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Collaboration Engineering and Citizen Science for overcoming Sustainability Challenges

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COLLABORATION ENGINEERING AND CITIZEN SCIENCE FOR OVERCOMING SUSTAINABILITY CHALLENGES

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Abstract

One of the biggest challenges of our time is ensuring sustainability on an ecological, social, and economic level. Therefore, the United Nations created 17 Sustainable Development Goals (SDGs). These goals can only be achieved if a diverse group of stakeholders and citizens worldwide manages to formulate, understand, and negotiate competing interests and collaborate toward general welfare. Based on research on collaboration, it is evident that effective collaboration, especially when many different interests are involved, most likely not happens spontaneously. Research on collaboration engineering focuses on designing well-structured, effective, and repeatable collaboration processes to achieve a collaborative outcome. While collaboration engineering initially focused on smaller and mostly synchronous collaboration settings, recent research extends this perspective towards more extensive and more diverse groups and asynchronous settings (in time and place) based on novel technological possibilities. Consequently, we motivate and outline the development of an IT-based collaboration process that leverages the potential of citizen collaboration in the context of SDG 12 – sustainable consumption and production.

Keywords: Sustainable Development Goals, Collaboration Engineering, Citizen Science, Sustainable Consumption and Production.

Introduction

Today's society is confronted with increasingly complex and comprehensive – often referred to as "grand" – challenges in which digitalization and interdisciplinary collaborations play a decisive role. One of the biggest challenges of our time arises around sustainability. To master related sustainability challenges in order to mitigate climate change and the ongoing loss of biodiversity, the United Nations developed seventeen Sustainable Development Goals (SDGs) to save our planet socially, ecologically, and economically (United Nations, 2015). These goals cover topics such as quality education (SDG 4), responsible consumption and production (SDG 12), climate change (SDG 13) or global partnerships for sustainable development (SDG 17). SDG 17 addresses the relevance of international collaborations and highlights collaboration as a functional aspect of achieving solutions. However, it quickly becomes apparent that attaining these goals individually is hardly possible and that they can only be achieved through collaboration. Consequently, a collaboration between experts of multiple disciplines is necessary to map the different subject-specific problems and develop various approaches to solving them together. It is also significant that citizens' perspectives are collected and considered since they are the ones facing the consequences if we fail to transform towards a more sustainable society. So, it is necessary to involve citizens in developing strategies for achieving the SDGs to work collaboratively with experts. A possible procedure for applying citizens in research or data collection is the so-called Citizen Science (CS). This specific mode of participatory research is known as community-based approach, which fosters the assumption that every person can contribute relevant information to scientific research and societal challenges such as sustainability issues (Pettibone et al., 2018).

Moreover, such a global collaboration, as the SDGs are striving for, requires the use of digital technologies to be able to communicate regardless of time and place. Nowadays, new technologies enable numerous possibilities to promote worldwide collaboration, but the mere use of technology does not automatically make collaboration productive. So, promising technologies are not enough for effective collaboration; their value depends on how they are used (Briggs et al., 2006). Due to this, it is necessary to have a structure for effective collaboration, primarily when a transdisciplinary collaboration of practitioners (citizens) with diverse backgrounds joins forces.

The approach of Collaboration Engineering (CE) can help with crucial structuring to design repeatable collaboration processes. This approach aims to guide a group of practitioners through a pre-designed process to reach a previous group goal without the ongoing support of an external facilitator. For this purpose, a so-called collaboration engineer goes through different phases to design a repeatable and high-quality collaboration process (de Vreede et al., 2009). Here, detailed documentation is essential for the design and implementation. As already slightly mentioned, our modern world offers many digital tools that can make a collaboration process more effective if it is pre-structured. They offer new possibilities to design a collaboration process, e.g., an AI-based bot can moderate a brainstorming process to generate data or guide the group through the previously created collaboration process. However, CE is a suitable approach for designing effective collaborations with various participants.

Keeping that in mind, combining CE and CS could be a promising approach to involve citizens in the attainment of the SDGs in a structured way. Therefore, in the following study, we want to answer the following research question:

RQ: How can a collaboration process of citizens be designed with the approach of Collaboration Engineering?

