Chapter 13
Participation and Open Innovation for Sustainable Software Engineering

Martin Mahaux and Annick Castiaux

13.1 Introduction

For decades, economists have put innovation at the core of economic growth. In their classical conception, sustainability is the capability to maintain and develop the level of economic performance of the society. In this regard, entrepreneurs who creatively change the rules of the economic game by proposing innovative technologies and businesses are key actors that support growth [45]. The ICT sector has obviously been a key provider of this kind of innovation in the past years, the new information and communication technologies being at the foundations of a transition towards a post-industrial economy.

More recently, the acceptation of 'sustainability' has changed in order to take into account the increasingly important issues of sustainable development. In addition to their economic challenge, firms have to deal with growing environmental and social requirements from their stakeholders, that is, actors that affect or are affected by the actions of the firm. From the firm's side, environmental and social requirements can be seen as additional constraints to the firm's innovation space, limiting its opportunities to develop and grow, that is, to reach its own sustainability. In contrast, it can also be seen as an enabler for differentiation and consequently as a competitive advantage.

In this context, innovation processes should be thought differently, as the complexity of sustainability issues asks for systemic approaches, going beyond the borders of a given organisation and integrating economic, social and environmental objectives that are very often antagonist. The purpose of this chapter is twofold: first, we want to demonstrate the importance of participation and openness in innovation processes integrating sustainable development, illustrating it with a prominent example in the software domain—open source software (OSS); second,

M. Mahaux (✉) • A. Castiaux
University of Namur, Namur, Belgium
e-mail: martin.mahaux@unamur.be; annick.castiaux@unamur.be

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we want to propose elements of a methodological framework supporting participation in the context of software requirements engineering.

13.2 Participation, Openness and Sustainable Innovation

13.2.1 Why Is the Innovation Process More and More Open?

13.2.1.1 Openness and Participation to Enlarge Innovation Sources

Traditionally, the innovation process was managed in a closed manner, inside the firm's borders. We see two reasons in this closure. First, firms wanted (and still want) to protect the competitive advantage they build through innovation, as interactions with other actors can lead to knowledge spillovers and intellectual property losses. Second, technological firms based their development on knowledge and experience accumulated through the years, in which they found the main sources of innovation. They did not see opportunities outside their usual field. This behaviour is often called the 'not-invented-here' effect. Even inside the firm, the involvement in the innovation process was very limited, as it was the prerogative of some categories of personnel, mainly researchers developing new technologies in the R&D department or engineers conceiving and improving processes in plants.

Progressively, things changed as firms faced highly publicised failures due to their lack of openness in their innovation process. A well-known example is the case of Xerox in the late 1970s. Xerox launched a research centre—PARC, Palo Alto Research Center—in 1970, where excellent and creative computer engineers developed inventions that were never commercialised by Xerox. Instead, these ideas served other companies, such as Apple. Xerox exited the computer market in 1975, refocusing on its core business: printing [17]. One of the reasons of this failure is the lack of integration of the R&D function with other functions of the company, which did not allow Xerox to transform creativity into innovation. More recently, firms realised that every person in the company is able to propose interesting ideas that can lead to innovation. A company like Renault, for instance, challenges its personnel on tricky technological problems, associating human resources in the early stage of the innovation process and using such participatory approach as a motivation factor [9]. Such a participation in the innovation process can even go beyond the borders of the firm, including customers, users or citizens. Several motivations can explain this trend to open the innovation process:

- Thinking out of the box: Firms—especially if they are established—are influenced by their culture, knowledge and competences. Opening innovation to external sources of ideas helps them to think out of the box. This is the principle of inbound open innovation [10].

- Practising cross-fertilisation: Associating multiple profiles in idea generation allows to explore unexpected areas and to combine complementary knowledge backgrounds [6]. In increasingly complex products, this combination of multiple knowledge sources has become mandatory.
- Combining problem and solution focus: Faced with the same problem, a user and a supplier think differently. The user wants to solve a problem (whatever the solution), while a supplier wants to sell a solution (as close as possible from his expertise). Combining these problem and solution orientations seems to lead to better innovations, satisfying both parties [23].
- Assessing technology: Collaborating with users helps to assess technology on various criteria (quality, user-friendliness, design, etc.) and avoids market failures.
- Benefiting from innovative attitudes: A lot of people are innovative and like to contribute to a creative process. They value this participation in itself, as studies in the open source community have shown [22]. Integrating them in the innovation can be a factor of motivation for human resources as well as a method of loyalty development for customers.
- Propagating standards: When developing breakthrough technologies, there is a strong risk that competitors develop similar technologies concurrently and that one of those competitive technologies become the dominant design (the standard), making all other technological designs irrelevant. Cooperation with other actors (users, partners, suppliers) is a way to reduce such a risk [1].

For various reasons that we develop in this chapter, sustainability will greatly benefit from these aspects of open innovation.

13.2.1.2 Openness and Participation to Involve Stakeholders in the Strategy

Freeman proposes an alternative view of strategic management [14]. Beyond a performance path oriented mainly to the satisfaction of shareholders, he demonstrates how other parties with whom the firm is in relation have to be taken into account to optimise the chances of success on a marketplace. At a moderate level, the firm can consider its stakeholders in an instrumental way in order to enhance its performance. Especially in uncertain periods and environments, taking into account the viewpoints of key stakeholders opens alternative and more informed strategic paths. However, Freeman recommends a more radical change: strategic management should integrate stakeholders intrinsically through a strong partnership. In this view, the interests of stakeholders are taken into account in decision making even before strategic decisions, as ethical foundations of the strategy. This is the key principle of corporate social responsibility (CSR).

