Chapter 3: Communication

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Design processes in collective innovation communities: A study of communication

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Despite the growing importance of collective intelligence, little is known about the design processes that lead to effective social innovation. A study of communication describes design process visualisations from three sites for collective innovation, in terms of their ability to structure and present design tasks and to situate design communication within the context of these tasks. Empirical data on design communication provide the basis for protocol studies on three project forums from a website for social product design. Mechanisms were identified which describe ways collective innovation produces successful solutions shaped by community input: i) structuring design as a hybrid process, which combines online communities for design development and appointed experts or inbuilt system features for technical and organizational aspects; ii) providing distinct roles for users to assume and manageable tasks for them to perform; iii) clarifying task requirements, and iv) supporting social communication to strengthen the impact of ideas, with particular focus on the social processes of ideation and evaluation. A framework is defined for structuring and understanding the management of collective innovation processes and the roles of participants. These findings have significant practical and theoretical implications for social innovation.

Keywords: collective design; collaborative design; collective intelligence; design communication; social innovation; online community

1. Characterising Collective Design

Collective design is an emerging application of collective intelligence that integrates online communities into the innovation process. It has been gaining attention in the design community as a growing number of online platforms implement new ways of enabling motivated individuals to solve complex problems collectively.

When individuals from a diversity of backgrounds become involved in online innovation, their collective focus can be used to address complex problems that benefit from multiple perspectives. This phenomenon, arising from the collaboration and competition of many, connected individuals, is known as *collective intelligence* (Levy 1997).

Collective design is based on collective intelligence and involves an open, online community (or crowd) contributing to the design process. 'Design' is used here in a discipline independent way, as presented, for example, by proponents of "Design Thinking" (Brown, 2009): a way of incorporating design thinking into a business model that focuses on user centric, creative problem-solving. Design thinking also refers to the study of design cognition in order to better understand design processes employed by individuals and groups, for example, the studies reported in Cross, Christiaans, and Dorst (1996).

Collective design is a type of group intelligence, characterised by high levels of collaboration, as opposed to collected design, which aggregates design solutions (Maher, Paulini and Murty 2010). An example of collective design is the Quirky.com website, which encourages open design discussion among the crowd to produce a solution. An example of collected design is the website Designcrowd.com where over a hundred individual solutions are produced by the crowd and the 'best' one is selected for implementation.

The behaviours inherent in group communication have been investigated widely in collaborative design research (for example Maher et al. 2006). Findings from studies based on team design only partially reflect online collective design since design *communities* are of a fundamentally different composition to design *teams*. Five key areas where they differ are described here:

1. Collective design is an emergent property of some online design communities while team design groups are generally intentionally structured and maintained through selection and reselection rather than voluntary participation.
2. Collective design is inclusive and encourages people across a vast range of backgrounds and experiences to participate and contribute. Conversely, team design is exclusive, being only available to selected individuals.
3. Community members are not committed to remain for any fixed period of time, unlike team members who may remain in a prescribed role (not necessarily the same one) for the duration of the project.
4. Community members find their role (bottom-up) by selecting tasks within the project based on what they feel they can contribute, while team members roles are defined (top-down) by management and matched to the expertise they bring to the project.
5. While it is common for team members to meet together physically at designated times, this is not usual practice with collective communities (unless they choose to

meet for social reasons). Generally, members have little or no face-to-face interaction and come and go freely, often contributing at different times.

Participatory design, developed in the 1970s, is a recognised mode of professional design practice where stakeholders and communities are involved in the design process. Participatory design enables the inclusion of stakeholders who are not necessarily designers - and while expertise, specialized training and experiences are an important resource, they are not a source of unchallenged power and authority (Schuler and Namioka, 1993). Collective design communities allow the inclusive nature of participatory design to be extended to almost unlimited levels by providing an open platform and supportive tools for representation, communication and motivation (Maher, Paulini and Murty 2010). Schuler and Namioka (1993) outline three elements to participatory design, which can also be applied to collective design. The points were originally intended for the design of computer applications and have been paraphrased here to apply to general design, followed by a brief explanation:

1. *The designed artifact needs to be better suited to those who use them.* Unlike participatory design, collective design is not always comprised of end users; however, if the crowd is sufficiently diverse, a wide range of insights into the problem can be offered, which can lead to a better end design (Brown and Wyatt 2010).
2. *Work is a social activity involving the interaction of many groups of people.* In collective intelligence, work is conducted over a social network. Although individuals often never meet in person, the relationships formed online are of a highly social nature, reflected in their communication (see 4.6).
3. *Barriers between technical specialists and people using the artifacts need to be broken down in order to build effective communication during the design process*. Collective design is inherently meritocratic and members are encouraged to contribute in whatever area they feel they can make a difference. Communication reveals that members will often support their design commentary with examples of their experience, possibly to gain credibility and trust (see 4.6). Some sites (ie. TopCoder.com; see Paulini, Murty and Maher, 2011) provide rankings and ways to compare the abilities of members: this is developed during the period of their involvement with the site.

The online collective design systems studied here attract a wide user base, beyond targeted stakeholders, to allow any motivated individual to contribute to the design process.

Collective design platforms can be distinguished by the extent to which and manner by which individual contributions are included in the design process and the degree of collaboration among members of the collective. As with collaborative design, members of group intelligence do not participate equally or even necessarily collaboratively (Cuff 1991). Not all collective intelligence platforms encourage collaboration: for example, Innocentive.com broadcasts a challenge publicly and encourages people to submit solutions independently. Figure 1 shows a continuum ranging from *Collected Design*, where each member contributes a solution, to *Collective Design* where members collaborate to produce a solution that is a synthesis of many contributions. This paper focuses on collective design, which involves high degrees of collaboration.

