Scenarios, shared understanding, and group decision support to foster innovation networks

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Abstract. Collaborative innovation involves diverse individuals and organizations working together to develop new ideas, products, or services. Successful collaboration in networked innovation projects is challenging due to the need to cross the knowledge boundaries that exist between organizations, disciplines, and cognitive frames. We propose an approach to support knowledge mobilization and learning in networked innovation projects. Scenarios, stored in a shared repository, are used to capture and share information about application and solution domains. A collaborative process guides participants to reach a shared understanding and construct shared meaning. Stakeholders engage in a collaborative decision-making process of scenario ranking that includes identifying and negotiating comparison criteria. Although the approach is presented with examples in the domain of agriculture, where validation of the constituent elements took place, it is domain independent.

Keywords: Innovation networks · Scenarios · Shared understanding · Group decision · Knowledge mobilization

1 Introduction

Collaborative innovation refers to the process of bringing together individuals or organizations with different backgrounds, experiences, and expertise to develop new ideas, products, or services[34]. It is defined as a collaborative effort that unites diverse organizations around a shared question. Its objective is to create an inclusive environment where the exploration of alternative perspectives and the full engagement of individuals can contribute to the strengthening of both organizations and entire sectors [36].

It is increasingly recognized that including multiple perspectives and international collaboration is essential for successful innovation [16]. Countries and organizations commit to initiatives to support multinational, industry-academia collaboration. Horizon Europe, for example, is the largest research and innovation funding program of the European Union (EU) and supports international research collaborations with countries outside the EU. Diverse perspectives bring a range of ideas, experiences, and knowledge to the table, which can help to identify new opportunities and solutions. International collaboration, in particular, can be valuable in addressing complex global challenges that require a broad range of expertise and resources.

Collaboration in such networked innovation projects is challenging as it implies crossing knowledge boundaries. Knowledge boundaries arise from the differences that exist between organizations, disciplines, and cognitive frames. They constitute major barriers to knowledge mobilization and learning [24]. Therefore understanding their nature is of paramount importance to successful networked innovation. Equally important is the development of strategies to mobilize knowledge across them.

In this work, we propose an approach to support knowledge mobilization and learning in networked innovation projects. We focus specifically on the need to capture and mobilize knowledge of value to create opportunities for innovation. Scenarios, stored in a shared repository, are used to capture and share information about application and solution domains. A collaborative process guides participants to reach a shared understanding and construct shared meaning. Stakeholders engage in a collaborative decision-making process of scenario ranking that includes identifying and negotiating comparison criteria.

This article is organized as follows: Section 2 introduces the core background concepts, namely, knowledge boundary and boundary crossing mechanisms, scenarios, shared understanding, and multi-criteria decision-making. Section 3 discusses related work. Section 4 presents the approach by first providing an overview and then going onto the details of its three core activities. Section 5 discusses preliminary evaluation efforts. Finally, Section 6 discusses the article's main contributions and presents conclusions.

2 Background

2.1 Knowledge boundaries

A knowledge boundary represents the limit between an agent's knowledge in relation to a different knowledge domain [24]. Paul Carlile [11, 12] proposed a topology of knowledge boundaries consisting of three distinctive types: syntactic boundaries, semantic boundaries, and pragmatic boundaries.

Syntactic knowledge boundaries are the easiest to cross as people have shared logic, values, and world views. Strategies to cross syntactic boundaries usually rely on knowledge transfer (mainly explicit knowledge) based on documents and information systems and using a common lexicon. In an international networked innovation project, the differences in language (e.g., French, Spanish, etc.) and vocabulary among experts from the same discipline constitute a simple example of a syntactic knowledge boundary.

In semantic knowledge boundaries, stakeholders do not have shared knowledge or a set of values but different understandings of the same knowledge. There is a need to develop sensitivity to other people's understanding. Strategies to cross semantic boundaries emphasize translation and the development of a common meaning. Differences in meaning and context specificity become important, and tacit knowledge becomes more relevant. An international networked innovation project will certainly face semantic knowledge boundaries as it involves experts and practitioners from several disciplines and organizations, each of them with a potentially different understanding of the shared endeavor.