Such a point of view questions the classical definition of performance. An intrinsic partnership with stakeholders considers that satisfying stakeholders' interests must be taken into account when evaluating the firm's performance [13]. This

means that performance is not only economic but has to integrate dimensions that are valued by stakeholders, in particular social and environmental dimensions. In this sense, participation is strongly linked with sustainability.

13.2.2 Participation, Openness and Sustainability: Is It Possible to Innovate for Sustainability in a Closed View?

Sustainable development issues can only be considered and tackled using a systemic approach of innovation. As a matter of fact, such issues necessarily involve multiple actors that have an impact on their mutual performances because of their strong interactions, both on environmental and social matters. In this section, we demonstrate the necessity to adopt a systemic and open view, beyond the firm's boundaries. We consider two levels of analysis: the global economy and the firm in its value chain.

13.2.2.1 Sustainability and Innovation at the Global Economy Level

Sonntag shows that environmental and social challenges require a global change in consumption modes and technology developments, as both co-evolve [46]. Traditionally, firms try to continuously increase their economic performance and to grow. To meet growth, firms innovate, developing technologies allowing them to produce more at lower costs and with shorter life cycles, in order to enhance their performance, maintain their leadership and ensure their survival, that is, their sustainability. Once they are engaged in a technological path, the cumulative nature of the innovation process and the importance of their investments in a set of dedicated capabilities will affect their future strategic choices and, by 'ricochet', have an impact on the whole industry (by imitation) and on their markets (which become used to some consumption behaviours). This lock-in effect [4] has led to dominant technological trajectories: since the beginnings of mass production technologies after World War II, this trend has increased, notably thanks to information technologies. Cheaper goods and reduced production cycles have changed our consumption habits, which in turn have changed firms that must meet consumer requirements to survive.

Moreover, competitiveness policies developed by governments are based on advanced manufacturing technologies. Even current sustainable policies are embedded in this paradigm: they focus on limiting environmental damages and integrating sustainability criteria into organisation decision making, trying to demonstrate that clean production and eco-efficiency lead, in the end, to economies for the firm. However they do not question the acceleration of consumption and the subsequent low-cost manufacturing. Of course, this race in production and

consumption cycles is damaging for macro-sustainability, as it increases aggregated use of natural resources [21].

Alternative paradigms are possible. For example, the extension of product durability could lead to a reduction of the global consumption of resources. However, this requires a change in business models, where value is created and captured in a different way. In particular, services with added value and co-creation with customers offer alternative opportunities of revenue. These two possibilities ask for collaborative (open) approaches beyond the traditional manufacturer–consumer unidirectional relationship.

13.2.2.2 Sustainability at the Value Chain Level

In a seminal paper, Hall demonstrates the systemic nature of environmental innovations that involve not only the firm but its whole supply chain, as well as other actors affected by its environmental impacts [19]. He underlines that innovations developed to take into account environmental considerations—that he calls 'eco-innovations'—cannot easily emerge spontaneously. He proposes a systemic view putting at stake different agents, inside and outside a firm's supply chain, who influence each other towards the emergence, the development and the adoption of such eco-innovations. He identifies two types of pressures favouring eco-innovations, as illustrated in Fig. 13.1.

First, the vertical pressure goes backwards through the supply chain, from the end customers up to the producers of raw materials. The importance of this vertical pressure depends on two major factors: the power of the agent on upstream agents in the chain and the competences of this agent concerning the technical knowledge at stake in the choice between alternatives. If an agent has such a power and the asymmetry of information between this agent and its suppliers is sufficiently low, this leads to interfirm innovations and systemic improvements. However, this vertical pressure is not sufficient to foster eco-innovation. As a matter of fact, externalities, should they be positive or negative, are not taken into account by the actors of a given supply chain. To favour the integration of externalities in the eco-innovation processes led by firms, an additional pressure has to play its role: the

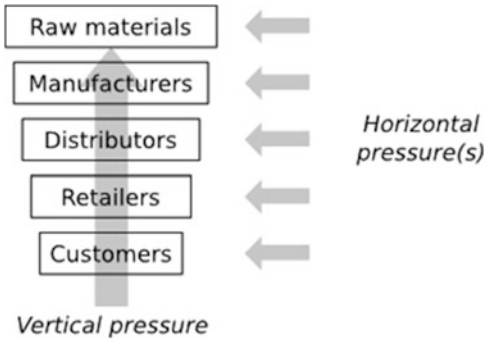

Fig. 13.1 Pressures favouring the emergence of eco-innovations (adapted from [19])

environmental pressure, represented in Fig. 13.1 as the horizontal pressure. Exerted by organisations, which are external to the considered supply chain (e.g. governmental authorities, NGOs), this pressure is motivated by externalities, as the environmental impact of industrial activities. It takes the form of regulations, rules, quality labels or reputation threats. This horizontal pressure is local, as it impacts a given firm or a given group of competitors. Along the whole supply chain, levels of pressure are variable, which has only a limited impact on the whole supply chain. These two pressures, horizontal and vertical, are complementary conditions to the successful emergence of eco-innovations [19].

