Collective intelligence on a crowdsourcing site

Juho Salminen
Lappeenranta University of Technology, Lahti School of Innovation
juho.salminen@lut.fi

Abstract
This study focuses on collective intelligence and its emergence on crowdsourcing sites. It has been claimed that crowdsourcing facilitates, uses, or benefits from collective intelligence, but instead of thorough analyses, the discussion has been more on the level of metaphors. The goal of this study is to find out, whether crowdsourcing can really be connected to phenomena that can be considered to be collective intelligence. In addition the aim is to increase understanding on the exact mechanisms that lead to emergence of collective intelligence. Using ethnography as an approach, activities on a crowdsourcing site were analyzed using two interpretations of collective intelligence: wisdom of crowds and swarm intelligence. A contradiction in the mechanisms giving rise to collective intelligence was found: while feedback loops emerging on the site can help direct the attention of the crowd, the very same feedback loops might undermine the wisdom of the crowd.

1 Introduction

Crowdsourcing supports, uses or benefits from collective intelligence. At least that seems to be a common assumption. But is it really so, and what does the statement actually mean in practice? This working paper presents the first results from a study that is looking for evidence of collective intelligence on crowdsourcing sites. The focus is specifically on the sites that use crowdsourcing to create innovations. Innovation is a suitable context to look for collective intelligence, because innovating requires many different capabilities: analytical skills, intuition, creativity, decision-making, and craftsmanship. The increasingly popular (Doan et al 2011) use of crowdsourcing as a part of innovation process promises benefits by allowing more people to participate to the creation of innovations. The assumption is that the innovation process will benefit from the participation of more people as they bring in new knowledge, skills, and diverse viewpoints (Terwiesch and Xu 2008). Even though collective intelligence is often mentioned in connection to crowdsourcing (e.g. Bonabeau 2009, Malone et al 2010, Brabham 2008, Sullivan 2010), it is not clear whether it actually is a useful concept to describe what is going on at crowdsourcing sites. The concept of collective intelligence is fuzzy and allows for many different interpretations, such as comparison to general intelligence factor g (Woolley et al 2010), Wisdom of crowds (Surowiecki 2005) and swarm intelligence of social insects (Bonabeau 1999). Crowdsourcing is still much in the state of experimenting and although many organizations are already relying on it, clear best practices have not emerged yet. The idea that crowdsourcing might be one form of universal, distributed intelligence arising from the collaboration and competition of many individuals (Levy 1997), is appealing, but it is not clear whether this really happens and how useful the phenomenon is for practitioners and designers of crowdsourcing sites. For instance, we do not know should practitioners of crowdsourcing aim for collective intelligence, and if so, how can it be done? What is the role of wisdom of crowd effect in crowdsourcing applications? Does something similar to swarm intelligence of social insects take place on crowdsourcing sites when humans are interacting with each other? How important is collective intelligence, whatever it might mean, to performance of crowdsourcing sites? The research questions this study seeks to answer are 1) how collective intelligence is manifested on crowdsourcing

sites? and 2) how important collective intelligence is for the functioning of the crowdsourcing sites?

The research approach of the study is participatory ethnography. The paper presents the first results from a pilot study, the purpose of which was to develop and test data collection and analysis procedures. Next the plan is to extend the study with multiple cases, which will allow comparison of different approaches to crowdsourcing innovations. The pilot case is analyzed using two interpretations of collective intelligence: wisdom of crowds and swarm intelligence. It turned out that on the case site the crowd does not recognize the best ideas, defined as the ones the experts select for refinement, but can filter out the very worst ideas. In swarm intelligence self-organization and emergence play a big role. Despite the efforts, not much evidence on emergence could be found on the site, compared to some other examples, such as Wikipedia, Twitter and 4chan. Most interestingly, there seems to be a contradiction between these two interpretations of collective intelligence: feedback loops that could help direct the attention of the crowd, contributing to emergence of swarm intelligence style behavior might at the same time undermine the wisdom of the crowds effect due to violation of independence of decisions.

The paper is structured as follows. First the relevant literature is shortly reviewed and a conceptual framework to direct data collection and analysis is developed. Methodological approaches used in data collection and analysis are described. Then the pilot case and results of analyzes are presented. Finally the results are discussed and conclusions drawn on the findings.

2 Literature review and conceptual model

In order to understand the context and contributions of this study, it is first necessary to review three fields relevant to the study: innovation processes, crowdsourcing and collective intelligence.

2.1 Innovation processes

Innovation is usually defined as a new invention, be it a product, service of improvement to process, which is taken into use. In other words innovation is a combination of a problem and a solution (Hippel 2005). As such, creation of innovations is also closely related to design (Ulrich 2011). Although complex and iterative by nature, creation of innovations (and design) follows loosely a certain process. Various frameworks have been developed to model the innovation processes. They are usually described as multi-stage processes with feedback loops between the stages. The typical phases of the innovation process are depicted in Figure 1.

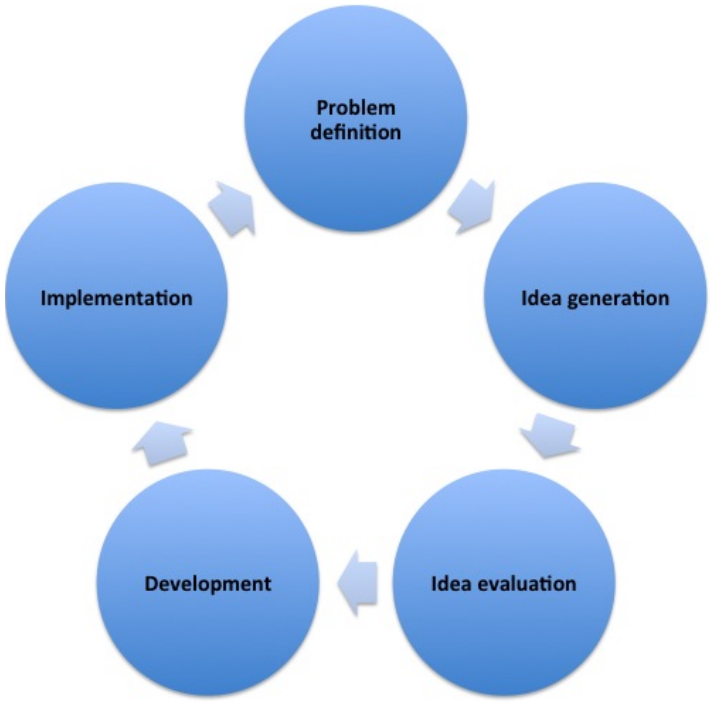


Figure 1. Innovation process.

2.2 Problem definition

The innovation process begins with an implicit or explicit problem definition. Some of the models place a very strong emphasis on this phase (Kumar 2009), while in others, the process starts with idea generation (Desouza & al 2009, Cooper 1990) and problem definition is only implicit. Problem definition is about learning about the environment, technologies (Veryzer 1998) and user needs (McFadzean & al. 2005). Learning can be passive scanning of environment for relevant signals (Tidd & al. 2005) or active research on the needs, hopes and issues of users (IDEO 2009).

2.3 Idea generation

Most models recognize idea generation as a separate phase of the innovation process. New ideas are created to form a basis for further development. Again, this part of the process can be either explicit or implicit, as exemplified by use of brainstorming (IDEO 2009) and emergence of a vision about the possibilities of new technology (Veryzer 1998). The relative location of idea generation in the innovation process varies throughout different models. The innovation process may start at the creation of an idea (Desouza & al. 2009, McFadzean & al. 2005), just after it (Cooper 2002) or long before it (Kumar 2009, Veryzer 1998, IDEO 2009). The number of initial ideas is often very large; in idea generation, quantity is considered to be more important than quality (IDEO 2009).

2.4 Idea evaluation

After idea generation the number of ideas in the process is reduced through evaluation and selection. Depending on the context, the focus can be on technological aspects (Veryzer 1998), human aspects (IDEO 2009) or economic aspects (Cooper 1990). The most promising ideas are refined and combined. During this process, the requirements of users and technological features are defined more rigorously. Preliminary design and even some early prototypes can be developed to clarify ideas (Veryzer 1998). The end result of this phase is the concept, which will be turned to reality in the next steps of the process.

2.5 Development

The development phase is executed based on the concept (Tidd & al. 2005). Lots of experimentation takes place when more and more comprehensive prototypes are built and tested for their technological functionality and user acceptance (Desouza & al. 2009, Veryzer 1998, McFadzean & al 2005). Expected and unexpected problem solving loops are characteristic and most of the costs are generated in this phase (Tidd & al. 2005). The viability of the project is tested from the perspectives of product, production process, customer acceptance and financial aspects (Cooper et al 2002). Manufacturing processes are designed and marketing becomes increasingly involved in the project (Cooper 1990).

2.6 Implementation

In the implementation phase the innovation is more or less ready; technological issues have been solved and the current prototype works as required (Veryzer 1998, McFadzean & al. 2005). The business plan is now implemented, manufacturing is ramped up and marketing to customers begins full scale (Cooper 1990, McFadzean & al. 2005). The innovation is launched onto the market, or taken into everyday use (Tidd & al. 2005, Shaw & al. 2005).

There is substantial consensus about the structure of the innovation processes in literature, although different models use different terms to describe the phases, emphasize different aspects of the process and have divided the process in varying ways. In short, innovation processes are about identifying a problem, searching for a solution and putting the solution into practice. It is assumed that the elements of the process described above can be found also on the crowdsourcing sites focusing on creation of innovations.