Pragmatic knowledge boundaries present different understandings and interpretations, and interests that may lead to conflict. Actors must be willing and prepared to negotiate existing practices and transform existing knowledge toward common interest. Crossing pragmatics boundaries is challenging and normally characterized as a process of "creative abrasion", negotiation, and co-creation of common ground that leads to new practices. A networked innovation project brings together academics and practitioners, suppliers and consumers, partners, and competing companies. Each stakeholder may have a different motivation to participate and a different outcome in mind.

There are well-known (boundary-spanning) mechanisms that can be applied to work across and around knowledge boundaries. We talk about a "boundary object" when boundary crossing is based on a shared object (for example, a software artifact) that sits between sides in the border and is the focus of collaboration[11, 12]. When boundaries are crossed as a result of the participation of individuals in collaborative spaces and activities, we talk about boundary practice [19].

2.2 Scenarios

A scenario [13] is an artifact that describes situations (in the world, the application, or the software domain) using natural language. It describes a specific situation that arises in a certain context to achieve some goal. There is a set of steps (the episodes) to reach that goal. In the episodes, actors use materials, tools, and data as resources to perform some specific action. Although there are many templates to describe scenarios, this work is based on the one proposed by Leite et al. [31].

To illustrate how the template is used, let's consider a situation related to the agricultural domain, where there is an infrastructure in the field to provide irrigation. The infrastructure is managed from an operations room, that is, the room that has the control to start and stop the pump. Table 1 captures the situation as a scenario.

Table 1. Scenario that describes the start of the irrigation system from an operations room.

Attribute	Description
Scenario title	Start of the irrigation system through an operations room.
Goal	Protect access to the water infrastructure to ensure responsible water use.
Context	The field counts with an irrigation infrastructure (pipes, tanks, pumps, and valves) to irrigate the field.
Actors	expert, supervisor, operator
Resources	The checklist to determine whether it is necessary to irrigate the field. The security protocol to access and operate the pump and valves.
Episodes	An expert evaluates the conditions of the field to determine whether it is necessary to irrigate. The expert writes a report to the supervisor with the recommendation to irrigate. The supervisor authorizes the operator to start the irrigation system. The operator accesses to the operations room. The operator starts the pump and opens the valves.

2.3 Shared understanding

Collaboration is an essential issue in today's interconnected and complex world. Whether it's in the workplace, academia, or any other collective endeavor, successful collaboration relies on effective communication, coordination, and, most importantly, shared understanding [20]. Shared understanding refers to the collective comprehension and agreement among individuals within a group regarding the goals, objectives, tasks, and expectations. It could be identified as the foundation for productive collaboration and enables teams to achieve remarkable outcomes.

Shared understanding could be interpreted as the bedrock of successful collaboration within groups. It enhances communication, promotes trust and cohesion, facilitates decision-making, and enables teams to adapt to change. By fostering a collective comprehension and agreement among members, shared understanding paves the way for productive collaboration and outstanding achievements [5].

There are many benefits to building shared understanding in collaborative groups, which have been investigated and proven by several authors. It allows for predicting the group's performance and obtaining better quality and quantity of products. In addition, it is more likely that the team will be successful and minimize time losses due to reprocessing [23]. Some of the main benefits of shared understanding are enhanced communication and coordination[22], trust and cohesion, improved decision-making, and better adaptation to change[14].

2.4 Multi-criteria decision making

Multi-criteria Decision Analysis (MCDA) is used to support decision-makers when several scenarios or alternatives are possible. These scenarios or alternatives are generally evaluated thanks to several criteria [37]. This kind of problem-solving may involve decisions on how to design the best choice or how to select the best solution from a finite set of alternatives [25]..

Researchers in this area are concerned about topics on requirements of multiple decision-makers, more informed decision-making support, and formalization of actors' preferences, the ability to cope with several points in decision-making, taking into account human, organizational and social issues in decision-making [26].

Zaraté [38] wrote that to implement decision support, the techniques and methodologies used are extracted from the field of applied mathematics, such as optimization, statistics, and decision theory, as well as less formal and more multidisciplinary fields, such as organizational analysis and cognitive science. These techniques lead to two types of results: the optimum result and the satisfactory result. The satisfactory result is generally the one that guides to the best compromise among all constraints: technical, social, human, etc.