13.2.3 Open and Participatory Innovation to Integrate Stakeholders and Reach Sustainability

The preceding discussion leads to the conclusion that innovations favourable to macro-sustainability should integrate as much as possible the firm's stakeholders. Such participative approaches of innovation should involve internal (employees) and external (users, suppliers) actors in a co-innovation process. This helps the firm to integrate key elements in new technologies and services, favouring the adoption of the innovations. So, not only does participatory innovation meet the stakeholder integration necessary for macro-sustainability, but it is also favourable to micro-sustainability, providing the firm with competitive advantages that it obtains from a better understanding of customers' needs and suppliers' possibilities. Moreover, associating the employees in the innovation process has also been demonstrated as a positive factor for the intrinsic motivation of employees, which benefits both the social sustainability and the efficiency of the firm.

Open innovation [10], which is presented as a shift of paradigm in the way innovation is practised by firms, can also favour macro-sustainability. On the one hand, inbound open innovation, which consists in seeking sources of innovation outside the firm, should strengthen the vertical pressure given by Hall and raise awareness of cultural changes, for instance, in consumption patterns, to begin a virtuous cycle between sustainable consumption and production modes. On the other hand, outbound open innovation should favour the propagation of good innovation practices and sustainable technologies. Once more, however, political intervention is required to support alternative performance values. If open innovation can help to meet the conditions of macro-sustainability, does it favour micro-sustainability? Firms listening to their environment (thus using inbound open innovation) avoid to be surprised by new trends they would not have anticipated. Moreover, outbound open innovation helps the firm to focus on core competencies while leaving space for curiosity and creativity, only keeping the innovative results that can reinforce the firm's competitive advantages. In this perspective also, open innovation is favourable to micro-sustainability.

13.3 Understanding Participation and Co-creative Processes in Socio-technical Systems Design

When building a socio-technical system and in particular software-intensive systems, requirements engineering (RE) refers to the activities through which business problems and solutions are defined, in contrast to implementation activities. While other activities of the software development process may be more of a specialist affair, the RE phase relies heavily on every stakeholder, in particular the user. Indeed, the requirements discovery process can be seen as a process of collaborative creativity [29]. Consequently, participation is always present, in a more or less intense way. The question is thus not whether or not to use participatory processes, but which ones and to which participation degree. This section explores the concept of participation in more detail.

13.3.1 Governance for Participation

Citizen participation has been classified by Arnstein [3] in a number of levels, from pseudo-participation (non-participation) to full citizen control, in raising the level of power given to the citizen. Thirty-five years and several criticising papers later, researchers have augmented this vision with a more subtle way of assessing participation levels. The quality and methods of involvement as well as the type of people involved have notably been lacking in Arnstein's model [16, 50]. These more recent works indicate that there is no simple way to assess the level of participation. They, however, can inspire a simplified multi-ladder framework for describing various participative degrees in the RE process, as illustrated in Fig. 13.2. It focuses on *who* will participate (how many different stake areas and how many representatives from each category will be represented in the various discussions), *how* participation will be facilitated (how frequently, how directly, how qualitatively), *how far* participants will be allowed to influence decisions (from bare consultation to real decision making—this corresponds to Arnstein's ladder) and *on what* matter(s) participation will be allowed (low-level details, high-level objectives or everything that is in between). This framework allows one to assess a

Fig. 13.2 Ladders of participation in RE

level of participation for every RE process, so we now understand better what a participative RE process may mean.

We may thus define 'participative RE processes' as those where stakeholders from various areas of stakes are expected to actively work together to discover, validate, document or analyse requirements elements. A process is considered more participative if more people from more stake areas are involved; if they interact more frequently, in a richer and more direct way with each other; if their potential influence on decisions is bigger; and if they are allowed to influence on more topics.

We refer to *governance* as the way the participative process is managed to reach the desired participation level. The first condition for a successful participative process is an adequate stakeholder selection. Fung describes the five main stakeholder selection techniques in citizen participation [16]:

- Fully open self-selection (anyone may register)
- Self-selection augmented by selective recruitment (open but some less represented areas are recruited)
- Random selection
- Lay stakeholders (unpaid representatives, e.g. neighbourhood association representatives)
- Professional stakeholders

The fully open selection method is known to over-represent some stakeholders; augmentation by selective recruitment is supposed to lower the bias. Using unpaid representatives enables to reach people that have an interesting mix of strong visions, expertise and field experience, while professional stakeholders bring even more expertise and visions—at the risk of being more partial. The parallel with RE is only limited: it applies only to mass-market-driven products, that is, those that target an important number of buyers. The way stakeholders are involved in such projects has evolved strongly. Many developers now tap in the wisdom of the crowd, using information networks to involve a large amount of users and gather new requirements, in the form of feedback on existing products. Some more sophisticated mechanisms enable users to request and vote for specific features to be implemented. Open source communities are the most radical in this direction, offering full-fledged forums and voting schemes to discuss feature requests. Studies have shown that communities at large drive the future of products [37]. The structures implementing the 'fully open' selection pattern have to live with its main drawback: a highly biased population participates, mostly made of tech-savvy people. The perceived lack of usability of open source solutions for non-tech-savvy people might come from this bias. Commercial development may enjoy more professional market survey practices, including a mix of the four selection techniques, which is probably a more profitable cocktail if managed adequately.

