Co-creating Computer Supported Collective Intelligence in Citizen Science Hubs

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Abstract. Collective Intelligence system can be conceptualized as knowledge network created by web-mediated interaction amongst individuals with personal knowledge. Citizen Science Hubs are ideal environment for collective intelligence to emerge and can be considered as Collective Intelligence systems. The current research aims to deepen and expand knowledge for designing scientific evidence supported engagement motivation strategies and developing digital supported co-creation methods. Citizen Science aims to bring different stakeholders together and bridge society with science in an institutionalized way by developing Collective Intelligence ecosystem which entails collaboration between all QH stakeholders: the public and researchers/institutes, also governments and funding agencies. The development of crowdsourcing platforms and networks that enable volunteers to contribute to different research projects, the use of machine learning technologies and artificial intelligence may extend ecosystem capabilities, especially those depending on human intelligence. It is essential that citizen science platforms leverage the complementary strengths of humans and machines to take full advantage of the onslaught of data being experienced across the disciplines. The paper presents conceptual model of Collective intelligence ecosystem focusing on human-computer interaction providing insights to support Citizen Science communities to deliver intended intellectual outcomes.

Keywords: Collective Intelligence, Co-creation, Citizen Science

1 ICT supported Collective Intelligence Systems

All the types of human groups can be regarded as a source of collective intelligence. Community, according Luo et al. [1] "refers to any human group in which the members have some common characteristics, share same interests or views, have similar purposes." Lykourentzou et al. [2] define online community as a "system which hosts an adequately large group of people, who act for their individual goals, but whose group

actions aim and may result – through technology facilitation – in a higher-level intelligence and benefit of the community." There is no doubt that the widespread and availability of the Internet is one of the prerequisites for a new form of interconnection, different forms of social cohesion and conditions to collectively build community interactions. Enabled by the information communication technologies (ICT) and under the right circumstances "the communities may exhibit higher intelligent features than a traditional community does because artificial intelligence provides an effective communication channel for massive exchange of data, information and knowledge" [3]. The computation capabilities of the modern ICT also may be of great help for the information processing tasks within the entire community. Similar as in the case of "swarm intelligence" [4] in natural systems, Collective Intelligence systems consist of human beings and supporting computer systems. Human intelligence blended together with intelligent machines enable communities to resolve problems and achieve unprecedented results. The Structural Model of Community Intelligence [1] explains how the community level intelligence may generate from the knowledge-related activities of the participants or the community members. Firstly, the community should "contain a memory system that stores information and knowledge, analogous to the memory system in a human brain. Secondly, the community should have the capability of 'intelligent' problem-solving, i.e. the capability of utilizing the stored knowledge to solve problems. Theoretical insights and empirical research results [5] reveal that at the current knowledge level technological preconditions are important features of the CI systems and evaluating them could be useful in predicting the performance of the system as a whole.

2 Citizen Science Hub as Collective Intelligence ecosystem

Collective Intelligence system can be conceptualized as knowledge network created by web-mediated interaction amongst individuals with personal knowledge. Citizen Science Hubs are ideal environment for collective intelligence to emerge and can be considered as CI systems. Citizen Science (CS) projects involve members of the general public as active participants in research. Essentially, Citizen Science aims to bring different stakeholders together and bridge society with science in an institutionalized way by developing Collective Intelligence ecosystem which entails collaboration between all QH stakeholders: the public and researchers/institutes, also governments and funding agencies [6]. New knowledge, new ideas, found solutions, suggested problem solving methods, shaped up public opinion, structured opinions and views, developed innovations, prototypes, generated added value, etc. are considered to be intellectual capacities of the ecosystem. The development of crowdsourcing platforms and networks that enable volunteers to contribute to different research projects, the use of machine learning technologies and artificial intelligence may extend ecosystem capabilities, especially those depending on human intelligence. The knowledge network embodies the collective knowledge of the community and consist of a technological network or media network that supports information and knowledge transfer, a human network of community members, and a content network of knowledge and information, which is

hosted in humans and computer systems [1]. Human intelligence in convergence with "machine" intelligence create opportunities for network participants to achieve impressive activity results. A range of digital infrastructures (e.g. mobile apps, low-cost sensors, games, and gamification) have been developed to facilitate interaction and communication between citizens and scientist and to expand the scale and scope of project and protocol design, data collection, information delivery, data processing, and visualization [7,8,9]. It is essential that citizen science platforms leverage the complementary strengths of humans and machines to take full advantage of the onslaught of data being experienced across the disciplines [10].

