ResearchGate

See discussions, stats, and author profiles for this publication at: https://www.researchgate.net/publication/331679084

The Innovation Ecology: Collaborative Information, Community Support, and Policy in a Creative Technology Community: 14th International Conference, iConference 2019, Washington, DC...

Chapter · March 2019

DOI: 10.1007/978-3-030-15742-5_58

CITATION
1

READS
28

4 authors:

Guo Zhang Freeman
Clemson University
44 PUBLICATIONS **752** CITATIONS
SEE PROFILE

Jeffrey Bardzell
Indiana University Bloomington
132 PUBLICATIONS **2,168** CITATIONS
SEE PROFILE

Shaowen Bardzell
Indiana University Bloomington
136 PUBLICATIONS **2,592** CITATIONS
SEE PROFILE

Nathan J. McNeese
Clemson University
64 PUBLICATIONS **310** CITATIONS
SEE PROFILE

Some of the authors of this publication are also working on these related projects:

Human-Autonomy Teaming in Command-and-Control Environment View project

Paradigms in design research View project

All content following this page was uploaded by Guo Zhang Freeman on 05 July 2019.

The user has requested enhancement of the downloaded file.

The Innovation Ecology: Collaborative Information, Community Support, and Policy in a Creative Technology Community

Guo Freeman[1(✉)], Jeffrey Bardzell[2], Shaowen Bardzell[2], and Nathan J. McNeese[1]

[1] Clemson University, Clemson, SC 29634, USA
guof@clemson.edu
[2] Indiana University, Bloomington, IN 47405, USA

Abstract. In this paper, we explore a network of distributed individuals' collective efforts to establish an innovation ecology allowing them to engage in bottom up creative technological practices in today's information society. Specifically, we present an empirical study of the technological practices in an emerging creative technology community – independent [indie] game developers in the United States. Based on indie game developers' own accounts, we identified four themes that constitute an innovation ecology from the bottom up, including problem solving; collaborative information seeking, sharing, and reproducing; community support; and policy and politics. We argue that these findings inform our understanding of bottom up technological innovation and shed light on the design of sociotechnical systems to mediate and support such innovation beyond the gaming context.

Keywords: Bottom-up innovation · Collaborative information exchange · Informal learning · Online communities · Indie game development

1 Introduction

Innovation turns knowledge and ideas into value [1]. We are now witnessing an era when social computing and collaborative technologies have fundamentally changed the Web "from a comprehensive information repository to a set of collective projects, a worldwide community of communities" [2]. This change has led to the emergence of a bottom-up user-centric innovation model (i.e., users of products and services are increasingly able to innovate for themselves) [3, 4]. In this new model, innovation is initiated and driven by end users rather than introduced top-down by large firms, corporations, and enterprises such as technology giants [5]. From Wikipedia, digital volunteerism, open source software development, citizen science, to crowdsourcing platforms such as Amazon Mechanical Turk, a body of information science and social computing research (e.g., [6, 7, 9–11]) has tackled important problems on innovation in an information society, including how social computing tools and platforms support the collaborative construction of knowledge (e.g., [12, 14]) and team coordination within online creative communities (e.g., [7]). Yet, how exactly technological innovation can happen from bottom up and what mechanisms support its operation remain understudied.

© Springer Nature Switzerland AG 2019
N. G. Taylor et al. (Eds.): iConference 2019, LNCS 11420, pp. 614–624, 2019.
https://doi.org/10.1007/978-3-030-15742-5_58

In this paper, we explore a network of distributed individuals' collective efforts to establish an innovation ecology allowing them to engage in creative technological practices from the bottom up. We understand innovation ecology as an important concept in social informatics. It refers to the sociotechnical infrastructure of interrelated institutions, regulations, technologies, and resources that can enable, encourage, foster, and catalyze the generation of ideas and creation of value out of them [1, 13]; it also involves core social informatics themes such as social contexts and work processes, sociotechnical networks, and public access to information [8]. Specifically, we present an empirical study of the technological practices in an emerging creative technology community – independent [indie] game developers in the United States. A common understanding of indie games is that they are games made by amateurs who are not professional game developers. We choose this community as an exemplar to explore bottom up innovation ecology because indie games are often praised as a "moral, artistic high-ground" for their new forms of gameplay, innovative design, engaging experiences, and nostalgic properties [15]. What makes indie game developers' creative practices possible, and how their practices inform our design and development of sociotechnical systems for end-user driven innovation and content creation beyond the gaming context deserves research attention not only from game researchers but from information scientists and social computing scholars concerned with social creativity and bottom-up innovation.