Whether or not the product is a mass-market one, there is a need for the participative process to tap on a variety of stake areas. Collaborative creative processes gain richness when the creating team is sufficiently diverse. More participative processes will include and involve as early as possible representatives from the users, customers, sponsors, developers, regulators, experts, etc.

Once the right people are selected, the frequency and richness of the interaction between them will be crucial in shaping the participative process. Do we just ask people to send a comment once via a software distribution platform (like Google Play or Apple's App Store)? Do we allow discussion on a forum in the way open source does? Or do we invite them to take part in creative requirements workshops? These are very different ways to interact. From expressing preferences, through developing them, to building together a consensual solution, there is a wide range of possible participation techniques. More participative processes will tend to support the latter. In this case, political literature will usually talk of negotiation or consensus seeking [16]. In our opinion, however, there is a large spectrum between pure negotiation and creative consensus making. In the first end of this spectrum, the conflicting views are competing, while in the second end, they are enriching each other. Instead of reaching a deceiving middle-point compromise after negotiation, co-creation encourages to use conflicting views as the source for creativity, exploring new dimensions to reach a consensus that is seen by all as better than what each had originally in mind. While crucial in order to yield the best fruits out of participation, switching from negotiation to co-creation is however a step that is not easy to take, and we will suggest a methodological framework for this in Sect. 13.5.

Finally, we can assess the influence of the participative process on the final decisions. More participative processes allow more power to the group, on a broader scope of decisions.

13.3.2 Promises of and Obstacles to Co-creative Processes in Requirements Engineering

Beyond the impact of participatory processes at macro- and microeconomical scales described in Sect. 13.2, the importance of collaborative creativity in RE [29] leads us to think that more participatory approaches to RE will indeed reach better results, more efficiently, as they suit better the natural participative nature of the problem at hand. But further, what is 'better results'? In our context, we are probably interested in 'more sustainable systems', that is, systems that perform better in terms of economical, ecological and social values. First things first: as far as a system that does not bring value to its users is worth trashing, we may confidently conclude that 'sustainable systems' are at least systems that suit the needs of users, which is the core objective of RE as a discipline. Beyond that, sustainable systems will have to take ecological and social requirements into account.

Studies in several domains lead us to think that, indeed, participation has a strong potential to provide more sustainable systems. However, this will not be automatic, and many obstacles have to be mitigated. We develop below an initial argumentation, building on studies in the social development and journalism domains.

13.3.2.1 Promises

Firstly, it is worth noting that in social development projects, participation is seen as being a component of sustainable development [35]. In this discipline, participation has long been seen as a must, not only to ensure acceptance but also as a way to empower people, consequently leading to a better control of their own lives in the long term [28]. A similar pattern exists when, in a company, participative innovation is fostered, leading to empowerment and more satisfaction [53]. In short, we can say that successful participation will lead to long-term empowerment, which in turn supports social sustainability, as having control of one's life is a crucial human need and right. Empowerment also means power to act and think by oneself, thus retrieving an active role in the society, potentially leading to more responsible behaviours. The power to create is seen by many as a core human asset. Creating in groups rebuilds links in a society that is missing them more and more. It has the potential to revive the feeling that we are interconnected, and all depend on each other, on this single planet, which is likely to reinforce responsible behaviours too.

Empowering people also relates to democracy. Many experts estimate that democracy urgently needs to be revived in order to offer the world a chance to adequately tackle the century's challenges, and many lean towards participative processes as the best chance in this domain: participation efforts in this sector have shown that sustainable development indeed needs participation [44]. Both in Africa and in Belgium, participative governance is shown to work well and to relate to sustainable decision making from involved citizens [28, 35]. Those works also indicate that projects using successful participation have a better acceptance rate, last longer and consequently have a stronger impact. This relates to sustainability in that projects that are not accepted or short-lived represent an important waste of resources and energy.

Further, cases illustrate how participation allows deconstruction and creative reconstruction of problem frames, by allowing circulation of the problem in various dimensions and spaces. Participation helps to open up the solution space and let us come to richer solutions that cope with more objectives and constraints, including sustainability constraints that were sometimes out of the initial scope, before the participation [35]. Doelle and Sinclair also advocate that a consensus-making form of participation will be more efficient and lead to more sustainable outcomes than an a posteriori assessment one [11]. Journalists also point to promises from participation, imagining the discipline as a conversation rather than broadcasting [2], nurturing better democracy. People are ready to participatively fund independent journals and are shown to do so for contributing to common good and social change [18].

13.3.2.2 Obstacles

It is clear that participation is not automatically a success. Real participative processes may be rich but always cost time and are not always possible or even desirable. The first problem with participative processes concerns the possibility for the participation to be controlled by a certain type of people, more skilled or culturally stronger. The idea that participation is a discussion forum without rules must thus be rejected, at the risk of seeing the stronger impose its opinions by influencing others in a way or another [35]. Lyons et al. indicate experiences where participation failed for such reasons [28].