2.7 Crowdsourcing

Crowdsourcing refers to outsourcing tasks traditionally performed by an organization to an undefined crowd, usually through an open call posted to Internet (Howe 2008). Defining a crowdsourcing system explicitly is challenging, but one approach is to frame crowdsourcing as a general-purpose problem-solving method: a crowdsourcing system enlists a crowd of humans to help solve a problem defined by the system owners (Doan et al. 2011). As creation of innovations is closely related to problem solving, it is no wonder that crowdsourcing is increasingly used as part of innovation processes. Some famous examples include:

- InnoCentive, a site where companies can post difficult problems for anyone to solve (Jeppesen and Lakhani 2010)
- Threadless, an apparel company that crowdsources the design of its products (Brabham 2010). The company focuses mostly on graphical t-shirts, but has lately expanded also to other product categories
- Dell IdeaStorm, a website used to collect ideas for computer company Dell (Di Gangi and Wasko 2010)
- My Starbucks Idea, where ideas are collected to improve services and products of Starbucks coffee shop chain (Sullivan 2010)

Exactly when and why crowdsourcing is a suitable method for problem solving is still being explored, but it has been proposed that its usefulness depends on characteristics of the problem, knowledge required for the solution, characteristics of the crowd and characteristics of solutions to be evaluated by the crowd (Afuah and Tucci 2012). Increased diversity of problem solvers might be one reason for the success of crowdsourcing (Terwiesch and Xu 2008). A large population of problem-solvers includes people in technical and social marginality with different perspectives and heuristics. Such people have been shown to have an important role in successful problem solving (Jeppesen and Lakhani 2010). It has also been

suggested that collective intelligence might contribute to effectiveness of crowdsourcing (Bonabeau 2009, Malone et al 2010). Connecting large numbers of people around a shared problem-solving task might bring out some phenomena that could be considered collective intelligence, a system that has qualitatively different properties than the individuals forming it (Heylighen 2013).

2.8 Collective intelligence

Collective intelligence refers to phenomena, where the intelligence of a group can be considered to be at least partially independent and usually greater than the intelligence of individuals forming the group. A recent literature review on collective intelligence reveals three levels of abstraction in literature regarding the collective intelligence: micro, macro and meso levels (Salminen 2012). At the micro-level, collective intelligence is a combination of psychological, cognitive and behavioral elements. The immersion of self in a social network is a typical human condition and our unconscious ability to read and display social signals allows smooth coordination within the network (Pentland 2007). At the micro-level the focus is thus on prerequisites of intelligent group behavior and human psychology. At the macro-level, collective intelligence becomes a statistical phenomenon, at least in the case of the 'wisdom of crowds' effect (Lorentz et al. 2011). Here the focus is mostly on the outputs of the system. Between these extremes resides the level of emergence, a meso-level that deals with the question of how system behavior on the macro-level emerges from interactions of individuals at the micro-level. A common approach used to explain how collective intelligence as a statistical or probabilistic phenomenon emerges from individual interactions is to use the theories of complex adaptive systems. They are systems characterized by adaptivity, self-organization and emergence (Ottino 2004). Adaptivity means the ability of a system, or its components, to change themselves according to changes in the environment (Schut 2010). In self-organization order at the system level arises without central control, solely due to local interactions of the system's components (Kauffman 1993). Emergence means a rise of system level properties that are not present in its components; "the whole is more than the sum of its parts" (Damper 2000). For the purposes of the study the framework from the literature review was simplified according to figure 2. It is assumed that by collecting data about the elements presented in the figure all the relevant aspects will be covered and an understanding on collective intelligence at the site can be developed.

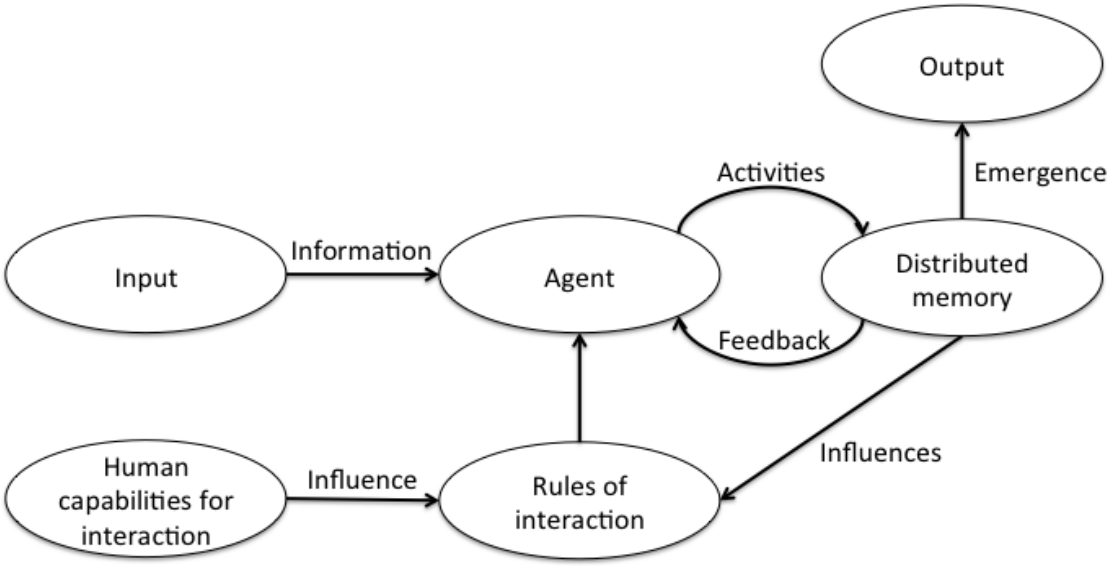


Figure 2. The theoretical framework of collective intelligence used to guide data collection.

According to the framework, the human capabilities for interaction, such as intelligence, trust, motivation and other psychological and cultural factors, together with environmental constraints, create the rules of interaction. Inputs to the system arrive through cognitive agents. An agent processes and integrates information from the outside and feedback from the distributed memory and performs actions according to more or less strict rules. The distributed memory is the shared environment of the agents, which stores the information they create. Actions can also change the state of distributed memory. Changes to memory are fed back to the agent, and may also change the environmental constraints. Out of the multiple interactions between agents and distributed memory emerges the output of the system. Agents, their rules of interaction, distributed memory and environmental constraints form a complex adaptive system, which reacts to information from outside. The output is the emergent property of the system and may demonstrate wisdom of the crowds: the decisions made by the system as a whole may be of better quality than individuals are capable to produce alone. These high quality decisions result from diversity, independence and information aggregation.

The framework does not tell what collective intelligence is, but only suggests how it might come about. There is still plenty of room for many alternative interpretations on what collective intelligence is, including general factor of intelligence manifested at group level, artificial intelligence, decisions-making, wisdom of crowds and swarm intelligence. This study focuses on two interpretations: wisdom of crowds and swarm intelligence.

3 Methods

In this study the emergence of collective intelligence is framed as a complex system, and to understand complex systems, ethnography should be used (Agar 2004, Güney 2010). Ethnography is an open-ended research practice that is based on participant observation. It focuses on the local and particularistic knowledge of meanings, practices and artifacts of a particular social group (Kozinets 2002). This has consequences to research design: instead of planning everything beforehand, the methodological issues are expected to come up during the study as it develops in unforeseen ways. This flexibility is one of the ethnography's greatest strengths.

Analysis in ethnographic research is usually qualitative and based on holistic view developed in intense contact to field. Data is captured from the inside, in natural settings. The groundedness to local knowledge and long-term exposure to the field make it possible to study processes and give qualitative methods strong potential for testing hypotheses (Miles and Huberman 1994). On the other hand, the field notes and observations are texts constructed by researcher, and as such they are influenced by his values and biases. Things also always happen in context. The data tells more about actions people have taken instead of their behavior in general.

The critical assumption of ethnography and qualitative research is the researcher-as-instrument (Güney 2010, Miles and Huberman 1994). The researcher has a major role in data collection and analysis, and while the researcher carries with him a value system and all the biases it brings with it, he is also capable of critical reflection on his own influence to the

interactions in the research setting. In terms of complex adaptive systems, the researcher is one of the agents making the system run, but being only one of the many he has only minor responsibility on the events that emerge (Agar 2004).

The qualitative analysis is mostly done with words. Many interpretations of the data are possible, but some are more compelling (Miles and Huberman 1994). End product of ethnography is a holistic, context-sensitive narrative of the every-day life of the social group. It is essentially two stories: one story is about the representation of results and the other about how that representation was constructed (Agar 2004). In order to do ethnography it must be accepted that the researcher is a part of the story (Agar 2004).

The research process

Although two ethnographic studies are never done the same way, the research process usually involves certain phases: making cultural entrée, gathering and analyzing data, ensuring trustworthy interpretation and feedback from members of the social group (Kozinets 2002).

Entrée consists of selecting the case(s) and entering the field to learn as much as possible about the social group. In this study the ethnography is performed on the web, an approach sometimes called netnography. Theoretical sampling (Eisenhardt 1989) is used to select cases. Although propositions derived from existing literature are used to guide the research, the study is more focused on building an emerging theory than testing an existing one.

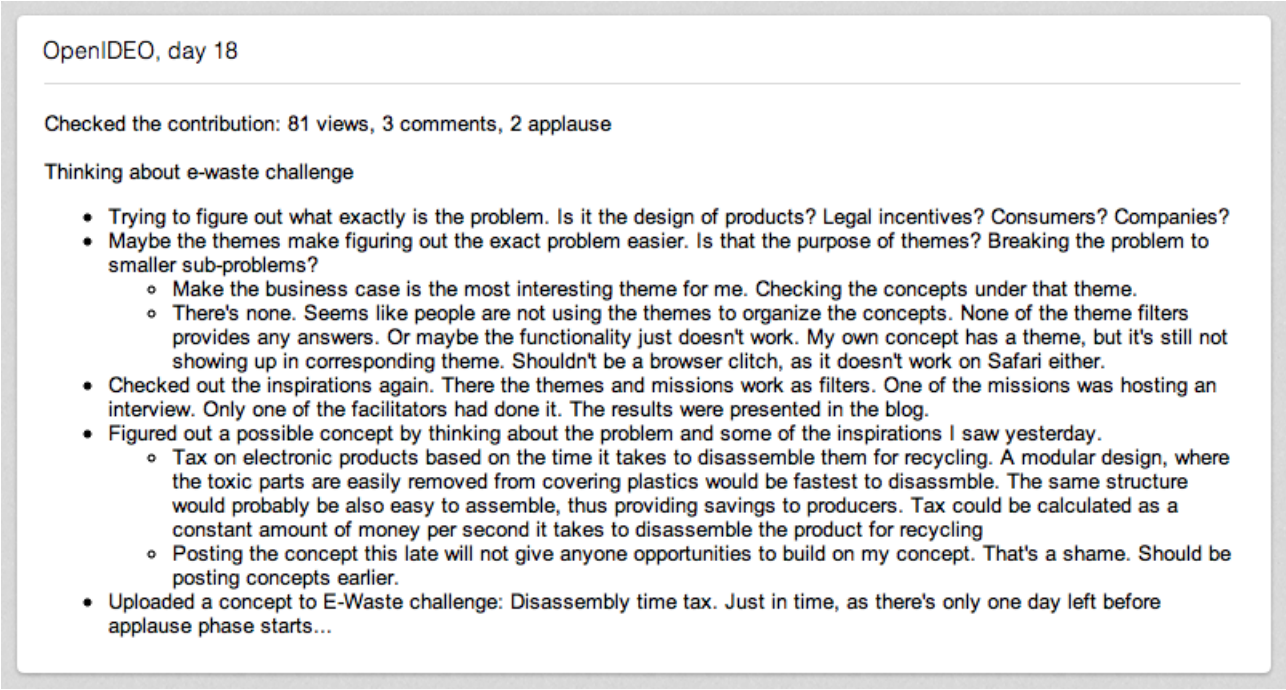
The initial pilot case was selected both because of personal interest and because the site is hosted by a renowned design company. Understanding how a company that is generally considered to be innovative implements crowdsourcing might be a good starting point for this kind of research. I had signed on the site already on 3 August 2010, soon after the site was launched, but did not participate actively. The research approach was inspired by 30-day challenges popularized in the movie Super Size Me (Spurlock 2004). Starting from July 26, 2012 I visited OpenIDEO daily for 30 days, participating to challenges and gathering data. After that the data collection was continued with less intensity for a total of 51 days of observation. The observation period was extended from the initial plan, because new insights were still being generated.

