How can knowledge integration in crowdsourcing help to tackle grand challenges?

An exploratory case study of tackling food waste

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ABSTRACT
Global challenges such as reducing food waste have shown to be hard to overcome due to complex networks of actors. This study aims to explore whether crowdsourcing can be a new tool to help address these extremely complex 'grand challenges' with knowledge integration of the crowds. To do so, a pilot case study is conducted on the food waste problem on existing crowdsourcing initiative OpenIDEO, to explore how observed dynamics can reflect Robust Action strategies to tackle these grand challenges. Results offer evidence for crowdsourcing as a useful tool as well as two key development points.

Keywords
Crowdsourcing, Knowledge Integration, Grand Challenges, Wicked Problems, Robust Action

INTRODUCTION

"The issues we face are so big and the targets are so challenging that we cannot do it alone, so there is a certain humility and a recognition that we need to invite other people in. When you look at any issue, such as food or water scarcity, it is very clear that no individual institution, government or company can provide the solution."

- Paul Polman, CEO Unilever (Confino, 2012)

As the quote above reflects, a variety of actors are increasingly addressing today's challenges, such as food or water scarcity (Ferraro, Etzion & Gehman, 2015). These problems can be said to move beyond traditional notions of complexity and are thus often referred to as wicked problems or grand challenges, causing traditional problem-solving strategies to fall short (van Tulder, 2018; Ferraro et al., 2015). To be precise, the high degree of diversity in involved actors and their perspectives, motivations and behaviors calls for a participatory approach where these actors can coordinate, collaborate and bring about systemic change on a global scale (van Tulder, 2018; Ferraro et al., 2015). Initiatives such as OpenIDEO, our Oceans Challenge or Climate Colab created online platforms to facilitate a similar type of collaboration and tap into the 'wisdom of the crowds' in order to solve societal problems. This technique is often referred to as crowdsourcing (Howe, 2006). However, the success potential of crowdsourcing for grand challenges largely depends on the presence of effective knowledge integration (Majchzrak & Malhotra, 2014). When assessing this mechanism of knowledge integration, characterized by a notion of integrating a variety of perspectives, it is perhaps possible to draw parallels with the form of diverse collaboration that is seen in strategies to solve grand challenges. However, before actors can successfully deploy crowdsourcing as a tool in tackling grand challenges, a better understanding must be obtained of knowledge sharing behavior in the context of grand challenges. Therefore, the aim of this paper is to explore how knowledge integration behavior in crowdsourcing challenges occurs and what parallels can be drawn with problem solving strategies for grand challenges. This aim translates into the following research question: *How can knowledge integration behavior on crowdsourcing challenges help in tackling grand challenges?* As a result, this study will add to the understanding of knowledge integration in this new context, explore if future research is warranted and if so, which research direction are useful starting points. Moreover, insights in the dynamics on these crowdsourcing initiatives may benefit practitioners aiming to deploy crowdsourcing as a tool and help them how to manage the crowds. Finally, not only management may benefit from these insights: advancing crowdsourcing as a tool may empower and engage more actors in tackling the various grand challenges (Ferraro et al., 2015). Perhaps, these new forms of involvement may even increase a sense of urgency to tackle the most pressing grand challenges of our time.

The paper is structured as follows. First, key concepts and their interrelationship will be outlined. Second, the methodological steps will be explained. Third, the results will be outlined. Fourth, these results will be discussed in light of the Robust Action (RA) Framework to address grand challenges and to explore the potential of crowdsourcing as a tool. Lastly, a conclusion will follow from this discussion.

THEORETICAL FRAMEWORK

First, the key theoretical constructs of the study are elaborated on in consequent order: 1) Grand Challenges, 2) Knowledge Integration in Crowdsourcing and 3) their theoretical relationship.