2 Background: Indie Game Development and Innovation in Social Computing

A body of research in information science and social computing has sought to design and implement systems and applications that mediate and support social creativity and collective innovation. A common design principle is to facilitate the presentation, spread, and use of information within groups. For example, Gregg [16] proposed that such systems and applications should be data centric, which not only enable data collection and sharing among users but also support user-generated/modified data.

Other researchers noted that improving online users' awareness of collaboration and co-presence can help design, develop, and evaluate interactive systems for group creativity. For example, Geyer et al. [17] designed a digital team collaborative space (i.e., TeamSpace) to integrate both synchronous and asynchronous team interactions into a task-oriented environment. Similarly, Gutwin et al. [18] suggested that information required for group awareness included "knowledge about who is on the project, where in the code they are working, what they are doing, and what their plans are."

However, new bottom-up models of innovation and participatory culture have raised new and important questions about how to better support innovation and emerging creative technology communities' information needs [5, 19]. One example is the indie game development community. Indie games are broadly defined as games that are consciously created within alternative production and distribution structures compared to mainstream game companies [15]. Tools such as easy-to-use free game engines (e.g., Unity and Unreal), comprehensive online coding libraries (e.g., Unity Scripting Reference) and Assets Stores (e.g., Unity Assets Store), unlimited online and

offline community support (e.g., Unity online live training, Unity online forums, offline social gatherings of indie game development Meetup groups), and direct developer-to-consumer digital distribution platforms (e.g., App Store) have also contributed to game development no longer being a closed and secretive tech industry.

In general, the indie game development community in the United States has become a novel technology community, who endeavors to collectively innovate cutting-edge graphic and interactive technologies, explore new forms of gameplay, create inspiring and refreshing human experiences, and promote open development process. These new phenomena raise a number of interesting research questions, including how indie game developers can innovate and how their practices inform the design and development of sociotechnical systems that mediate and support bottom-up innovation. This paper endeavors to explore these questions.

3 Methodology

To collect data, we joined six Facebook Groups for indie game developers and indie game development. We then posted a message on these groups to recruit indie game developers who were willing to be interviewed as voluntary participants. All developers who responded to our requests and agreed to participate were inter-viewed. As a result, 12 semi-structured in-depth interviews were conducted via text/audio Skype chat based on participants' preferences from December 2017 to February 2018. In each interview, 15 predefined open-ended questions were asked and the average length of interviews was 80 min. All 12 participants are Americans. Six are female (50%) and 3 are non-Caucasian (25%). The average age of the participants was 31 years old (min. = 25, max. = 51) and average years of experience in indie game development were 8.5 years (min. = 2 years, max. = 17 years). Five of them (42%) developed indie games full time as freelancers or working in small studios (two to three people) while seven (58%) as part time or a hobby.

We then used an empirical, in-depth qualitative analysis of the collected data with a focus on indie game developers' innovative practices. We first closely read through the collected data to acquire a sense of the whole picture as regards developers' technological practices. We then collectively identified thematic topics and common features in the data for further analysis and carefully examined and reviewed the thematic topics and developed sub-themes. Finally, we collaborated in an iterative coding process to discuss, combine, and refine themes to generate a rich description synthesizing how and why indie game developers can innovate from the bottom up.

