Cooperation Analytics for Citizen Science Projects in the Social and Human Sciences

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INTRODUCTION

Our presentation is based on the Deliverable D5.1 WP5 - Cooperation Quality Assessment: Development and Implementation of the Cooperation Analytics (Available at https://zenodo.org/record/5599052#.YuEM4ITP02x), covering the conceptualisation and operationalisation of indicators to measure multiple cooperation practices for citizen science projects in the social sciences and the humanities (SSH) as part of the H2020 project COESO: Collaborative Engagement on Societal Issues.

The SSH contribution to citizen science is often a blind spot in the field (Kieslinger et al., 2017). The COESO project sheds light on this blind spot through the development of a platform called VERA that will help cooperation between citizens and social scientists. This platform will support public engagement practices and allow measuring users' practices through an empirical test on 10 case studies. These case studies consist of five Pilots selected for a first testing-validation phase, and five other Pilots for a final-validation and improvement phase.

COESO's Work Package 5 (WP5) is dedicated to the learning process of these pilot projects through indicators that will be integrated in the VERA platform as a continuous and direct feedback to Pilots stakeholders that contribute to their broader objectives of citizen science. More specifically, WP5 is developing "Cooperation Analytics" for the understanding of the cooperation conditions and the cooperation quality of Pilots practices, based on a conceptual framework and quantifiable criteria made operational in a computing system.

The cooperation analytics that we define avoid being normative a priori. Instead, the analytics put forward the plurality of cooperation practices of social actors: "a group of individuals [can] be deeply involved in the entire process of research while others participate in discrete activities such as data collection or analysis" (e.g., Farquhar and Wing 2008). Indeed, participative "initiatives arise in unique contexts, in response to different needs, meaning prescribed approaches are unreasonable" (Wiggins and Crowston 2010).

Based on the state of the art (see https://zenodo.org/record/5599052#.YuEM4ITP02x) about the definition of cooperation, we operationalised the cooperation analytics as a monitoring grid for practitioners. First, we present the features identified from the literature for defining cooperation indicators. Second, we develop a new cooperation typology that will enable actors to understand and embrace the plurality of their cooperation practices based on the compass method (Boullier, 2003). This cooperation typology does not intend to position a Pilot project into a specific box. It rather allows actors to identify the proportion, balance and degree of the different types of cooperation they might develop throughout their collective learning process, and that ultimately actors can modify if they consider it necessary.

1. CONCEPTUALISATION OF COOPERATION ANALYTICS

The process of conceptualisation of cooperation analytics that we conducted is the following:

1/ cooperation features were identified from the literature and translated into real practices of actors.
2/ a cooperation typology was defined from the literature and adapted in relation to the features selected.
3/ the features enabled us to define four categorical values, one for each of the four cooperation types: ad hoc, plan-oriented, institutional, revision. This typology will be used later for data visualization purposes, as a guidance to actors indicating the results of the cooperation analysis.
4/ from the cooperation typology it was possible to define the indicators that enable actors more concretely to measure their activity on the platform. Every indicator measures a feature defined in the typology.
5/ every indicator is constructed in an aggregated or simple way according to the data that can be collected in the VERA platform or in external platforms used by the actors.

Cooperation Features

27 cooperation features along with 36 indicators were identified from different definitions of cooperation in the bibliography. We present below the features' definition and their corresponding indicators can be found in Table 1.

Skills: individual and organizational (No. 1, 3), are a main source of contribution within citizens and researchers' practices. According to Millerand (2021), it is commonly observed that while citizens provide experiential skills, researchers provide technical skills. The latter are often the only actors considered as experts.
Culture diversity: individual and organizational (No. 2, 4), are important elements that define in advance the cooperation possibilities. The diversity relies on the multiple disciplines involved in the project, and on the actors' professional and experience background.
Ways to obtain data sources (No. 5): data is a major element for analysing citizen science participation, often expected to be collected and labelled by citizens for science. While some authors call this a passive form of participation, others consider it key in citizen science, in particular in life sciences. More broadly, the way data are obtained characterises the organizational profile for cooperation.
Citizen/Research compensation (No. 6). The compensation of actors influences the development of cooperation practices and the possibilities of engagement. The formalisation of the compensation also defines the time that can be dedicated to the project.
Main type of funding (No. 7): While citizen science research is increasing, the allocated funds can come from multiple sources. The funding acquisition organizes the cooperation availability and investment that can be given.
Results dissemination type (No. 8): is a main element for evaluating cooperation in the literature: the products to deliver in the project and its dissemination process. It is an important phase for knowledge production.
Methods for recruiting citizens/researchers (No. 9). Literature shows that the way actors are recruited can, more or less, formalise the cooperation practices and the expectations for each party involved.
Device specificity (No. 10): the technology used for developing projects, as well as communication tools for the cooperation development characterise the possibility of including citizens in the scientific practices.
Organization of citizen/science participation (No. 11). It defines the type and configuration of actors' participation for cooperating in the project.

