Design Creativity Research: From the Individual to the Crowd

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Abstract. Research in design creativity has focused on individual creativity and on creativity in a collaborative or organizational setting. Collective design and crowdsourcing creativity differ from individual and collaborative creative design by building on the foundations of social computing so thatindividuals are motivated to contribute voluntarily. Research that improves our understanding and support for this phenomena is a trajectory from existing creativity and design research methods and modelsthat study individuals and teams to studying crowds. Three directions for research in crowdsourcing creativity are: technology development, creative design processes, and evaluating creativity.

Keywords: creative processes, evaluating creativity, collective intelligence, crowdsourcing

1 Introduction

Research in design creativity has focused on individual creativity and on creativity in a collaborative or organizational setting. This paper looks at how research based on individuals and teams can provide direction for understanding design creativity in large scale collective intelligence. In this paper, collective intelligence refers to the phenomena of using social computing and crowdsourcing as the approach to generating creative designs. Creative design from collective intelligence can best be described by a continuum for sourcing creative ideas: from the individual to the crowd.

- *Individual:* An individual is the source of a creative design.
- *Team:* A team is selected to develop a creative design.
- *Self-selected Teams:* A design challenge is announced and teams form to address the challenge: one or more teams are selected to develop their creative design.
- *Crowd:* A challenge is announced and through crowdsourcing and social computing, individuals, groups, and teams contribute ideas in response to the challenge and each other to develop one or more creative designs.

Creativity is a topic of philosophical and scientific study considering the scenarios and human characteristics that enable creativity as well as the properties of computational systems that enhance or simulate creative behavior. When studying creativity, we can study how creativity occurs focusing on the *processes* that produce creative designs and we can study what makes a design creative focusing on how we *evaluate*a design to determine if it is creative. There are at least three ways in which creativity research is focussed:

- *human creativity:* psychological studies of creative people and their characteristics or cognitive studies of people performing tasks in which creativity can be observed possibly using prescribed methods or computer tools;
- *computational creativity:*philosophical studies and artificial intelligence studies of computational systems that are based on models or theories of creativity expressed in a formal language such as search spaces and algorithms;
- *creativity in organizations:* the study of methods, environments, and leadership behaviors that encourage creativity and innovation in the workplace.

Creativity is explored and studied in the context of educational environments using students as subjects and in professional contexts using professionals as the subjects. In both educational settings and professional organizationsindividuals are selected to work on projects. The results of researchon creativity in organizationsprovides guidelines for stimulants and obstacles to creativity as well as informs organizations on how to compose project teams to encourage creativity (Amabile et al, 1996). Similarly, research studies have established a set of behaviors and guidelines for leadership that encourages creativity (egPolitis, 2003). Computer supported collaborative work (CSCW) is a research field that studies how groups are supported with computational systems that facilitate communication and collaboration. Some of these studies consider whether the new collaborative

technology enhances creativity. For example, Kim and Maher (2008) study the impact of tangible user interfaces on the collaborative design process for evidence of the problem finding behaviors associated with creativity.

Crowdsourcing, or more generally collective intelligence, invites anyone to participate in a project, or challenge. In crowdsourcing, the organization and corresponding work environment is replaced with a distributed, self-organizing, and potentially large number of people volunteering their time. People self organize rather than fitting in to an established organizational structure with established leadership roles. Howe (2009) describes why crowdsourcing should be so appealing to organizations by quoting Bill Joy, co-founder of Sun Microsystems: "No matter who you are, most of the smartest people work for someone else". Examples of crowdsourcing creative design solutions are

- Myoo Create[1], a web site that crowdsources solutions to sustainable and social challenges;
- Quirky[2], a web site that crowdsources product design;
- Threadless[3], a web site that crowdsources t-shirt designs; and
- Top Coder[4], a web site that crowdsources software design and development.

This paper explores research directions for creativity in design that may lead to a better understanding of the self-organizing phenomena of crowdsourcing creativity in three categories: technologies that support and encourage crowdsourcing, creative processes in crowdsourcing environments, and evaluating designs as creative or routine in crowdsourcing environments.