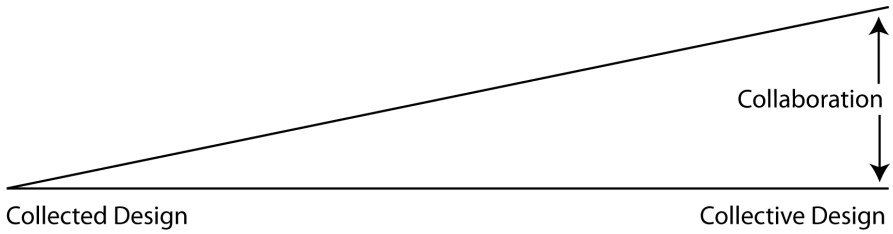

Figure 1. The Presence of Collaboration: collected design to collective design (adapted from Maher, Paulini and Murty 2010)

Shea and Guzzo (1987) offer three factors necessary for the effectiveness of collaboration, which also apply to collective design:

1. *task interdependence*: the degree to which members work together:
2. *outcome interdependence*: the rewarding of group performance:
3. *potency*: individual belief in the group's effectiveness:

These three factors become even more important when the project is scaled up to collective design, as it can be challenging to encourage members from a variety of backgrounds who participate for their own personal reasons to work together effectively. All three factors above can be addressed by the design of the site or system. For example, providing adequate tools and applications to support communication and the sharing of design representations can facilitate task interdependence. Incorporating appropriate incentive structures into the system can facilitate outcome interdependence. Potency can be achieved by many methods, including the showcasing of previously successful projects; the smooth functioning and visual aesthetics of the system, visual indicators of progress; user histories; and allowing social connections to be formed.

Collective design distinguishes itself from *collaborative design* by including contributions from any motivated individuals rather than only from a pre-selected team of individuals. This is possible due to advances in social technology and the increasing interest in and ubiquity of social networking. Maher et al (2010) present a conceptual space, shown in Figure 2, to model how technology has supported and enabled the transition from individual design, to team design, to collective design along three dimensions: representation, communication, and motivation. The representation dimension captures the ways in which computing technology has facilitated increasingly complex design solutions by providing digital models for analysis, visualization, and simulation. The communication dimension is crucial to understanding collaborative design and more recently for enabling collective design. The motivation dimension characterizes a shift in emphasis from collaborative to collective design in which the technology platform provides incentive structures that motivate people to participate in design processes. This paper focuses on developing a better understanding of communication in collective design and the ways that communication has been focused in a structured design process.

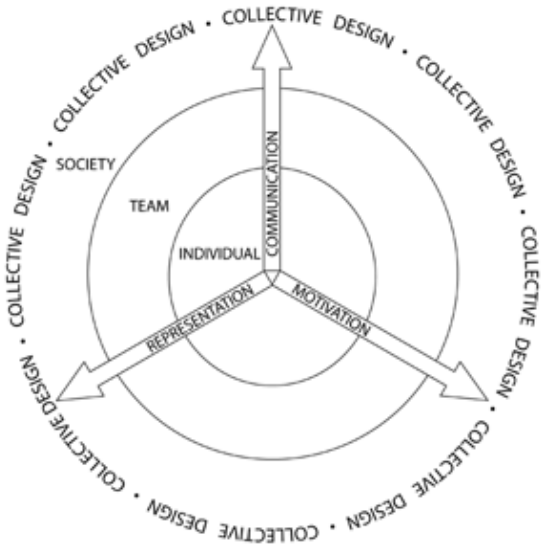

Figure 2. Conceptual space for collective design from Maher et al (2010).

The central concept behind collective design is that knowledge relevant to a project can be dispersed among, and collected from, a multitude of physically distributed individuals. There are many successful examples of online design sites leveraging the diversity within a community by crowdsourcing design problems in a way that involves members independently developing solutions. This paper looks beyond online platforms that aggregate results to focus on three collective design environments with a large degree of collaboration in the community and innovative practice. These three case studies provide the data for an analysis of communication in collective design. More specifically, this paper: (i) outlines the ways collective design environments integrate online communities into a collective design process; and (ii) explores how such communities contribute to solving real world design problems through a study of communication content.

2. Examples of Collective Design

Collective design as a practice is still developing and as such there are a limited number of successful online communities for social innovation. The three collective design platforms selected for analysis are Quirky.com, OpenIdeo.com and MyooCreate.com. These three were chosen to highlight similarities and differences in how the design process is structured and in the role the community assumes in the design process. The platforms provide a good source of data as the design process is transparent, well-documented and publicly available online. Data in design research is often obtained from experiments where the design problem has been artificially created and the subjects are aware they are being studied. In contrast, the typed communication data in this study was the primary channel of communication for a real world design process and offers an accurate representation of online collaboration where participants were not influenced by research or study conditions.

All three systems support direct, asynchronous communication, chiefly via forums. Quirky is a platform for social product design selected for its clear contribution to design practice and

its established presence (one project a week for over two years at the time of writing and demonstrated commercial viability). The OpenIdeo and MyooCreate platforms address global welfare issues to create positive change through community collaboration. They were selected for their different ways of applying design thinking to problems crossing design disciplines. At the time of writing, OpenIdeo had fourteen challenges of which seven were completed, MyooCreate had four. These systems are rapidly evolving and much of their success can be attributed to adapting to their community and the changing landscape of the social web. To this effect, OpenIdeo pledges to remain forever in beta and to design for continuous improvement. Although the systems reported here may have evolved by the time of publication, their current incarnation will remain relevant to understanding how collective design mechanisms inform social innovation.

All three sites manage community members. The Quirky site maintains detailed statistics on chief 'influencers', individuals from the public who have a significant role in shaping the project. OpenIdeo provides similar statistics on each individual through a badge of honour (a "Design Quotient"). By following the username of influencers, their comments and contributions can be tracked. Public design communication over MyooCreate can also be followed through the screen names of individuals. A chronologically ordered forum for each stage of the design process catalogues design communication between members on all three platforms.