Flow of citizen/research participation (No. 12). The flow refers to the process characterised in quantity and the intensity of the actors' participation in cooperating.
Rhythm of citizen/research participation (No. 13). It adds to the process analysis the pace, frequency and duration, of the actors' contribution for cooperating in the project within a timeline.
Distribution of roles in scientific/citizen participation (No. 14): the role or status of actors in the project configures the direction of contributions distributed among the parties involved.
Conflict and problem solving (No. 15). Management literature and pragmatic sociology pay particular attention to conflict and problems as important activities to identify by managers, and more broadly to overcome (as tests) by actors in coordination. The feature tackles the formalisation of these unavoidable activities for actors to cooperate.
Networking method and quality (No. 16, 17) describes the creation of a social structure and its dynamic evolution for creating stable and new cooperative situations.
Governance principles (No. 18) is mainly based on Boltanski and Thévenot's (2006) reference "The orders of worth" for describing the principles that guide the cooperation practices. Other authors in the citizen science literature have highlighted the relevance of principles in organizing communities of practice.
Idiom management (No. 19) enables us to detect the idiomatic tension and flexibility of actors considered when communicating with others in different media.
Knowledge diversity processing (No. 20) enables us to detect the idiomatic tension and flexibility of actors considered within knowledge production processes when cooperating for producing a result (e.g. writing a report, an article).
Knowledge exchange orientation (No. 21): social exchange and knowledge production are often considered in the cooperation evaluation. They constitute a key element for establishing trust, which ultimately leads actors to decide to cooperate or not. We combine these criteria to focus on the orientation of the knowledge exchange in cooperation. In other words, how much actors balance their contributions to others.
Management style (No. 22). It describes the managers' communication forms adopted and the type of feedback provided to others, which can more or less stimulate cooperation. The style is relevant in the literature of cooperation as it configures the community of practice.
Division of labor (No. 23): the functional differences of actors within the project organization relate to the cooperation tasks that can be performed individually or together between citizens and researchers.
Data articulation mode (No. 24) refers to the flow or process of managing data accessibility and sharing within teams and with external actors.
Stakeholder and data scalability (No. 25). As previously mentioned, data often constitutes a starting point, and a major interest for citizen science projects. Stakeholder and data scalability refers to the capital accumulated and its complexity for creating shared goals with different actors or institutions.
Learning process (No. 26): cooperation achievement is often defined by the capacity of actors to learn in action, as well as by their capacity to revise their actions. This feature refers more particularly to the way actors and actions are assessed continuously.
Legal and ethical compliance (No. 27). The feature refers to legal and ethical codes, as explicit conventions, to which actors need to comply for data, infrastructure and management.

No.	Cooperation Features	Indicators	Operationalised from
1	Skills	Skill type	(Chibois et Caria, 2020; Haklay et al. 2021; Morillon, 2021)