2 Understanding Creativity in Design

One approach to studying creativity in design is to describe and understand the processes that generate potentially creative artifacts, which focus on the cognitive behavior of a creative person or team, or the properties of a computational system that can generate creative designs. Another approach is research that leads to characteristics or metrics to evaluate the results of an individual or team to determine if a design is creative.

2.1 Understanding Creative Processes

When describing creative processes there is an assumption that there is a space of possibilities. Boden (2003) refers to this as a conceptual space and describes such spaces as structured styles of thought. In computational systems such a space is called a state space. How these spaces are changed, or the relationship between the set of known artifacts, the space of possibilities, and the potentially creative artifact, is the basis for describing processes that can generate potentially creative artifacts.

There are many accounts of the processes by which a potentially creative artifact can be produced. The processes for generating potentially creative artifacts are described generally by Boden (2003) as three ways in which creative artifacts can be produced:

- combination,
- exploration,
- transformation.

Each of these are described in terms of the way in which the conceptual space of known artifacts provides a basis for producing a creative artifact and how the conceptual space changes as a result of the creative artifact.

Computational processes for generating potentially creative designs are articulated by Gero (2000) as:

- combination,
- transformation,
- analogy,
- emergence,
- first principles.

These processes can become operators for generating artifacts that explore, expand or transform the relevant state space.

Shah, Smith, and Vargas-Hernandez (2003) associate creative design with a process they call ideation. They show that processes that generate more ideas are more likely to produce creative designs.

Research in understanding creative processes is done by interviewing or observing creative designers or establishing experiments that study the cognitive processes while a person is engaged in a design task. This research requires collecting data during the design session and analyzing the data using grounded theory or hypothesized models of creative processes. In the final section of this paper, a method for collecting and analyzing data in crowdsourcing creativity is proposed.

[1] http://www.myoocreate.com/
[2] http://www.quirky.com/
[3] http://www.threadless.com/
[4] http://www.topcoder.com/

2.2 Evaluating Potentially Creative Designs

While processes associated with creative design provide insight into the nature of creativity and provide a basis for computational creativity, they have little to say about how we know if the result of the process, a potentially creative artifact, is creative. The articulation of process models for generating creative designs does not provide an evaluation of the product of the process and is insufficient for evaluating if a potentially creative design is creative.

Most definitions or evaluations of creativity, including definitions in the dictionary, include novelty as an essential aspect of creativity. Some definitions state that value is the umbrella criteria and novelty, quality, surprise, typicality, and others are ways in which we characterize value for creative artifacts. For example, Boden (2003) claims that novelty and value are the essential criteria and other aspects, such as surprise, are kinds of novelty or value. Wiggins (2006) often uses value to indicate all valuable aspects of a creative artifact, yet provides definitions for novelty and value as different features that are relevant to creativity. Oman and Tumer (2009) combine novelty and quality to evaluate individual ideas in engineering design as a relative measure of creativity.

Several researchers consider unexpectedness, or surprise, to be a relevant feature of creativity. Wiggins (2006) argues that surprise is a property of the receiver of a creative artifact, that is, it is an emotional response. Wiggins' view of surprise is similar to the definition of value because the interpretation lies outside the description of the artifact. Boden (2003) claims that surprise is a kind of novelty. In this paper, surprise is a separate essential criterion for evaluating a potentially creative artifact because it is possible for something to be novel and valuable, but not be surprising. Since unexpectedness is associated with creativity and is different operationally from both novelty and value, then novelty and value are not sufficient.

According to Maher (2010), novelty, value, and surprise are distinct features of a creative artifact:

- *Novelty* is based on a comparison of a description of the potentially creative artifact to other artifacts in the same conceptual space.
- *Value* is a derivative feature that requires an interpretation of the potentially creative artifact from outside the description of the artifact.
- *Surprise* is a feature that is based on expectations and so is a function of the attributes of the potentially creative artifact in comparison to other artifacts (like novelty), but also depends on a projection or expected value that lies outside the description of the artifacts (like value).

Research in evaluating potentially creative designs is typically done by asking individuals to report on their own creativity and/or by asking a selected group of experts for their opinion on the design. By establishing a common set of features that are essential for a design to be creative, it may be possible to compare across the different design disciplines in crowdsourcing environments. In the final section of this paper, an approach for evaluating the results of crowdsourcing creativity is presented.