3 Related work

Duin et al. [15] propose the Unified Collaborative Innovation Framework (UCIF), a methodological framework that aims to organize and simplify user-centered, open innovation. UCIF aims to remove scientific and linguistic obstacles and obstacles stemming from different backgrounds and perspectives that inhibit collaboration. Thus, their proposal has the same goal as ours. Nevertheless, they propose a framework with a specific technique to tackle the problem.

Greer et al. [18] review the literature studying how firms engage in collaborative innovation with individual and business customers. Their work highlights areas where research is needed for a greater understanding of the strategic issues and for managing the collaborative process. We agree with the review since our proposed approach addresses both concerns. Our proposed approach includes one step to deal with shared understanding and another step to find an agreement collaboratively.

Serrano et al. [32] discuss the possible contributions of pervasive intelligence for enhancing collaborative distributed innovation processes. They state that pervasive intelligence enables a new quality of information sharing, joint planning, joint problem-solving, integration of operations, etc. These factors will positively influence collaborative innovation processes. We think that, in some way, our proposed approach provides some kind of pervasive intelligence.

Gonzalez Benito et al. [17] analyses the role of collaboration in the contribution of innovation. A survey administered to Spanish firms from industrial, building, agriculture, and trade-service sectors measured two levels of innovation, incremental and radical, and two dimensions of collaboration, channel, and consulting advice. Small businesses take more advantage of channel collaboration, whereas large businesses rely more on consulting advice-based collaboration. Although our proposed approach focuses on small business and channel collaboration, we believe that it can also be used in the scope of large businesses with a consulting advice-based collaboration.

Ozcan et al. [30] analyze the stages of the innovation process and find three main steps: (i) input, (ii) transformation, and (iii) output. Our proposed approach matches these steps. Our capturing the knowledge step is the input since the knowledge is captured. The agreeing on the understanding is the transformation since the scenarios are described in a way to be understood by all the participants. Finally, the out is the rank of scenarios where the participants involved agree about the decision.

Khan et al. [21] report the conclusions of some innovative processes developed in Finland. They find that interdependencies are an important variable to be considered in the collaboration and innovation process. These interdependencies are also present in our proposed approach since scenarios (the artifact to capture the knowledge) are interdependent between them. So, there is also interdependence between the participants.

Bommert et al. [7] discuss the risks and advantages of innovation in the public and private sectors. They emphasize that bureaucracy is a big risk. We think that our proposed approach involving different stakeholders and pushing them to have a shared understanding of the situation can help to tackle this issue.

Ojasalo et al. [27] performed an empirical study about open innovation in smart cities, particularly the role of the actors. They have found that the cities (their government) must be orchestrators while the other actors (citizens, companies, and other cities) contribute. It is interesting these two different roles. A further revision of our approach will consider this aspect.

4 The proposed approach

4.1 Our approach in a nutshell

The proposed approach captures, in a repository of scenarios, the stakeholder's knowledge regarding the domain of innovation. Figure 1 provides an overview of the key components of the approach. In the "Capture knowledge" activity, stakeholders collaboratively write scenarios. Scenarios are kept in a shared scenario repository. Scenarios and the repository act as boundary objects. The "Reach shared understanding" activity engages stakeholders in boundary practice that aims to obtain mutually understood versions of the scenarios. This activity also results in a shared vocabulary. Collaborative work to improve the value of the scenarios repository for innovation continues as stakeholders engage to "Rank the scenarios". This improves the stakeholder's understanding of the scenarios and their contribution to innovation. As it occurs in the boundary between knowledge domains, the ranking of the scenarios is a practice that can lead to new knowledge and innovation.

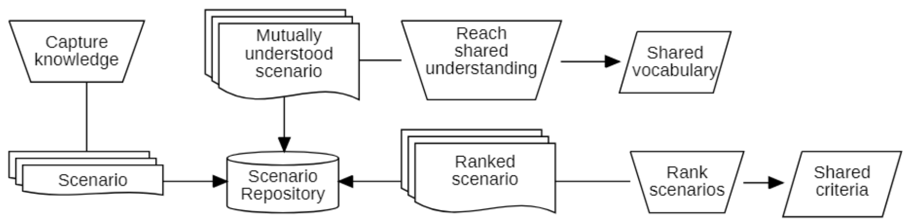

Fig. 1. Approach overview

As an example, let's consider the agricultural domain mentioned. The irrigation can be started manually by physically accessing the operations room to start the pumps as depicted in Table 1. Still, an IoT web application can also be used to do it. Table 2 describes this later alternative.

