. Participants describe sharing information with supporters on how to perform research at home and what tools they used in their research process. Currently, the value of scientific work is mainly judged through publications and grant funding. While these methods of peer review within the scientific community ensure scientists are following proper standards and methods, the practice of crowdfunding introduces a new model of how the public could play a role in the research ecosystem.

While many participants described sharing their work with people outside their field as one of the most rewarding aspects of crowdfunding, they also faced challenges learning to communicate with non-scientists. As such, learning how to create a project pitch might be even more difficult for crowdfunding scientists compared to general crowdfunding project creators. Related work on cognitive science and learning sciences describe how scientists have trouble distilling their work in a way that is easily understandable by the public [37] because they often become so knowledgeable about their subject that they develop an "expert blind spot" [12,42]. Others describe how some scientists feel that simplifying their work to a point where the public can understand would misrepresent their findings [12].

While sharing one's work publicly has shown to build competence and support motivation to participate, scientists also need to learn the skills to share their work effectively so that they can evolve with how science may be performed and evaluated as crowdfunding becomes more popular.

Relatedness through Peer Collaboration and Crowdfunding Communities

Similar to findings on research collaborations [17] and motivations to crowdfund in general, scientists are also motivated to build professional connections. Compared to general crowdfunding platforms, Kickstarter having launched over 160,000 projects, crowdfunding science platforms are still very much in the nascent stage with about 150 projects launched on Experiment [31] and Rockethub's SciFund Challenge [9] each. This small community benefits crowdfunding scientists because platforms can hold close-knit online wikis and forums where project creators come to know each other's work in order to give feedback. Traditionally, scientists give feedback during peer review for publications or in established work contexts [17]. Crowdfunding provides a new context for these relationships to happen, which could increase the strength and innovation of science work by involving more diverse perspectives [24,25] and increased opportunities for feedback [27].

Scholars who study collaboration in science find that working with other scientists improves access to resources and equipment [33], information [6], and authorship status [22]. We found that scientists who made collaborations through crowdfunding engaged with other scientists by submitting project proposals with people they met in the crowdfunding community.

However, compared to general crowdfunding project creators where there are thousands of existing projects, crowdfunding scientists do not have the same level of access to mentors or role models from which to draw inspiration [19,20]. Unlike many creative-type crowdfunding projects, the outcome of science crowdfunding is not a product or form of entertainment (e.g. iPad accessory, film), but artifacts of the research process, such as copies of the crowdfunder's research articles [61] or naming rights for a research specimen. Because these rewards may not be as enticing as a commercial product, crowdfunding scientists face greater challenges with building a community of supporters and fans. Thus it is more imperative to build tools that provide access to other more expert crowdfunders who may be able to provide help or advice.

Autonomy through Crowdfunding as a New Funding Model

Scientists are acutely aware of the importance of funding on their research agenda. Studies on scientific work reveal that researchers often spend 40% of their time on bureaucratic duties like grant writing [59]. Our data suggests that scientists, particularly novices who have a limited track record, found that they have a higher chance acquiring funds through crowdfunding than through applying for a grant. Others described how crowdfunding allowed them to overcome small obstacles in their research process, such as quickly soliciting small amount of funds for a last minute round of data collection, which applying for a research grant would have taken months to accomplish.

However, even though crowdfunding may provide funds quicker and to people with limited research reputation, many crowdfunders do not realize the amount of work it takes to create and sustain a crowdfunding project [9,30]. Unfortunately, crowdfunding is more than just creating a project page with video and written description. It requires crowdfunders to publicize their work constantly on social media, learn new communication skills, and manage hundreds of supporters [30]. While research on crowdfunding has shown that people have turned to community support tools and resources to achieve these tasks [30], project creators of both science and non-science campaigns agree that crowdfunding takes a concerted effort.

Summary

While we found scientists to be motivated to experience a sense of competence through acting as a field expert, relatedness by connecting with other scientists, and autonomy by being able to seek resources quickly, we also found that scientists were not used to communicating their work to a new audience and felt overwhelmed by the responsibilities of crowdfunding work. Furthermore, we find that crowdfunding science is different from crowdfunding creative-type projects for two main reasons:

1) Scientists have traditionally not had to rely on communicating their work to an extended network of friends, family, and the general public in order to fund their science research, which may make learning the process of crowdfunding science more difficult.

2) Unlike general crowdfunding projects, which typically involve creating a product or service that supporters can have or experience, such as a video game, the outcome of science research is furthering scientific knowledge. This more ambiguous end goal may make it more difficult for scientists to reach the same level of Internet popularity as other types of crowdfunding projects creating consumer products.

While crowdfunding platforms have succeeded at using the Internet to remove many of the barriers needed to collect financial resources from a large number of people, CSCW researchers must continue to better understand what about this new model of fundraising can motivate increased communication and collaboration between scientists and a wider extended audience.