3 Collective Intelligence in Design

Crowdsourcing is part of a larger phenomenon called Collective Intelligence. Collective intelligence (or CI) is an emergent phenomenon that has long existed and evolved in human cultures. The term collective intelligence is commonly used to characterize the phenomenon of large numbers of people contributing to a single project and exhibiting intelligent behavior. The phenomenon is not new but it is being defined and redefined as new variations on the theme are emerging on the Internet at an increasing rate.

Collective intelligence can be described along a continuum: from aggregating the knowledge or contributions of individuals, a kind of collected intelligence, through to collaboration among individuals with the goal of producing a single, possibly complex output as a kind of collective intelligence. Rather than thinking of collected intelligence and collective intelligence as two separate entities, we can view them as two ends of a continuum, as illustrated in Fig. 1, where the degree of direct interaction between individuals and their contributions differs. Systems may lie anywhere along this continuum as they incorporate more or less collaboration.

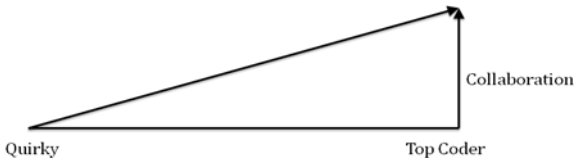

Fig. 1. The Collective Intelligence Continuum (adapted from Maher, Paulini, Murty 2010)

Collected intelligence, on the left side of the continuum in Fig. 1, describes systems in which an individual contributes to a specific challenge. Each solution or outcome for a design challenge is not synthesized with other solutions and therefore stands

alone. Quirky is an example of collected intelligence where anyone cancontributea product design. The underlying principle behind collected intelligence lies with individuals providing a single solution based on their own interpretation of the specific challenge. Collective intelligence, on the right side of Fig. 1, involves both collaboration and synthesis: individuals collaborate in the production of the solutions and individual solutions are synthesized for a synergistic solution. Top Coder is an example of this type of collective intelligence where anyone can contribute to the complex task of software design.

Quirky is a web site that uses crowdsourcing for product design. Anyone can submit, influence, or purchase a product design. Each submitted product design is critiqued by the community, which often includes improving the product design. The community can vote for the designs they like best by committing to a pre-sale. The reasons for participating are on the quirky web site:"candidacy to be next week's Quirky product, detailed community comments and feedback, real-time analytics and demographic profile of supporters and non-supporters, if chosen, your product could be on the market in as few as 10 days, influence that will earn you at least 4-12¢ of every dollar your product ever makes, an excited community as your product's evangelists."Designs are contributed and modified by an individual, and collaboration occurs through critique.

Top Coder is implemented as a websitethat uses social computing and crowdsourcing for software design and development. Individuals can compete for prize money or post a project for others to complete. Social computing support is provided in the discussion forum pages, which not only supports social interaction, but also learning from the community. Unlike Quirky, Top Coder presents complex software design problems that are decomposed and synthesized by the community. An individual may contribute a portion of the design, but a single individual does not propose a total solution. Individuals can collaborate on a submission, and the finished product is the successful integration of many smaller parts.

4 Research Directions for Creative Design Emerging from Collective Intelligence

Design challenges are placed on collective intelligence web sites in order to crowdsource creative solutions. We can see from the Myoo Create web site that companies are looking at crowdsourcing as a way of bringing new ideas to a company or to solve a long standing challenging problem that has not been solved within the organization. For example, Myoo is specifically interested in challenges that incorporate sustainable design as an essential and integral part of the requirements; where Quirky is open to any significantly innovative idea. There are many open research questions that could inform this kind of creative design that fall into the following categories:

- *Technology development:* What are the design considerations for a web site that successfully motivates people to contribute to crowdsourcing creativity? A principle of crowdsourcing is that there needs to be a crowd: while a small percentage of people are highly creative, a small percentage of a large number is still a large number.
- *Creative design processes* in crowdsourcing creativity: Does collective intelligence as a process look similar to individual or team intelligence when working towards creative design? Understanding how the process of crowdsourced creativity develops could help determine what sort of problems are suitable for crowdsourcing.
- *Evaluating creativity* in collective intelligence: Does collective intelligence produce more creative designs than individual or team intelligence? Establishing a common metric for evaluating creativity allows us to compare potentially creative designs independently of their domain or source.