Table 2. Scenario that describes the start of the irrigation system with an IoT web application.

Attribute	Description
Scenario title	Start of the watering system.
Goal	Protect access to the watering system to ensure responsible use.
Context	The field counts with a watering infrastructure (pipes, tanks, pumps, and valves).
Actors	expert, supervisor
Resources	The checklist to determine whether it is necessary to water the field.
Episodes	An expert evaluates the conditions of the field to determine whether it is necessary to water. The expert writes a report to the supervisor with the recommendation to water. The supervisor logs in to the IoT web application. The supervisor starts the pump and opens the valves.

Thus, scenarios described in Table 1 and 2 are examples of scenarios obtained after the "Capture knowledge" activity. It is important to mention that both scenarios are quite similar, and they differ in the use of an IoT web application. Nevertheless, they also differ in the use of a specific word: one scenario uses the term irrigation, while the other scenario uses the term watering. This is a tiny difference, but it is an example of some difference that will be dealt with in the "Reach shared understanding" activity. This activity deals with the description of the scenarios considering the language and the style of writing and also the knowledge stated. For example, after describing both scenarios, the stakeholders involved can agree that there is only one way to start the irrigation system, and it should be done by accessing the operations room (because there is no IoT web application or because it is too dangerous to expose this control to the internet). Let's consider that both scenarios are true, and the language issue was already dealt with in both scenarios using the term irrigation. Then, the activity "Rank scenarios" deals with these two scenarios, and stakeholders decide which scenario they prefer. They can rank the scenarios in different ways. They can assess security issues, financial issues, or other different factors. Thus, "Ranking scenarios" includes determining the factors and using the agreed factors to rank the scenarios according to them.

4.2 Capture knowledge with scenarios

Scenarios are a simple way to describe a macro-system. The term simple denotes that scenarios are described with natural language, accessible for people without technological backgrounds. To make scenarios richer, it is important to involve a group of people with different backgrounds and different points of view (perspectives). The result of this activity of capturing the knowledge is a repository of scenarios describing the same phenomenon. These scenarios may have the same or different perspectives. Moreover, the scenarios can use different terminology (terms), for example, synonyms, hyponyms, and hypernyms.

The technique proposed for writing scenarios (based on [3]) adopts an incremental approach. One person initially describes certain attributes, which are then further elaborated upon by either the same individual or another participant. This collaborative process allows for the gradual development of scenario descriptions by incorporating multiple perspectives. Specifically, the technique proposes to describe in the first place the title, the context, and the goal of the scenario. Although the title and the goal could be enough, different contexts (starting points) can arise to obtain the same goal. Thus, it is important to start with these three attributes and then continue with describing the episodes as a second step. The third step consists in identifying actors and resources. This activity can be done independently of the episodes, but by analyzing the episodes, the identification of actors and resources will be richer. Thus, after describing every group of attributes, the complete scenario can be reviewed and improved by the previously described attributes.

For instance, let's consider a scenario to describe the start of the irrigation system. This task can be carried out in two different ways: by accessing manually to an operation room (Table 1) or by using a web app (Table 2). The title, the goal, and the context of both scenarios could be the same. In our example, the titles are different. Nevertheless, if two different people had described every scenario, it could happen that they did not realize that there are two different scenarios and the description of the attributes could be quite similar.

The following step is the description of the episodes. The episodes should be a set of steps for achieving the goal considering the context as a starting point. In our example, if people think there are two different ways of starting the irrigation system, they should include these specific aspects in the episodes. In Table 1, it is clear that an operator enters the operation room, while in Table 2, it is clear that the operator logs into a web application.

Since the technique is iterative and incremental, its philosophy is describing the attributes in phases and, at the same time, reviewing and improving the attributes previously described. For example, after describing the episodes, somebody can discover that the title should contain some expression that differentiates both ways of starting the irrigation system. Thus, somebody can modify the scenario title in Table 2 by adding “Start of the watering system using an Iot web application”.