IMPLICATIONS FOR DESIGN

We suggest design implications for tools supporting 1) a wider range data sharing and visualization, 2) building science communication strategies with non-scientists, 3) interactions between crowdfunding scientists for feedback and

collaborations, and 4) financial on-boarding strategies for large research institutions and universities. By designing crowdfunding tools and platforms, we can help more scientists involve the public in a variety of research efforts.

Currently, crowdfunding science platforms look very similar to general crowdfunding platforms. Project pages include a video, project description, funding goal and rewards. However, because crowdfunding science projects focus less on producing a consumer product and more on furthering knowledge, these forms of public engagement may not be enough. Although most platforms include forums where scientists and supporters can converse, they offer few other capabilities to support dissemination of in-depth research material. In order to provide easier avenues for engagement, platforms could create interactive galleries to share images of data or mechanisms for scientists to solicit feedback before launching the campaign. Following research in public engagement in science, such tools would support knowledge transfer, active discussion, and collaborative shaping of the research agenda [7,53].

Many scientists don't have the technical skills to create a custom platform themselves [36]. Unlike citizen science, which requires much more work by the scientists to set up a custom system for mass data collection or analysis, crowdfunding platforms are able to streamline certain platform features like providing video uploading features or a comment feed. Some platforms like Experiment help scientists communicate their work effectively through one-on-one support with platform staff and requiring crowdfunding scientists to answer three basic questions on their campaign page: "What is the context of this research?", "What is the significance of this project?", and "What are the goals of the project? " Including more mentorship support and structured presentation formats in other platforms could ease the communication process for new crowdfunding scientists.

Furthermore, as described earlier, crowdfunding science is still relatively new and has a much smaller community of participants than general crowdfunding platforms like Kickstarter. Some platforms, such as Rockethub and Experiment, have taken advantage of the smaller community size and incorporate forums where scientists can comment and send messages to other crowdfunding scientists. However, only three of the six platforms that we studied reported having an online forum just for project creators.

In addition, we find that crowdfunding is particularly attractive to novice researchers who have difficulty getting grants from more prestigious funding sources. Economic research on the effects of decreasing government funding in research find that federal funding does not crowd out private funding of researchers [14]. Our results suggest that crowdfunding may be particularly valuable to people who have trouble getting traditional funding, such as novice researchers. In order to better support novices, crowdfunding platforms may need to design better onboarding interfaces for universities. Already, some platforms [61,69] have started setting up official relationships with universities, and some universities have started their own crowdfunding platforms [63,70].

LIMITATIONS

Our participants used four of the most popular crowdfunding science platforms. However, there are additional crowdfunding platforms and it is possible that participants on other platforms are motivated to participate for different reasons. It is also possible that platforms motivate participants differently [35]. We also do not discuss motivations for donating to crowdfunding science projects, as what scientists may find valuable may not be what supporters find valuable. Further, we suspect that motivations for participation may vary slightly as platforms are redesigned, more people are aware of the phenomenon, and expectations for participation in crowdfunding are altered.

FUTURE WORK

Learning how to interact with the public effectively takes an entire new skillset that scientists may not have, and acquiring this skillset is time and effort intensive. Future work will focus on designing support tools for crowdfunding platforms that are informed by scientist's needs to alleviate the strain of onboarding for scientists who may want to crowdfund their research. We also plan to perform a study of supporter motivations in order to better understand what type of people support and whether crowdfunding science is targeting a representative sample of the public.

CONCLUSION

Science research is crucial for the advancement of society. Yet the struggle continues to overcome obstacles that broaden participation and funding of innovative work. As CSCW researchers, we are called to study and design emerging systems that fundamentally reduce the barriers to participation. By realizing new opportunities for funding and communicating science, crowdfunding can provide new ways for scientists to engage the public and scientific peers in their research process.

ACKNOWLEDGEMENTS

We thank Amy Laurin, Lauren Tindal, and Cassie Coravos for helping with data collection, coding, and insights. We also thank Michael Greenberg for his feedback.

REFERENCES

1. Aragon, C.R., Poon, S., and Silva, C.T. The changing face of digital science: new practices in scientific collaborations. *Proc. of CHI*, (2009), 4819–4822.
2. Bandura, A. *Self-efficacy: The exercise of control*. W. H. Freeman and Company, 1997.
3. Belleflamme, P., Lambert, T., and Schwienbacher, A. Crowdfunding: tapping the right crowd. *Journal of Business Venturing*, (2013).
4. Birnholtz, J.P. and Bietz, M.J. Data at work: supporting sharing in science and engineering. *Proc. of GROUP*, (2003), 339–348.

