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Can we solve wicked problems? A conceptual framework and a collective intelligence system to support problem analysis and solution design for complex social issues

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ABSTRACT

Wicked problems are complex and multifaceted issues that have no single solution, and are perceived by different stakeholders through contrasting views. Examples in the social context include climate change, poverty, energy production, sanitation, sustainable cities, pollution and homeland security. Extant research has been addressed to support open discussion and collaborative decision making in wicked scenarios, but complexities derive from the difficulty to leverage multiple contributions, coming from both experts and non-experts, through a structured approach. In such view, we present a conceptual framework for the study of wicked problem solving as a complex and multi-stakeholder process. Afterwards, we describe an integrated system of tools and associated operational guidelines aimed to support collective problem analysis and solution design. The main value of the article is to highlight the relevance of collective approaches in the endeavor of wicked problem resolution, and to provide an integrated framework of activities, actors and purposeful tools.

1. Introduction

Many relevant problems in the real world are “wicked” as they have no single or definite computational formulation or a set of valid solutions or right answers, but only answers that are better or worse from different angles. Wicked problems are unique, multi-causal and generate a contradictory and changing requirements situation that is difficult to diagnose. They are messy and devious systems of interacting problems and the effort to solve one aspect may thus create other problems (Ackoff, 1974; Ritchey, 2011; Rittel and Webber, 1973).

West Churchman (Churchman, 1967) has firstly used cases such as global warming, climate change, health care, poverty, education, and crime to introduce examples of wicked problems. More recently, the US National Academy of Engineering (NAE) has studied a family of “grand challenges” that address complex or wicked issues (e.g. improvement of urban infrastructures, pollution reduction, and enhancement of cyberspace security). In 2015, the United Nations have identified seventeen sustainable development goals related to a set of universal, integrated and transformational problems that cover global and complex issues such as poverty, nutrition, instruction, sanitation, employment, climate change, preservation of natural resources, and justice (ICSU, 2015). The term wicked problem has been also used in the business world to refer to the complexity of some strategic planning processes (Camillus, 2008).

The attempt to find possible solutions to critical human issues has been a major driver for undertaking research in the field of participatory approaches as an effective decision-making strategy. This is in line with the tendency to ascribe superior value to decisions when people with different interests, expertise, worldviews and values are involved in deliberations (Nogueira et al., 2017). In fact, wicked problems involve constellations of stakeholders, which may have conflicting interpretations as well as different life experiences, competencies, goals, and values. Their strategies to address the problem are based on the perceptions of the problem and its solutions, which may differ from the view of others (Van Bueren et al., 2003).

Today, the open contribution and participation of large groups is facilitated by the Internet and social networking, which have driven the emergence of the “wisdom of crowds” (Surowiecki, 2005) as a foundation of open innovation (Gassmann et al., 2010; von Hippel, 2005) and collective intelligence (Lévy, 1994; Pór, 1995). In particular, collective intelligence systems (Malone et al., 2010) allow harvesting knowledge and experience possessed by potentially thousands of individuals to support better decisions or generation of novel knowledge, ideas and products. Examples of collective intelligence “in action” (Alag, 2008) include ratings, reviews, recommendations (e.g. Trip Advisor and Amazon), user-generated content (e.g. Wikipedia and

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YouTube), bookmarking and voting (e.g. Tumblr and Del.icio.us), tag cloud navigation (e.g. Flickr), R&D problem solving (Innocentive), start-up creation (e.g. Kickstarter), and idea crowdsourcing (e.g. Spigit).

Although the potential benefits of large group participation are evident in many fields of human activity, the application of collective intelligence principles for public good is still poorly supported by collaborative social platforms (De Liddo and Buckingham Shum, 2014). Complexities derive from the difficulty to define the state of a multi-faceted topic and to generate feasible ideas and effective actions by engaging all the stakeholders that can contribute in devising possible futures. The effectiveness of decision-making relies on the capacity to link the varied contributions of the involved agents, which depend on their different interests and expertise, points of view and values, and the way in which the process of decision-making is conducted (Nogueira et al., 2017). For socially relevant decisions, it is necessary to combine multidisciplinary knowledge and a variety of actors, organize information, generate consensus and legitimate collective action into structured approaches. Finally, it is important to understand the boundaries between the role of idea crowdsourcing and expert decision, as well as to identify the specific nature of the problem to be solved, which has an impact on the approach to problem solving.

In such endeavor, we aim to present a conceptual framework for the study of wicked problem solving as a complex and multi-stakeholder process characterized by a number of different interrelated perspective or dimensions. Based on that, we describe the functional elements of a collective intelligence system to support the resolution of wicked problems. In particular, we present a set of tools and associated operational guidelines aimed to support collaborative problem analysis and solution definition in complex social endeavors. At this purpose, we first present extant research in the area of group/collaborative problem solving and the adoption of collective intelligence. Next, we describe a process of problem resolution and a problem resolution matrix attempting to integrate different dimensions involved with complex problem solving. In Section 4, we introduce a set of tools and methodological guidelines for the implementation of the resolution process; finally, we provide in Section 5 some discussions and conclude the article with avenues for further research.