Quirky, OpenIdeo and MyooCreate structure design as a hybrid process that can be applied to a range of contexts to encourage innovative thinking. A hybrid design process involves a dedicated group of professionals taking responsibility for the technical and organizational aspects of design and an open community taking on creative roles. Stempfle and Badke-Schaub (2002) analysed collaborative design teams and found that approximately one third of their time was spent on the organizational aspect of structuring the group process rather than on content. The hybrid design process allows the crowd to dedicate all their contributions to content, while the structured design process embedded in the site's layout and dedicated technical team take care of structuring group processes. Sites such as Wikipedia use a different model, which allows members to take on additional organizational and administrative aspects of the system.

Quirky: a site for "social product design". Quirky crowdsources ideas from individuals, which are collected and presented to the community in what resembles an ideas popularity contest. Each week, the idea with the most votes is selected for development: the decision is community-sourced. The crowd is comprised of people who choose to participate and make contributions, and volunteers are involved in the design process at key stages: creating the original idea, voting on which idea to progress, product research, industrial design, evaluation, product naming, tagline and logo design. Formal aspects of the design are carried out by a dedicated in-house, professional design team, which takes place offline, with the outcomes of each stage in product development made available online to the community. A legal team also evaluates projects, presumably for copyright infringement.

OpenIdeo, a site "where people design better, together". OpenIdeo crowdsource challenges for social good. This can involve the development of new ways to use existing

technologies, designing public awareness campaigns and improving existing services. The platform draws on its crowd of contributors to provide background research, suggest ideas and applaud and evaluate proposed solutions. The three stages the community is involved in are termed: inspiration, concepting and evaluation. Community members submit a range of contributions from photos, sketches, business models and programming code. They can build on others' work and other members provide ongoing feedback. The top concepts are selected via voting by the crowd and are evaluated by a panel of experts for business viability and technological feasibility before a winner is announced. Dedicated in-house experts are responsible for framing the challenge, prototyping and encouraging conversation.

MyooCreate – "the community that believes in the power of stories and adventure to drive social and environmental change". MyooCreate's challenges are specific about how individuals contribute solutions. In one example, the solution is to be submitted as a photograph of a design with a 200 word description; in another, the solution is a 500 word essay on the future of social enterprise. Collaboration in the form of a discussion occurs after a person submits a solution, and there are parallel submissions to each challenge. For example, the Care to Air challenge crowdsourced product design by asking participants to invent a sustainable air-drying solution for clothing. A panel of judges from affiliated sponsors and invited guests from industry select the winning solution.

The three hybrid communities employ a variety of communication tools to maximise and utilise the inter-dependent strengths of their crowds and in-house teams. Sections 3 and 4, which follow, describe how collective design platforms communicate with participants and how they facilitate communication between participants.

3. Communicating to Collective Design Participants

Open, online communities are characterised by the ebb and flow of member involvement. As with online forums, members can be moderators, fully active contributors, contribute only once or sporadically, or "lurk" - observing passively. Stages of participation in an online community are described in the Reader-to-Leader framework (Preece and Schneiderman (2009). In this framework, individuals begin as readers of content, become contributors by adding small edits then larger ones as they become collaborators, until they might develop into leaders who promote participation, mentor novices and create and enforce the policies of the community. To achieve continuity and progress within a design community, leaders take responsibility for developing user contributions according to design constraints. Online communities realise leadership structures implicitly by supporting the self-organising of roles by individuals willing to take responsibility for the project. Peer production allows individuals to self-identify tasks to which they are suited; thus, some remain collaborators while others naturally progress to more involved roles (Benkler and Nissenbaum, 2006). Other communities (often businesses with the finance to hire people) incorporate a dedicated team to monitor progress and keep the design within given constraints. In forming a hybrid system where both crowdsourcing and a dedicated team are used, good communication is essential. This can be achieved by updating shared representations so contributing members

can know where they are located in the design cycle and how their contributions are being used.

One way to increase the usefulness of contributions is to provide members with a set of guidelines to apply to a task. If the experience and task is limited, an individual can, in a short space of time, be trained to a level where they are able to complete a limited task to a sufficiently high standard. Community training has been demonstrated in the specialised domain of molecular biology. Fold.it is an online protein-folding game built around a task usually carried out by biologists or biochemists. The principles of protein folding are introduced to individuals via a series of introductory puzzles, encouraging them to learn field-specific terminology and protein-folding rules. Skills such as spatial reasoning (Cooper et al. 2010) and decision making for solving 'wicked' problems are utilised in the exercise, demonstrating that an individual's creative thinking can benefit domains other than those in which they are formally qualified. This is relevant to collective design as it suggests that some of the skills and techniques of professional designers can be transferred to amateurs. Findings show that few of the top players in Fold.it were biochemists, or even possessed a scientific background, yet they contributed valuable work to a specialized domain. The outputs of this game (optimally folded proteins) have implications in Alzheimer's disease, cancer and HIV/AIDS research. Giving communities the skills and knowledge to use design thinking in new contexts is a viable option for increasing the usefulness of their contributions.

In cases where extensive expertise is required and a crowd cannot be trained for practical reasons, the platform or challenge can target suitable people by broadcasting to those with expertise: either by specialising in a niche market (TopCoder.com focuses solely on software design), or by wording the problem description (challenge) in such a way that only those with the relevant knowledge can contribute. This is the case with Innocentive.com, where problems are so specialised that their descriptions alone will turn away those without the necessary background to solve them. This 'necessary background' does not directly translate to domain expertise, as solvers often come from related fields, bringing a novel perspective that enables them to solve the problem where domain experts have failed (Lakhani & Jeppesen 2007).

An important characteristic of open, online communities is the diversity of member's backgrounds, education and opinion. In this diversity lies an inherent ability for the crowd to generate unique perspectives. Some theorists (for example, Arias 2000; Benkler and Nissenbaum, 2006) argue that knowledge relevant to a problem is distributed among stakeholders and that by bringing together different and controversial points of view, new insights, ideas and artifacts can be made. Diversity is particularly useful in the ideation phase of design, where multiple potential solutions are evaluated against specific criteria. Shah, Vargas-Hernandez and Smith (2002) show processes that generate more ideas are more likely to produce creative designs. Unique perspectives may re-frame the problem or produce an unexpected solution, thus enlarging the known solution space, which is more likely to lead to innovation.