To answer this research question, our study focuses on one SDG, and we designed a collaboration process to solve one specific problem of the SDG in particular. In our use case, we address SDG12: "Ensure sustainable consumption and production patterns" (United Nations, 2015). While many politicians, media and researchers talk about plastic and air pollution risks, the fashion industry grows. Integrated sustainable change is not in sight despite the knowledge about significant challenges such as the emission of pollutants caused by production processes (Niinimäki et al., 2020). Unfortunately, most clothing production is neither ecologically nor socially sustainable. Ecological problems concern a high resource input of partly scarce resources such as water or the non-sustainable disposal of old clothing. Concerning social sustainability goals, it can be stated that working conditions along the clothing supply chains may also be improved. Since the demand for unsustainably produced clothing prevails in economically developed countries such as

Germany, a collaborative process with Citizen Scientists bears the potential to reflect on barriers to sustainable consumption and to collect ideas for possible solutions to this challenge.

Our study presents the combination of CS and CE to structure a collaboration of citizens to develop new strategies to consume clothes in a more sustainable way. Therefore, in the following, we first explain the approach of CE and CS, followed by our use case inclusive of the designed collaboration process.

Collaboration Engineering

Collaboration is a feature of organizational life, but it brings socio-emotional, cognitive, or economic challenges, among other things (De Vreede et al., 2009). To manage challenges like these, Collaboration Engineering (CE) is an approach for structuring a collaboration, and it can involve various digital technologies. It is a method to develop and implement collaborative processes for recurring and high-value tasks that non-collaborative experts can perform without training in tools or techniques (Briggs et al., 2006). This approach aims to improve the efficiency and effectiveness of complex collaboration processes and thus achieve high-quality results (Kolfschoten et al., 2006). In this context, collaboration is a group goal-oriented cooperation task that focuses on processing common materials to achieve the collaboration goal. Therefore, the central principle of CE is that a so-called collaboration engineer develops repeatable, collaborative processes. Thereby, practitioners can independently achieve a collaboration goal without relying on external support (de Vreede et al., 2009). A practitioner is a task specialist who carries out the collaborative process by accomplishing tasks in cooperation with other practitioners (at least two).

Moreover, such collaborations can also occur across departments or institutions (Kolfschoten et al., 2006). So, an important part of CE is that a practitioner is empowered to take over the implementation of the collaborative process, thus eliminating the need for an additional facilitator. A facilitator can also develop and lead a collaborative process. Compared to a collaboration engineer, the facilitator does not design the process in a way that can be repeated without him. Thus, the facilitator supports the collaboration during the implementation by structuring or guiding tasks or technologies (Bostrom et al., 1993). In this aspect, CE differs from other related methods. Practitioners can collaborate effectively without external help and do not have to think about collaboration techniques. They can focus on specific tasks and do not have to think about developing ad-hoc collaborations.

Furthermore, human-machine collaboration gets more popular, e.g., so that technologies can be used as intelligent collaboration partners in collaboration settings (Seeber et al., 2020). One example is made by Winkler et al. in 2019 when they applied a voice-based bot instead of a human facilitator. This study showed that an AI-based system could effectively guide a group's collaboration process based on the collaboration principles of CE (Winkler et al., 2019).

Designing and Implementation

The primary process of CE is the design phase, in which the systematic collaboration process is conceived, developed, evaluated, and documented for the practitioners. To guide the collaboration engineer through the design phase, the six-layer model and the collaboration process design approach are standard methods for developing a repeatable CE process (Kolfschoten & de Vreede, 2009; see Figure 1).

The Six Layers of CE

For designing a CE process, a collaboration engineer needs to complete six steps documented in the so-called Six Layer Model of collaboration (Briggs et al., 2014; see Figure 1). The first and subordinate layer addresses the *collaboration goal*, such as a desired condition (e.g., satisfaction) or an aspired product (e.g., a prototype) that should be accomplished in the collaboration process. The following layer involves the *group products* the participants need to create to reach the goals. The third layer highlights the activities a group needs to execute to create the products. These *group activities* contain subtasks that lead to the attainment of the previously defined products.