5. Bonney, R., Cooper, C.B., Dickinson, J., et al. Citizen science: a developing tool for expanding science knowledge and scientific literacy. *BioScience 59*, 11 (2009), 977–984.
6. Bozeman, B. and Corley, E. Scientists' collaboration strategies: implications for scientific and technical human capital. *Research Policy 33*, 4 (2004), 599–616.
7. Bucchi, M. Of deficits, deviations and dialogues: Theories of public communication of science. *Handbook of public communication of science and technology*, (2008), 57–76.
8. Bucchi, M. *Science and the media: alternative routes to scientific communications*. Routledge, 2013.
9. Byrnes, J.E., Ranganathan, J., Walker, B.L.E., and Faulkes, Z. To Crowdfund Research, Scientists Must Build An Audience For Their Work. *PeerJ PrePrints*, (in press).
10. Cohn, J.P. Citizen science: Can volunteers do real research? *BioScience 58*, 3 (2008), 192–197.
11. Crowston, K. and Prestopnik, N.R. Motivation and data quality in a citizen science game: A design science evaluation. *Proc. of HICSS*, (2013), 450–459.
12. Davis, P.R., Horn, M.S., and Sherin, B.L. The Right Kind of Wrong: A "Knowledge in Pieces" Approach to Science Learning in Museums. *Curator: The Museum Journal 56*, 1 (2013), 31–46.
13. Deci, E.L. and Ryan, R.M. *Intrinsic Motivation and Self-determination in Human Behavior*. Plenum Press, New York, 1985.
14. Diamond, A.M. Does Federal Funding "Crowd In" Private Funding of Science? *Contemporary Economic Policy 17*, 4 (1999), 423–431.
15. Farzan, R. and Kraut, R.E. Wikipedia classroom experiment: bidirectional benefits of students' engagement in online production communities. *Proc. of CHI*, (2013), 783–792.
16. Feder, T. Scientists Experiment with Crowdfunding. *Physics Today 66*, 4 (2013), 23–24.
17. Finholt, T.A. Collaboratories. *Annual review of information science and technology 36*, 1 (2002), 73–107.
18. Galloway, A.W., Tudor, M.T., and HAEGEN, W.M.V. The reliability of citizen science: a case study of Oregon white oak stand surveys. *Wildlife Society Bulletin 34*, 5 (2006), 1425–1429.
19. Gentner, D., Loewenstein, J., and Thompson, L. Learning and transfer: A general role for analogical encoding. *Journal of Educational Psychology 95*, 2 (2003), 393.
20. Gentner, D. The mechanisms of analogical learning. *Similarity and analogical reasoning 199*, (1989), 241.
21. Gerber, E.M. and Hui, J. Crowdfunding: Motivations and Deterrents for Participation. *ACM Transactions on Computer-Human Interaction 20*, 6 (2013), 34:1–34:32.
22. Hagstrom, W.O. *The scientific community*. Southern Illinois University Press Carbondale, 1975.
23. Hara, N., Solomon, P., Kim, S.-L., and Sonnenwald, D.H. An emerging view of scientific collaboration: scientists' perspectives on collaboration and factors that impact collaboration. *Journal of the American Society for Information Science and Technology 54*, 10 (2003), 952–965.
24. Hargadon, A. and Bechky, B. When collectives of creatives become creative collectives: A field study of problem solving at work. *Organization Science 17*, (2006), 484–500.
25. Hargadon, A. and Sutton, R.I. Technology Brokering and Innovation in a Product Development Firm. *Administrative Science Quarterly 42*, (1997), 716–749.
26. Hargittai, E. Digital Na(t)ives? Variation in Internet Skills and Uses among Members of the "Net Generation."*Sociological Inquiry 80*, 1 (2010), 92–113.
27. Hattie, J. and Timperley, H. The power of feedback. *Review of Educational Research 77*, 1 (2007), 81–112.
28. Hourihan, M. *AAAS Report XXXVIII: Research and Development FY 2014*. 2013.
29. Hui, J., Gerber, E., and Gergle, D. Understanding and Leveraging Social Networks for Crowdfunding: Opportunities and Challenges. *Proc. of DIS*, (2014).
30. Hui, J.S., Greenberg, M.D., and Gerber, E.M. Understanding the Role of Community in Crowdfunding Work. *Proc. of CSCW*, (2014), 62–74.
31. Jasklowski, O. Project people distribution (from chat). 2014.
32. Katz, J.S. and Martin, B.R. What is research collaboration? *Research policy 26*, 1 (1997), 1–18.
33. Kevles, D.J. *The physicists: The history of a scientific community in modern America*. Harvard University Press, 1995.
34. Kim, S., Mankoff, J., and Paulos, E. Sensr: evaluating a flexible framework for authoring mobile data-collection tools for citizen science. *Proc. of CSCW*, (2013), 1453–1462.
35. Kraut, R. and Resnick, P. *Building Successful Online Communities: Evidence-Based Social Design*. MIT Press, Cambridge, 2012.
36. Law, E., Dalton, C., Merrill, N., Young, A., and Gajos, K.Z. Curio: A Platform for Supporting Mixed-Expertise Crowdsourcing. *Proc. of HCOMP*, (2013).
37. Lemke, J.L. *Talking science: Language, learning, and values*. ERIC, 1990.
38. Litt, E. Measuring users' internet skills: A review of past assessments and a look toward the future. *New Media & Society 15*, 4 (2013), 612–630.
39. Mitra, T. and Gilbert, E. The language that gets people to give: Phrases that predict success on kickstarter. *Proc. of CSCW*, ACM (2014), 49–61.