Data collection

Ethnography generally uses three data sources: participant observation, interviews and documents. In netnography the focus is usually mostly on documents copied from the web during participation and notes inscribed by researcher regarding his observations. Selecting what data to collect is an important analytical decision and already a part of data reduction for the analysis (Miles and Huberman 1994). As lots of data is available on the web even on a small scale forum, dealing with information overload is an important concern (Kozinets 2002). Yin (2008) lists three principles to be followed in data collection for case studies: using multiple sources of data, creating a case study database, and maintaining a chain of evidence.

I used Evernote notebook software (Evernote 2013) and Evernote Web Clipper add-on (Evernote 2013b) to Chrome web browser to collect interesting web pages I visited during the participant observation. Ease of use allowed minimum distraction to participation due to data collection, and build-in functionality of the software helped to create an easily managed database. I ended up having two modes of data collection: usually I saved the pages on which I

had spent some time or shown interest as a user, and resulting data is a sample of what a user of a site might encounter. The sample is probably biased, as I explored some less used functionality of the site, which I might not have done without research interest. Occasionally data was collected more systematically, for example all the blog posts were gathered from the site. I documented my own observations in a diary, also stored in Evernote, where I noted all the major actions I took on the site and observations and feelings I had at the time. Diary entries varied from just a few lines to more than a page of text per field visit. Figure 3 depicts a sample note from diary.



OpenIDEO, day 18

Checked the contribution: 81 views, 3 comments, 2 applause

Thinking about e-waste challenge

- Trying to figure out what exactly is the problem. Is it the design of products? Legal incentives? Consumers? Companies?
- Maybe the themes make figuring out the exact problem easier. Is that the purpose of themes? Breaking the problem to smaller sub-problems?
  - Make the business case is the most interesting theme for me. Checking the concepts under that theme.
  - There's none. Seems like people are not using the themes to organize the concepts. None of the theme filters provides any answers. Or maybe the functionality just doesn't work. My own concept has a theme, but it's still not showing up in corresponding theme. Shouldn't be a browser clitch, as it doesn't work on Safari either.
- Checked out the inspirations again. There the themes and missions work as filters. One of the missions was hosting an interview. Only one of the facilitators had done it. The results were presented in the blog.
- Figured out a possible concept by thinking about the problem and some of the inspirations I saw yesterday.
  - Tax on electronic products based on the time it takes to disassemble them for recycling. A modular design, where the toxic parts are easily removed from covering plastics would be fastest to disassmble. The same structure would probably be also easy to assemble, thus providing savings to producers. Tax could be calculated as a constant amount of money per second it takes to disassemble the product for recycling
  - Posting the concept this late will not give anyone opportunities to build on my concept. That's a shame. Should be posting concepts earlier.
- Uploaded a concept to E-Waste challenge: Disassembly time tax. Just in time, as there's only one day left before applause phase starts...

Figure 3. Example of a note from the research diary.

Additional documents, such as toolkits for workshops and presentations of challenge results, were also collected when encountered. Statistics on numbers of views, comments and applause on concepts were collected from three challenges. All the data collection principles of Yin (2008) were thus followed. Web pages, researcher's diary entries, documents and evaluation statistics provide multiple data sources. Evernote was used to create and maintain a case study database and chain of evidence, including dates of collection, web addresses and content.

Data analysis

Qualitative data analysis relies on three principles: data reduction as part of analysis, use of data displays, and drawing and verifying conclusions based on said displays (Miles and Huberman 1994). As data reduction is a part of the analysis, the way in which it is done is an important analytical decision. There are many ways to reduce data. Anticipatory reduction limits the amount of data collected before the actual fieldwork through selection of conceptual frameworks, cases, research questions and data collection approaches. During data collection data is reduced by coding, by categorization, clustering and partitioning, and by writing summaries and memos. (Miles and Huberman 1994) This form of analysis sharpens, sorts, focuses and organizes data so that conclusions can be drawn.

Dedoose qualitative data analysis software (Dedoose 2013) was used to organize the data collected with Evernote. The notes were imported to analysis software as Microsoft Word documents. All the data was coded using the code list presented in appendix 1. Codes are tags that assign meaning to chunks of data, such as words, phrases or paragraphs. They are used to organize data to some system of categorization to facilitate retrieval of chunks of data relevant to particular research question or theme. An initial list of codes should be created before the fieldwork begins, but researcher should also maintain the flexibility to refine the codes when they turn out to be inapplicable or ill-fitting to actual data. (Miles and Huberman 1994) The initial code list was derived from conceptual frameworks of collective intelligence, innovation processes and crowdsourcing. The codes evolved during the analysis: some were dropped, some added, and usage of some codes changed. Such variance in coding practices does not threaten the validity of results and was even expected, as one of the purposes of this pilot study was to develop a coding scheme and analysis procedures to be used in further cases. The coding was used to make retrieval of relevant data easier, and variation in coding practices could be compensated. For example, when retrieving data on Inspiration phase of OpwnIDEO challenges, the researcher just had to be aware that both "problem definition" and "idea generation" tags should be used.

A good way to start the analysis of a case is to write an interim case summary. It is a provisional synthesis of what researcher knows about the case, usually 10-25 pages in length, and provides the first coherent account of the case (Miles and Huberman 1994). After coding the data on Dedoose, the software was used to export selected data for further analysis using relevant codes. Excerpts both from web clippings and diary entries were included. Majority of data came from the web documents, expect for the code user experience, where diary was slightly more important source. Focus of the analysis was on tasks (activities), rules, feedback, and user experience (agents), because the theoretical framework suggests these themes to be important, and because these aspects turned out to be most difficult to grasp. Determining outputs of the system in different phases was straightforward, and as the website itself functioned as the distributed memory, more detailed analysis of these themes was forgone. Inputs to the system come through the participants and consist of everything they have seen or experienced. As such they are unknowable and were thus excluded from analysis. Human capabilities for interaction were left outside the scope of this study, because literature on psychology discusses them in much more detail than is possible here. Finally, emergence is not directly observable in the data, but may or may not be revealed during the analysis and comparisons. These reduced data sets were read through and insights were collected on sticky notes, which were then clustered around emerging themes to reveal patterns in the data. A slightly different approach was used to analyze feedback due to large amount and repetitiveness of data. The excerpts relevant to feedback were read in random order[1] and insights written on sticky notes until saturation was reached. An interim case summary was written based on the patterns revealed by this analysis. Care was taken to use the same language, terms and phrases as used in raw data. The interim case summary is 35 pages long and describes the operation of the site from the above-mentioned perspectives.

Extended text, even in compressed format of a case summary, is cumbersome to use for analysis: the data tends to be dispersed, sequential, poorly organized and bulky. Therefore valid analysis requires data displays that are focused enough to show full data set at once in a

[1] Random numbers were generated using a random number generator at Random.org, http://www.random.org/.

systematically arranged format, permitting conclusion drawing. Miles and Huberman (1994) aptly underline the importance of displays: "You know what you display". Displays can take a form of matrices, charts and networks. Good displays are designed to organize information so that it is immediately accessible, compact and allows the analyst to make careful comparisons, detect differences and note patterns and trends in the data. Conclusion drawing and verification then consists of noting patterns, explanations, causal flows and propositions in displays created. At first these conclusions should be held only lightly and openness and skepticism should be maintained. The meanings emerging from the data must be tested and confirmed, for example by seeking feedback from the stakeholders (Kozinets 2002, Yin 2008), to ensure their validity and trustworthiness.

Data displays used in this study are mostly based on the interim case description. Table 1 lists the most relevant displays and the purposes for which they were created. The displays themselves and conclusions drawn based on them will be presented in results section. Other stakeholders or participants of the site have not yet verified the conclusions, because the study is still in the pilot phase. The verification will take place after all the cases are completed, so that results emerging from comparisons between cases can be verified simultaneously.

Display	**Purpose**	**Data sources**	**Notes**
Innovation process	Description of the innovation process used at OpenIDEO	Case description, comparison of all challenges on the site	The process varied during the early challenges, but has now remained stable for the past 13 challenges.
Collective intelligence genome of OpenIDEO	Identification of interesting phases for further analysis	Case description	Malone et al. (2010)
Features of collective intelligence systems	Comparison of criteria for collective intelligence systems and OpenIDEO	Case description	Schut 2010
Local vs. global	Identification of	Case description	

	emergent properties in the system		
Feedback loops	Description of an emergent property found in the system	Case description	
Wisdom of Crowds factors	Comparison of facilitating factors of wisdom of crowds and OpenIDEO	Case description	Surowiecki 2005, Lorenz et al 2011, Krause et al 2011, Hong and Page 2004
Wisdom of crowds statistics	Evaluation of wisdom of crowds effect	Statistics on views, comments and applause collected during challenges	

Table 1. Data displays created during analysis of OpenIDEO

Research ethics

Unobtrusive nature of ethnography on the web, or netnography, makes the approach both attractive and controversial (Kozinets 2002). Should online forums be considered as a private or public space, and what constitutes informed consent in this context? In order to do ethical netnography, the researcher should disclose his presence, affiliations and intentions to online community members. Confidentiality and anonymity of informants should be ensured, and permission should be obtained to use specific quotes and idiosyncratic stories in the research. (Kozinets 2002) The ethical issues of this study are not very prominent, as the focus of the research is on the processes, not so much on the behavior of individuals. Direct quotes or personal stories attributable to individuals are not used in the report. I announced my identity and affiliations as a researcher on my profile page. Because of these aspects, I consider the research to follow ethical guidelines.