4.1 Technology Development

Recent studies of the social construction of knowledge in social computing environments such as wikipedia (eg Nov 2007)provide a basis for understanding how and why the internet is a technology that facilitates collective intelligence and encourages people to volunteer their time.Shirky (2008) provides an overview of many examples of how the internet encourages people to volunteer their time to make the world a better place. Malone et al (2009) reports on a study of successful collective intelligence web sites and proposes a design pattern approach for formalizing the development of technology for collective intelligence. Research in computer supported collaborative design also provides insight into how technology can support crowdsourcing creative designs.

Maher, Paulini, and Murty (2010) present a conceptual space for extending our understanding of computer supported individual and collaborative design to collective intelligence in design, shown in Fig. 2.

In this conceptual space there are three dimensions that frame technology development for collective design:

- *Representation*: Computer support for design implies that there is an external representation of the design solution that facilitates individual and collaborative design. For crowdsourcing creativity, this representation is essential for encouraging the community to contribute, evaluate and analyze ideas and solutions.
- *Communication*: Providing facilities for people to communicate is essential for collaborative and collective design.
- *Motivation*: There are many ways in which the design of the web site for crowdsourcing can motivate individuals to contribute.

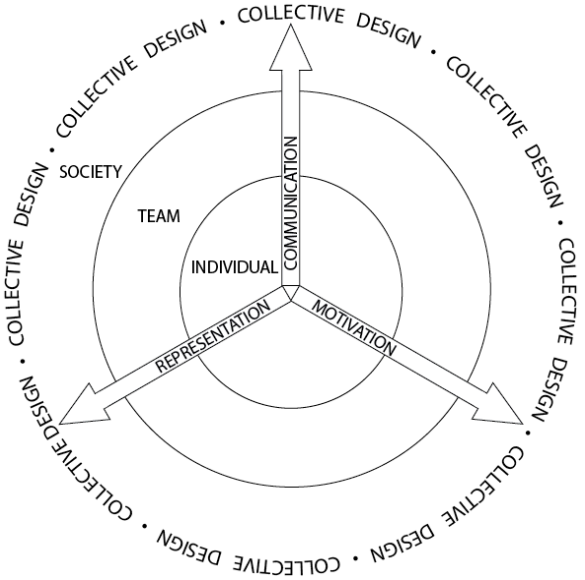

Fig. 2. Conceptual Space for Collective Design (Maher, Paulini, Murty 2010)

Research directions for technology development include identifying patterns that lead to successful collective creativity, developing frameworks that identify this type of design environment as a conceptual space for design of new environments, and understanding how different aspects of new technology encourage and facilitate creativity.

4.2 Creative Design Process

Cognitive studies of individual designers and design teams have lead to numerous models of design cognition. The use of protocol analysis as a basis for studying designers has produced many interpretations of the design process and creativity. In individual design, the protocol data is a continuous stream of verbal utterances (think aloud method), gestures, actions, etc, collected during (concurrent) or after (retrospective) a design session. In team design, similarly, the protocol data is a continuous stream of verbal utterances (communication content), gestures, actions, etc collected during a collaborative design session. This method easily translates to studying collective intelligence by using the list of comments associated with a specific design challenge and a proposed design solution.

So far, crowdsourcing creative design has the following characteristics: a design challenge is announced, individuals respond with their proposed design solutions, the crowd comments on the proposed designs in a discussion forum, the crowd votes and/or a group of experts select one or more designs to be developed further. This process has two distinct parts: individual creativity and collective creativity. During the individual creativity phase, the designer works offline and does not leave a trace of their design process. Studying this phase of the design process is similar to studying individual designers. During the collective creativity phase, the crowd (including the designer) communicates via a discussion board, leaving a trace of their thoughts about the proposed design. This aspect of the design process can be studied by analyzing the text in the discussion forum.