Grand Challenges

Complex problems that transcend traditional boundaries and problem-solving methods are elaborately discussed in academia as well as practice in an attempt to define and deconstruct common analytical characteristics and find successful strategies (Verweij, 2006; Ferraro et al., 2014; Koppenjan & Klijn, 2005). In literature, these challenges are often defined as 'wicked problems', derived from the pioneering work from Churchman (1967). Other terms include 'grand challenges' as defined by Ferraro and colleagues (2014), which will be the definition adopted throughout this paper as this framework offers a pragmatic view moving beyond a mere policy perspective (Ferraro et al., 2014).

Several common analytical characteristics of these problems have been distinguished by Ferraro et al., (2015): 1) complex, 2) uncertain and 3) evaluative. In turn, these refer to 1) the complex, varying network of diverse stakeholders that is involved in a problem, 2) the uncertainty that results from the involvement of many actors and their actions thus resulting in transparent problem status, and 3) different evaluative criteria from the variety of stakeholders such as for instance the opposing evaluations of a for profit or non for profit actor.

The RA strategy is threefold, based upon a structural, interpretive and practical dimension, and aims to foster: "*sustained engagement along multiple, distributed paths of action, increasing the probability of positive field-level outcomes*" (Ferraro et al., 2015 p. 373). The first part of the strategy offers a structure to facilitate engagement from a diverse audience of actors to interact over a longer period of time, referred to as a 'participatory architecture' (Callon et al., 2009; Ferraro et al., 2015).The second part of the strategy adds an interpretive dimension by allowing the interpretations of the diverse audience to be integrated and coordinated without the need for a consensus during these interactions. This strategy is described as 'multivocal inscription' (Ferraro et al., 2015). To be precise, this notion builds on the work of Pinch & Bijker (1987) that artefacts are interpretively flexible by various participants, However, these do not only co-exist, but as Verweij et al., (2006) argues, there is also a need to ' *creatively combine these perspectives on what the problems are and how they should be resolved'* (2006, p. 829). This way, different actors may have raised their evaluative criteria and by doing so, expose new dimensions to the problem that other actors in the problem may not have seen before (Ferraro et al., 2015). The third and final part of the strategy is defined as 'distributed experimentation' that allows for an interactive process in which it is '*possible to analyze, design and implement a variety of alternative solutions simultaneously*' (Ferraro et al., 2015, p. 276) along the work of De Young & Kaplan (1988). Consequently, the relevance of this form of experimentation is that governments or other more strategic stakeholders can learn from these initiatives in a more 'step by step' approach, and these experiments can be combined into 'different solutions in ways that complement their differential strengths and weaknessess.' (Ferraro et al., 2015).

Crowdsourcing and Knowledge Integration

There are varying definitions of the term 'crowdsourcing', yet Estellés-Arolas & González-Ladrón-De-Guevaras (2012) summarize the discussion by describing crowdsourcing as an online activity where a heterogeneous audience offers knowledge and experience in exchange for various rewards such as economic rewards, social recognition or self-esteem. Consequently, an abundance of perspectives can be found when a heterogeneous audience offers their knowledge. To ensure more insightful ideas and solutions with this mix of perspectives, Majchrzak & Malhotra stress the importance of effective knowledge integration (2014). This 'knowledge integration approach' is not often found in crowdsourcing challenges, whilst encouraging and rewarding a combination of these behaviors yields better ideas according to Majchrzak & Malhotra (2014).

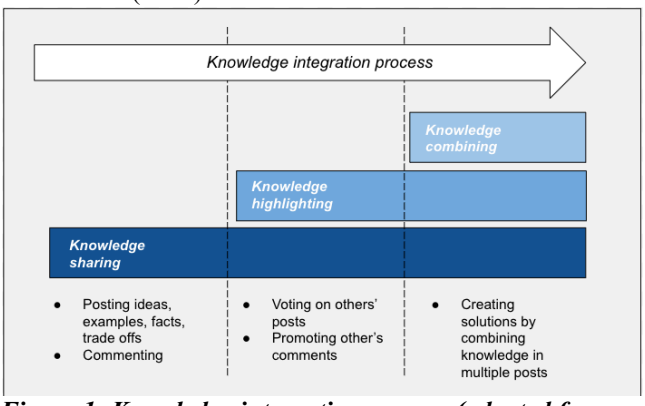

Figure 1: Knowledge integration process (adapted from Majchrzak & Malhotra, 2014)

