How Collective Intelligence Can Gear Agility with Sustainability

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Abstract. Some emergent research works have identified that Agile methodologies and sustainability goals are, somehow, aligned. This alignment can be advantageously used to implement new transformation approaches with the objective of implementing a more effective adoption of both Agile and sustainably goals in organizations. Studies claim that Agile and sustainability can be geared with team collaboration and learning. Collective Intelligence has proven to be a very powerful tool, to generate solutions to complex problems, because it is able to combine the diversity of knowledge and skills of different actors into better solutions or processes, which can be extended to wider contexts. In addition, individuals participating in any collaborative process, benefit at the level of skills and new knowledge. In this article, the application of the concepts of collective intelligence to support a transformation process in which the combined adoption of the Agile and Sustainability goals is described.

Keywords: Collective Intelligence · Agile · Sustainability · Team Diagnostic Survey

1 Introduction

The UN in its Sustainable Development Agenda for 2030, mentions 17 Sustainable Goals [1], those goals are a concern for our society, and, according to the position elaborated in [2], it could happen that the journey to a more sustainable society is performed in companion with Agile. In the software development world, agility was born to face a needed change in the way software was developed. An emerging interest around agility and sustainability is taking place and providing its first results. Agile, for the software world, was established in the Agile Manifesto as a set of values, and principles, that would guide the execution of practices [3]. Melo and Eckstein [4] have elaborated how, from Agile software development principles and practices, sustainability can be comfortably, and even, necessarily considered. It looks like Agile could not ignore sustainability.

It is interesting to see how this situation also stands in the case of Agile and sustainability in other domains, different from software development. In the case of organizational culture values and agility [5], it happens that sustainability comes hand in hand with agility. It is also the case project management in Engineering [6]. After analyzing literature from different domains, even when a more in-depth research could be needed

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to get more empirical evidence, it looks like agility and sustainability could supplement with each other, one brings/needs the other.

Following [4], values and principles are a gate to sustainability and sustainable development. To understand the relevance of values in Agile, Sommer [7] reports that the adoption of Agile values has a very positive impact in the operation of the transformed to Agile organization. Based on the alignment of Agile and sustainability discussed above in this Section, it could make sense that transformations could consider both Agile and sustainability.

To understand how this transformation, involving Agile and sustainability can be reached, authors in [2, 3, 5, 6], provide us with some results of interest, especial mention to [3], an empirical study. These papers agree that the journey towards Agile and sustainability is supported by a common background, including learning and team collaboration as relevant activities. Learning and collaboration seem to gear agility with sustainability.

Team collaboration and learning are regarded as central issues to Agile. Patterns have been identified, nevertheless, a systemic approach that can be applied to support or get advantage of them [8] does not seem to be feasible, at least in available literature.

Collective Intelligence (CI) is a paradigm that emerges naturally in groups of individuals who collaborate to solve a set of complex tasks or problems; and according to Malone in [9], Collective Intelligence can be defined as the ability of a group of individuals to act in an intelligent way. Collective Intelligence has been used in Agile software development such as by Diegmann and Rosenkranz [10].

Within this current paper we claim that CI can be used to gear Agile and sustainability because its application will help assess and improve team collaboration and learning.

The rest of the paper is as follows, Sect. 2 defines the concepts of Collective Intelligence, Agility, Sustainability, and the relationship between them. Section 3 describes the relationship between Collective Intelligence and Team Learning, providing a background on these subjects. Section 4 is a proposal on how Collective Intelligence could be used to gear Agile with Sustainability. Finally, Sect. 6 include some conclusions and future work.

2 Collective Intelligence, Agility, and Sustainability

Nowadays, ICTs plays an important role in achieving global sustainability goals, reducing not only their own carbon footprint, but also as a tool to find solutions to help reduce the carbon footprint resulting from society's production and consumption [11]. For this, two terms should be considered, sustainable development and sustainable use. On the one hand, sustainable development is based on creating goods and services that are more sustainable during their life cycle, on the other hand, sustainable use is based on creating and promoting sustainable patterns of consumption and production [11].

Therefore, at any stage of software development, we must be able to create solutions with better performance that meet the new global needs of sustainability. In fact, Agile methodologies must begin to consider these new requirements. A first approach is presented by Eckstein and Melo in [4], where they mention that sustainability is directly related to the Agile Manifesto and more specifically to the Agile principles. Taking one

of the Agile values, which says "Our highest priority is to satisfy the customer through early and continuous delivery of valuable software", we can realize that nowadays the definition of "valuable software" has evolved to pick up new needs of citizens concerning global sustainability goals [4]. This means that developers in Agile teams will find themselves in continuous learning considering the three pillars of sustainability [4]: economic, environmental, and social.