The *group procedures* layer addresses the main designing part of the CE process. The central foundation is using design patterns. A design pattern describes a specific problem; for instance, it can support teaching, capturing, or sharing expert design knowledge (de Vreede et al., 2009). A more extensive system can be designed by combining different design patterns. In CE, these design patterns are called thinkLets (Briggs

& de Vreede, 2009). These thinkLets are reusable and transferable facilitation techniques, and each of them is scripted. Combining these patterns moves a group through a process and toward a previously defined group goal. ThinkLets are thus used as building blocks to design a repeatable collaboration process (Kolfschoten & de Vreede, 2009). They invoke a rhythm of different activities, which can be recognized as so-called patterns of collaboration. In the CE process, six different patterns of collaboration can be combined: generate, reduce, clarify, organize, evaluate, and build commitment (de Vreede et al., 2009). Each thinkLet can be classified based on the patterns of collaboration they create and the type of results (Briggs & de Vreede, 2009). Consequently, these techniques are necessary for moving a group through the different activities and can include, for example, a precise form of brainstorming (Briggs & de Vreede, 2009).

The fifth layer addresses different *collaboration tools* a group needs to instantiate its procedures (Briggs et al., 2014). Therefore, this layer deals with the design and configuration of group support technologies. Finally, the sixth layer focus on *collaboration behavior*. It includes all statements and actions of the group members to achieve the group goal.

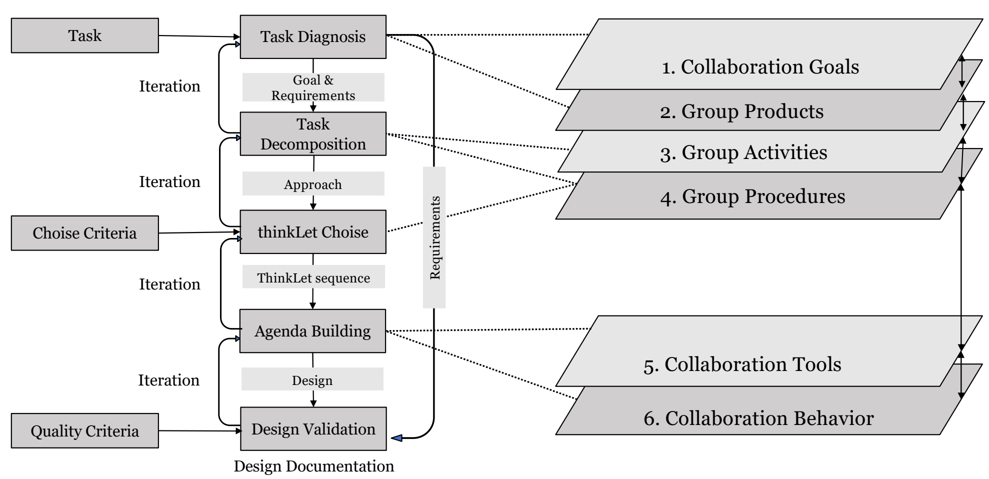

Figure 1. Collaboration Process Design Approach and the Six Layers of CE (according to Leimeister, 2014)

The Collaboration Process Design Approach

The Collaboration Process Design Approach links the six layers of collaboration (Kolfschoten & de Vreede, 2009; see Figure 1). The first step is a *task diagnosis*, including a task, stakeholder, and resource analysis (Kolfschoten & de Vreede, 2009). The task diagnosis is followed by a *task decomposition* and contains a pattern decomposition and a result decomposition. The third step addresses the *thinkLet choice*. Therefore, the collaboration engineer uses an overview of all available design patterns and, thus, the possible thinkLets. Here, the engineer needs to consider that the chosen thinkLet fits the current activity, as well as in combination with the preceding and subsequent thinkLet (Kolfschoten & de Vreede, 2009). After selecting suitable thinkLets, an *agenda can be built* (step 4). The thinkLets itself does not map a collaboration process. Activities, specific questions, and instructions for each activity must be defined. Documented is this process in the process agenda, which includes the group goal, specific breaks, presentations, and any other activities the group needs to do. Also, time marks and time management are necessary aspects here. The agenda can be documented in a so-called Facilitation Process Model (FPM). This model is a modeling technique to help the collaboration process flow can be depicted in the constituent activities. The activity aims to produce an output that can be used as an input for the following activities until the group product is achieved (Leimeister, 2014). The FPM includes the sequences of actions, the decision that influences the flow process, the pattern of collaboration (e.g., generate), the step number, the activity name, and the used thinkLet (Kolfschoten & de Vreede, 2009). The main aim of modeling an FPM is to overview the collaborative work practice the Collaboration Engineer developed. The final step of the Collaboration Process Design Approach addresses the *Validation* of the designed process. Therefore, pilot testing, a walk-through, a simulation, or an expert evaluation are possible approaches (Kolfschoten & de Vreede, 2009).