The concept of knowledge integration is threefold, visualized in figure 1: knowledge first needs to be shared, it can then sometimes be highlighted by users for its relevance, and in even fewer cases the highlighted knowledge can be combined into a solution (Majchrzak & Malhotra, 2014). For instance, participants can *share* their ideas on the design of a food container in a crowdsource challenge, *highlight* a popular opinion that the size is crucial in the design, and *combine* this with the design of the idea creator. However, these diverse perspectives are not always shared, as Davenport & Prusak (1998) and Wang & Noe (2019) shed light on the many factors that may limit knowledge sharing such as the tradeoffs between effort and reward, and factors such as personality, context and motivations of the individual. These factors may all influence an individual's knowledge sharing, and thus, knowledge integration actions. Highlighting may be done through commenting on the relevance or 'upvoting' relevant comments in the challenge (Majchrzak & Malhotra, 2014).

Crowdsourcing to tackle grand challenges

By theorizing on similarities between what is required for RA and what crowdsourcing may offer as a tool, parallels can be formulated. First, the various perspectives of 'the crowd' can be shared, may oppose each other and can co-exist in the online architecture of crowdsource challenges, thus reflecting core elements of *multivocal discourse* on a *participatory architecture*. Moreover, crowdsource challenges occur during a substantial - yet limited - timeframe in which many local, bottom-up solutions can be developed simultaneously to solve the challenge, reflecting a similar practice as *distributed experimentation*.

METHODS

To explore how participants on crowdsourcing platforms perform knowledge integration behavior in the context of grand challenges, a pilot case study is conducted on one of the early initiatives of crowdsourcing for grand challenges: OpenIDEO. The Food Waste Challenge (OpenIDEO, n.d.) was selected as case study as it reflects Ferraro et al's (2015) three characteristics of grand challenges: 1) a *complex* network of actors such as consumers, retailers, transporters, retailers and producers all take part in the global food industry, 2) *uncertainty* exists amongst these actors as the global scope and variety and number of actors make it hard- if not impossible - to oversee all actions in the network, 3) actors in this network may have varying or even opposing *evaluations* on the problem/solution, where a solution for one group (e.g. less un-seasonal product offer by retailers) may lead to a problem for other groups (e.g. consumers with less choice). On this challenge, the textual interactions amongst participants in the online comments are systematically coded with an iterative data analysis along the key theories, inspired by the work of Tracy (2013). In total, 1120 comments (362 pages of raw data) are analyzed in a selection of 29 ideas. Winning and losing ideas were randomly included in the selection to explore whether differences existed in the different idea threads until no new patterns emerged from the data. In addition, as Kozinets (2002) suggests for online text analysis, additional steps are taken to anonymize the textual data to ensure ethical conduct, as well as verify that consent by participants was given to publicly post their comment.

RESULTS

The interactions that were observed from the participants in the crowdsource challenge were grouped together in several

knowledge integration mechanisms. When assessing these from a wider perspective, it became evident that the crowdsource architecture and observed interactions could be distinguished in different levels, visualized in figure 2. These levels pertain to 1) interactions concerning single ideas and 2) combinations of these ideas. Also, subdivisions of the problem of food waste were added with 'missions' to deconstruct problem elements.