Inputs provided by a diverse crowd are often predictable and mundane, but some will be surprising in the way they successfully address the task. Encouraging, identifying and

developing useful contributions are the most important functions of these systems. Methods of identification can be intrinsic to the system, i.e. individuals rate each other, or extrinsic where professionals or accredited individuals conduct evaluative measures.

3.1 Communicating the design process

This section outlines the ways in which existing online, collective design platforms encourage and integrate communities into the design process to produce valuable user contributions by establishing a project along a timeline or as a design process. An awareness of the community's place in the design process can lead to a better understanding of how their communication reflects their contributions to the design. Two of the three collective design platforms analysed (Quirky and OpenIdeo) incorporate a structured design process to guide the community in design while the third (MyooCreate) uses a timeline to track progress in the project.

Specifying each stage of the design process helps guide the content of communication and provides a focus for decisions at each stage, providing a scaffold to drive the design forward.

Quirky provides a product timeline, which includes specific parts of the design process that can expand to suit the unique needs of the project. An image from one of the projects in Quirky is shown in Figure 3. Some projects undergo several iterations of evaluation or industrial design, which is reflected in the graphic. The example in Figure 3 was taken from a product that had completed the design process and proceeded to the manufacturing stage. Strikethrough lines are placed across the text at the conclusion of each task. The text strikethroughs act as a visual indicator of the level of completion at which the project stands. Emphasis is placed on product evaluation, research, industrial design and branding. Product research involves questionnaire-type surveys to assess the market rather than precedent analysis.

Figure 3. Quirky design process. (from quirky.com, last accessed: August 2011)

OpenIdeo present a 'bar graphic' that treats design as a linear process, shown in Figure 4. This may seem like an over-simplification, but it allows the platform to manage multiple streams of projects developing concurrently. The graphic contains visual elements that

communicate important aspects of the design process. The bar originally starts as a light gray, with colours filling sections as they are completed. Sections are separated from each other by their colour, which is a visual theme that runs through the sub-pages of each project i.e. appearing in the hyperlinks. This acts as a visual reinforcement of the content of communication within a section. The project commences with Inspiration - a form of precedent analysis where existing work is profiled for its relevance to the current challenge. Once this part of the design process is completed, a factor determined by a deadline, the timeline begins to highlight the next section. The content of the smaller text below the title changes depending on whether a section is active or looming. While active, it reflects the number of ideas submitted, but if the previous section in this linear arrangement has not been completed, it provides either a countdown to the number of days remaining (if immediately following the active section), or otherwise a static date.

Figure 4. OpenIdeo design process: at the start and completion of projects (shown by colour fill progression) (from openideo.com, last accessed: August 2011)

MyooCreate differs from the other examples, as their graphic does not feature elements of the design process. MyooCreate communicates a timeline for each project, as shown in Figure 6. This indicates that the design process is not distributed to the community but is performed by individuals and the community is asked to comment on the design solutions to help enhance them.

Figure 5. MyooCreate timeline (from Myoocreate.com, last accessed August 2011)

These graphics help in part to reveal the emphasis each platform places on the content of design communication and the role of the community, with Quirky and OpenIdeo guiding the individual along the design process and MyooCreate highlighting submission deadlines, leaving the design process to the individual.

Online, collective design communities use elements such as *time lines* and *stages in the design process* and allow each member of the community to determine how they wish to contribute. Participation can be as simple as clicking on an icon to vote, or more elaborate, such as being involved in ongoing design discussion. Time lines and design process diagrams are useful visualisations of the current stage of the design process. Members who are 'dropping in' or 'passing through' can immediately see what kind of contribution is appropriate

for the stage of the design cycle and their form of contribution can be guided by this information.

The linear design process, Figures 3-5, used on these collective design sites means tasks are completed consecutively rather than concurrently. Each stage relies on the completion of previous stages, ie. the product research stage has to be completed before concepting can commence. This format differs from most collaborative design scenarios, which involve multiple task collaborations including the organizational aspects of design. The collaborative teamwork described in Simoff and Maher (2000) shares the distributed, applications based nature of collective design but does not employ a hybrid design process to manage the organizational and technical aspects of the design process. Instead, the members participate across all aspects of the project. Stempfle and Badke-Schaub (2002) question whether it is reasonable to assume that designers work systematically and instead suggest that methods are applied in a flexible manner involving constant reflection. Collective design may currently lack the technological support to enable a truly flexible methodology, which is why such heavy emphasis is placed on sequential items such as timelines. This development may be similar to the evolution of software and web design, which traditionally relied on the Waterfall method of sequential development, but is being superseded in many cases by the Agile[1] method which is highly adaptable and modular.

The structure of the design process has an impact on the way communication among participants is carried out. Conversations occur within a precise context rather than across the project. Breaking down the design process means it is easier for members to become involved as they don't need to grasp detailed knowledge of other stages, merely the summary that is provided. Such segmenting negatively influences the content of communication as any gaps in knowledge need to be restated and important insights may not be made, being deemed 'off-topic'.

This next section examines how design communities contribute to design based on their role in the design process.

3.2 Defining design roles

One of the main differences between individual designers and collaborative designers, whether in a team or in a community, is that members of groups have roles and relationships relative to each other (Cross and Cross 1995). In some cases, members adopt design roles to suit themselves (Preece and Schneiderman 2009) and in others, as with these three collective design systems, particular roles within the design process are ascribed to the community. Roles are defined to facilitate communication according to specific types of user contribution. OpenIdeo describe their development phases as inspiration – where participants share related material, concepting – where participants produce novel solutions or partial-solutions and evaluation – where individuals provide feedback on the design solutions. Professionals and amateurs are suited to different roles in collective design. A useful role for professionals in the design process is in keeping the project running to schedule, as communities are less

[1] http://agileintro.wordpress.com/2008/01/04/waterfall-vs-agile-methodology

conscious of schedules than work teams (de Souza and Preece 2004). This has been implemented across the three communities studied here. Roles within team design communication can include gathering and sharing information, developing concepts, and conflict resolution, as described in Cross and Cross (1995). Here, the public interactions of innovation communities are examined in relation to the roles they have been ascribed. The crowd's role in the design process depends on the nature of the problem and the ability of the system to identify relevant expertise.