4 Case description

"OpenIDEO is a place where people design better, together for social good. It's an online platform for creative thinkers: the veteran designer and the new guy who just signed on, the critic and the MBA, the active participant and the curious lurker. Together, this makes up the creative guts of OpenIDEO." (OpenIDEO 2012)

OpenIDEO is a website hosted by design and innovation firm IDEO, a renowned global design company with human-centered approach to design. The website is dedicated to designing social innovations collaboratively and including broader range of people to design process. The activities on the site are organized around challenges. The challenges are difficult design tasks, which are usually related to some large and complex environmental or societal issue, such as food production, health care, or unemployment. Organizations and individuals can sponsor a challenge. At OpenIDEO the innovation process is considered to be a collaborative learning process. Sharing of information and collaboration are encouraged over competition.

Each phase has a deadline, before which the contributions to that stage have to be made. Figure 4 depicts a screenshot from the OpenIDEO website.

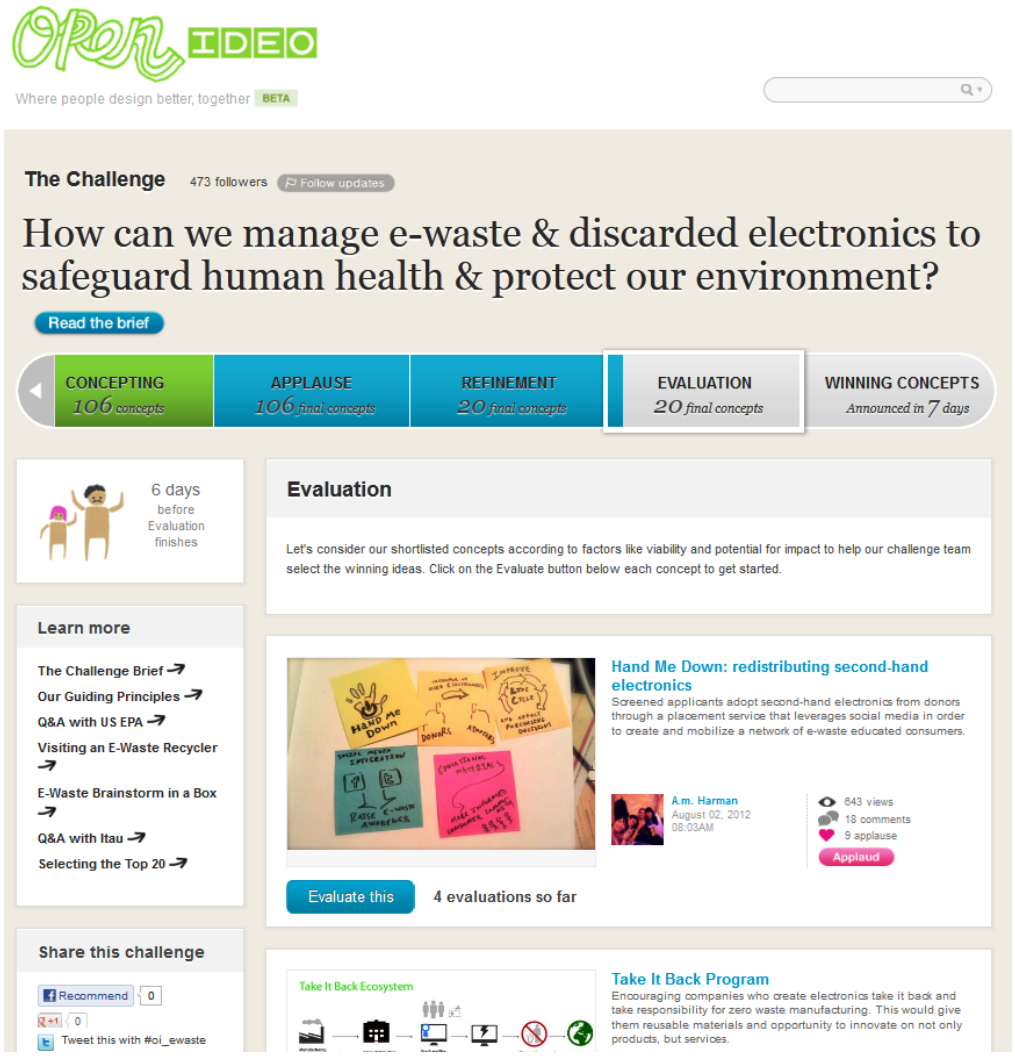


Figure 4. OpenIDEO web site.

The OpenIDEO innovation process has several well-defined phases. Except for the early variations, the structure of the process has remained stable from challenge to challenge, although depending on the challenge some of the phases may be left out. In addition to the public phases, the process contains also implicit phases taking place behind the scenes. The full process, including the implicit phases, is described in table 2.

Phase	**Description**	**Output**
Challenge design	Before launching a new challenge it is designed in collaboration between representatives of the sponsor and employees of OpenIDEO.	Challenge brief
Challenge brief	Challenge brief describes shortly describes the design problem, context and goals and marks the beginning of the challenge. It is usually a combination of a written description and short video featuring a representative of the challenge sponsor	
Inspiration	Inspiration phase consists of two related tasks:	Inspirations

	learning as much as possible about the problem and finding examples of solutions that have worked elsewhere.	
Synthesis meeting	After Inspiration phase the OpenIDEO team, possibly with the help of representatives of the sponsor, hold a synthesis meeting, where they group the gathered inspirations under the emerging themes.	Themes
Concepting	New ideas are generated for solutions to the problem described in challenge brief.	Concepts
Applause	The users are asked to help select the best concepts for further refinement by applauding and commenting on the concepts they like.	Concepts ranked by views, comments and applause
Shortlist selection	The OpenIDEO team first reads through all the concepts and comments and takes note of the applause given for the concepts, and then selects usually 20 concepts for refinement.	20 shortlisted concepts
Refinement	The shortlisted concepts are improved upon in a collaborative fashion.	Refined concepts
Evaluation	Users evaluate all the shortlisted concepts against a specifically developed evaluation criteria.	Evaluated concepts
Winner selection	OpenIDEO team decides the challenge winners in collaboration with the representatives of the sponsor.	Winning concepts, sometimes challenge reports
Winning concepts	The winning concepts are announced on the site.	
Realization	Realization phase is about telling stories and dissemination of information about implementation taking place outside the site. Implementation of developed concepts is outside the scope of the platform	Reports on implementation

Table 2. OpenIDEO innovation process.

On the OpenIDEO site users can submit inspirations, submit concepts, update their own concept, evaluate concepts, and comment and applaud blog posts, inspirations and concepts. Commenting and applauding are possible in every phase and even after the challenge has ended. Other activities are possible only for a limited time, during the corresponding phase.

4.1 Rules

OpenIDEO's approach to managing the innovation process is soft and indirect, and seems to be based on creating shared culture. Instead of direct tasks and explicit rules, the tasks are given indirectly and rules are enforced gently but firmly in the discussions taking place on the site. The approach used to create innovations has been termed collaborative competition: although there are winners, collaboration is encouraged in every turn. Apart from appreciation from the community, the winners do not get any rewards. According to the principles of OpenIDEO, the site is an online platform for creative thinkers who care about social good. It seeks to be inclusive, community centered, collaborative, optimistic, and always-in-beta. Organizations and individuals can sponsor a challenge for social or environmental good. This is the place where translation of stellar skills into real world action

is celebrated. Social impact is the big focus of the collaborative community at OpenIDEO and they're keen on transformation of ideas to impact.

4.2 User experience

Participating to OpenIDEO requires a lot of motivation and effort from the user. In the beginning the site can feel overwhelming, and it is difficult to know where to start. Due to nature of issues discussed on the site it takes lots of effort already in the beginning: the user has to develop an understanding on the issue at hand before making any meaningful contributions, perhaps apart from applauding concepts and other content. In the challenges I participated I was left with the feeling I was only scratching the surface, and to gain real insights I should have worked much, much more. The same thing happened after inspiration phase, when users are supposed to come up with new concepts. The user has to figure out alone how to best use the contributions of other users. These feelings were reflected by some other participants of the site, too: one mentioned it being a bit overwhelming to see so many creative inspirations and concepts posted, and another was sure that everyone is finding it difficult being across all about hundred concepts in that particular challenge. Developing concept, although satisfying, also feels like a lot of work, and some participants even mentioned scheduling freelance work for concepting.

Refining the concept during the applause phase was easier, and here it was possible, at least for me, to leverage the community. I got a couple of comments and then asked for suggestions on how to develop the concept. This resulted in two thorough replies pointing to many related concepts that could be used to improve my idea. Here OpenIDEO reduced the amount of work I had to do: instead of going through all the concepts by myself, I could rely on the community searching the relevant inspirations and concepts for me.

4.3 Feedback

Feedback is immensely important for the functioning of OpenIDEO site. The practices of giving feedback are rarely mentioned explicitly, but the amount of feedback on the site is large. There are two general sources of feedback: the site itself and its official representatives, and the other users. Feedback is given through written comments, blog posts and by displaying the numbers of comments and applause each contribution has gathered. Several flavors of feedback can be identified. A typical comment might look something like this:

"Great concept! I like how it combines the ideas suggested by Tom and Jerry. Have you thought about how this could be used if electricity is not available? Thanks for sharing your thoughts!"