Citizen Science

Regarding the involvement of citizens, a whole stream of research and literature, Citizen Science (CS), explores different options and potentials. CS is a Community Based Approach (Pettibone et al., 2018), part of Open Science (Hecker et al., 2018) and a way to involve citizens in scientific research, draw on their (expert) knowledge and gain insights into different livelihoods (Bonn et al., 2016). When Citizen Scientists contribute to data generation and -analysis, i.e., by noting observations in the public sphere, this is considered a contributory approach. In this way, CS contributes to the monitoring of the SDGs by quantifying specific phenomena such as food loss and -waste in supply chains (Pateman et al., 2020) or seafood sleuthing (Warner et al., 2019). So far, mainly contributory approaches are associated with digital technologies, i.e. when Citizen Scientists train algorithms to recognize and categorize picture content[1]. Moreover, Co-Creation approaches allow to develop research projects together with citizens, which begins by developing the research question and ends with the dissemination of research results. In specific cases, collaborative approaches may be appropriate, whereby citizens contribute to a specific phase of the research process (Bonn et al., 2016). Co-Creation and collaboration might come in handy when trying to find solutions to sustainability challenges on a regional and local level (Schneider et al., 2019) since they have been shown to favor sustainable behavior change (van Noordwijk et al., 2021) and get citizens involved in politics as agents of change (Hajer et al., 2015). In this sense, CS evokes public participation and collaboration in scientific research, allowing society to deal with complex modern problems (Ceccaroni et al., 2019).

Collaboration in Heterogeneous Groups and Developing Strategies for more Sustainable Consumption (SDG 12)

As already mentioned, the SDGs can only be accomplished through the collaboration of heterogeneous groups, and the participation of citizens is crucial. A collaborative work practice in CE can involve different actors, such as technical systems (e.g., AI for moderation) and human actors (e.g., citizens). Thus, combining CS and CE seems to be a valuable approach to making a collaboration process including multiple citizens effective and replicable. This combination can be an efficient concept to capture the population's perception and map it with the help of digital technologies.

Use-Case SDG12 – Sustainable Consumption

To clarify this statement, we will discuss the development of a possible CE process in relation to SDG 12. SDG 12 addresses sustainable consumption and production (United Nations, 2015). However, when it comes to clothing consumption, for example, it quickly becomes apparent that most of it is not sustainable and has several social and ecological impacts**:** The value chain of clothing has largely been outsourced to countries with low labor costs over the last ten years.[2] For example, clothing supplied to Germany largely comes from China, Bangladesh, India, Pakistan and Turkey (Stamm et al., 2019; UBA, 2021). The textile and clothing industry employ approximately 75 million people worldwide, with three quarters of the employees being women (Stamm et al., 2019). These people are heavily dependent on the jobs that the garment industry creates in their home countries, as it allows them to secure their livelihoods. However, as a result, they have to submit to working conditions that are most hazardous to their health and ethically questionable (Stamm et al., 2019). In addition to the social impacts, the garment industry creates negative impacts on the environment since it is responsible for up to 10% of global greenhouse gas emissions (e.g., European Parliament, 2020; Niinimäki et al., 2020; UNFCCC, 2018). According to the German Federal Environment Agency, polyester ranks first among all substances used in the production of clothing fibers,

[1] See for example: *FIUME.Annotation.ES.T3.2* (2023); *Snake Identification* (2023).