2	Culture diversity	Diversity score	(Eaton, 1948; Haklay et al. 2021)
3	Collective skills diversity	Collective skill diversity	(Chibois et Caria, 2020; Haklay et al. 2021; Morillon, 2021)
4	Collective cultural diversity	Collective diversity score	(Eaton, 1948; Haklay et al. 2021)
5	Ways to obtain data sources	Ways to obtain data sources Sources mentioned in the project	(Chibois et Caria, 2020)
6	Citizen/Research compensation	Level of recognition	(Haklay et al. 2021; Shirk et al., 2012)
7	Main type of funding	Percentage of type of funding obtained for operations	(Chibois et Caria, 2020)
8	Dissemination type of results	Degree of field hybridation	(Chibois et Caria, 2020; Shirk et al., 2012)
9	Methods for recruiting citizens/researchers	Contractual formalism	(Chibois et Caria, 2020; Shirk et al., 2012)
10	Device specificity	Device specificity degree	(Haklay et al. 2021)
11	Organization of citizen/research participation	Type, scale, medium of meeting	(Millerand, 2021; Chibois et Caria, 2020)
12	Flow of citizen/research participation	Number, intensity of conversations and contributions	(Millerand, 2021; Liu, 2008; Eaton, 1948; Neale et al., 2004; Haklay et al. 2021; Shirk et al., 2012; Gongora et al. 2018)
13	Rhythm of citizen/research participation	Frequency of conversations, contributions and meetings	(Liu, 2008; Eaton, 1948; Chibois et Caria, 2020)
14	Distribution of roles in scientific/citizen participation	Degree of asymmetry, Contribution type	(Eaton, 1948; Liu, 2008; Chibois et Caria, 2020; Haklay et al. 2021; Sanders and Schyns, 2006; Josserand, 2004; Shirk et al., 2009; Jamali et al., 2006)
15	Conflict and problem solving	Formalism degree and efficiency of problem solving	(Liu, 2008; Axelrod, 2006; Sennett, 2013; Sanders and Schyns, 2006; Jamali et al., 2006)
16	Networking method	Evolution of network size	(Koster et al. 2007; Granovetter, 1985)
17	Networking quality	Network diversity	(Koster et al. 2007; Sanders and Schyns, 2006; Granovetter, 1985)
18	Governance principles	Social world balance	(Boltanski et Thévenot, 2006; Josserand, 2004; Morillon, 2021)
19	Idiom management	Idiom diversity degree	(Boullier, 1984; Morillon, 2021)
20	Knowledge diversity processing	Knowledge convergence degree	(Chavalarias et Cointet, 2013; Chibois et Caria, 2020; Haklay et al. 2021; Morillon, 2021; Shirk et al., 2012)

21	Knowledge exchange orientation	Knowledge distribution balance	(Sanders and Schyns, 2006; Khawaji et al., 2013; Gongora et al. 2018; Morillon, 2021)
22	Management style	Manager style and balance	(Josserand, 2004)
23	Division of labor	Plan work organization formalism, official revision and drifting	(Koster et al. 2007; Eaton, 1948; Gongora et al. 2018)
24	Data articulation mode	Documentation flow management for data storage, access control and security measures	(Strauss, 1997)
25	Stakeholder and data scalability	Increase/decrease of stakeholders and data volume	(Haklay et al. 2021)
26	Learning process	Degree of collective assessment, justification of results, milestones and quality criteria accomplished	(Livet, 1994; Josserand, 2004; Morillon, 2021)
27	Legal and ethical compliance	Legal and ethical compliance score concerning gender balance, open science standards and data protection	(Haklay et al. 2021;Le Cardinal, et al., 1997)

Table 1. Conceptual monitoring grid including cooperation features and related bibliographical references

2. COOPERATION TYPOLOGY

From the literature about citizen science and about cooperation in organizations and interpersonal relationships as well, we identified some dynamic tensions based on the features presented above. We use the compass model (Boullier, 2003) to address innovation issues in order to emphasize the pluralism of choices. In this compass, all types of cooperation are treated equally, with no normative judgement. The typification that results (the labelled types) is less important than the tension that is documented precisely on some specific features of cooperation that gives room for each specific project to combine different types in their own way. The tension is represented in two axes: Axis *x* refers to the cooperation duration, axis *y* to the level of formalisation in the cooperation.

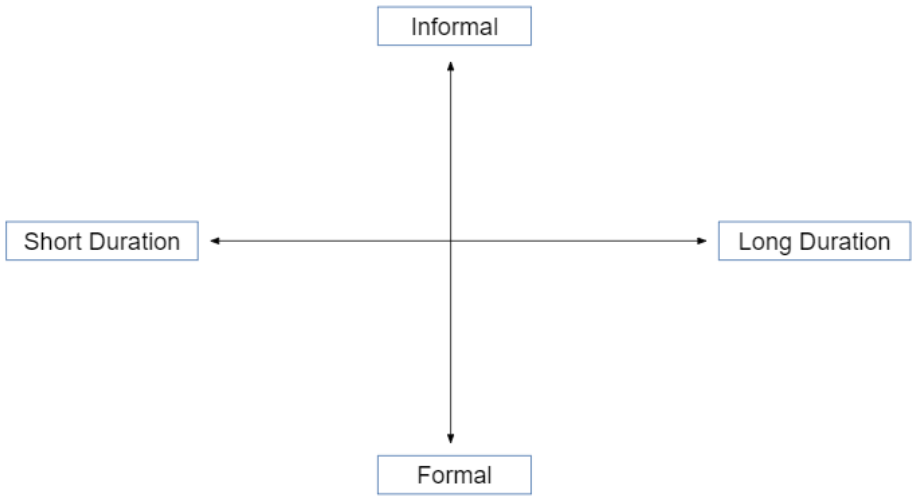

Image 1. Compass method designed for cooperation in two axes: duration and formalisation.