Instant feedback from virtual collaborators and, as one participant on the site mentioned, knowing that someone is looking over their shoulder is an important motivational factor. In my personal experience, just a few positive comments and tips can make a big difference. The comments were thorough and the user had clearly put some thought and effort in constructing them. In response to the comments I ended up spending a couple of hours refining the concept. Without the feedback I definitely would not have worked on the concept on Sunday. In contrast, my other concept did not generate similar feedback, and I never returned to work on it. I also developed a strong habit of checking the numbers of views, comments and applause my concepts had gathered as the first thing to do when visiting the site, and often did it repeatedly during the day. Getting the first applause for a concept was uplifting, and a new comment was always exciting.

5 Results

OpenIDEO case was analyzed using two interpretations of collective intelligence: wisdom of crowds and swarm intelligence. First the Collective intelligence genome framework (Malone et al 2010) was used to classify the phases of the OpenIDEO innovation process (see table 3). This way the most interesting phases for further analysis could be identified.

Phase	**What**		**Who**	**Why**	**How**
Challenge brief	Create	Challenge brief	Hierarchy	Money, Love	Hierarchy
Inspiration	Create	Inspirations	Crowd	Love, Glory	Collection
Synthesis meeting	Decide	Themes	Hierarchy	Money, Love	Hierarchy
Concepting	Create	Concepts	Crowd	Love, Glory	Collection
Applause	Decide	Number of views, comments and applause	Crowd	Love, Glory	Voting
Shortlist selection	Decide	Shortlisted concepts	Hierarchy	Money, Love	Hierarchy
Refinement	Create	Refined concepts, prototypes, visualization	Crowd	Love, Glory	Collaboration
Evaluation	Decide	Evaluation of concepts	Crowd	Love, Glory	Voting
Winning concepts	Decide	Challenge winners	Hierarchy	Money, Love	Hierarchy
Realization	Create	Prototypes, tests, implementation of concepts	Crows	Love, Glory	Collection

Table 3. Collective intelligence genome for OpenIDEO

5.1 Wisdom of crowds at OpenIDEO

The term 'wisdom of crowds' was coined by Surowiecki (2005) and it describes a phenomenon where, under certain conditions, aggregated estimate of a large and diverse group may be more accurate than the estimates of any single individual in the group. The wisdom of crowds is largely a statistical phenomenon and relies on random errors in estimations cancelling each other out (Lorentz et al 2011). Three conditions are necessary for the wisdom of the crowds effect to emerge: diversity, aggregation and independence (Surowiecki 2005). Diversity in groups of people refers to differences in demographic, educational and cultural backgrounds and differences in the ways people frame and solve problems (Hong and Page 2004). Both a simulation (Hong & Page 2004) and experiment on humans (Krause et al 2011) confirm the benefits of diversity on problem solving. Aggregation simply means that there should be a mechanism to integrate the opinions of the individuals. Aggregation of opinions makes randomly distributed errors to cancel each other out, thus resulting in more accurate and consistent evaluations than the individuals could produce alone. Independence refers to keeping the individual decision makers oblivious to decisions that others have made. Human beings are highly social and easily influenced by decisions of others. If the decisions people make are not independent of each other, the mistakes the people make might become correlated, thus ruining the wisdom of crowds effect. Experiment shows that in simple evaluation tasks even minimal social interaction is enough to ruin the effect (Lorentz et al 2011).

The wisdom of crowds effect is about crowd making good decisions. Using the Collective Intelligence Genome for OpenIDEO to identify the phases of the innovation process where the crowd makes decisions reveals two options for further analysis: Applause and Evaluation. Applause phase was selected for further analysis, because 1) the availability of data on crowd's decisions is better, 2) relying on crowd in decision making is more useful when there is more options to select from. 3) In the applause phase the numbers of views, comments and applause are available for each concept in numeric format. In contrast, in the evaluation phase the results of the crowd's decision are only displayed in graphical form, and interpreting the crowd's decision is difficult due to multiple evaluation criteria.

As it is possible for the participants to view, comment and applaud on the concepts after the applause phase is ended, reliable data can only be collected near the time when the OpenIDEO team decides the shortlist. This is why data was collected only on three challenges. For the lack of better knowledge on when the team decides the shortlist, data was collected as close to the change of phases as possible, usually a couple of hours before the announcement of the shortlist and once the next day after the announcement. In the delayed case the activity stream on the site showed that only a few comments had been given after the announcement of the shortlist, so the data was not badly contaminated. The descriptive statistics of three challenges that took place during the observation period are presented in table 4.

	How can we equip young people with the skills, information and opportunities to succeed in the world of work?			**How can we manage e-waste & discarded electronics to safeguard human health & protect our environment?**			**How might we identify and celebrate businesses that innovate for world benefit – and inspire other companies to do the same?**		
Number of concepts	149			106			95		
Number of shortlisted concepts	20			20			20		
Number of views min/median/max	75	235	1448	37	165.5	820	13	91	677
Number of comments min/median/max	0	5	49	0	6	46	0	3	29
Number of applause min/median/max	1	5	43	1	5	36	0	3	23
Views SD	198.34			181.29			153.27		
Comments SD	6.71			7.46			5.17		
Applause SD	6.53			6.47			4.19		

Table 4. Descriptive statistics from three observed challenges on OpenIDEO.

As a qualitative analysis the necessary conditions for the emergence of wisdom of crowds effect were compared to what actually took place on the site. The results of this comparison are presented in table 5.

Criteria	**Analysis**	**Evidence**
Diversity	Yes. Open website, in principle anyone can participate People from different parts of the world participate Possible bias towards design background	No special requirements for joining Names of the participants indicate different cultural backgrounds Many of the most notable users mention design background, and users featured in the blog tend to have something to do with design
Aggregation	Yes. Simple summing of views, comments and applause	Numbers of views, comments and applause are summed and displayed on the site
Independence	No. Users have access to information on the decisions of other participants.	Numbers of views, comments and applause are displayed on the site Lists of inspirations and concepts can be ordered based on these numbers

Table 5. Comparison of conditions required for wisdom of crowds and activities on the OpenIDEO site.

Interpreting the results, the lack of diversity does not appear to be an issue at OpenIDEO. In principle anyone with internet access can participate on the site, although participants might be biased towards design background. Decisions of individuals are aggregated by summing up the number of views, comments and applause. Most interestingly for this analysis, the independence condition is violated. Current numbers of views, comments and applause are displayed on the site next to each concept or inspiration. Furthermore, the concepts and inspirations can be sorted according to their ranking, as measured by numbers of views, comments or applause. This is exactly the kind of social interaction that Lorentz et al (2011) showed to be able to undermine the wisdom of crowds effect.

The quality of the crowd's decisions was analyzed by comparing the decisions made by the crowd to the decisions made by hierarchy. The OpenIDEO site creates a natural experiment for such a comparison. First, the crowd makes its assessment by viewing, commenting and applauding the concepts in Applause phase. After that the OpenIDEO team, with help of experts, decides which concepts to include on the Shortlist. For the purposes of analysis, the team's decision is assumed to be "correct" and the usefulness of the crowd is estimated by looking at how closely their decisions match with the decisions the experts. The figure 5 presents the comparison of decisions of the crowd and the team. Horizontal axis displays the ranking of concepts by the crowd and vertical axis shows the number of concepts the team shortlisted in the ranked set.

How can we equip young people with the skills, information and opportunities to succeed in the world of work?	How can we manage e-waste & discarded electronics to safeguard human health & protect our environment?	How might we identify and celebrate businesses that innovate for world benefit – and inspire other companies to do the same?

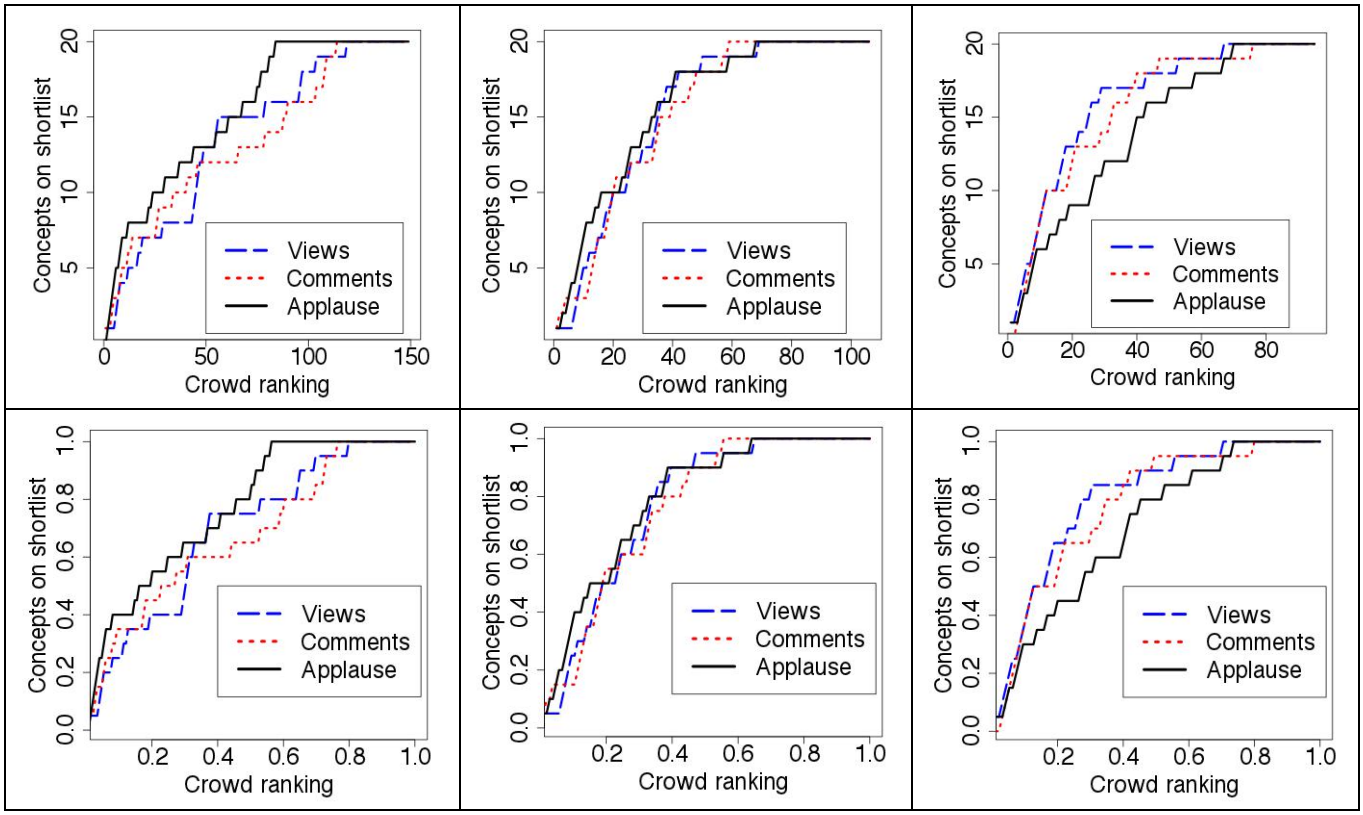


Figure 5. Wisdom of crowds compared to expert decision. In the top row the numbers of are absolute values and in the bottom row they are scaled to range 0-1.