[2] According to Stamm et al. (2019), garment workers in Bangladesh receive less than 1% of the final retail price of a branded T-shirt they produced.

accounting for 52% (UBA, 2021). This is a synthetic resource that is not biodegradable, which can cause problems with disposal. In relation to other resources, polyester requires less water during production. However, microparticles of the synthetic fabric are released into the environment through abrasion during wearing and washing (UBA, 2021). The high use of chemicals in synthetic fiber production leads to water pollution, hazardous waste, and air pollution (Stamm et al., 2019). In regard to natural fabrics, cotton is used first and foremost for the production of clothing. Cotton accounts for around 25% of the total share of all materials used by the clothing industry[3] and counts as biodegradable raw material. A negative environmental impact of cotton includes the immense need for water and the use of pesticides during cultivation. This also has a negative impact on the health of workers on cotton fields (UBA, 2021). In addition, Stamm et al. point out that cotton is largely grown in monocultures, which leads to losses in soil fertility. To compensate for these losses, artificial fertilizers are applied, and consequently lead to salinization and erosion of the soil (Stamm et al., 2019).[4]

However, previous research on clothing consumption shows that consumers are well aware of these problems but that they find multiple reasons to justify unsustainable consumption patterns to themselves and others (e.g., Farsang et al., 2015; Greenpeace, 2015; Weller, 2019). As part of a master's thesis, Jennifer Mantel (2015) investigated the significance of cognitive dissonance (Festinger, 1978) for the consumption of clothing. This involves the question of how individuals deal with the tension between awareness and action or what strategies they use to avoid such feelings of tension. These include the decision not to obtain further information. The main reason for this is the difficulty of finding reliable information. Another strategy is to ignore the actual working conditions in the Global South. This follows the slogan, what you don't see, doesn't exist, and is supported by the fast fashion suppliers. Doubt about self-efficacy is another strategy to avoid tensions. I alone, it is often said, can achieve little. Also, moral enhancement is used: My consumption is less problematic than that of other consumer groups, which leads to the question of how such defensive mechanisms can be interrupted (e.g., BMU, 2021; Stengel, 2011).

As an alternative to conventional clothing consumption, we can resort to forms of sharing and circular economy, which are often offered via digital platforms – and which can certainly be considered "modern" (e.g., Kleinhückelkotten et al., 2017). They appear as emerging practices of sustainable consumption but at the same time remain in the margins of the clothing sector, which is visible, for example, in clothing rental platforms that are hardly gaining in popularity (Henninger et al., 2021). The circular economy of clothing, which is mostly expressed in the form of second-hand sales, also requires stronger cooperation between producers and retailers in order to be structured more sustainably (D'Adamo et al., 2022). These alternatives to traditional clothing consumption require further systematic research to determine their actual impact on the social and environmental sustainability of the clothing sector.

To minimize these problems and to be able to map possible solutions from a diverse society, CE in combination with CS can be a helpful approach. Specifically, in a pre-designed collaborative process, citizens (consumers) of a country in the Global North (Germany) will be invited to develop potential strategies concerning how to consume clothes more sustainably. This includes perspectives on how sustainable consumption could be enabled for the broader population. However, as citizens have very different views, such collaborations must be precisely pre-structured to produce effective strategies.

Designing a Collaboration Process for Citizens

As already mentioned, we focus on the discrepancy between the consumer mindset about sustainable consumption and the actual purchase behavior. For developing new strategies for more sustainable consumption, in this design, university students represent our citizens. We decided to focus on university students as a first step to narrowing our potential citizens of the designed collaboration. Based on the use case mentioned above, consumers (students/citizens) of the global north should develop five strategies for consuming more sustainable and environmentally friendly clothing. Therefore, the five strategies are the

[3] Stamm et al. even put the processing of cotton in the entire clothing industry for 2016 at 31% (Stamm et al., 2019). The data from the Federal Environment Agency are from 2017 (UBA, 2021, Figure 5).