4 Findings

Digital game production was considered a professional technological practice for profit. Everyday users had little role beyond purchasing and accepting produced games as commodities. Yet, the increasing growth of indie game development seems to signify a cultural shift in how people perceive games and the gaming industry, as one participant reported, "*You get to be on the cutting edge of technology or see really cool things or*

be a part of the really cool thing before the public goes crazy over it. This is the reason why so many have gone indie" (P4, female, 33, African American). Many participants, who were not professional game developers, acknowledged that innovative games might originate from individual creativity and passion. However, they explained that (1) *problem solving*; (2) *collaborative information seeking, sharing, and reproducing*; (3) *community support*; and (4) *broader politics and social* policies constituted an innovation ecology – through which they engaged in a bottom-up movement to turn their creativity into IT products (e.g., digital games) and reshape the ways that games were designed, created, and shared. In this section, we explain each of the four themes using quotes from indie developers' own accounts.

4.1 Innovation Emerges in Problem Solving

Many participants highlighted that actively identifying problems and seeking solutions was the first step to transform creative ideas to innovative products. For many of them, the willingness and persistence to encounter various problems in a tech field that they were not professionally trained for was essential for any creative endeavors. One participant summarized, "*The best thing about making indie games is that we become better problem solvers. Most of us had no experience in game development before. This means we usually seek solutions that are 'outside of the box.' That's the start point for any innovation in this field.*" (P6, female, 29, Asian) Some others also related problem solving to the fact that gaming as a rapid changing industry: "*I love learning how to use software to a tee. However recently the game development tools have been updating so quickly it's hard to keep up. Most of the time when that happens I have to look at it to see if it's worth upgrading and risking re-doing certain pieces. I have to solve so many problems but I feel I get better every time after I solve some problems*." (P5, male, 27, white)

However, many others described that problem solving was not merely limited in the technical aspect of game making (e.g., programming and using game engines) but also about design, aesthetic, and teamwork – all of which made game development a challenging practice but opened new and emerging opportunities for experimentation and innovation. One participant revealed,

Game development is fraught with challenges. If you're a one-man-band, you have to become knowledgeable in many areas. Programming and logical thought, design and aesthetic sense, sound design–the whole kit. Aside from the technical difficulties, there's also the social aspect of making games. Having team members or even just interested bystanders helps a lot with motivation and training and growth. Making indie games is not just about making software but about imagination, creativity, collaboration, management, marketing, fundraising… etc. You are solving all kinds of problems – tech, social, political, financial. That's why indies grow up so fast and can keep making cool things. (P7, male, 25, white)

For indie game developers, solving problems across various domains often inspired them to innovate. Their problem solving practices not only helped them prepare and sharpen necessary technical skills to develop games but also encouraged them to "think outside the box," leading to creative approaches and strategies beyond the gaming area.

4.2 Innovation Centers on Collaborative Information Seeking, Sharing, and Reproducing

Many participants regarded collaborative information seeking, sharing, and producing as the core mechanisms through which they not only solved problems but also pursued new and innovative solutions in their game development process. Participants shared how they benefited from information and resources shared by others and also contributed to creating, updating, and spreading useful information to benefit other indie game developers:

Sometimes I am the one asking questions and some other times I am the one who provides answers of my own from experience. I especially like to interact with other users on forums for specific tool kits or plugins. I think those information are very valuable for both experienced and new developers. (P6, female, 29, Asian)

Open forums where users can share experiences, experiments, code, and open source tools are the reason why many indie developers and some studios like ours can survive and make new things. Since we are so small, many of our technologies were developed by a third party of some sort, like on Unity's asset store or snippets of code shared by users on GitHub. I think the community as a whole across many platforms is what makes endeavors like ours possible and we are happy to provide what resources we can for the community as well. (P10, male, 27, African American)

These two quotes highlight the importance of voluntary and free information exchange for bottom up technological innovation- innovation is initiated and driven by individual indie game developers or small studios rather than massive game companies. Comparing to companies who enjoy abundant information and cutting edge tools, indie developers often have limited access to resources, money, platforms, and tools. How to provide them with necessary resources at low or no cost became a crucial component in the innovation ecology. The indie gaming context represents a subculture within a broader tech culture: everyone is benefited from free knowledge and information in the innovation ecology; everyone is also producing, sharing, and spreading free knowledge and information to promote more innovation.