A high-level model of design was used to map the three platforms; Maher's (1990) model comprises three phases of the design process: formulation, synthesis and evaluation. This model has elements in common with OpenIdeo's development phases: i) evaluation, and ii) inspiration/concepting, which is similar to the synthesis process. Maher's model has the additional benefit of including the process of creating design specifications, which is an important part of Quirky's design process but does not feature in either OpenIdeo or MyooCreate as the design brief is produced by industry sponsors in collaboration with the company rather than crowdsourced.

3.2.1 Design Formulation

Design formulation in the context of this research refers to a process of identifying and specifying the requirements of a design in the form of a brief. Typically this involves interpreting and defining or re-framing unwanted situations, or wanted outcomes in solvable terms.

Quirky involves the community in the earliest stage of design formulation, whereas OpenIdeo and MyooCreate collaborate with industry sponsors to provide design briefs in the form of challenges to the community. Each week within Quirky, several potential design projects are suggested by individuals in the community, and the community votes on which to select for further development. The community formulates the design brief through market-research style questionnaires, aimed at revealing the needs of the community, who also act as representatives and predictors of future consumer markets.

A part of formulation is the gathering of information relevant to the design task. The OpenIdeo design process initially begins with a period called *inspiration*, which requires the community to source concepts and products that can have an effect on the direction of design development. The search strategies are somewhat poorly understood (Cross and Cross 1995), but by finding elements of existing projects that can be related back to the challenge, an act of re-formulation takes place, where the challenge is re-framed in terms of the collected material.

The chat forums on each platform contain communication that suggests the community seeks to better understand the design brief by asking relevant questions. The questions are answered by other members of the community as well as the design team employed by each collective design company.

3.2.2 Design Synthesis

Design synthesis includes the identification of one or more design solutions consistent with the requirements defined during formulation and any additional requirements identified during synthesis.

Design synthesis in online communities can occur in two ways: an individual proposes a solution or many members collaborate to synthesise a single solution. Usually, when an individual proposes a solution, others in the community comment. When the community collaborates, there is a discussion and synthesis of ideas. The products designed at Quirky represent cumulative decisions along the design process, and key influencers are recognised and publicized on the website. At OpenIdeo, synthesis is a process that occurs as a collective decision between voting members of the community and an expert panel, who take into consideration the community's views.

OpenIdeo's crowdsourced "inspirations" section in the design process is dedicated to identifying and sharing existing information and projects related to the design brief. This acts as a form of precedent analysis and is particularly suited to the diversity within the community to locate relevant material. The concepting stage draws on inspirations to generate a unique solution.

Ideation is a significant aspect of design synthesis and is encouraged on several crowdsourcing platforms: Quirky.com, MyooCreate.com, OpenIdeo.com, Threadless.com, TopCoder Studio, and others. Users submit ideas in the form of logos, sketches, textual descriptions and keywords. Idea-jams occur on the discussion forum, where the community engages in lively discussion about the product, coming up with a large list of design features. Quirky uses this model of crowdsourcing when seeking a brand name for the product or brand artwork.

3.2.3 Design Evaluation

Design evaluation involves interpreting a partially or completely specified design description for conformance with expected performances. This phase of the design process often involves scrutinizing the state of the subject under study.

Evaluation is a mechanism to ensure proposed design solutions satisfy potential user needs and desires and to ensure they have popular appeal. It can occur within the crowd through collected or collective means, or by a process separate from the crowd. Quirky encourages the crowd to discuss their personal views and evaluation of ideas during ideation. This provides feedback on the appeal of the design to the collective.

When the crowd is assigned the role of evaluation for integrity and selection, the qualifications of the evaluator are important. TopCoder uses competitions and a history of 'wins' to rank their members and provide performance metrics of their coding skills in particular areas of software development, such as algorithm or conceptualisation. The best coders of TopCoder.com are given the executive ability to evaluate code submitted in competitions and select winners. Rather than give the crowd the role of evaluating and selecting a winning design, Innocentive.com and Quirky.com employ an expert panel to judge

submissions; in Quirky's case, this is a dedicated professional design team who evaluate the design, market and viability of each submission[2]. Viability is also assessed by Quirky's legal team, who bring specialised legal knowledge to the evaluation process. This expert evaluation occurs alongside the crowd's opinions and votes on the designs.

Howe (2009) identifies prediction markets benefiting from collective intelligence. Prediction can be a way of evaluating the potential of a solution. Quirky makes use of prediction markets in a limited way by opening pre-sales of the product to its community, using the purchases by its members as a predictor of future sales.

4. Communication Among Collective Design Participants

A way to understand the design process of an online community is to study communication between individuals. Communication content can reveal the degree of individual contribution; how a collective understanding of a design problem is formed; how active and engaged a community is within the design process; how ideas are developed; how they grow or decline in popularity; and the extent of collaboration (Simoff and Maher 2000).

In an earlier study, (Paulini Murty and Maher, 2011) differences and similarities between collective design and traditional team or individual design processes were studied through an analysis of design communication on the Quirky website. The research discussed here is based on data obtained during that study. The Quirky platform was selected because its projects are strongly rooted in product design; they possess the feature of supporting the community's textual communication via forums and have additional means of gathering member opinion via surveys and rudimentary voting mechanisms.