The first tension is the one between *short term and long term cooperation* in axis *x* (duration). Duration is something that the theories of choice and the evolution of cooperation (Axelrod, [1984] 2006) have well documented. As in the prisoner' dilemma, the number of turns plays a role in the way the participants can learn from each others' behavior. And a long term or supposedly infinite number of moves (of cooperative /defective acts) improve to a large extent the chances of adopting the cooperative behavior by participants. This must be considered as a distinctive feature of projects in citizen science, while it does not mean that short term style of projects cannot reach a significant level of cooperation. However, it makes sense to anticipate the higher investment required to assess each other and understand each other when a project is one-shot as opposed to a regular basis cooperative activity. On the other hand and to be sure that the balance is well maintained between all these different styles, one could argue that these repetitive and instituted projects may become more ritual and rigid and lacking some flexibility since routines would dominate. This situation is exemplified and formalised by Richard Sennett in his book "Together", where he put the emphasis on what he calls the "ritual" part of cooperation. It means that any project may introduce a part of ritual and even should be aware of the need to do so in order to gain some stability and to naturalize the relationships.

The other tension in axis *y* is focused on the level of formalisation of cooperation. When formalising the rules, the protocols and its rhythm, a cooperative assemblage gains many guarantees and certainties. This is supposed to be a good climate for cooperating, and it is an important effect of "conventions" (Eymard-Duvernay, 2006), that require careful description of roles, division of labor and explicitation of expectations. On the opposite side, any project must develop some tolerance to uncertainty or it would become just the implementation of a predesigned plan which is not realistic especially in our environments of social issues. But some stakeholders may favor more formalisation while others may feel more comfortable with adaptation to circumstances (i.e., a low level of formalisation), to the point that the whole project may become opportunistic, while missing its previously established goals. Due to this low formalisation, the participation of citizens can be facilitated in some cases with scientists who are trained into the respect of procedures, from data collection to validation of hypotheses and interpretation. However, cases may differ a lot in social sciences since social scientists are often criticized for a lack of formalism and robustness in their arguments.

The combination of both axes can deliver a four quadrant view of the cooperation opportunities and styles that is clearly a way to amplify the differences, for the sake of the style elicitation based on features. It should not be considered as a realistic rendering of the types of projects we can observe. However, by adopting the polarization method we can offer a dramatic tension between the poles of the compass that is realistic enough from the stakeholders' point of view on their experiences. Some cooperation types insist more in the formalisation dimension, others on a long duration. Depending on the project stage, one can observe a change in these positions. The combination of axes leads to four types of cooperation that are defined in the next subsection:

Ad hoc
Plan-oriented
Institutional
Revision

In order to describe these cooperation types we did not try to classify the existing COESO Pilots because our goal is to help the participants make their own balance among these tensions. What we shall do by offering cooperation measurement is to display indicators that are expressing the features of these axes, so that stakeholders can monitor their own activity on a permanent basis. We put forward a transparency value so actors know the way indicators are constructed: they will know explicitly how these indicators are designed and weighted. As mentioned previously, we are aware that these measures can influence the way actors analyse their performance. Indeed, once actors learn how they are being evaluated online, they could put in place dynamics to change their score (Pidoux, 2021) or to ensure that a cooperation type is displayed, which is not a type that reflects their real tendency. However, the cooperation analytics we defined are not conceived for judging or ranking the individual characteristics, their actions, or their projects along a unique scale. We avoid the use of rankings as a standard for excellence which does not allow actors to have a reflexivity on their projects. We avoid defining one type of excellence that is accepted and computed as many platforms are doing today, within the broad ranking phenomena. The different features of cooperation will be calculated from data or traces (metadata and text mining) so that users declare very little via online forms or interviews: their own behavior on the platform will be sufficient to extract the necessary data for the majority of indicators.