40. Mollick, E.R. The Dynamics of Crowdfunding: An Exploratory Study. *Journal of Business Venturing 29*, 1 (2013), 1–16.
41. Muller, M., Geyer, W., Soule, T., Daniels, S., and Cheng, L.-T. Crowdfunding inside the enterprise: employee-initiatives for innovation and collaboration. *Proc. of CHI*, (2013), 503–512.
42. Nathan, M.J., Koedinger, K.R., and Alibali, M.W. Expert blind spot: When content knowledge eclipses pedagogical content knowledge. *Proceedings of the Third International Conference on Cognitive Science*, (2001), 644–648.
43. Nov, O., Arazy, O., Lotts, K., and Naberhaus, T. Motivation-targeted personalized UI design: a novel approach to enhancing citizen science participation. *Proc. of ECSCW*, (2013), 287–297.
44. Nowotny, H., Scott, P., and Gibbons, M. *Re-thinking science: knowledge and the public in an age of uncertainty*. SciELO Argentina, 2001.
45. Orelli, B. Biotech crowdfunding paves way for angels. *Nature Biotechnology 30*, 11 (2012), 1020–1020.
46. Peterson, I. Touring the scientific web. *Science Communication 22*, 3 (2001), 246–255.
47. Raddick, M.J., Bracey, G., Gay, P.L., et al. Galaxy zoo: Exploring the motivations of citizen science volunteers. *Astronomy Education Review 9*, 1 (2010), 010103.
48. Robson, C., Hearst, M., Kau, C., and Pierce, J. Comparing the use of social networking and traditional media channels for promoting citizen science. *Proc. of CSCW*, (2013), 1463–1468.
49. Rotman, D., Preece, J., Hammock, J., et al. Dynamic changes in motivation in collaborative citizen-science projects. *Proc. of CSCW*, (2012), 217–226.
50. Ryan, R. and Deci, E. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55 55*, (2000), 68–78.
51. Sheppard, S.A. and Terveen, L. Quality is a verb: The operationalization of data quality in a citizen science community. *Proceedings of the 7th International Symposium on Wikis and Open Collaboration*, ACM (2011), 29–38.
52. Strauss, A. and Corbin, J. *Basics of Qualitative Research: Grounded Theory Procedures and Techniques*. Sage Publications, London, 1990.
53. Trench, B. Science Communication and Citizen Science: How Dead is the Deficit Model. *IX International Conference on Public Comunication of Science and Technology (PCST), Seoul, Korea*, (2006).
54. Trench, B. Internet: turning science communication inside-out? In *Bucchi, Massimiano and Trench, Brian, (eds.) Handbook of Public Communication of Science and Technology*. Routledge, London and New York, 2008.
55. Wheat, R.E., Wang, Y., Byrnes, J.E., and Ranganathan, J. Raising money for scientific research through crowdfunding. *Trends in ecology & evolution*, (2012).
56. Wiggins, A. and Crowston, K. From conservation to crowdsourcing: A typology of citizen science. *Proc. of HICSS*, (2011), 1–10.
57. Wiggins, A. Free as in puppies: compensating for ict constraints in citizen science. *Proceedings of the 2013 conference on Computer supported cooperative work*, (2013), 1469–1480.
58. Wulf, W.A. The national collaboratory–a white paper. *Towards a national collaboratory*, (1989), 17–18.
59. Dr. No Money: The Broken Science Funding System. *Scientific American*, 2011. http://www.scientificamerican.com/article/dr-no-money/.
60. Rockethub. 2011. http://www.rockethub.com/.
61. Experiment. https://experiment.com/.
62. SciFund Challenge. http://scifundchallenge.org/.
63. UCLA Spark. https://spark.ucla.edu/.
64. Benefunder. http://benefunder.org/.
65. MicroVentures. https://microventures.com.
66. Petri Dish. http://www.petridish.org/.
67. TED: Ideas worth spreading. http://www.ted.com/.
68. Merit Review Criterion: Broader Impacts. *National Science Foundation*. http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=13626.
69. Launcht. http://www.launcht.com/.
70. Crowdfund MIT. https://crowdfund.mit.edu/.