But even if there is no such strong person or group, the risk of seeing participants fighting for their own personal, local, short-term interests exists. In these circumstances, the process will be, at best, inefficient. Lyons et al. also show such examples in African development projects: where no democratic and transparent cultures and infrastructures were in place around the project, the participation failed to bear its promises [28]. Participative processes are indeed vulnerable to malfunctioning environments. There is sometimes a huge work to accomplish before the environment is ready for participation. The failure mentioned above draws this conclusion, along with failures in participative journalism: Goode indicates that *people and systems, including software running at major crowd-media platforms, have to make their way* (in order to yield results from participative processes) [18]. In other words, we are not there yet, and the road is not as easy as some would like to let it think. In many places, we live and work in a culture that is focused on the individual, on fighting for one's own ideas, on competition. In particular, in the innovation sphere, competitiveness is still seen as the main objective of most innovation initiatives. Education too is still mostly centred on the individual and on pragmatic skills, rather than on relational skills. Software education, in particular, is still focusing on individual and technical skills, underexploiting the softer and more relational aspects of the discipline, despite some attempts to tackle these problems [40]. Providing training and education in requirements engineering and focusing on human and participative aspects, it is the author's experience that practitioners and students alike have an important gap to bridge in order to be able to exploit the full power of collaboration.

Finally, we underline that if participation is to lead to more sustainability, beyond the positive social aspect of empowering people, we need participants who care about sustainability. The various cases of urban development in Belgium showed that involving a greater public did bring environmental concerns to the front, while experts had neglected some of these aspects. In general, participation relies on strong stakeholder analysis, which we have been used to in requirements engineering. In the case of sustainable systems design, we need to ensure that some stakeholders will stand up for sustainability concerns [41].

In short, we can say that real collaboration is not the norm and that it represents an important paradigm shift at various levels. Participation is a fragile process that

needs to be protected and supported, requiring new infrastructures, mindsets and skills.

13.3.3 A New Role for Experts

A common concern is about the quality of work that can be achieved by amateurs participating and the place that professionals, or experts, should take in the process. The example of online medical forums (a form of participative medicine) is probably making this problem clear. Bypassing doctors and mutually diagnosing and medicating each other online can potentially be extremely dangerous. Similarly, information relayed by microblogging platforms (a form of participative journalism), escaping the journalistic validation, has the potential to convey wrong information at a dangerously rapid rate [18]. Crowdsourcing cars (participative engineering) is nice but should not mean forgetting centuries of engineering to reinvent the wheel.

Consequently, participation must not be seen as excluding professionals and experts from the process, as it tends to be done in the examples above. Instead, we have to reinvent the relation between experts and the public/users/audience. This relation cannot be unidirectional, from top to bottom anymore, but places experts and professionals at the centre of a discussion: they have to act as facilitators and consultants. For example, a participative policy-making effort led in Belgium had invited experts from the academy and industry to present the state of the art and answer questions in the various areas of expertise that the 1,000 selected citizens would discuss. The process was managed professionally and employed trained facilitators [54]. So neither do we reject experts nor do we give them the power to decide on their own: we use them as facilitators and consultants. Journalists cross-checking and validating Twitter feeds to provide accurate uncensored information are another example of a new relation between experts and the public.

13.4 Case Illustration: Open Source Software

13.4.1 Open Source Software: Open and Participative

Open source software (OSS) is a paramount example of open and participative efforts for developing software-based systems. After exploring the notion of open source in terms of participation and openness, we will discuss the effect that this movement has had on innovation and sustainability.

13.4.1.1 Openness

OSS is, of course, by definition open: it allows software to be freely used, modified and shared. There are, however, various levels of openness, as indicated by the many flavours of open source licences. The open source initiative publishes the definition of what constitutes open source and validates open source licences as compliant to their definition [56]. This definition is made of ten items that are directed at ensuring that OSS plays its role in the collaborative evolution of software, involving as many participants as possible, including commercial ones.

13.4.1.2 Participation

As we have mentioned above, participation in OSS mostly follows the fully open self-registration paradigm. Various kinds of stake areas are represented. Coders are the most prominent group, but non-coders also participate, mostly through writing the requirements. In an attempt to understand user participation in writing the requirements for OSS, Noll traced features from first mention to release. The results confirm the importance of user participation in open source projects [37]. There is a public, open role in setting the agenda for OSS, whereas in closed software this was not the case: profit-related objectives would always be the main driver.

The fact that developers with all sorts of skills, origin, background and motivation co-construct software is core to open source. OSS licences ensure that the openness in that regard is total. The only restriction is then sociocultural: only a fragment of the population is skilled and equipped for participation. However, the barrier is lowering quickly, as equipment gets cheaper (thanks to open source hardware and software initiatives) and software education and resources get available on the Internet (thanks to open and/or participative education initiatives).

The richness of interactions of collaborators in OSS projects is diverse. It is rarely direct; most interactions happen via online interfaces that have various levels of richness in the discussions they can support. It goes from classical forums through ticketing systems (e.g. [55]) until clustering and voting mechanisms or specific distributed requirements gathering platforms (e.g. [34]). Online discussion can never support a consensus process as well as a well-facilitated workshop can. But in the context of massively distributed RE, this is probably as good as it can be.

Concerning the power that is given to participants, the term *forking* denotes the possibility for anyone to make a copy of a project and continue to develop it in parallel with the original project. Studies have shown that this pattern obliges project leaders to listen to their community, giving them a formal power that avoids dictatorial situations to the benefit of more participative situations [38]. This also allows for a situation where the scope of participation is total: participants may decide from high-level strategic options until code line level details, just by forking if they do not agree with the current direction.