Four Cooperation Types: Definition

1. Ad hoc cooperation

The ad hoc cooperation type is reactive, ephemeral or short term and it is highly adaptable to the circumstances as they arise. Actors in ad hoc cooperation take advantage of opportunities as they occur to achieve an end in accordance with situations and not according to a plan.

2. Plan-oriented cooperation

The plan-oriented cooperation type is driven by a plan, the results that can be obtained and the indicators that measure them. Actors in the plan-oriented cooperation follow explicit actions with a focus on the goal to achieve.

3. Institutional cooperation

The institutional cooperation type is organized by tacit and repetitive actions that become habits. Actors in the ritual cooperation integrate conventions into their daily working practices with others

for building loyal practices. The conventional actions followed by actors are supposed to be recognized and legitimate by the collectivity.

4. Revision cooperation

The revision cooperation type is evolving and does not take for granted the plan. Instead, it is based on the iterative evaluation and negotiation of practices. Actors are in continuous learning, they control and overcome the situations that arise to update the plan and finally review its coherence with others. The cooperation types are now graphically presented in the compass (Image 2). The types are positioned in the four quadrant view of the cooperation opportunities and styles to demonstrate their opposition. In the *x* axis one can find the duration, in the *y* axis one can find the formalisation.

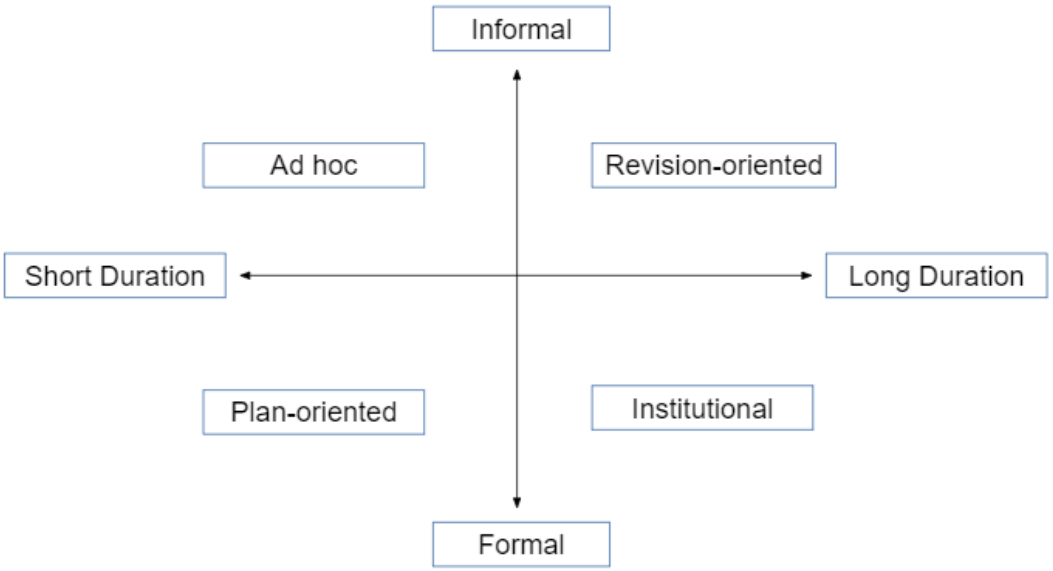

Image 2. Compass of the cooperation typology

These are only ideal types that will not be found in real life settings. The principle of generating clear-cut oppositions in this way resembles the oppositions produced by Support vector machines (SVMs). SVMs are a set of supervised machine learning methods used for classification, regression and outliers detection, in which clusters have to be separated with as vast margins as possible to be comparable. The clear-cut oppositions that we make manually help demonstrate the polarities and the tension that trigger cooperation practices but real projects are always a composite arrangement between these solutions. This model helps us with the variety of choices available and to be sure that we do not get trapped into one and only one style of cooperation. Participants will obtain enough feedback and levers of action so that they can anticipate the evolution of the project and take corrective action on time if they wish.

Cooperation Typology: Categorical Values

We previously identified and defined four types of cooperation: ad hoc, plan-oriented, institutional, revision, for embracing the plurality of Pilots' practices without being normative and creating absolute positions. In order to measure the proportion of every cooperation type in the Pilots, it is necessary to define beforehand how every cooperation feature relates to every cooperation type.