[4] Both resources together account for 77% of the materials used in the production of clothing, which is why they are in focus here. Other resources should nevertheless be mentioned for the sake of completeness: Synthetic materials include acrylic and elastane/spandex in addition to polyester. Natural materials include cotton, linen, hemp and wool (UBA, 2021).

designed collaboration process's primary goal (see Table 1). Moreover, in the task decomposition, we executed a resource analysis. Here, we set a timeframe for the process, which should be one day. Therefore, the five strategies should be developed in small groups in a digital one-day online workshop. At the end of the workshop, each strategy will be recorded on a single page that presents a precise summary of the practitioners' results. The single pages' results represent the group products' material artifacts (see Table 1). Furthermore, during the process, the practitioners are most likely to develop an individual increase in knowledge about the topic and a shared awareness of the problem – so these two factors are immaterial artifacts of the collaboration process (see Table 1).

Problem:	Discrepancy between attitudes towards sustainable consumption and actual purchasing behavior of citizens
Collaboration Goal:	Development of five strategies for consuming more sustainable and environmentally friendly clothing in a one-day online workshop
Group Product:	- A single page for each strategy that presets a precise summary of the practitioners' results → material artifact - Shared awareness of the problem and an individual increase in knowledge → immaterial artifact

Table 1. Main Elements of the CE-Process

Afterward, we defined the group activities and the group procedures, including the necessary thinkLets, to reach the collaboration product and goal. Therefore, in the first step, we determined different patterns of collaboration that are necessary to structure the workshop. Here, two collaboration engineers worked in a loop together to design the main process. The workshop is divided into six main patterns, such as generate, reduce and clarify, organize, evaluate, build commitment, and generate the single page at the end (see Appendix A, Facilitation Process Model). The collaboration process starts with a Warm-Up, where the participants receive input on the mentioned problem in order to be able to create a common knowledge base for the further process. However, after building a common understanding of the problem to be solved and a first session to generate, clarify, organize, and evaluate strategies for solving it, the collaboration engineers decided to implement a second collaboration process loop after the first evaluation pattern in the main collaboration process (see Appendix A, Facilitation Process Model). The aim of this second loop is to analyze, during the workshop, if enough ideas have been generated in the first procedure. If the evaluation, based on a 5-point Likert scale, results in insufficient ideas, the group needs to go through the patterns of generating, organizing, and evaluating again (see Appendix A, Facilitation Process Model). Moreover, based on the required patterns of collaborations, the collaboration engineers selected suitable thinkLets and built an agenda, illustrated in the FPM Model (see Appendix A, Facilitation Process Model). Additionally, the necessary collaboration tools for the digital workshop were analyzed. We decided that basic technology tools, such as web-enabled computers or laptops, are necessary to communicate in an online workshop. Further, a platform to connect the citizens (students) is required – here, we decided on the platform Zoom. Supplementary, digital pinboards, such as Mural, are needed for collecting new ideas. Finally, also a platform for shared documents is necessary for developing strategies collectively. The aim of the process is that the developed strategies can be published, so independent citizens can also be guided in their consumption by these strategies.

After finishing designing the collaboration process with citizens, the process was validated by independent collaboration engineer experts. Moreover, the designed collaboration process can be expanded by various digital technologies. For example, a chatbot or a voice bot can guide the participants through the process. In a nutshell, such a designed collaboration process can be run repeatedly and with various stakeholders. Based on the one page summarizes created in the CE process, these strategies for more sustainable consumption can be independently evaluated and compared. Thus, independent citizens can evaluate these developed strategies in a follow-up setting.

Discussion

In our use case, we presented a designed collaboration process for citizens (students) based on the principles of CE to develop new strategies for more sustainable consumption. The case faces the problem that many consumers buy unconsciously based on greenwashing or misinformation.

In the designed collaboration process, we confront this by providing basic information on this problem in the introduction section. The aim is to sensitize the practitioners from the beginning and to convey common basic knowledge about the situation. Based on this, the practitioners develop strategies for addressing the problem. Therefore, in the future, the participants and independent citizens can be guided in their consumption by these developed strategies. In a nutshell, these strategies also can address the problem of greenwashing or misinformation.