However, some participants pointed out the challenges of such a subculture:

I think in general, mid level information is very hard to find. There is so many tutorials on how to get started in a project. And there are forums about super technical programming stuff, but there is a big gap between those two things. […] you have to reinvent that information yourself. (P8, male, 30, white)

The availability of information and being able to find what you need quickly and efficiently is important. A lot of time is wasted in searching for information and finding up-to-date requirements, specs, techniques, etc. Unity has great support, but finding practical examples on places like YouTube can be frustrating. You get the theory from the documents, but watching someone do it makes it that much easier. YouTube can do that, but there is so much bad information to sift through on YouTube, it eats valuable time. (P9, male, 51, white)

According to these developers, they learnt most from step by step tutorials that were appropriate to their skill level and visual/video information such as YouTube videos. Yet two large issues persist: limited resources for intermediate level difficulty, and abundant low quality or irrelevant information. The indie culture of volunteerism

and free labor thus becomes a double-edged sword. On the one hand, it makes essential experiences and knowledge for game development available to everyday users, turning game development into a bottom up innovation movement. On the other hand, all indie developers are encouraged to contribute to a central "knowledge/skill repository" but no mechanism has been established to evaluate those shared information, making their quality and relevance questionable.

4.3 Community Support Sustains Innovation

Problem solving and information exchange may build the foundation for an innovation ecology in indie game development. Yet it is community support that retains indie developers and sustains their efforts to innovate. One participant described, "*Community is so important. Without it, I probably already quitted long time ago. People help each other out, share what they have found or what worked for them. No matter whether you work alone or with others on a project, you need those people to point you to the right direction, and as a member of any community, it's one's responsibility to reciprocate these help and contribute to the community*" (P9, male, 51, white).

Other participants added that the support they received from the indie community was not limited to technical assistance but also for social and emotional purposes, because creating games could be both physically and emotionally challenging:

Absolutely, there are many supportive communities online for game development that I take part in. Some of them are more about mentoring people who are just learning game design and some are very much about social support. Doing something creative is not just about you but also people supporting you, since this can be very stressful. (P1, female, 33, white)

Typically you're scattered across the country, if not the world. There has to be passion, and agency. […] you need a well functioning and coordinated team. And it can be tough emotionally and physically. You need friends. You need this community. (P11, male, 32, white)

Regardless of working alone or as a distributed team, indie developers seemed to value and appreciate all types of help they received from the indie community – ideas, knowledge, teammates, friends, or just someone they could talk to. For them, bottom-up innovation was a long and emotionally exhausting journey where personal persistence was not enough. To continue this journey, they needed confidence, encouragement, bravery, endurance, and sympathy, which they gained from other fellow indie developers and the broader indie community. One participant (P7, male, 25, white) summarized how the community supported his growth both as a developer and as a human being: "*Game developers are generally very nice and socially progressive people. People learn from each other and push each other to new heights and encourage each other. I have made good friends in the community and found role models to learn from, engaged with artists' new growth of the medium, and even developed part of my own personal identity from it.*"

4.4 Policy and Politics Facilitate (or Hinder) Innovation

A few participants stressed how policy and politics in the broader social context affected how they innovated. They especially highlighted the role of the nation's economic development policies in facilitating or hindering technological innovation:

When I was in college, I knew that the "tech growth Ohio" program helped fund our school's small game conventions as part of the STEM education program and helped link various tech businesses together. (P6, female, 29, Asian)

I know of one indie studio that has thrived because of government grants for their work in ecological storytelling. And I know of one studio that flopped after becoming complacent with major funding from the state (as an economic investment), which drew a lot of ire from people. Government involvement can be both an asset and a liability. There's a history of misunderstanding by Congress of the video game industry (See: Mortal Kombat in the 90s) and some knee-jerk legislation, but we do have people more familiar with the medium coming into office and doing positive things. (P7, male, 25, white)