Three design projects from the Quirky website were chosen for analysis. Three were studied to avoid drawing conclusions from anomalies that may have occurred in a single data set. The projects consisted of a waffle maker (Waffler Waffle Maker), switchblade (Switch Modular Pocket Knife) and iPad cover (Cloak iPad Case). These projects were chosen because they had completed the design process and at the time of selection were either available for pre-sale (waffle maker) or already offered for sale (switchblade and iPad cover). When a product is offered for sale, it means enough people indicated they intended to purchase the product to warrant the cost of manufacture. For the product to be available for purchase indicates a certain degree of success in terms of moving through the design process and reflecting user needs as defined in the market analysis which is unique to each project.

Protocol analysis of communication data from the three projects was carried out to map the communication in collective design to a model of the design process. The following sections describe: the protocol analysis method (4.1); how data was collected (4.2); how segmentation on the data was carried out (4.3); and how the codes were developed and the segments coded (4.4). Section 4.5 consists of an analysis of the data and 4.6 provides an interpretation of the analysis.

[2] http://aquirkyblog.com/2011/02/what-does-quirky-look-for/

4.1 Overview of Protocol Analysis Method

A protocol study was carried out on three public forums on Quirky.com. Protocol analysis is a methodology whereby a coding scheme is developed and applied to design protocols. It is an established research technique allowing elucidation of social design processes (Cross and Cross 1995). Protocol analysis has been used to study designers engaged in design to investigate the process of designing (Gero and McNeill 1997). The protocol analysis of design communication is an approach that has been used in the past to understand the design process for a team of designers collaborating (for example, Maher, Bilda and Gul 2006). The authors consider it is an appropriate tool to use in understanding collective design transactions, which also involve high levels of collaboration. The method has 5 phases: data collection, data segmentation, segment coding using a coding scheme, analysis of codes, and interpretation of results. Data collection typically involves recording written, typed, audio and/or video conversation. The 'Think Aloud' method commonly used in design studies requires designers to verbalise their thinking processes while carrying out a design task, or retrospectively while they are reviewing footage of themselves carrying out a design task. Their speech (and sometimes gestures etc.) is recorded and later transcribed into text. Data segmentation occurs when the text (or video) is broken into short sections according to rules that allow each segment to reflect one code. The coding scheme is theory-driven, based on design process models. The coded data is analysed to discover trends and patterns and the results of the analysis are interpreted in the context of the study.

4.2 Data Collection

In this study, data was collected by Quirky, not the researchers, via the website's open, public forums, as the community participated in product design. The forum comments take the form of text typed directly by the participants. The comments cannot be edited and are chronologically ordered. The communication data selected for analysis was not part of the problem formulation process but represented design communication leading to the solution. The three design project forums were for a waffle maker (265 segments of data), multi-tool switchblade (426 segments of data) and iPad cover (88 segments of data). Projects had a range of member involvement, with 84 people posting comments for the switchblade, 60 for the waffle maker and 21 for the iPad Cover.

4.3 Segmentation

The forum comments for each project appear as a continuous stream of chronologically ordered text, which was copied from the Quirky webpage to a spreadsheet, during which time segmentation was also performed. Segmentation occurred at three levels: the speaker level, the sentence structure level, and the code level. At the first level, the data was segmented whenever a new person added a comment. At the second level, each person's comments were segmented at sentence breaks. At the third level a sentence was segmented so that each segment could be assigned only one code.

Figure 6 is an example of the stream of data taken from forum posts for the waffle maker. Table 1 shows how the forum posts have been segmented and coded.

Figure 6. Example of forum comments

Table 1. Example of Figure 6 after coding the data

Member	Segment	Ideation	Evaluation	Referencing	Qualifications	Social	Uncoded
Vicki DeShazo	Have you considered an accessory that would measure out the perfect amount of batter evry time?	1					
Bulldawg	How about some place around the Griddle to melt butter.	1					
	Then use a brush to butter up the waffle after its done …	1					
	I'm getting hungry just thinking about this … :-)					1	
matthew smith	keyboard waffle [url]			1			

4.4 Coding

Two people independently coded the protocol analysis and any discrepancies in coding were discussed and mediated. The inter-rater reliability was satisfactory with 90% agreement between coders and a Cohen's fixed marginal Kappa of $\kappa = 0.87$.

The coding scheme was initially coded according to the part of the design process to which the discussion contributed: synthesis and evaluation. The codes *ideation* and *evaluation* were used as these terms clearly indicate whether the community member was contributing

new ideas or contributing to an evaluation of existing ideas. Other codes were added to capture the content of communication that formed part of the social process of designing, rather than contributing directly to the solution description. Segments were coded into 5 categories: Ideation, Evaluation, Referencing, Qualifications and Social. Ideation segments referred to the design solution space. Evaluation segments could refer to either the problem or solution space.

Ideation describes segments that contributed a new concept to the discussion about the product's function, behaviour or structure. In the context of the waffle maker design, examples of segments for ideation include:

- "Would be great to see the waffle maker as a pancake maker too". This segment describes a suggestion for an alternate purpose for the product.
- "May be [sic] this waffle iron could have the highest setting determined so that no waffle gets cooked more than a golden brown". This segment describes a suggestion for the performance of the product.
- "An eject button or lever to assist in removing the waffle". This segment relates to the product's physical properties: how it looks or is composed.

Evaluation describes segments that contributed an appraisal about either the problem space or the solution space. Evaluation described the solution's function, behaviour and structure. In the context of the waffle maker design, examples of segments for evaluation include:

- "Seriously, the modular approach is excellent...". This segment is an appraisal of the product's purpose (even though it refers to a structural property).
- "When I saw this item … I, too, agreed with the concern about the toxicity of the non-stick coating". This segment is an appraisal of the product's ability to perform.
- "I feel like the decision to make it in the shape of a shot glass was a really bad idea". This segment is an appraisal of the product's physical properties: its form.