The potential of combining CE with CS can be summarized as follows: With the help of CE, Citizens can work in a structured way together. Through CE, heterogeneous teams can collaborate effectively, especially with the systematic use of technologies, even if the practitioners have different background knowledge. Moreover, collaboration with citizens worldwide is possible since digital technologies can connect the participants in real time. With the help of digital technologies, new opportunities to ensure multidisciplinary collaboration, regardless of the practitioners' location, are offered. To design a repeatable collaboration process, documentation is a fundamental part so that other practitioners can follow the same design to a group goal without the help of an external facilitator. Since human-machine collaboration gets more popular, technologies can be used as intelligent collaboration partners in collaboration settings.

An initial combination of CE and CS offers promising possibilities for further research. Since this structured approach allows Citizens to participate in research in an optimized and efficient manner, they can actively contribute to new solutions. To reach this goal, motivational aspects are important for Citizens to engage and to spend their free time volunteering in research projects (Asingizwe et al., 2020). So far, collaborative workshops have been led by humans, and therefore the CE-CS cooperation needs to be evaluated on its impact on the motivation of citizens. Here, a possible question for further research could be: How do AI-based technologies, such as intelligent collaboration partners, influence the motivation to participate in Citizen Science?

Furthermore, an evaluation of the ecological value or the creation of potential rebound-effects (Coeckelbergh, 2020; Santarius, 2015) through the inclusion of digital technologies could be appropriate to further reflect on the possibilities to reach the integrative sustainability approach of the SDGs (UN, 2015).

Moreover, after a subsequent implementation and evaluation of the developed process, an adaptation for other specific problems from SDG 12 can occur. Furthermore, the basic approach is also transferable to other SDGs. SDG 17 (Partnerships for the goals), in particular 17.16 and 17.17, offers exciting application cases.

However, due to the far-reaching relevance of the sustainability topic, it is necessary to involve diverse participants from all over the world. To master this challenge, the arranged usage of digital technologies, various methods, and considering the different cultural origins are essential. Therefore, Collaboration Engineering in combination with Citizen Science is a purposeful approach.

Contributions and Limitations

One main contribution of the study is that in the classical approach of CE, domain experts are the practitioners and CE processes are mostly implemented in business or teaching contexts. The design and implementation in society is a new way of thinking. Here, as already mentioned, citizens as practitioners offer many possibilities. Through the demonstrated combination, we can contribute to theory and practice. We can enrich the theory of CE by aiming at mass collaborations with citizens and thus define and include a new target group of practitioners. Moreover, we provide a CE process with Citizens that can be implemented in practice.

In addition to existing approaches to using CS to reach the SDGs, the (here presented) CE-CS collaboration process introduces digital technologies to reach sustainable clothing consumption and production (SDG 12). This contributes to the implementation of the SDGs, especially SDG 12 since many SDG targets demand the use of digital technologies.

However, our work also has some limitations. We first only designed a short CE process in our use case for university students. Here, it would be the next step to implement this process and, following, to design a more comprehensive process for various citizens.

Finally, the highlighted approach considers AI-based solutions for sustainability. For AI-supported CE processes to contribute to the SDG goals, it will be necessary to consider how AI can be designed socially and ecologically sustainable (Sustainable AI; van Wynsberghe, 2021). Participatory AI design seems vital to reach this goal (Mohamed et al., 2020). Also, the high potential of digital sufficiency to reach ecologically sustainable AI could contribute to reaching the SDGs (Colaço, 2021; Santarius et al., 2022).

Conclusion

As outlined above, we need collaborations with diverse participants to master grand challenges like the sustainability challenge. However, it is also apparent that effective collaboration with participants who have diverse backgrounds does not happen automatically. A structured approach is essential, especially when various citizens are involved and need to collaborate. With the help of CE, it is possible to analyze such practices and design repeatable collaboration processes to guide citizens or diverse stakeholders toward a group goal. Based on our use case, we can highlight that the combination of Citizen Science and Collaboration Engineering can be a promising approach to designing repeatable collaboration processes and involving citizens (practitioners) to master the sustainability challenge. Combining the different patterns of collaboration (e.g., generate, organize, clarify) enables various design options to achieve the respective group goals in different ways. In our opinion, this multitude of combination possibilities offers excellent potential, especially when digital technology is included.

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Appendix A. Facilitation Process Model