In these quotes, developers were well aware that the upper level national development and economic policies could affect how people created and innovated in the indie community. Their technological practices were not conducted in a vacuum. Rather, what they could innovate and how they innovated was intertwined with policymakers' attitudes towards technology. As they described, the current emphasis on STEM and technology-driven U.S. economy fostered a supportive environment for their technological practices. Though not being widely recognized, indie gaming has been playing an important role in enhancing STEM education and game-based learning (e.g., educational games). Innovation in indie gaming also contributes to the growing technological power (e.g., in terms of creative design, improved user experience, novel interaction mode, and upgraded visual effects). Yet they were anxious that high level policy makers might hinder their innovation due to misunderstandings or unfamiliarity with gaming and game development. In particular, some participants pointed out how the current tax law and political atmosphere might undermine indie game development as a creative technology industry:

I think national laws certainly play a role., particularly in how teams can raise money. And tax law is certainly hard on indies. We spent a big chunk of our budget just to hire decent accountants to track our expenses and make sure we were prepared for taxes. (P11, male, 32, white)

The xenophobic policies that have become prominent in the last few years have made it very difficult for people I know from other countries to live and work in the US. They just want to come here and make games, but current politics has become a huge hurdle there. They're often waiting for months to years just hoping their name comes up in a lottery. (P10, male, 27, African American)

P11 was worried that the current tax policy was not friendly to the indie community (or technological startups in general), which made game development – an already technologically and psychologically challenging creative practice – more financially challenging. This may discourage people to continue their efforts or even enter this field. P10 further pointed to the risk of losing workforce and diversity in indie game development due to the ambiguous political atmosphere. According to him, if people

did not feel safe, welcomed, or comfortable in a society, they simply would not participate in innovative activities despite of how much they loved doing so.

5 Discussion

Using indie gaming as a context, in this paper we have identified four themes emerging in indie game developers' accounts that constituted an innovation ecology from bottom up. Though innovation often originates in personal creativity and ideas, how it can be materialized and generate values depends on a sophisticated sociotechnical infrastructure. This infrastructure involves: (1) innovators' active problems seeking and solving that transform creativity to feasible ideas; (2) collaborative information seeking, sharing, and reproducing that enable innovators to turn feasible ideas to innovative products; (3) consistent community support that encourages innovators to continue their efforts and catalyze their creation; and (4) policies and politics that foster a supportive social environment and public perception for technological innovation. In this section, we discuss how these four themes informed our understanding of bottom-up technological innovation and the design of sociotechnical systems that mediate and support such innovation.

Above all, a user-centric bottom up innovation mode is distinctive from other types of innovation; it is driven by everyday users with various backgrounds, knowledge bases, and motivations. In addition, it is often built on users' personal and subjective experiences and it suffers from limited information and resources but provides an alternative way of creating and producing technology. Finally, it requires tremendous social support due to its technological, emotional, and financial challenges. All of these features raise important questions about how to (re)design sociotechnical systems to support this new and emerging form of technological innovation. Our research confirms previous findings regarding the presentation, spread, and use of information as a key design principle to facilitate collaborative innovation [16]. Yet our focus on bottom-up innovation also points to some aspects of technological innovation that may have been overlooked in other studies. We suggest that a sociotechnical system that supports innovation from bottom up involve design features to facilitate informal learning, effective searching and filtering information, social and emotional support, and an awareness of policies and politics.

Informal Learning. People who participate in bottom-up innovation are often non-stereotypical technology workforce; they may be new to a given tech area (e.g., game development) and have little or no experience of designing and creating technology. Yet they are passionate about turning their creativity into technological products. During this process, mechanisms of informal learning make their innovative practices possible. Rather than taking classes in a formal learning environment, they learn by doing (e.g., making their own games), by trial and error, by acquiring and verifying useful information online (e.g., forum posts and YouTube videos), and by peer assistance (e.g., questions and answers). Therefore, designing and developing systems that better support and evaluate informal learning in STEM become crucial to foster an innovation ecology from bottom up. For example, our participants complained that the

available learning materials were either too easy or too challenging but they had no control over what was shared and published. A system that facilitates nominating tutorials for topics of various levels of difficulty and supports crowdsourcing feedback for user created content/products would improve bottom up innovator's learning experiences.