Rankings of concepts based on the numbers of views, comments and applause follow each other closely. The question is, how many of the best concepts, as decided by the crowd, would experts have to consider to capture the same concepts on the shortlist they now do by considering all the concepts? The answer seems to be around 70 %, if concepts are ranked by the number of applause. If the experts were satisfied by capturing 80 % of the shortlisted concepts they could ignore the worst half of the concepts. The crowd clearly cannot recognize the best concepts, as decided by the experts, but it can filter out the worst.

5.2 Swarm intelligence at OpenIDEO

Social insects show interesting group behavior, where relatively simple agents' interactions result in the emergence of much more complex problem solving capabilities, such as regulating foraging, selecting nest sites, and building nests (Gordon et al 2008, Visscher 2007, Turner 2011). This collective, largely self-organized behavior is called swarm intelligence (Bonabeau and Meyer 2001). Schut (2010) gives a framework for evaluating these kinds of collective intelligence systems. There are three enabling and five defining properties of these systems. If enabling properties are observed, the system might be a collective intelligence system. If also defining properties are there, then system can be called a collective intelligence one. The framework is presented in Table 6. These criteria were used to determine the existence of phenomena similar to swarm intelligence at OpenIDEO site.

Property	Definition	OpenIDEO	Evidence
Enabling properties			
Adaptivity	Changing one's structure to fit the environment: individuals, rules or the system.	Yes	Individuals: People can change their behavior, self-selection to participate Rules: Rules change from phase to phase

			System: The system does different things in different phases and adapts to different challenges
Interaction	Individual behaviors and interaction between individuals	Yes	Reading and writing comments, submitting inspirations and concepts, applauding
Rules	Implications between inputs and outputs	Yes	Explicit and implicit cultural rules.
Defining properties			
Global-local	Individuals in the system vs. the system as a whole	Yes	Users creating concepts – network of related concepts Users viewing, commenting and applauding – ordered lists Users creating concepts, commenting and responding to comments – feedback loops
Emergence	Coherent and novel emergents at the macro-level arising dynamically from the interactions between the parts at the micro-level (De Wolf and Holvoet 2005).	Yes	Network of related concepts Ordered lists Feedback loops
Randomness	Elements of randomness in the system	Yes	Fresh & surprising filter shuffles the content of the site randomly.
Redundancy	The same information represented in many places	Yes	Shared cultural rules
Robustness	Even if some parts fail, the system stays functional	Yes	Performance does not depend on single user

Table 6. Comparison of OpenIDEO and criteria for collective intelligence.

OpenIDEO satisfies all the enabling criteria of collective intelligence systems. Although not very explicit, there exist a set of rules the OpenIDEO community is supposed to follow. Adaptivity can be found in the behavior of participating individuals, rules of interaction and at the system level. People, the "agents" of the system, can also adapt to different situations. The rules that the participants are supposed to follow change from one challenge phase to another. For example, the participants are not supposed to post ideas during the Inspiration phase, but in the Concepting phase submitting ideas is expected. Similarly, the system as a whole is able to produce different outputs in different phases (e.g. concepts in concepting phase and evaluations in evaluation phase) and deal with varying challenge topics. Interaction between the participants happens by submitting concepts, inspirations and comments, by reading what others have posted and by applauding.

Out of the defining properties, the satisfaction of randomness, redundancy and robustness criteria is easily observed. In addition to randomness inherent in human behavior, the site displays the concepts and inspirations in randomized order by default. The cultural rules and the tasks are shared between many individuals participating to activities on the site. System is thus robust against such failures as some of the participants leaving to the site. The final two criteria, global-local and emergence were more challenging to identigy and they are discussed next in more detail.

Three examples of phenomena that could be considered showing distinction between global and local levels and some level of emergence could be identified: rankings of inspirations and concepts, Collaboration map and feedback loops. Ranking of concepts and inspirations is described in the analysis of wisdom of crowds. Ranking is a borderline example of emergence

at best: the aggregation of decisions is just a simple sum of decisions of individuals. It is left for the reader to decide if this actually counts as emergence. Collaboration map (see figure 6) is a visualization tool on the OpenIDEO site, the content of which emerges as a side product of users generating content. When users create inspirations and concepts, they have an option to link it with already existing content within the challenge using the "Build on this" feature. Linked concepts and inspirations are shown next to the post and can be followed to the original post. The end result is a network of concepts and inspirations displaying how the concepts and inspirations are related to each other, as depicted in figure 6.

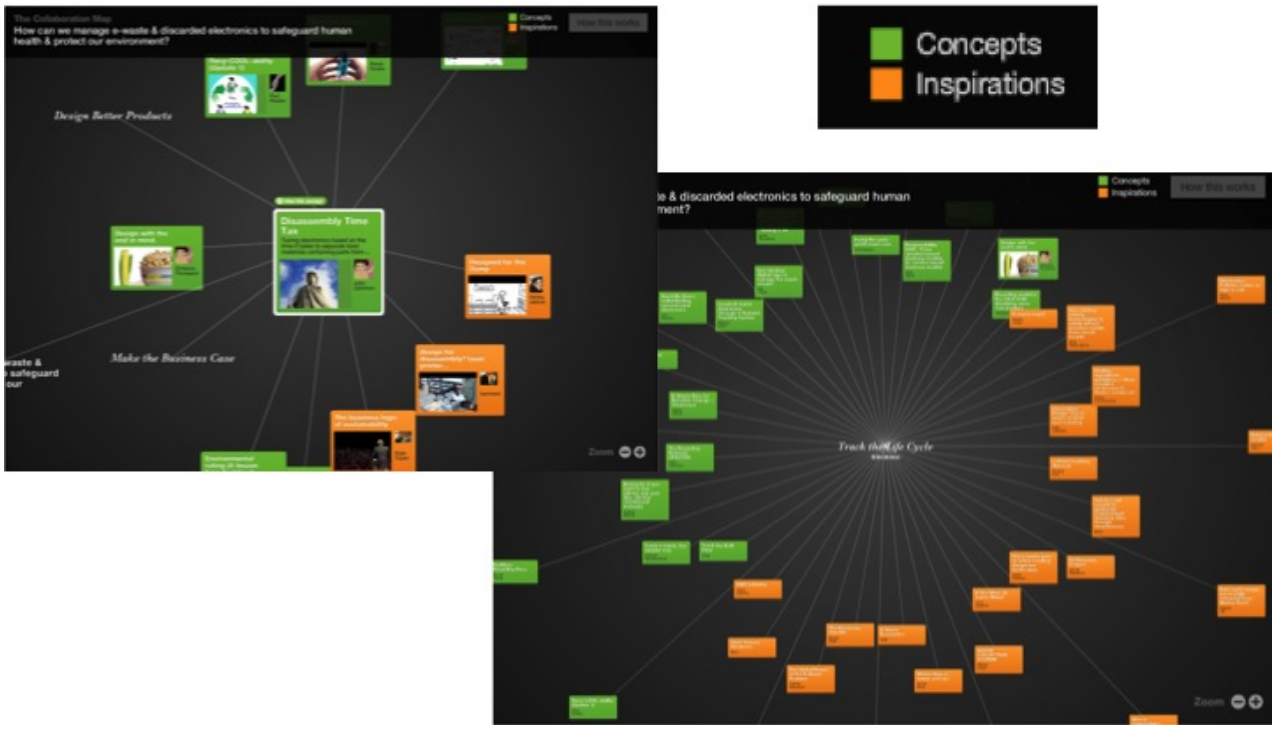


Figure 6. Collaboration maps on OpenIDEO

As mentioned in case description, feedback plays a major role at OpenIDEO. In addition to motivating users, feedback loops potentially help direct the attention of the crowd towards the more promising concepts, but it could just be amplification of random fluctuations. In any case, the crowd would focus its effort towards a few concepts, which might be beneficial. A diagram depicting the structure of feedback loops is presented in figure 7. The diagram is based on the case description and experiences of the researcher.

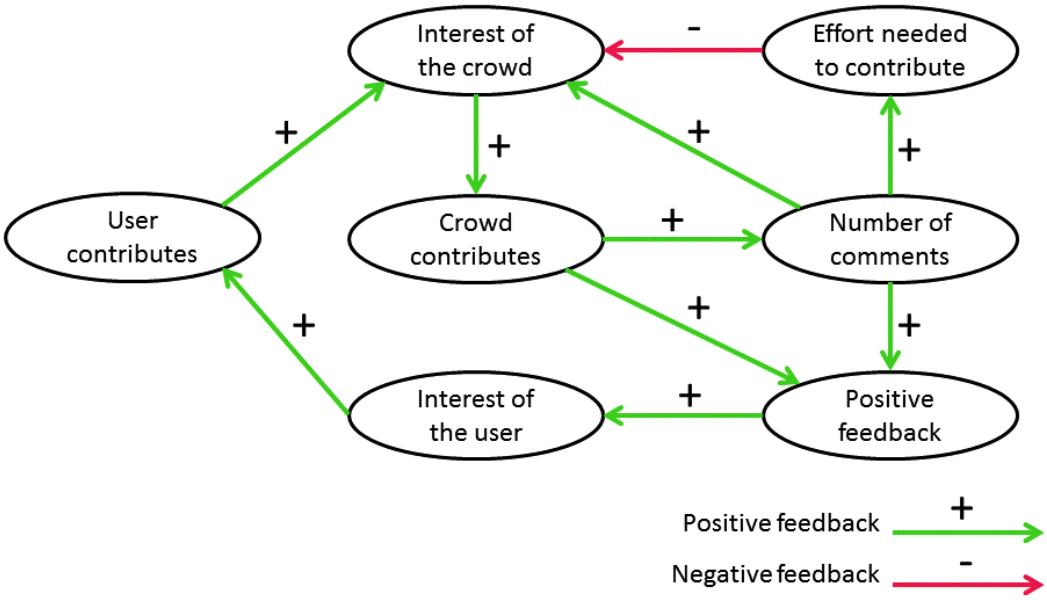


Figure 7. Feedback loops at OpenIDEO.