13.4.2 Open Source and Innovation

There is a common critique of open source projects: they are thought to merely copy other software, making it free but of lesser quality. A typical example of this is the famous OpenOffice project, based on the even more famous Office suite from Microsoft. However, in 2007 already, Ebert [12] summarised 3 years of 'open source' column in *IEEE Software* with an article 'Open Source Drives Innovation'. He underlined that open source components, such as operating systems, databases, application servers and Web servers, are at the heart of an immense amount of innovative systems. But more, open source has brought innovation in the software world by changing the way we develop systems, augmenting the quality, revolutionising software architecture, supporting standards, re-establishing fair competition and reinventing business models.

Another critique to open source is that it facilitates imitation and thus results in lower value for the inventors. In 2008, Pollock [42] examined the relative performance of an 'open' versus a 'closed' regime and explicitly characterised the circumstances in which an open approach, despite its effect on facilitating imitation, results in a higher level of innovation. The outcome is strikingly simple: when open source reduces the cost of innovation at least as much as the cost of imitation, open regime is supporting innovation. This is frequently the case in open source thanks to user involvement, crowd development, code reuse, etc. And this is not even taking into account business model innovations that have brought many additional advantages to the first mover, supporting innovation even more by augmenting the value of it for the inventor.

More recently, Rayna and Striukova [43] compared the performance of open source and patent pools in the open innovation context. Patent pools are a way to pool patents from various inventors such that they are made available as a package, simplifying their use for innovation. They follow the intellectual property paradigm, adapted to the open innovation context, in a 'coopetition' [36] setting. The issues of financial and nonfinancial benefits, appropriability, standards, cooperation, risks and feasibility are, in turn, discussed for each of the structures. No structure is declared better than the other per se, but the authors underline pros and cons of each. The lesson for us is that open source is at least as valid as traditional patent systems for innovation. Sometimes it will work better; at other times it should be avoided.

Some obstacles remain indeed present for open source innovation. A major problem is that open source brings with it an inherent risk of licence conflicts that may become an issue when aiming to develop an innovative demo into an actual product [25]. A lot of work is ongoing to reduce this risk. Another risk is that adopting open source increases the business risk coming from the integration of differentiating contributions within the core release stream. It is also not very clear how the requirements management should adapt to the use of OSS to fully exploit its innovation potential [52].

13.4.2.1 Open Source and Sustainability

We relate hereunder a number of ways in which OSS can be considered more sustainable than traditional software.

Being free (as in 'no money required'), OSS is potentially contributing in larger diffusion of modern living tools, thus hoping to reduce inequalities. In particular, the potential of OSS in developing countries is therefore important. But, more importantly, beyond reducing licensing costs, OSS is hoped to promote indigenous technological development by having access to the source code, avoiding being hostage to proprietary software, advancing knowledge more quickly and helping to set up an information economy, in a way that respects the local culture and techniques [7]. In this way, it is not only the free and open character of the software but also the participative development process that is a factor of sustainability. While the process of building that new economy may not be cheaper than buying proprietary software, its benefits are much higher for the developing country. What is true for developing countries is true in general: OSS has an important role in open learning, potentially reducing inequalities more extensively than reducing licensing costs. Programming is not limited to chartered engineers any more: the barrier to join has been significantly reduced. The educational world is more and more grasping the opportunities offered by OSS, sometimes in advanced ways [24].

The possibility to adapt to OSS easily is also a vector for reducing inequalities. In developing countries, it is an essential property that enables to use software that is really adapted to the huge variety of contexts and specific needs [7]. In the same way, OSS is also an important provider of software for people with disabilities. There are many examples, such as text-to-speech libraries for visually impaired people [48], text-to-Braille [15], improvement of open source Web browsers [20], etc. Again, it is not only the free character of OSS that is important but also the fact that communities are available to develop in a participative way that makes it a sustainability driver.

Open source has also demonstrated an important potential in managing natural disaster crises and humanitarian situations, and more work is ongoing in that direction [27]. At a more preventive stage, it is known that OSS plays an important role in supporting, among others, climate science [47]. Other humanities benefit from this characteristic of OSS, such as health [5].

One of the main interests of open source is its ability to support standardisation and reuse. An important challenge at this level is continuously the attention of an important researcher community [47]. This allows allocating fewer resources to build better products, offering a huge advantage for the sustainability of the sector.

Opening the source code has also an obvious impact on its auditability by the public, that is, its transparency. Consequently, it can offer important guarantees to users, notably in terms of security, privacy and sustainability in the sense of the absence of planned obsolescence. These nonfunctional concerns are gaining more and more interest from the public, and experts have been studying them since long. Privacy is considered by experts as a key stone for the future of the Internet (the

term *privacy* counts >11.900 hits on DBLP [26], versus 314 for *maintainability* for example). Obsolescence has since long been pointed as a key problem of unsustainable innovation [51]. While OSS solves this problem on the one hand, it is however important to note that the obsolescence of an OSS product is mostly linked to the sustainability of its community.

Finally, if strengthening social links between people on the planet is indeed part of social sustainability, then the OSS movement can certainly be seen as a driver for it. Indeed, the main reasons why people engage in OSS projects are peer recognition and the feeling of belonging to a community, as well as the feeling of enjoyment procured by one's creative contribution to something, as Camara and Fonseca summarise from many studies [7].