Effective Searching and Filtering Information. Our findings point to the risk of wasting innovators' time on low quality or irrelevant information online. Most innovators dedicate their personal spare time to innovating. Therefore, they regard wasting time on unnecessary information search and verification as one of the most significant challenges in their innovation process. For example, many innovators depend on YouTube and its commenting feature to decide whether a tutorial video is relevant to their practices or not. Yet YouTube as a general video viewing site has little quality control on its content's technical matter, which hinders rather than benefits their innovation. Therefore, in addition to information presentation as suggested in previous studies [16], a system that affords sharing and verifying accurate information on specific technical topics and offers effective searching and filtering mechanisms for such information (e.g., searching keywords in scripts of videos) would be central to support technological innovator's efforts.

Social and Emotional Support. Our findings also highlight that bottom-up innovation is a highly challenging practice both technologically and socially, as many indie developers are not tech savvy and may not financially benefit from their practices for a long time. We found that regardless of working alone or as a team, innovators highly appreciate the social and emotional support that they receive from the community. Such support may not directly help them solve a technical or management problem but lead to a friendly and encouraging social atmosphere for bottom-up innovation as a long-term endeavor. In this sense, design features that facilitate social and emotional support from the community should be encouraged to be implemented so as to better support technological innovation. Such features may include gifting and donating, dedicated online social space (e.g., a sub-forum) for anonymously sharing sensitive personal concerns and seeking advice, and value-sensitive designs that encourage and reinforce particular community norms and ethics [22] (e.g., protection of personal privacy and effective reporting and reaction mechanism to tackle harassment).

Awareness of Policy and Political Concerns. The idea of policy preceding and prefiguring design and practice [20, 21] in social computing is not new: As Jackson et al. [20] discussed, policy, as a third factor, can determine the "shape, meaning, and trajectory of shifting computational forms" together with design and practice. Our data have shown that indie developers perceived their technological practices as driven and influenced by a series of national policies – for example, the current focus on STEM education and technology-driven economy. They also believed that how appropriately indie game development fit into these national priorities significantly affected the quality and the public perception of their products. In addition, they acknowledged that politics (e.g., immigration) played a role in encouraging or discouraging the growth and diversity of a technology workforce. Taken together, there seems to be a demand for an increasing awareness of the broader sociopolitical context surrounding innovation.

Building an ecology for bottom-up innovation does not only include designing and creating sociotechnical systems for collective informal learning, information exchange and filtering, and social/emotional support but also requires a better understanding of the intertwining relationships among design, policy, and technology.

6 Conclusions

Using indie gaming as a context, we have explored the innovation ecology that makes bottom-up innovation possible in today's information society. We have identified four themes that constitute an innovation ecology from bottom up, including problem solving; collaborative information seeking, sharing, and reproducing; community support; and policy and politics. We argue that these findings inform our understanding of bottom up technological innovation and shed light on the design of sociotechnical systems that mediate and support such innovation beyond the gaming context.

We offer three interrelated contributions to information science and social computing. First, we emphasize the new information needs and requirements from innovators who are non-stereotypical technology users, which presents empirical evidence on how technological innovation can happen from the bottom-up in today's information society. Second, we extend previous studies on designing sociotechnical systems for distributed innovation by highlighting the importance of supporting informal learning, effective searching and filtering information, social and emotional support, and awareness of policy and political concerns. Finally, we point to how national policies and politics on STEM education, economic development, and technology workforce significantly affect the motivations, trajectories, and public perceptions of bottom up innovation. As innovation is seen as a key economic driver, our findings concerning the mechanics by which innovative ecologies operate can inform policy makers' effective decision-making.

Acknowledgements. We thank our participants and the anonymous reviewers. This work was supported in part by the National Science Foundation under award 1513604 and 1849718, the University of Cincinnati Office of Research, and Clemson University School of Computing.