With the aim to deeper understand complexity of relationships at different levels of human-computer interaction in Collective Intelligence ecosystem, conceptual model was developed on the basis of theoretical insights. The framework presented in Figure 1 below provides a holistic view into the Citizen Science Hub as co-creative collective intelligence ecosystems.

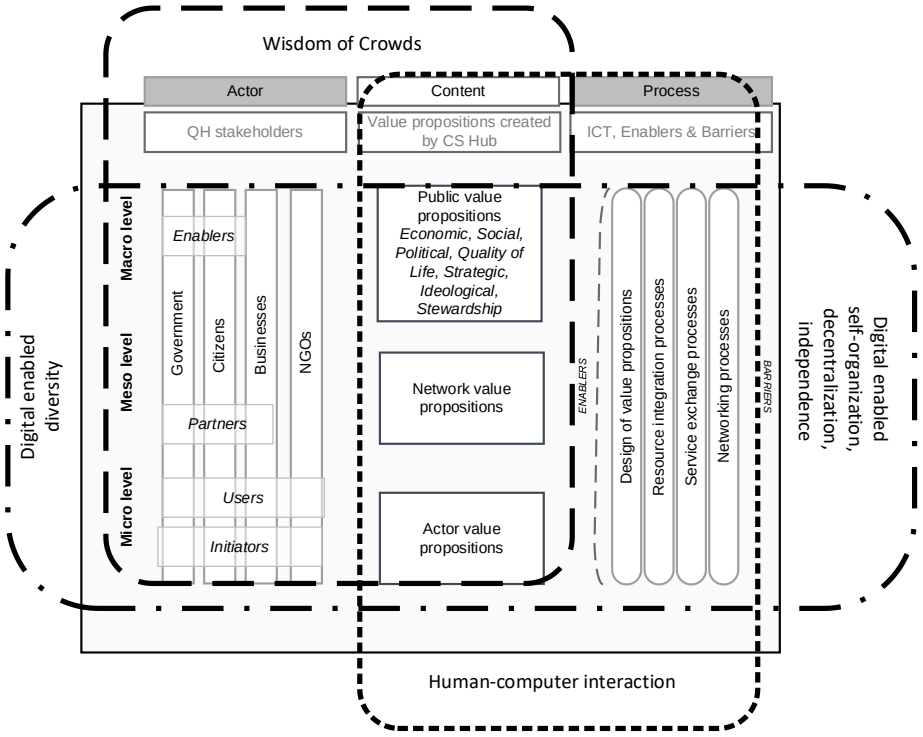

Fig. 1. Citizen Science Hub as a Collective Intelligence Ecosystem

In the context of this research project, Collective Intelligence ecosystem refers to a system in which actors work together to achieve a mutual benefit – public value. The

proposed model has three dimensions – actors, content and processes distributed on three levels – Micro, Meso and Macro between economic and social actors within the networks. Hence, the services offered by the Citizen Science Hubs are only inputs in to public value creating activities in the context of civic society. The Micro level refers to the direct service-for-service exchange, i.e., end-users of the platforms. The Meso level refers to the indirect service-for-service exchange with the external stakeholders i.e. partners or competitors. The Macro level refers to the complex relationships between different systems with diverse interests co-creating public value. No one stakeholder has all the resources needed to reach their goals, and each actor is a potential source of resources for other actors within the ecosystem. Interactions happen through the digital enhanced creation, sharing, obtainment, and integration of the resources. Collective intelligence emerges in the ecosystem when a number of entities work collectively to create mutual benefits by granting access to one another's resources including people, technologies, organizations and information.