For this purpose, we now define categorical values for each feature, creating this way a matrix (Table 2). This refers to the third step of the monitoring grid's operationalisation.

It is important to note that the revision cooperation type is not documented as such. One justification is that we did not get enough field information to account for this style of cooperation for citizen science projects, while we observed many features related to other types in the currently existing Pilot projects. The second reason is that this quadrant is supposed to assemble the "best" solutions found by other types. We would like to pretend that we hope the VERA platform will demonstrate the feasibility of such a revision model of cooperation and will help support these trends in all Pilot projects. It should be considered as a future outcome of the Coeso project: to deliver not only a technical solution such as a platform but also the justification and the organizational recommendations that would help citizen science projects succeed.

The categorical values defined for each feature follow a principle of opposition. They do not seek to describe a continuum as did previous research (Millerand, 2021). Instead, the values in each type and features are designed for describing the tension and the poles towards which the interaction can be oriented.

For instance, the feature "skills" presents the following categorical values depending on the style of cooperation adopted: experiential, academic-expert, procedural for ad hoc, plan-oriented and institutional respectively. The traditional way of exposing the skills relies on procedures, qualifications that are part of a systematic and administrative description of skills. For the plan-oriented type, it is not an administrative description that is the most important but the qualification related to a specific expertise (academic or other professional expertise). By contrast, the ad hoc type of cooperation may accept more experiential skills, obtained through very different types of experiences, from amateur training to personal life situations.

	Categorical Values according to Cooperation Typology			
Cooperation Features	**Ad hoc**	**Plan-oriented**	**Institutional**	**Revision**
Skills	experiential	academic-expert	procedural	
Culture diversity	cultural mix	pluricultural	unique	
Collective skills diversity	experiential	academic-expert	procedural	
Collective cultural diversity	cultural mix	pluricultural	unique	
Ways to obtain data sources	snow ball	sampling	captive audience	

Citizen/Research compensation	incentives	contract	altruistic duty	
Main type of funding	crowdfunding	mixed	institutional	
Dissemination type of results	open	divided according to fields	academic oriented	
Methods for recruiting citizens/researchers	informal	call procedure	membership	
Device specificity	ad hoc assemblage	scientific and technical	standard compliant	
Organization of citizen/research participation	encounters	scheduled meetings	platforms	
Flow of citizen/research participation	spontaneous conversation	goal oriented conversation	asymmetric conversation	
Rhythm of citizen/research participation	burst	planned	continuous	
Distribution of roles in scientific/citizen participation	sharing	expert discussion	coaching	
Conflict and problem solving	arrangement	negotiation	procedural resolution	
Networking method	incrementation	ad hoc	already instituted	
Networking quality	diversification	specialization	simplification	
Governance principles	interpersonal	market industrial	bureaucracy	
Idiom management	polysemic tolerance	jargon translation	conventional language	
Knowledge diversity processing	conceptual creolization	correspondence and translation table	contribution to common knowledge	

Knowledge exchange orientation	egalitarian	differential	unidirectional	
Management style	support	stimulation	control	
Division of labor	ad hoc distribution	skill based	statut based	
Data articulation mode	data lake	data network	data workflow	
Stakeholder and data scalability	staggering	anticipated	stable	
Learning process	trial and error	scientific method	capitalization	
Legal and ethical compliance	versatility	risk taking	certificated	

Table 2. Cooperation features and corresponding categorical values according to the cooperation typology

CONCLUSION

We provided the operationalisation of the cooperation analytics in the form of a monitoring grid that further develops the conceptual framework into indicators and a cooperation typology that can be adapted to the Pilot projects' realities. In that sense, we contribute to formalise and justify a cooperation learning process that translates the concepts identified in the literature to computable indicators in VERA platform. However, this possibility of measurement is limited to the criteria that can be actually collected within VERA given its functionalities yet in development, including the API connections, e.g. for funding, and the decision that will be taken according to the user research outputs and consequent platform design. Moreover, the next step of WP5 is to review the cooperation analytics with Pilots. The social actors are the main evaluators of the adaptability of these indicators to their realities. Indeed, we intend to provide the monitoring grid as a resource for discussion and receiving the practitioners' feedback. The grid will be given as a support to negotiate and update the criteria, as well as to test its comprehension according to the practitioners' practices. The results of reviewing work with Pilots will allow us to reduce the number of criteria to be measured according to what makes sense to them and their daily practices.

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