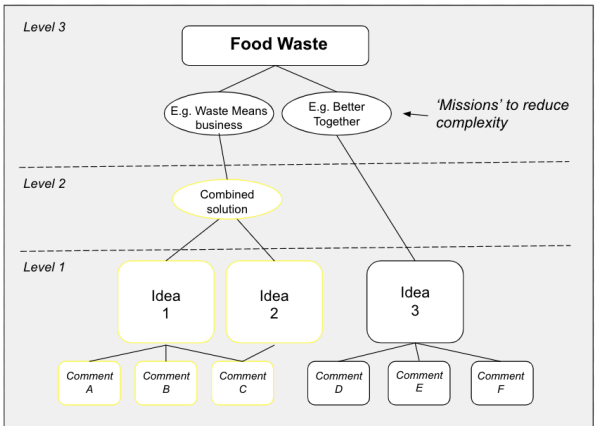

Figure 2: Levels in the crowdsource challenge

Within this framework of levels, several interactions were observed, grouped together in eleven knowledge integration mechanisms that can be found in table 1. The extent to which these behaviors were observed are added for a more comprehensive overview, ranging from 'very few'- a few observations in specific ideas - to 'highly observed' – present in almost every post/idea.

Table 1: Eleven key knowledge integration mechanisms

Mechanism (1): Share/emphasis on specific positive element of the idea	highly observed
"Excellent idea! It's simplicity can bring your design on stream quickly"	
Mechanism (2): Add to the idea with suggestions	moderately observed
"*... wanted to suggest that if you can develop a portable model which can be given to small and medium farmers then it will be boon for the farmers in emerging market.".*	
Mechanism (3): Link new knowledge	low- to moderately observed
"*I noticed a conversation about finding more efficient ways of [problem in idea] in* [link to other idea]*"*	
Mechanism (4): Sharing of background participant	little observations
"While I am working currently on food waste issue in urban India, I have observed that.."	
Mechanism (5): Add or emphasize concerns on the idea	highly observed
"However, my concern is, is there any ignored side effect of this procedure? Have you ever evaluate greenhouse gas emission during the process of dehydrating?" .	
Mechanism (6): Add or emphasize concerns on the problem	low- moderately observed)
"People don't educate themselves on food waste the way they should."	
Mechanism (7): Clarification/ updating of information	little observations
"How do you dry them to turn them into flour?"	
Mechanism (8): Reflective statements about interaction	moderately observed
"People have already mentioned that it would be hard for people to remember what produce needs to be..."	
Mechanism (9): Collaboration	moderately observed
"Great idea! I'm in the bay area and I can help with…"	
Mechanism (10): Encouragement idea & interaction	highly observed
"This is pure genius! Just thinking of the possibilities and the impact this could potentially have on world hunger is very exciting!"	
Mechanism (11): Combining knowledge or ideas	very few observations
"*Good idea!, but it's better when complemented with [name]'s idea to … because …"*	

DISCUSSION

So far, eleven key knowledge integration mechanisms have been discussed. This last section of the report discusses these findings in light of the study's main question: *How can knowledge integration behavior on crowdsourcing challenges help in tackling grand challenges?*

Multivocal Inscription

The varying and sometimes opposing perspectives seem to co-exist on the crowdsource platform, yet a certain form of knowledge combining is also needed for RA to '*creatively combine these perspectives on what the problems are and how they should be resolved*' (Verweij et al., 2006, p. 829). Therefore, when assessing the second element of multivocal inscription, questions can be raised if the little evidence of knowledge combining (M11) observed within idea threads (level 1) or across the challenge (level 2) addresses this strategic element of RA. Moreover, highlighting and combining behaviors were mostly performed by idea owners in the challenge as opposed to participants, in line with insights from Davenport & Prusak (1998), Majchrzak & Malhotra (2015) and Wang & Noe (2019) on different behaviors along an individual's motivations, background and involvement.