References

1. Dvir, R., Pasher, E.: Innovation engines for knowledge cities: an innovation ecology perspective. J. Knowl. Manage. **8**(5), 16–27 (2004)
2. Carroll, J.M.: Beyond being social: prospects for transformative social computing. Commun. Assoc. Inform. Syst. **27**(1), 641–650 (2010)
3. Von Hippel, E.: Democratizing innovation: the evolving phenomenon of user innovation. Int. J. Innov. Sci. **1**(1), 29–40 (2009)
4. Ahonen, M., Antikainen, M., Mäkipää, M.: Supporting collective creativity within open innovation. In: European Academy of Management (EURAM) Conference Paris, pp. 1–18 (2007)

5. Freeman, G., Bardzell, S., Bardzell, J.: Bottom-up imaginaries: the cultural-technical practice of inventing regional advantage through IT R&D. In: Proceedings of the 2018 ACM Conference on Human Factors in Computing Systems (CHI 2018), paper 325, pp. 1–11. ACM, New York (2018)
6. Kittur, A., Chi, E.H., Suh, B.: Crowdsourcing user studies with mechanical turk. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 453–456. ACM (2008)
7. Kittur, A., Lee, B., Kraut, R.E.: Coordination in collective intelligence: the role of team structure and task interdependence. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 1495–1504. ACM (2009)
8. Kling, R.: Learning about information technologies and social change: the contribution of social informatics. Inform. Soc. **16**(3), 217–232 (2000)
9. Rotman, D., et al.: Dynamic changes in motivation in collaborative citizen-science projects. In: Proceedings of the ACM 2012 Conference on Computer Supported Cooperative Work, pp. 217–226. ACM (2012)
10. Starbird, K.: Delivering patients to sacré coeur: collective intelligence in digital volunteer communities. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 801–810. ACM (2013)
11. Yamauchi, Y., Yokozawa, M., Shinohara, T., Ishida, T.: Collaboration with lean media: how open-source software succeeds. In: Proceedings of the 2000 ACM Conference on Computer Supported Cooperative Work, pp. 329–338. ACM (2000)
12. Kim, S., Mankoff, J., Paulos, E.: Sensr: evaluating a flexible framework for authoring mobile data-collection tools for citizen Science. In: Proceedings of the 2013 Conference on Computer Supported Cooperative Work, pp. 1453–1462. ACM (2013)
13. Wulf, W.A.: Changes in innovation ecology. Science **316**(5829), 1253 (2007)
14. Li, Z., Shen, H., Grant, J.E.: Collective intelligence in the online social network of Yahoo! answers and its implications. In: Proceedings of the 21st ACM International Conference on Information and Knowledge Management, pp. 455–464. ACM (2012)
15. Lipkin, N.: Examining Indie's Independence: the meaning of "Indie" games, the politics of production, and mainstream cooptation. Loading **7**(11), 8–24 (2013)
16. Gregg, D.G.: Designing for collective intelligence. Commun. ACM **53**(4), 134–138 (2010)
17. Geyer, W., Richter, H., Fuchs, L., Frauenhofer, T., Daijavad, S., Poltrock, S.: A team collaboration space supporting capture and access of virtual meetings. In: Proceedings of the 2001 International ACM SIGGROUP Conference on Supporting Group Work, pp. 188–196. ACM (2001)
18. Gutwin, C., Penner, R., Schneider, K.: Group awareness in distributed software development. In: Proceedings of the 2004 ACM Conference on Computer Supported Cooperative Work, pp. 72–81. ACM (2004)
19. Freeman, G., Bardzell, J., Bardzell, S.: Aspirational design and messy democracy: partisanship, policy, and hope in an Asian city. In: Proceedings of the 20th ACM Conference on Computer Supported Cooperative Work and Social Computing (CSCW 2017), pp. 404–416. ACM, New York (2017)
20. Jackson, S. J., Gillespie, T., Payette, S.: The policy knot: re-integrating policy, practice and design in CSCW studies of social computing. In: Proceedings of the 17th ACM Conference on Computer Supported Cooperative Work & Social Computing (CSCW 2014), pp. 588–602. ACM, New York (2014)
21. Light, A.: Troubling futures: can participatory design research provide a generative anthropology for the 21st century? Interact. Des. Archit. **26**, 81–94 (2015)
22. Shilton, K.: Values levers: building ethics into design. Sci. Technol. Human Values **38**(3), 374–397 (2013)

View publication stats