2. Problem solving and collective intelligence

The literature on problem solving is rich and differentiated. Most general contributions have analyzed *strategies* such as abstraction, analogy, brainstorming, lateral thinking, morphological analysis, root cause analysis or trial-and-error (Wang and Chiew, 2010), and *methods* like APS (Applied Problem Solving), GROW (Goal, Reality, Obstacles/Options, Way forward), OODA (Observe, Orient, Decide, Act), TRIZ (the "theory of inventive problem solving"), and SPS (Systematic Problem Solving). With a more specific focus on systems enabling problem analysis and related decision making, group decision support systems (GDSS) have emerged as interactive computer-based systems facilitating the solution of unstructured problems by a group of decision makers (DeSanctis and Gallupe, 1987). A GDSS includes a set of software, hardware, language components, and procedures that support a group of people engaged in a decision-related meeting (Huber, 1984).

Group decision and collaboration is today impacted by the research conducted at the crossroads of computer science, behavioral science, and management science. The development of information systems for wicked problems (Schoder et al., 2014) benefits from advancements in areas such as collective intelligence and social media, with a relevant challenge being related to how to canalize the large participation and get the best contributions from the crowd. Information systems for group problem solving have been improved thanks to major research findings in the fields of dialogue and casual mapping, argumentation, and knowledge representation. In contrast to restrictive structures, dialogue mapping facilitates group intelligence to emerge (Conklin, 2005), whereas causal mapping methods support the analysis of complex tasks, with examples in engineering and construction projects (Ackermann and Eden, 2005).

In a collaborative setting, the relevance of the argumentative process has been highlighted as effective way to tackle wicked problems (Rittel and Webber, 1973). An argument is a structured connection of claims, evidence and rebuttals, and it is part of the route that goes from unshared individual knowledge to shared team knowledge and common ground (Beers et al., 2006). Argumentation systems have been applied to improve the GDSS prediction ability of market trends, with examples in the housing market (Introne and Iandoli, 2014), and to support discourse among decision makers (Karacapilidis and Papadias, 2001). Argumentation platforms have been described as systems through which users can quickly and comprehensively explore the debate on the discussion topic (Gürkan et al., 2010) whereas Information Aggregation Markets are effective tools for idea generation and evaluation (Bothos et al., 2012). Finally, knowledge representation techniques can support problem resolution by reducing environmental complexity and facilitating the shared understanding of concepts, variables and mutual interdependencies. Some applications can be found in the fields of education (Munneke et al., 2007) and innovation (Adamides and Karacapilidis, 2006).

Explicit applications of collective intelligence for domain-specific problem solving can be found in studies focused on developing recommender systems to support differential medical diagnosis (Pérez-Gallardo et al., 2013), open computer aided innovation (Lopez Flores et al., 2015), and national strategy exploration and scenario planning (Glenn, 2015). Other interesting contributions can be found in the fields of crisis and emergency management, with the analysis of multiple stakeholder perspective (Hernantes et al., 2013; Turoff et al., 2013), and the development of resiliency strategies for ports in case of adverse weather events (Gharehgozli et al., 2016).

Two examples of collective intelligence systems that leverage social networking and expert contribution to support the resolution of wicked problems are Open Ideo (www.openideo.com) and the Climate CoLab (www.climatecolab.org) (Introne et al., 2013). The systems tackle social challenges through the creation of a space for community members to contribute, by providing tools and resources for on-line voting, supporting, contributing and expert mentoring in the solution ideation and description endeavor. The key focus is on key actions such as share stories on specific challenges, ideation and community sharing of ideas, idea refinement for designing solutions, community feedback and solutions testing, selection of top ideas and community search for collaborators.

Other examples of tools supporting collaborative problem discussion are *Compendium* (http://compendiuminstitiute.net) for visual mapping and management of ideas and arguments, *CoPe_it!* (http://copeit.cti.gr) for argumentative collaboration and decision support, and *Debategraph* (http://debategraph.org) for supporting individuals and communities to deliberate and take decisions on complex issues. It can be also relevant to mention the EU2020 "Catalyst" project, a large-scale research effort aimed to generate and apply open tools for collaborative knowledge creation for public good, the CogNexus Institute, working on wicked problems and dialogue mapping, and the Swedish Morphological Society, on wicked problems and social messes.

Most of the existing approaches are focused on specific tools and services fostering collaboration, such as dialogue mapping, argumentation and information sharing, whereas the holistic perspective and system view of the entire problem resolution process (with phases, activities and roles) is not completely addressed. In such view, there is room for new contributions aiming to develop a more structured and integrated view of problem analysis and solution design for wicked problems, as well as to introduce a set of tools able to streamline the aggregation of controversial points of view and contributions of many stakeholders in multi-causal problem scenarios. Our work is focused on such major research direction.