And at this point, how CI is related with sustainability? Collective Intelligence is not a new term, naturally emerges from individuals working together, allowing to extend the knowledge extracted locally to a global scale, since through it is possible to learn from the experiences and diversity of other groups, which contributes to identify other ways to solve the same problem or conflict from a completely different perspective [9]. Those things that "works" can be transmitted from the local to the global context, in order to obtain human systems (societies, governments, organizations) with a set of policies, programs, behaviours, actions that produce good results [12]. Thanks to ICTs, new forms of CI have emerged, allowing communities of individuals to use the new infrastructures to transmit, create or exchange knowledge and resources [13]. In [13] the potential of different CI techniques to address different social problems is shown. Although its adoption has not been as widespread as desired, it is shown that the aggregation of knowledge for decision making for the generation of solutions gives better results than if it were done by a single individual. Collaboration seems to be the right strategy to generate solutions that meet the new global objectives [13]. For example, in [14] the authors apply CI through a Serious Game to help generate solutions in which citizens and students participate. Typically, decisions on what to do in public spaces were made by a small group of authorities, architects, engineers, etc. Through tools such as those adopted in [14], with a bottom-up perspective, citizen participation is promoted while improving students' knowledge concerning sustainability by allowing the transfer of knowledge to real contexts. In [15] a similar idea is presented, proposing a project whose main objective is to use Cultural Heritage to create a collective decision-making network to assist public and private entities and citizens. The reuse of Cultural Heritage has allowed sustainable urban development, mitigation of the adverse effects of climate change, waste reduction and much more. This, added to the new techniques in Collective and Artificial Intelligence, allows the generation of richer information networks that contribute to the creation of solutions with less development time and better resource management [15].

As can be inferred CI, agility, and sustainability, have a lot to do in common and are mainly related to the transfer of knowledge between individuals or diverse groups, therefore directly correlated with team learning, which will be discussed in more depth in the following section.

3 Collective Intelligence and Team Learning

Concerning problem-solving, there are various perspectives, such as technology-centric, human-centric and CI centric, but the collective intelligence-perspective has proven to be extremely useful when solving problems for the welfare of humanity [16]. Complex problem solving in science, engineering and business has become a highly collaborative

effort, where the collaboration and expertise of individuals from different disciplines is required. Teams of scientists or engineers collaborate together on projects using their social networks to gather new ideas and feedback [17]. CI will also emerges from groups of individuals collaborating together [18, 19], and according to Barlow in [20] CI is the ability to perform consistently well in a wide variety of tasks. Such is the case of Collaborative Innovation Networks (COINs) defined as the core of collaborative knowledge. They are highly interdisciplinary collaborative networks, which combine a large number of fields such as CI or crowdsourcing [21], driven by swarm creativity, where people work together in a structure that allows the creation and fluid exchange of new ideas [21]. The CoSpace, are spaces created as a collaborative work tool for the needs of industry, which focuses primarily on creating collaborative engineering spaces to plan, design and build new products for the automotive, space and construction industries [22].

Our capacity to generate better solutions depends on teams of scientists, engineers, or knowledge workers and their networks [17], in fact, the interesting thing about these collaborative networks, no matter what they are called or where they are applied, is the group intelligence and the exchange of information and ideas. Within collaborative groups, it has been determined that there is a "general intelligence" that arises from correlations between people's performance on a wide variety of cognitive tasks [23], similarly, it has been shown that the structure of social interactions can enhance or hinder the achievement of objectives [17]. In fact, the ability to solve complex problems could be greatly enhanced by improving the instrumental and expressive links between individuals [17].

Within Collective Intelligence, it has been found that individuals who participate in groups benefit. In fact it has been found that groups with high CI develop greater shared attention, transactive memory and a better problem-solving process [24, 25]. Thus, group learning emerges from collaborative work [26]. Collaborative teaching or also called co-teaching has been shown to be a pedagogical strategy of high value and potential as a support tool in the classroom, or as a strategy for the professional improvement of the individual's skills and knowledge [27]. Edmondson et al. in [28] classifies team learning into three distinct foci: performance improvement, or the speed at which groups improve their performance; task mastery, or how team members coordinate knowledge and skills to accomplish tasks; and group process, or what drives learning-oriented behaviours and processes in teams.

In [29] it has been shown that groups with higher CI improve their performance rapidly, indicating that they have learned faster than groups with low CI. It is also suggested that even a moderate level of cognitive diversity helps to improve overall group performance for different tasks, as high levels of cognitive diversity hinders the transfer of information between members, thus hindering coordination and collaboration per se [29].

4 How Collective Intelligence Could Be Used to Gear Agile and Sustainability

In terms of Melo and Eckstein, continuous collaboration allows the self-organization of teams and therefore the discovery of new market needs [4] and as we have already seen

in the previous sections, market needs have already changed and CI can be the gear that helps the transfer of knowledge through team learning to Agile teams. In other words, CI allows the introduction of a new Stakeholder which is the welfare of all citizens and can promote the adoption of new global objectives within Agile Methodologies through Team Learning, making Sustainability a new tacit or implicit requirement within any IT or Software development. The Table 1 shows how Agile principles and values fit with CI.