Referencing describes segments that allude to existing products or concepts. These often take the form of hyperlinks to outside sites (such as the Swiss Army knife website in the Switchblade project) or mention of a brand name, like a type of commercially available waffle maker in the Waffler project. *Qualifications* refer to instances where individuals qualify their judgments or design commentary by communicating their past experiences with the problem, product or situation. An example of qualifications is the segment: "Being a college student who has limited space in her apartment, I would suggest a feature that…". The member is justifying her suggestions by saying she has experience of living in limited spaces because she is a college student. *Social* refers to communication where the content is not directly relevant to the project or design process. An example of a social segment is "Great idea!" or typing a smiley face :-)

4.5 Analysis

Many members only posted once with opinions and ideas for improvement, choosing not to become engaged in the ongoing discussion - which was dominated by a few members. The results of coding the segments in the three projects and the mean across all three projects are shown in Table 2. The majority of contributions lay within three areas: Ideation (34.67%);

Social Communication (29%); and Evaluation (25.67%). Referencing was 9.33%; and Qualifications and Uncoded data were both 0.67%, Table 2.

Table 2. Quirky Data Top-Level Results

	waffle maker %	multi-tool switchblade %	iPad cover %	mean
Ideation	27	33	44	34.67%
Evaluation	24	22	31	25.67%
Referencing	12	8	8	9.33%
Social Communication	34	36	17	29.00%
Qualifications	1	1	0	0.67%
Uncoded	2	0	0	0.67

Design communication crossed from problem space to solution space and back again, but not in a consecutive fashion. The iteration was hidden in other discussion as other members joined in and contributed with other material. Particular threads of conversation could be followed, Table 3. The comments capture the way design discussion flows between the problem-space and the solution-space. Although it is chronological, it is not necessarily consecutive. Text unrelated to this specific topic of discussion (ie. comments about other design elements) has been removed for the purpose of clarity. Some text has been edited for brevity.

Table 3. Co-evolution

Design Space	**Discussion**
Problem Space	…[The device should be] like a charm bracelet that's useful--you can collect the tools, swap them out as needed, and **customize** it.
Solution Space	… I think I would make it as a kit that would hold say 5 to 7 items and in a nice carrying case you would have other items that could be switched out as needed....
Problem Space	If you are interchanging parts then I would assume the mounting of the parts couldn't and wouldn't be the sturdiest thing ever.
Solution Space	You are right that it is a risk, but I think we could come up with **sturdy fasteners** for people. One way to hold it together would be self-locking nuts as used by [url]
Problem Space	… I would prefer to customize without having to carry a **second tool**, which adds the benefit that I can take it apart more easily for reconfiguration or cleaning.
Solution Space	One way to do that would be with slotted bolts that can be tightened with **a coin**
Problem Space	…do you know how hard it's going to be to design something that is BOTH **simple** enough for the user (lowest common denominator) to take apart AND, at the same time, **strong enough** to handle day to day use? One seems to preclude the other...
Solution Space	…from a quality perspective, the 'tool lock' mechanism for attaching instruments is key. It needs to be rigid when installed and I'd envision either a 1/2-turn collet type connector (although this may require too much space for the form factor you're shooting for) or a retractable collet (similar to that of a bit driver base).

The final design, Figure 7, resulted in a **customizable** kit, with a **sturdy fastener**, which did not require a **second tool**, but used **a coin** to open. It is both **simple** to use and **strong enough** to withstand heavy-duty use.

Figure 7. Final design for the Switch multi-tool pocket knife.

4.6 Interpretation

Analysis of the coded data shows most collaboration occurs at two stages of the design process. It occurs first in the early conceptualization stage, then again during the evaluation of the proposed concepts. Social communication was strongly represented and may have helped individuals relate to others and win approval for design arguments. There was some evidence of co-evolution occurring as participants transferred search queries between the problem and solution. The dialogue was not continuous; however, the alternating comments indicate a transfer of attention from one perspective to another. This could prompt co-evolutionary thinking in the participants.

The authors have previous experience in coding team design communication that is recorded while the team is working together and at the same time (for example, Maher et al. 2006; Simoff and Maher 2000). Analysis of synchronous communication in team design studies had many similarities to asynchronous communication in collective design. For example, the highest number of segments were design process related, i.e. ideation and evaluation. An analysis of the content of the Quirky forum communications also brought to light some marked differences in communication in asynchronous and synchronous modes of design communication. What initially appeared to be a repetition of ideas on Quirky may actually be categorised as *new ideas* due to the failure of members to read the entire discussion history. As a result, members added an idea that to them was new, but had previously been submitted. Since all members of the design team were present for the entire collaboration period, the repetition of an idea was easy to track. In collective design projects members come and go and new members may not read all of the communication that occurred in the past. This reflects the inherent nature of the collective design crowd to "drop-in/drop-out".

Large numbers of ideas are often equated with solutions that are more creative or more likely to satisfy user needs, because of the belief that the pool of ideas must contain at least one valuable idea among them. A more explicit measure involves assessing the variety of

design alternatives, understanding that idea generation must both expand and explore the design space (Shah and Vargas-Hernandez 2002). Although this type of analysis is not the focus of this research, judging from the communication data, it appears initial comments state obvious suggestions for a solution, often naming precedents and suggesting changes or ways to adapt them to the specific requirements described in the project description. The comments that follow these initial suggestions present numerous alternatives to particular aspects of those solutions. Over time the solutions can evolve into descriptions that sufficiently deviate from the originally proposed solution to consider them separate solutions. It can be argued that this mechanism is particularly apparent in projects that crowdsource product design, since the crowd is highly aware of similar products on the market, in many cases having past, personal experience with them, as revealed in the comments coded as 'Qualifications'.

Ideation and evaluation both formed a significant and approximately equal portion of design communication, with a slightly higher level of ideation. Stempfle and Badke-Schaub's (2002) observation that the solution space in team design can be kept to a manageable level by alternating analysis (widening the solution space) and evaluation (narrowing the solution space) may explain why these figures are balanced. Further, the processes of ideation and evaluation occur throughout the chronology of design communication, suggesting a constant and continuous growth and reduction, or as Campbell (1960) calls the twin evolutionary processes: blind variation and selective retention. A constant iteration appears to occur between the two design 'spaces' of the problem-space and the solution-space. This matches the iterations of the co-evolutionary model of design (Maher and Tang, 2002) which suggests that insights developed in one of the design spaces informs the other and *vice versa* in a back and forth manner. The process of frequently challenging proposed design solutions through evaluation can result in closer scrutiny of the idea which brings about useful insights for stimulating new ideas.