Table 1 show an excerpt of a discussion about a design challenge posted on myoo. The discussion is segmented so that a single segment is a single sentence in the discussion. Each segment is coded, in this example, using four categories:

- Ideation: the comment suggests an idea to improve the design
- Analysis: the comment analyzes some aspect of the design
- Evaluation: the comment provides an evaluation of the design
- Support: the comment shows that the person likes this design

The total for each of the codes in this section of the discussion shows that ideation dominates the discussion. While this is not a significant sample, it shows that the discussion forum can support ideation, an important characteristic of creativeprocesses.

Research directions for developing a better understanding of the design processes that emerge from crowdsourcing creativity include collecting data from web sites that crowdsource creative solutions, developing appropriate analysis methods, and using coding schemes that are also used for protocol studies of individuals and teams of designers. This will

provide a basis for comparing crowdsourcing to individual and collaborative design.

4.3 Evaluating Creative Design

Research on the characteristics of a creative design provides a basis for evaluating creative designs regardless of their source. Maher (2010) presents three essential criteria for evaluating creativity, regardless of the domain or source of creativity: novelty, surprise, and value. Novelty can be formalized as a measure of distance from known artifacts, allowing novelty to be measured using an algorithm for distance measure in a state space or by asking people to evaluate their perception of the novelty of the design.Surprise is an aspect of creativity that we recognize when we say that something is creative because it does not meet our expectations for the next novel artifact in its class. Surprisecan be measured using pattern matching algorithms that look for variations across one or more attributes in a sequence of designs. When this pattern matching can be formalized as an algorithm, surprise can be recognized computationally. However, if we accept surprise as an essential criteria for creativity, it should be included in human evaluation of proposed designs. Value is a characteristic of creativity that reflects our individual or social recognition that a highly novel, random act or result is not sufficient for us to judge something as being creative. Measuring value is based on a set of performance criteria that can be adapted by the introduction of new performance possibilities in a creative artifact. Again, value can be measured computationally, or surveyed from individuals as we see in current studies of creativity and sites that crowdsource creativity.

Research directions for developing a better understanding of creativity in crowdsourcing include evaluating several design solutions using the same criteria, such as novelty, value, and unexpectedness, and comparing the responses across individual, team, and crowdsourced creativity.

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Table 1. Analysis of online discussion for crowdsourcing creativity

Person	Comment	Ideation	Analysis	Evaluation	Support
P1	If the Waffler really can make waffle cups, I can hardly wait to fill them with Ben and Jerry's pistachio ice cream....my favorite kind of dessert!				1
	And if it can shape bread into cups and toast them, I'll like the Waffler ever more!	1			1
P2	Why not give 2 sets of plates with it and charge extra for another set.	1			
	Maybe have two basic designs waffle and pancake and then make other designs that can be submitted by users.	1			
P3	I was thinking about bacon (happens a lot) and I realized you could use the waffle shot plate to make little bacon shot cups.	1			
	You would lay a bit down for the bottom of the cup and twist and wind the rest up in a cylinder shape in the space used for waffle shots.	1			
	Great fillers could be chicken, eggs, waffle bits...etc.	1			
P4	Your definitely making me hungry				1
P5	I love waffles but the main reason i don't make waffles is because of the mess.		1		
	The runoff channel looks way too small.			1	
	It would be nice if the waffle making part were separate from the heating element so you could just stick the waffle making part in the dishwasher.	1			
	Something along the lines of this one? http://www.waffleironworld.com/nemco-7020.html	1			
P5	Another idea for cleanup - make the heating element easily removeable.	1			
	Have a heating plate on top and bottom make it so you can slide the entire heating/electrical unit out of the waffle iron so you can submerge the rest of it in water or your dishwasher.	1			
P6	Yes exactly!				1
	REA				1
P7	So maybe I'm a little late for this but I'm not to sure that shots will cook correctly and even if they do if they will stand.			1	
	I guess drinking an ounce of syrup will be a new college trend but I really don't get it.			1	
	Has anyone tested the ability to create a 1 oz shot glass out of batter.			1	
	It seems as though this one has gotten away from us.			1	
	IMHO the KISS method should be reapplied.	1			
Totals		11	1	5	5