Distributed Experimentation

Within the boundaries of single idea threads, a solution is being developed simultaneously with the development of other ideas in the challenge. This resembles the simultaneous analysis and design of the 'innovative, local solutions' or in other words: distributed experiments in the RA framework (Ferraro et al., 2015). However, as Majchrzak & Malhotra (2014) argue, the little presence of highlighting and combining may result in less insightful solutions. Moreover, it seems that only these various solutions are developed with the ideas in the challenge. However, highlighting successful solutions, discarding unsuccessful solutions, and in turn combining the better solutions has not been observed. Thus, as described in the RA framework by Ferraro et al., (2015), strategic stakeholders could not be observed to integrate solutions, and learn from the experiments in a 'step-by-step' approach.

Participatory Architecture

Lastly, the role of the participatory architecture is more facilitative of the other two strategic elements and will thus be considered in this respect. First, the crowdsource challenge can be said to reflect a 'hybrid forum' to facilitate participation (Callon et al., 2009). The Food Waste challenge is open for stakeholders from all backgrounds to participate, yet questions can be raised to what extent this variety of actors reflects all the actors actually involved in the grand challenge, and to what extent it facilitates 'meaningful collaboration at strategic and

tactical levels' (Ferraro et al., 2015). Citizens and social entrepreneurs seem most present in the findings, while the involvement of governments or larger corporations relevant to the food waste problem could not be observed in the publicly visible discourse. Second, the present technical infrastructure of the platform seems suitable for ideas to be developed simultaneously, yet the integration of knowledge by upvoting, categorizing knowledge or combining entire ideas for synergies is not facilitated. Third, this entire architecture is now limited by the duration of a crowdsource challenge, thus limiting all the previously described dynamics to tackle grand challenges, conflicting with the 'prolonged timespans' of RA (Ferraro et al., 2015).

CONCLUSION

In conclusion, knowledge integration on crowdsourcing challenges may serve as a powerful tool for RA strategies by the parallels that can be drawn. This study has shown how current crowdsourcing initiatives already provide an architecture with open access to a heterogeneous audience in which multivocal discourse can and does seem to occur. In addition, this multivocal discourse occurs on many (partial) solutions that are improved and developed simultaneously. However, the *integration* of these solutions on level 1 to improve the partial solutions, or level 2 to combine ideas and find synergies was mostly absent. Thus, this first key gap - a lack of highlighting and combining in knowledge integration - seems to hinder crowdsourcing to better reflect the practice of distributed experimentation with the top-down learning and combining these partial solutions. A second key gap in this is how the architecture of crowdsourcing challenges seems inadequate to provide a sustainable participatory architecture, as it offers little features to highlight or combine knowledge easily, with a limited time span that causes almost all of the dynamics aligning with the strategic elements of RA to be terminated prematurely.

In short, this study has contributed to a better understanding of the various actions of knowledge integration in crowdsourcing challenges in the context of tackling grand challenges, as well as offer preliminary evidence to further investigate crowdsourcing as a tool to tackle grand challenges. From a practice perspective, management is advised to design the challenge infrastructure and implement managerial practices (e.g. incentives, instructions) along the two key gaps identified by the study to unlock the potential of crowdsourcing as a tool for grand challenges.

Limitations & Future Research

Lastly, as this study offers an initial exploration to connect the two theoretical constructs, future research is required to further investigate and validate the robustness of crowdsourcing as a tool. Useful starting points include the effectiveness of a 'levelled architecture' and managerial practices to increase more highlighting and combining behaviors.

Finally, it is important to remain critical to the effectiveness of the RA framework to tackle grand challenges. However, whilst future studies may continue to build towards increasingly better strategies to tackle these complex yet urgent problems, the RA approach already seems to be a useful starting point to tackle grand challenges. By doing so, it offers a promising way forward.

ROLE OF THE STUDENT

Ilse Hellemans was an undergraduate student working under the supervision of Dr. A. J. Porter & Dr. P. R. Tuertscher during this study. The topic is motivated by the author's strong drive to tackle the grand challenge of climate change by using the potential of digital innovation and is inspired by the expertise area of the supervisors: 'Crowdsourcing for sustainability'. All activities were carried out by the student.

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