These feedback loops are created as a side effect of activities taking place on the site. A user makes a contribution to the website, for example by submitting a concept. The crowd notices the new concept and contributes to it by commenting and applauding, which increases the number of comments to that particular concept. Comments and applause from the crowd increase the interest of the user to contribute more to that concept, for example by replying to comments or by making updates to the concept. At the same time the rising number of comments increases the likelihood that the concept is noticed by the crowd. This increases again the interest of the crowd. On the other hand, the increasing number of comments makes it more difficult for the new users to figure out what is going on with the concept. Increasing effort needed to contribute decreases the interest of the crowd, creating a balancing negative feedback loop.

6 Discussion

One case was analyzed using two interpretations of collective intelligence: wisdom of crowds and swarm intelligence. Analysis of wisdom of crowds revealed that the crowd is not accurate enough to identify the best ideas, but could still be used to filter out the very worst. Relative inaccuracy may be due to violation of independence condition by displaying the numbers of views, comments and applause on the site. Even such minimal interaction has been shown to be able to undermine the wisdom of crowds (Lorenz et al. 2011). Trying to find phenomena similar to swarm intelligence at OpenIDEO comes down to identifying emergence between local and global levels of the system. Other features of collective intelligence systems were easily observed. Three possible examples of emergence were found: rankings of concepts by the crowd, Collaboration Map, and feedback loops. Still, it does not seem like the emergence would play a crucial role in the functioning of OpenIDEO. None of the examples of emergence were as prominent as in other sites generally considered to demonstrate collective intelligence. In social networks, such as Twitter and Delicious, users follow people they find interesting, and the emergent property is the network's gradual adaptation to the tastes of the user (Zhou et al 2011). On the image board 4chan a very strong negative feedback loop is in the play, and only the most active discussion threads can survive. The inactive threads are

deleted when new posts replace them, often within minutes. As a result, only the interesting threads can stay alive. This strong evolutionary selection has arguably contributed to creation of many Internet memes in recent years. (Bernstein et al 2011)

Comparing the results from two analyses reveals a possible contradiction between wisdom of crowds and swarm intelligence at OpenIDEO. The lack of independence might undermine wisdom of crowds effect, but at the same time the interdependence of decisions facilitates the direction of crowd's attention, and is important feedback and encouragement for participants. In principle the two aspects would not have to contradict. One of the most remarkable and well-studied examples of swarm intelligence on insects is nest-site selection of honey bees. While the most of the swarm rest on a tree branch, a few hundred scouts fly around searching for suitable nest sites. When a scout finds a potential nest site it returns to the swarm to announce its finding by a waggle dance. Other bees following the dance then fly to investigate the advertised site. If they find it acceptable they also announce the site by a dance. The number of dance rounds a bee performs depends on how much the bee likes the site. When a quorum is reached at one of the competing sites, the scouts stimulate the swarm to take off and fly to the selected site. The experiments have shown that most of the time the swarm is able to select the best available nest site, even if most scouts see only one of the options (Seeley et al 2006). According to simulation models the reliability of the decision making process stems from the particular interplay of independence and interdependence between the bees (List et al 2009). The bees assess the quality of the different nest sites independently of evaluations of other bees, but which sites are given attention is interdependent on advertisement of other bees. Interdependence leads to rapid convergence of bees' dances to a consensus decision and independence in evaluations ensures the convergence happens to the best nest site instead of a random site that initially happened to gain support. Combining interdependence and independence in right way is crucial for the honey bees to achieve accurate and reliable decision making. Both in nest site selection of honey bees and at OpenIDEO multiple alternatives are evaluated and feedback loops increase attention given to popular items, but apparently only honey bees manage to strike the appropriate balance between independence and interdependence. Another reason for poorer performance of humans could be that the concept evaluation task lacks shared criteria. Each user assesses the quality of concepts according to their own, unknown criteria, which might differ from the criteria used by the experts making the decision. In contrast, the requirements for the nest-site are shared among all the honey bees taking part to decision making process, and the requirements have probably been stable for millions of years.

The practical implications for designers of crowdsourcing platforms are twofold. 1) When designing crowdsourcing platforms, the tradeoff between accuracy of evaluations and feedback to participants should be taken into account. Displaying information about the decisions of other users may help create motivational feedback loops, but can also decrease the accuracy the crowd. Visibility of decision of users is potentially a useful parameter for tuning the behavior of the crowdsourcing system. 2) At least when the independence condition is violated, the evaluations of the crowd alone are not accurate enough for decision making. While the crowd can probably be used to filter out the very worst ideas, additional mechanisms are needed to select ideas for further development.

6.1 Limitations and further research

This paper presented the preliminary results from a pilot study. The main limitation of the study is that only one case was analyzed. Therefore the results are not necessarily representative of crowdsourcing sites in general. The validity of the results is also questionable, as they have not yet been confirmed by thorough triangulation. Both of these issues will be addressed in the future. First, the developed research approach will be used to collect and analyze data from additional cases. After that, all the results from the multiple-case study will be confirmed more rigorously than was possible in this initial analysis.

7 Conclusions

This paper presented the results of a pilot study aiming to find collective intelligence at crowdsourcing sites. Using netnography as an approach, crowdsourcing site OpenIDEO was analyzed using wisdom of crowds and swarm intelligence as interpretations of collective intelligence. The analysis revealed a contradiction between the interpretations: the features that might support the emergence of swarm intelligence at OpenIDEO can undermine the wisdom of crowds effect. Still, the crowd is accurate enough to support decision making by being capable of filtering out the very worst ideas. Designers of crowdsourcing sites should also take into account the tradeoff between the accuracy of the crowd and feedback. Crowdsourcing may benefit both from swarm intelligence and wisdom of the crowds, but trying to achieve both at the same time requires striking a good balance.

References

Afuah, A. and Tucci, C. (2012) Crowdsourcing as a solution to distant search, Academy of Management Review, 37, 355-375.

Agar, M. (2004) We have met the other and we're all nonlinear: Ethnography as a nonlinear dynamic system, Complexity, 10, 16-24.

Bernstein, M., Monroy-Hernandez, A., Harry, D., Andre, P., Panovich, K., and Vargas, G. (2011) 4chan and /b/: An analysis of anonymity and ephemerality in a large online community. ICWSM: International Conference on Weblogs and Social Media 2011

Bonabeau, E. (1999) Swarm Intelligence: From Natural to Artificial Systems, Oxford University Press, 305 pages.

Bonabeau, E. (2009) "Decisions 2.0: The Power of Collective Intelligence," MIT Sloan Management Review, 50, 2: 45-52.

Bonabeau, E. and Meyer, C. (2001) "Swarm Intelligence: A Whole New Way to Think About Business," Harvard Business Review, 79, 5: 106-114.

Brabham, D. (2008) Crowdsourcing as a model for problem solving: An introduction and cases. Convergence, 14, 75-90.

Brabham, D. (2010) Moving the Crowd at Threadless, Information, Communication and Society, 13, 1122-1145.

Cooper, R. (1990) “Stage-Gate Systems: A New Tool for Managing New Products”, Business Horizons, 33, 44-54.

Cooper, R., Edgett, S. ad Kleinschmidt, E. (2002) “Optimizing the State-Gate Process: What Best-practice Companies Do – I”, Research Technology Management, 45, 21-27.

Damper, R. I. (2000) “Emergence and Levels of Abstraction,” International Journal of Systems Science, 31, 811-818.

Dedoose (2013) Dedoose. URL: http://www.dedoose.com/. Accessed 18.2.2013.

Desouza, K., Dombrowski, C., Awazu, Y., Baloh, P., Papagari, J., Jha S. and Kim, J. (2009) “Crafting organizational innovation processes”, Innovation: Management, Policy & Practice, 11, 6-33.

De Wolf, T. and Holvoet, T. (2005) Emergence versus self-organization: different concepts but promising when combined. in: S. Brueckner, G.D.M. Serugendo, A. Karageorgos, R. Nagpal (Eds.), Proceedings of the Workshop on Engineering Self Organising Applications, vol. 3464 of Lecture Notes in Computer Science, Springer, 2005, pp. 1–15

Doan, A., Ramakhrisnan, R. and Halevy, A. (2011) Crowdsourcing Systems on the World-wide Web, Communications of the ACM 54, 86-96.

Di Gangi, P. and Wasko, M. (2009) Steal my idea! Organizational adoption of user innovations from a user innovation community: A case study of Dell IdeaStorm, Decision Support Systems, 48, 303-312

Eisenhardt, K. (1989) Building theories from case study research, The Academy of Management Review, 14, 532-550.

Evernote (2013) Evernote. URL: http://evernote.com/evernote/. Accessed 18.2.2013.

Evernote (2013b) Evernote Web Clipper. URL: http://evernote.com/webclipper/. Accessed 18.2.2013

Gordon, D., Holmes, S. and Nacu, S. (2008) Short-term regulation of foraging in harvester ants. Behavioral Ecology, 19, 217-222.

Güney, S. (2010) New significance for an old method: CAS theory and ethnography, Communication Methods and Measures, 4, 273-289.

Heylighen, F. (2013) Self-organization in communicating groups: The emergence of coordination, shared references and collective intelligence. Understanding Complex Systems, 117-149.

Hippel, E. (2005) Democratizing Innovation, The MIT Press.

Hong, L. and Page, S. (2004) “Groups of Diverse Problem-solvers Can Outperform Groups of High-ability Problem-solvers,” PNAS, 101, 16385-16389.

Howe, J. (2008) Crowdsourcing: Why the Power of the Crowd is Driving the Future of Business, Random House Books, 312 pages.

IDEO (2009) Human Centered Design Toolkit 2nd Edition, IDEO. http://www.ideo.com/work/item/human-centered-design-toolkit/ Accessed 5 August 2010.