3 Conclusion and insights for future research

The long term vision of CI systems is "to fuse the knowledge, experience and expertise residing in the minds of individuals, in order to elevate, through machine facilitation, the optimal information and decisions that will lead to the benefit of the whole community" [11]. As systems become more complex and include more connections between humans and machines, the characteristics of those systems become important in determining the performance and successful development of the collaborations in the system. The challenging task for the researchers is to correlate different factors and to find realizable possibilities for the system performance in these causal relationships.
Collective Intelligence development field requires deeper research from academic and practical point of view. It would be important not only to identify the assumptions affecting development of ecosystem, but also to predict possible evolution scenarios and to define risk areas. Scientific viewpoint and analysis of the influence of social technologies on formation of Collective Intelligence raises many questions. Citizen science platforms and other networks face practical problems pertaining to the existence of a wide variety of technological tools and solutions; however, these pre-conditions do not encourage growth of Collective Intelligence since people do not collaborate, they express their opinion but do not structure it, do not assume obligations to implement decisions, etc.
From the scientific perspective, it is not the analysis of the phenomenon of Collective Intelligence in itself that is important. Future research should focus on the identification of the pre-conditions for the formation of collective intelligence, formulation of holistic conceptions and collection of empirical data. Deeper understanding of Collective Intelligence ecosystem is necessary to support Citizen Science communities to deliver intended intellectual outcomes and to provide a possibility for practitioners to integrate or create new tools and IT based solutions oriented towards societal social values.

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References

1. Luo, S., Xia, H., Yoshida, T., &Wang, Z. Toward Collective Intelligence of Online Communities: A Primitive Conceptual Model. *Journal of Systems Science and Systems Engineering*, 18(2): 203–221 (2009).
2. Lykourentzou, I, Vergados, D. J., Kapetanios, E., & Loumos, V. Collective Intelligence Systems: Classification and Modelling. *Journal of Emerging Technologies in Web Intelligence*, 3(3): 217–226 (2011).
3. Stiles, E.; Cui, X. Workings of Collective Intelligence within Open Source Communities. *Advances in Social Computing*, 6007: 282–289 (2010).
4. Surowiecki, J. *Wisdom of Crowds*. USA/New York: Anchor Books (2005).
5. Mačiulienė, Monika; Skaržauskienė, Aelita. Building the capacities of civic tech communities through digital data analytics // The journal of innovation and knowledge. Madrid : Elsevier Espana. ISSN 2530-7614. eISSN 2444-569X. vol. 5, iss. 4, p. 244-250 (2020).
6. Haklay, M. M., Dörler, D., Heigl, F., Manzoni, M., Hecker, S., & Vohland, K. (2021). Haklay M.., Dörler D., Heigl F., Manzoni M., Hecker S., Vohland K. (2021) What Is Citizen Science? The Challenges of Definition. In: Vohland K. et al. (eds) The Science of Citizen Science. Springer, Cham. https://doi.org/10.1007/978-3-030-58278-4_2
7. Newman, G., Wiggins, A., Crall, A., Graham, E., Newman, S., & Crowston, K. The future of citizen science: Emerging technologies and shifting paradigms. Frontiers in Ecology and the Environment, 10(6), 298–304 (2012)
8. Bowser, A., Hansen, D. L., & Preece, J. Gamifying citizen science: Lessons and future directions. Paper presented at the workshop Designing gamification: Creating gameful and playful experiences, at CHI (2013).
9. Eveleigh, A., Jennett, C., Blandford, A., Brohan, P., & Cox, A. L. Designing for dabblers and deterring dropouts in citizen science. In Proceedings of the 32nd annual ACM conference on human factors in computing systems (pp. 2985–2994). New York: ACM (2014).
10. Trouille, L., Lintott, C. L., & Fortson, L. F. Citizen science frontiers: Efficiency, engagement, and serendipitous discovery with human–machine systems. Proceedings of the National Academy of Sciences, 116(6), 1902–1909 (2019).
11. Kapetanios, E. Quo Vadis Computer Science: From Turing to Personal Computer, Personal Content and Collective Intelligence. *Data & Knowledge Engineering*, 67, 286–292 (2008).