As a conclusion to this subsection, we think there is ample evidence to show that OSS, a paramount example of openness and participation in IT, extensively supports sustainable innovation.

13.5 Methodological Proposition for Supporting Sustainable Innovation in Software Engineering

In the 3 last years, our lab has been pioneering research on how to support participative and sustainable innovation in the software domain. We are gradually building elements of a methodology, taking specific approaches on creativity, collaboration and sustainability in software and, more particularly, requirements engineering. Its basic constituents are depicted below (Fig. 13.3) and explained further down.

13.5.1 A Conceptual Framework for Creativity in the Design of ICT Systems

This framework, shown in Fig. 13.4, explains what different concepts may lie behind this simple word: creativity. It allows to better understand creativity in a particular context and the methods and techniques to be adopted accordingly. The framework describes five dimensions and three contextual factors that give the specific creativity *identity card* to a project.

13.5.2 Factors for Collaborative Creativity

In a recent work [29], which is under empirical validation, we have studied factors that influence the effectiveness of groups in collaboratively creative efforts

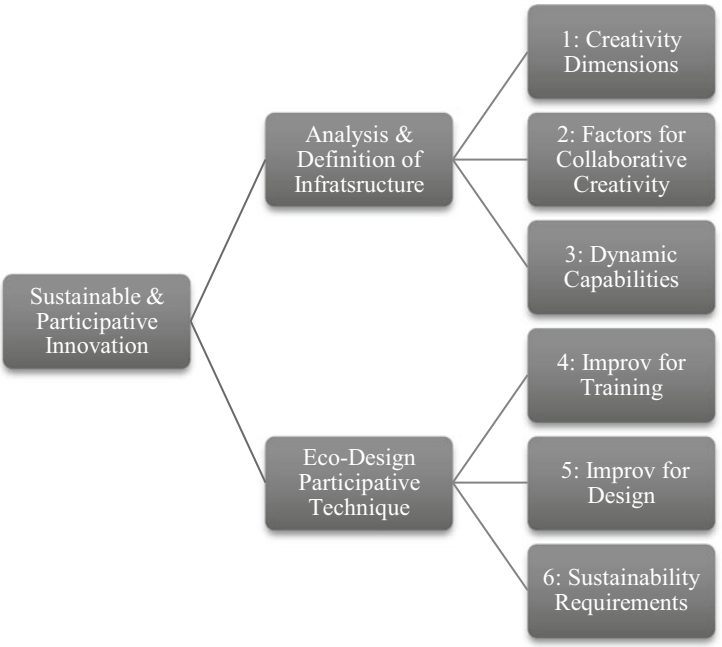

Fig. 13.3 Methodological framework for sustainable software innovation

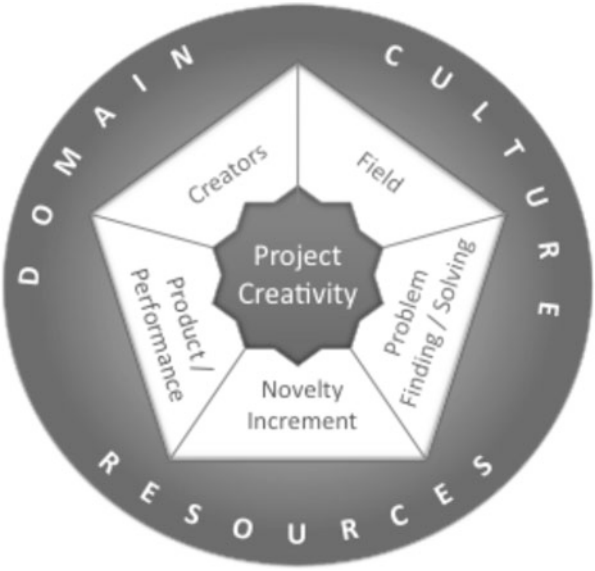

Fig. 13.4 Creativity dimensions framework

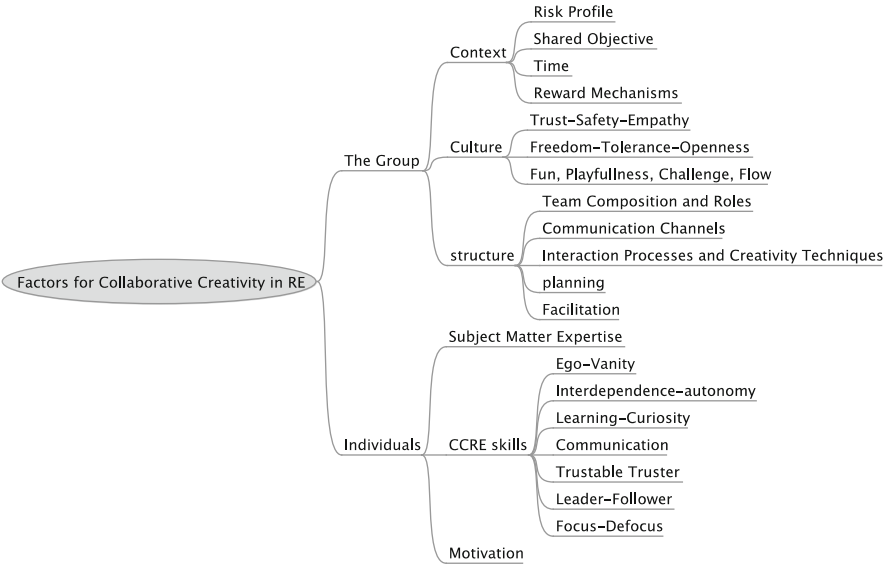

Fig. 13.5 A conceptual framework for collaborative creativity in RE

(Fig. 13.5). We distinguished between factors relating to the team and to the individual.