Jeppesen, L. and Lakhani, K. (2010) Marginality and problem-solving effectiveness in broadcast search, Organization Science, 21, 1016-1033.

Kauffman, S. (1993) The Origins of Order: Self-organization and selection in evolution, Oxford University Press, New York.

Kozinets, R. (2002) The Field behind the screen: Using netnography for marketing research in online communities, Journal of Marketing Research, 39.

Krause, S., James, R., Faria, J. J., Ruxton, G. D. and Krause, J. (2011) "Swarm Intelligence in Humans: Diversity Can Trump Ability," Animal Behaviour, 81, 941-948.

Kumar, V. (2009) "A Process for Practicing Design Innovation", Journal of Business Strategy. 30, 91-100.

Levy, P. (1997) Collective Intelligence: Mankind's Emerging World in Cyberspace, Basic Books, 277 pages.

List, C., Elsholtz, C. and Seeley, D. (2009) Independence and interdependence in collective decision making: an agent-based model of nest-site choice by honeybee swarms. Philosophical Transactions of the Royal Society B. 364, 755-762.

Lorenz, J., Rauhut, H., Schweitzer, F. and Helbing, D. (2011) "How Social Influence Can Undermine the Wisdom of Crowd Effect," PNAS, 108, 9020-9025.

Malone, T. W., Laubacher, R. and Dellarocas, C. (2010) "The Collective Intelligence Genome," MIT Sloan Management Review, 51, 3: 21-31.

McFadzean, E., O'Loughlin, A. and Shaw, E. (2005) "Corporate entrepreneurship and innovation part 1: the missing link", European Journal of Innovation Management, 8, 350-372.

Miles, M. and Huberman, M. (1994) Qualitative Data Analysis: An Expanded Sourcebook (2nd Edition), SAGE Publications, 352 pages.

Ottino, J. M. (2004) "Engineering Complex systems," Nature, 427, 339.

Pentland, A. (2007) "On the Collective Nature of Human Intelligence," Adaptive behavior, 15, 2: 189-198.

Salminen, J. (2012) Collective intelligence in humans: A literature review, Collective Intelligence 2012, Boston, USA. 18.-20.4.2012

Seeley, T., Visscher, P., Passino, K. (2006) Group decision making in honey bee swarms. American Scientist, 94, 220-229.

Schut, M. C. (2010) "On Model Design for Simulation of Collective Intelligence," Information Sciences, 180, 132-155.

Shaw, E., O'Loughlin, A. and McFazdean, E. (2005) "Corporate entrepreneurship and innovation part 2: a role- and process-based approach", European Journal of Innovation Management, 8, 393-408.

Spurlock, M. (2004) SuperSize Me.

Sullivan, E. (2010) A Group effort: More companies are turning to the wisdom of the crowd to find ways to innovate. *Marketing News,* February 28, 22-28.

Surowiecki, J. (2005) Wisdom of Crowds, Anchor Books, 306 pages.

Terwiesch, C. and Xu, Y. (2008) Innovation contests, open innovation, and multi-agent problem-solving, Management Science, 54, 1529-1543.

Tidd, J., Bessant, J. and Pavitt, K. (2005) Managing innovation: Integrating Technological, Market and Organizational Change. John Wiley & Sons.

Turner, J. (2011) Termites as models of swarm cognition. Swarm Intelligence. 5,19-43.

Ulrich, K. (2011) Design: Creation of Artifacts in Society. University of Pennsylvania, 184 pages.

Veryzer, R. (1998) "Discontinuous Innovation and the New Product Development Process", Journal of Product Innovation Management, 15, 304-321.

Visscher, K. (2007) Group decision making in nest-site selection among social insects. Annual Review of Entomology, 52, 255-275.

Woolley, A. W., Chabris, C. F., Pentland, A., Hashmi, N. and Malone, T. (2010), "Evidence for a Collective Intelligence Factor in the Performance of Human Groups," Science, 330, 686-688.

Yin, R. (2008) Case Study Research: Design and Methods, SAGE Publications, 240 pages.

Zhou T, Medo M, Cimini G, Zhang Z-K, Zhang Y-C (2011) Emergence of Scale-Free Leadership Structure in Social Recommender Systems. PLoS ONE 6(7): e20648.

Appendix 1. Coding scheme used to code the data used in the analyses.

Code	Times applied	Definition	Example
Collective intelligence	9	References to collective intelligence	DISCARDED
Human capabilities	5	The factors affecting a person's ability to interact with other human beings	DISCARDED
Input	170	Inputs to the system. All the information the agents have access to.	DISCARDED
Output	61	Outputs of the system. Descriptions of results.	The results of this challenge will be presented at the Digital Agenda Assembly in Brussels on June 21st and 22nd, and the European Commission is committed to implementing some of the top concepts thereafter.
Agents	65	Descriptions of users and their characteristics.	My background is in commercial real estate development so the idea of rethinking and repurposing space for community vibrancy really resonates with me.
Distributed memory	4	Information storage shared between the agents.	DISCARDED
Feedback	1112	Feedback to users from the system or from each other. Descriptions of feedback functionality.	The amount of feedback and collaboration you get is overwhelming. From all over the world, in different time zones people have commented on my concepts, and everyone brings a new view to the table – from their part of the world and their background.
Rules	314	Explicit and implicit rules of interaction. Descriptions of what is considered correct behavior.	Stay Optimistic, Positive and Respectful
Adaptivity	0	Changing one's structure to fit the environment: individuals, rules or the system.	DISCARDED
Interaction		Interactions and activities taken by the users. Descriptions of what users actually do.	We started out by talking with everybody we could – architects, investors, the planning commission, local community members, and others – to get a sense of what was appealing to them, what they saw as roadblocks to success, and what they needed from us in order to get on board with our efforts.
Randomness	6	Elements of randomness in the system	DISCARDED
Emergence	0	Rise of system level properties that are not present in its components	DISCARDED
Robustness	0	Even if some parts fail, the system stays functional	DISCARDED
Redundancy	0	The same information represented in many places	DISCARDED
Crowdsourcing	7	Outsourcing the tasks traditionally performed by an organization to an undefined crowd, usually through an open call posted to Internet.	DISCARDED
CS process	83	Descriptions of how interaction	And stay tuned: in the next few weeks

		between the site and users proceeds. Different phases of activity.	we'll be launching a new challenge phase called Realisation, which will enable the students of 100K Cheeks to share their implementation progress with the entire OpenIDEO community.
Tasks	503	Descriptions of tasks the site asks users to perform, either explicitly or implicitly.	We'd love you to share any examples you've seen of new and inspiring ways to develop soft or hard skills that are happening beyond the classroom.
Community	289	Descriptions of community of users related to the site.	The second thing OpenIDEO offered me was an opportunity to be part of an open source community. I am fascinated by the open source concept and by how people love to collaborate and share passions online.
Platform	98	Descriptions of web site and user interface and it's functionality.	Collaboration map. This somehow tracks how the concepts are build: what are the parts. Might be possible to evaluate whether it is more than the sum of the parts...
Motivation	48	Factors that motivate or are assumed to motivate participation. Descriptions of why do they participate.	One week to go guys – get your ideas posted to help us re-imagine the future of food. You might even win the chance to join us in sunny Queensland at the IDEAS 2011 Festival. And check out IDEO's Paul Bennett talking about the challenge and his vinyl record obsession.
Gamification	33	Game-like elements on the site or user interface	Translators can be rewarded with OpenIDEO Badges.
Learning	102	References to learning new skills or knowledge.	And if you're thinking about setting up a social enterprise or are in your early stages of one – catch some tips on Visualising Your Business Model from OpenIDEO's Tom Hulme.
Business model	49	Descriptions or references to ways how the site makes money.	There is a business model: OpenIDEO facilitates innovation process, the sponsor pays the costs and community does the work
Marketing	272	Descriptions of marketing efforts and references to elements on the site that support marketing.	On OpenIDEO we celebrate that our community members can join our challenges in whatever way works best for them: from adding content and comments, to reading posts and getting inspired.
User experience	183	Personal experiences from using the site.	Found the missions on the left panel of Inspirations site. Still don't really understand them. How do they differ from Themes?
Success factors	2	Descriptions of best practices and features that are considered to contribute to success.	DISCARDED
Innovation process	86	Descriptions of underlying innovation process.	Process description with the current phase and numerical measurements is clear, bright and colorful and immediately noticeable on the top of the page. Gives a lot of information to the user, fast and easy.

Problem definition	755	References to problem definition phase of innovation process.	How might we, for instance, help start-ups access funding across stages of development? Or help them find resources when working across countries? Or foster a culture of experimentation?
Idea generation	567	References to idea generation phase of innovation process.	It all starts with a good idea. After all, a good idea attracts a lot of supporters and is easier to make happen. Finding that good idea, however, is the challenging part!
Idea evaluation	273	References to idea evaluation phase of innovation process.	The evaluation phase allowed everyone to have their say on which concept should go forwards to become the OpenIDEO logo. Set criteria were used to make this judgement; things like fit with our community principles, and just how much they loved it.
Development	532	References to development phase of innovation process.	As I mentioned, getting the Grand Rapids community stakeholders onboard has been hugely important. Also, being open to prototyping – and potentially failing in the process – has been big for us.
Implementation	152	References to implementation phase of innovation process.	Comprised of refurbished shipping containers, Intermodal will house local food producers, artists, or other merchants to showcase their products and connect locally with consumers.
Wisdom of crowds	0	Phenomenon where, under certain conditions, aggregated estimate of a large and diverse group may be more accurate than the estimates of any single individual in the group.	DISCARDED
Diversity	8	Descriptions of diversity of users and impacts of it.	From all over the world, in different time zones people have commented on my concepts, and everyone brings a new view to the table – from their part of the world and their background.
Decision making	50	References to the process of making decisions, both individually and in groups	Eventually a selection of concepts are chosen as winners.
Bias	24	Evidence of the tendency of individuals and groups to make systematical errors in decision making situations	I noticed I decide whether to open a concept from a list view at least partly based on the applause it has already gathered.
Aggregation	1	The combination of individual pieces of information to form a synthesis or collective estimation	DISCARDED
Independence	11	The decision of an individual is not influenced by the decisions of other individuals	DISCARDED