The online discussion forum where this data was obtained is a permanent record of design communication, but the chronology of recorded segments does not necessarily mean the discussion itself moves continuously. Members may respond to a posting days or weeks after it was made. There may be significant delays in developing an idea or transfering insights between design spaces. The discussion in Table 3 is an example of co-evolution occurring during a discussion about configuring tools on a switchblade.

Social communication formed a significant portion of total communication with similar levels to ideation and evaluation. This may not be surprising considering the site is a type of social network and the company's tagline emphases the social nature of product design; however, with social communication forming 29% of total communication, the level was significantly higher than levels in a study on computer mediated collaborative design at 7-8%, and face to face design at 5% (Gabriel and Maher, 2000). This finding suggests social commentary plays a large role in collective design discourse, framing design commentary in a social context. Social communication may assist designing by developing the identity of members who are otherwise socially anonymous, thus enabling relationships to form between members. Luther et al (2010) writes that one of the eight principles of the open source process is to "talk a lot", with discussion venturing beyond the project to "other topics". This was also

observed here, where participants augmented their design contributions with social discourse not directly related to the design, but instrumental in persuading individuals of their view or for establishing credibility and rapport. Social comments consisted of: emoticons; abbreviations; jokes; friendly, comments to others that involved no design communication; and phrases such as "so....hmmmm" to give the text conversational properties. This indicated that some of the communication culture from mobile technologies: SMS language (Textese), typed chat programs and microblogging services were appropriated for the collective design context. Voicing agreement to other's ideas was high, indicating an emphasis on social support. Social support is communication related to the design, but more general than ideation or evaluation. Examples include comments such as "What do you guys think?" which is prompting others to contribute their opinions, and "Congratulations" when a member wins points of influence for their contribution.

In this collective design protocol data, people supported their evaluations or insights with details of their (usually informal) qualifications. During a discussion about a redesign of the multi-tool pocket knife, one member cited their experiences with airport security to ensure the blades would not be confiscated. Others admitted to being lifelong users of brand name pocket knives or their experiences with using similar products to justify their design inputs. One possible explanation for this behaviour is that participants are reacting to the open and anonymous nature of the community. In design teams, individuals are usually acquainted and have knowledge of each other's backgrounds, which qualifies them to put forward information. In a collective design community, individuals' backgrounds are unknown to one another. Citing *qualifications* adds weight to the content of their communication. The total percentage of qualifications in design communication was lower than anticipated at 0.67%. Future studies could investigate whether this low percentage is because members are hesitant to qualify their perspectives, or because it is not necessary to do so in this particular style of 'open' design culture.

5. Conclusions

This article examines the role of online communities in open innovation and analyses the content of design communication to identify the crowds' contributions to the design process and other aspects of participation. The structure of the online system, the visualisation of the design process and the roles available to the community were described as having an influence on member contributions. Frameworks were described for structuring and understanding the management of collective design processes and the roles of participants. Design discussion appeared to follow a co-evolutionary process.

Collective innovation is characterized as an emergent property of inclusive online communities where members choose the duration of their participation, type of contribution they wish to make, and have little or no face-to-face contact. The three examples of collective design described in this article employ a hybrid design process, which means formulation, synthesis and evaluation are attributed to the community while technical and organizational

aspects, such as bringing the product to market, are conducted by the company's dedicated team of professionals. Collective design environments are likely to become hierarchical

The visualization of the structure of the design process in a collective design platform helps to compensate for the lack of domain-specific professional expertise within the open community. The collective design community is self-forming rather than pre-selected like design teams. Unlike most design teams, collective design communities are self-organised to the extent that individuals choose their roles, the degree to which they contribute, and the duration of their involvement. Presenting individuals with clear roles shapes the style of their contributions so they adopt aspects of 'design thinking' and begin behaving like designers. Providing adequate channels of communication within the design process is essential for supporting collective design and breaking projects into well-defined tasks allows contributions to be specific to the task and therefore better managed.

A protocol study of communication content reveals two dominant areas of community contribution in the design process: ideation and evaluation. The communication content reflects ongoing co-evolution between the problem space and the solution space, indicating that collective design shares similar behaviours to other forms of design. The large number of proposed solutions in these case studies suggests collective design is similar to a computational model of co-evolution which favours a breadth-first search, while the extent to which a few solutions are analysed suggests collective design shares aspects of a cognitive model, which favours depth-first search (Maher and Tang 2002). It is possible that features of both models are captured by the collective design process.

Social commentary was found to form a significant part of design communication. A possible interpretation of the large amount of social communication in collective design is that it plays an important role in persuading others to agree with design statements and forms a sense of community. The site itself is a social network and the social nature of product design is recognised by the company in its tagline. The formality associated with design that occurs within a corporate setting might influence the degree of social communication.

Collective design communities contribute to innovation through the formulation of design briefs, the synthesis of potential solutions and the evaluation of proposed solutions. The three websites depict design as a linear process and use visual representations as guidelines to alert the community to the type of contribution required at each stage of design. Simple voting mechanisms and public profile status updates serve to encourage individuals to participate and show that their contributions make a difference. These online systems nurture collective, collaboratory design thinking leading to creativity and innovation. Mapping contributions onto design processes, particularly by differentiating roles within design, removes ambiguity about the design process. Ascribing roles and working within a design structure also means considerations such as keeping within time and budget do not have to be a responsibility of participants, who are freed to concentrate on contributing towards a creative outcome.

Some of these socially innovated products progress to manufacture and achieve sales success, while other products never move beyond the pre-sale stage (where a critical number of potential buyers are needed before the product is approved for manufacture). Future

research can investigate design communication to determine whether there are any marked differences in design process that may affect the popularity of a designed solution.

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