Table 1. Relation between Agile values/principles and collective intelligence

Agile value/principle	Relation with collective intelligence
Transparency	CI takes knowledge from the local context to the global context
Self-organization	CI promotes self-organized teams
Continuous learning	CI contributes to team learning
Constant customer focus	CI connects all the required stakeholders

Having new stakeholders and a new implicit requirement, it is possible to see that CI can work not only as a tool, but also as another member of the team, collaborating as Scrum Master/Coach regarding Team Learning, Organization and Values and as Product Owner transferring and curing the knowledge of the new stakeholders, to transfer them to the Agile Team. In this way the knowledge that is generated can be transferred from the local to the global context, adapting those solutions and therefore the Agile methodologies that work in the different contexts with the goal of achieving the global objectives of sustainability in the economic, environmental, and social axes, always keeping in mind the terms of use and sustainable development (Fig. 1).

Fig. 1. CI gearing Agility with Sustainability

Usually teams with better performance or with higher CI generate better solutions and, in fact, CI is a good predictor of the performance that the group will have [29], Therefore, assessing or measuring CI can be an indicator that Agile teams are adopting sustainability goals.

Experiments can be made with Agile Teams to confirm that CI can effectively contribute to Agile teams, the results of the experiments can be measured from several dimensions: first, using the Team Diagnostic Survey (TDS), the collaborative work of Agile teams can be evaluated, to determine how they work, how their workflow is and how their internal processes can be optimized. Second, the TDS also allows to measure the interpersonal process and collaborative learning, so it would be possible to evaluate the increase of skills and the quality of learning of new sustainability concepts, as well as how these new concepts are transferred to the software during the development and deployment stages. This whole process can help to understand how to extend Agile methodologies so that they can be adjusted to the new sustainability goals. In the following section how, CI can be measured is described more in depth.

5 Measuring Collective Intelligence

To evaluate Collective Intelligence in terms of group performance, Woolley et al. in [23] applies a set of tasks extracted from the quadrants of "McGrath task Circumplex" [30], which is an established taxonomy for group tasks; such tasks may include visual puzzle solving, brainstorming, moral judgments and negotiating under limited resources. Engel et al. in [24], uses the task battery used by Woolley et al. in [23] and also the MacGrath [30] and Larson tasks [31]. In [25], psychological sensing is used to understand the collaboration dynamics. This sensing provides a finer degree of understanding about the participants' experience during the collaboration process, facilitating awareness among peers or partners [25]. Variables such as group satisfaction and cohesion have been considered as reliable indicators of the team's level of rapport, even in online collaborations. Furthermore, authors in [25], also propose measuring the group satisfaction, in order to determine if there is some correlation between CI and the satisfaction perceived by the members of the group, to achieve this, six items which reflects the quality of the group collaboration through an adaptation of the "Team Diagnostic Survey" [32] are used.

The Team Diagnostic Survey or TDS, is a tool used for assessing the properties of a team, and was specifically designed to be useful in scholarly research on teams and in the practical diagnosis of teams' strengths and weaknesses [32]. According to [32], the team effectiveness is must accomplish these criteria's:

- The productive output of the team meets or exceeds the standards of quantity, quality, and timeliness of the team's clients.
- The social processes the team uses in carrying out the work enhance members' capability to work together interdependently in the future.
- The group experience contributes positively to the learning and well-being of individual team members, rather than frustrating, alienating, or de-skilling them.

6 Conclusions and Future Work

Achieving sustainable goals, requires the highly collaborative effort and work of Agile teams and stakeholders, to adjust to the new market's needs, at this point Collective intelligence has demonstrated its potential in many areas when generating solutions to

complex problems and extending local knowledge to a global scale, allowing the rapid adaptation of processes and methodologies. Collective intelligence, sustainability and Agility have a common point which is the transfer of knowledge, which can be measured through team learning.

Agile and sustainability share a common ground: they can supplement each other by an appropriate team collaboration and learning scheme. Collective intelligence can be used as a framework to convey this transformation. Collective intelligence, besides, can be of help, to understand how teams work, and how work processes can be changed to get improved. All this, thanks to the use of tools such as TDS, that allow us to assess team performance.

CI has proven to fit into the Agile manifesto and its values and principles, so CI concepts can be applied and transferred to Agile methodologies to achieve the new global goals concerning sustainability. CI allows to introduce Sustainability within Agile methodologies as a new implicit requirement in software development, where the new stakeholders are the whole humanity welfare.

As mentioned in the previous sections, sustainability in Agile teams has a lot to do with group learning, where collective intelligence has proven to have tools that allow to enhance group learning and not only evaluate group work, but also provide feedback on those aspects that can be improved. All this in a framework of Collective Intelligence among Agile teams can allow the adoption of sustainability goals, within Agile methodologies, for subsequent adoption in a global context.

Finally, experiments are needed to confirm the potential of CI to engage the concept of Agile in Sustainability and, perhaps, to help update the Manifesto.

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