The team factors are further split into team context, the team values that are shared among the team members and the team structure that describes how the team is organised internally. This study enables to take a holistic approach when trying to support collaborative efforts, by ensuring a full covering of the attention points. The framework however does not prescribe specific methods or techniques: the framework only helps the facilitator to build his process in a systematic way.

13.5.3 Dynamic Capabilities for Sustainable Development

In this research [8], we explore the impact of sustainability requirements on dynamic capabilities that a company must develop and maintain to remain competitive in a turbulent environment [49]. In particular, we analyse the new innovation capacity to integrate the three pillars of sustainable development. To do this, we consider the three basic functions of dynamic capabilities (detect, assess and transform) and identify new requirements to fulfil these three functions. A field study of the process of innovation in the ICT industry, in collaboration with IBM, supports this analysis. It shows the new dynamics introduced in this sector to strategically integrate the dimensions of sustainability—particularly energy efficiency—in innovation and the different phases of the innovation process. We finally derive a conceptual framework highlighting the dynamic in presence when

a socio-technical system transits towards sustainable development. The model allows evaluating which endogenous and exogenous organisational pressures shape the development and dissemination of these sustainable ICT technologies.

13.5.4 Improv-Based Training for Participatory Creativity

Theatrical improvisation (*improv*) is a form of stagecraft in which a group writes, directs and plays a piece in the instant. The challenge is to maximise exchanges between protagonists who do not have, by definition, the same vision of history at the beginning. Through a communication endangered by the immediacy of the moment, they will have to make their distinct imaginary worlds as one. The same problem arises in the participative design context: we need to be able to build together a unique solution tailored to a problem, taking into account a variety of visions and constraints. Similarly, participants often have a diverging idea of the problem and the solution; it will now have to converge, maximising the satisfaction of all stakeholders. The issues are the same: How to find good ideas? How to use the conflict as a source of creativity? How to find its place? How to effectively communicate its point of view?

Practitioners of improvisation have developed rules and techniques to perfect their art: our contribution was to recover this work to help design teams to understand the forgotten mechanisms underlying collective creativity—listening, openness, trust, acceptance, co-construction, shared responsibility, etc. [33]. This technique has the potential to help us make the switch from a deeply rooted habit for competition towards a collaborative spirit. Its strong points in this respect are its use of gaming to talk directly to our deeper instincts and provide safe but close-to-reality exercises that everyone can play as the capacities are built progressively. The feedback is also easier to receive in gaming than on the real job.

13.5.5 Creative, Agile and User-Experience-Centred Design Technique

Also based on improvisational theatre, this technique uses improv as a ‘machine to build stories together’. Under construction, this tool is hoped to help system designers who have realised the importance of scenario-based participatory work [31, 32]. Its strong points are to tap into people’s ability to tell stories and to embody them. Contextualisation and action are supposed to facilitate communication, while the framework of improvisation rules ensures true participation and facilitates the story-telling abilities of the group.

13.5.6 Sustainable Requirements Techniques

Recognising that sustainability could be seen as a particular nonfunctional requirement, as well as safety or performance for example, the centre has been working to initiate research on the tools needed taking those new requirements into account. In the area of security, for example, numerous studies have been conducted to design secure systems 'by design'. Our approach was to initiate a similar path for sustainability. We proposed a series of tools that can be added to the panoply of systems designers eager to control the environmental impact of the product [30]. These tools include add-ons to goal models, context diagrams, stakeholder analysis diagrams, misuse cases, etc. We also co-initiated a series of international workshops on the subject [39].

13.6 Conclusion

Open and participative innovation is gaining interest worldwide, as it shows its ability to perform better in a world that is not focused solely on economic growth. Greater participation is pushing a more subtle view on value, one where people and nature have their place. People at various levels are empowered, and if they feel part of a single common planet, they become more responsible and build more sustainable systems. Collaborative creativity has the power to give this feeling of unity back, and the few places where collaboration is successfully replacing competition are giving us reasons to hope.

At the core of the post-industrial economy, the software industry is a key enabler in this context. Software is an ideal place to play open and participative, as OSS demonstrates. It also has the power to facilitate participation in all other domains, by helping in barrierless knowledge transfer and facilitating distributed discussions.

As experts in the field, we must act as facilitators and consultants to help the world build sustainable systems. The building process will be key: it has to be participative and open to the best extent. It has to be smart about this, because neither participation nor openness is obvious in today's still dominant economical settings, company structures or people's minds. We have to keep reinventing business models and design techniques that will make it work. We have to use tools that will help us think about the impact of the system on society and the planet and to take informed decisions based on this.

We have never been so close to a massive transition of the economic and governance systems for a better world. We need to grab this chance: as ICT system builders, we have a key role to play.

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