The following step consists of the identification of actors and resources. The identification of actors and resources should primarily stem from the episodes themselves. While it is possible to perform this identification before describing the episodes, in certain cases, identifying actors and resources from the episodes can provide valuable insights that enrich the overall narrative. Such an approach allows for identifying elements that can enhance the episodes and contribute to a more comprehensive depiction. For example, analyzing episodes of the Scenario described in Table 1 it can be concluded that there are three actors: expert, supervisor, and operator. The episodes clearly describe the interaction between the three of them. Maybe, after identifying the three actors, some experts can think about describing episodes to notify the supervisor and the expert that the task has been done. Moreover, analyzing the episodes, two resources can be identified: (i) the procedure (or checklist) to determine if it is necessary to irrigate and (ii) the security protocol to access the operation room. With these resources, some experts can realize that some episodes are missing since they show that it is necessary to follow a protocol (authorization) to access the operations room.

4.3 Reach shared understanding

As previously stated, shared understanding refers to “The ability to coordinate behaviors towards common goals or objectives (meaning-in-use or action perspective) of multiple agents within a group (group level) based on mutual knowledge, beliefs and assumptions (content and structure) about the task, the group, the process or the tools and technologies used (object scope/perspective) that may change throughout the group work process due to various influencing factors and impacts the processes and outcomes of group work”[6], in addition to being a prerequisite for the successful implementation of collaborative work [29], this is because the groups engaged in this type of work must have some common knowledge and understanding, which functions as a joint baseline, to be able to work productively, where everyone can speak the same language and understand the meaning of the concepts on which they are working [6].

The objective of this activity is to ensure all actors understand the scenarios defined in the previous step. Two scenarios were defined in natural language, determining that irrigation can be initiated manually by physically accessing the operations room to start the pumps. Still, also an IoT web application can be used to do so. In addition to this, the use of different words to refer to the same action was appreciated. One scenario uses the term irrigation, while the other uses watering. That is why this second step aims to standardize the concepts and/or terms so that everyone can understand the same thing without using the same words that may have different meanings/interpretations (i.e., homonyms) or using different words for actions, elements, or situations that mean the same thing (i.e., synonyms). It is important to consider that this type of event also occurs because, in the previous step, to make the descriptions of the steps richer, a group of people with different backgrounds and points of view is involved, which generates different interpretations, perceptions, ideas that must be homogenized so that there are even understandings. The idea is that at the end of this step, the previously defined scenarios can be understood, thus generating a consolidated group of scenarios that everyone understands and that, subsequently, the actions to be taken can be determined based on decision-making management.

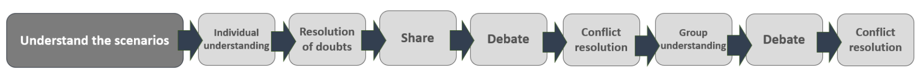

Fig. 2. Reaching shared understanding of the scenarios

Reaching a shared understanding of the scenarios is a collaborative process that involves several steps/activities, as depicted in Figure 2. The process starts with the "Understand the scenarios" activity. After finishing, each of the stakeholders individually defines what they understood about each scenario ("Individual understanding"), based on the need to build tacit knowledge (that which is acquired through their own experience) and which must subsequently be made explicit at the time of materializing it in a result [33]. Each participant resolves his or her doubts about what has been socialized ("Resolution of doubts"). After this, "Sharing" takes place, where each participant inserts a meaning, tuning in with the others in the group, who actively listen and try to grasp the explanation of what each one understood about the scenarios, using them to give meaning to the situation in question [35]. "Debate" is a moment in which a mutual construction of meaning takes place, dealing with the differences of interpretation between the group participants through discussions with arguments and clarifications [8]. It is during the debate that those different words that had been given to the irrigation are clarified, determining the selection of the most appropriate word ("Conflict resolution"). After solving these differences, the group actions are reached, which is the moment in which the interpretation of meanings or actions are materialized with the support and collaboration of all the participants of the group to clearly define these discrepancies of perceptions or knowledge that had not been previously considered, the scenarios are defined again with their elements, where differences have been solved and where all the participants have put their collaboration, and all are in agreement ("Group understanding"). Finally, additional debate or conflict resolution is generated if it is the case and if it is required. As a result of reaching a shared understanding, each scenario can result in one or more alternatives so that all participants understand what has been defined with the information of each one of them and that if something is subsequently talked about or referred to in these scenarios, everyone understands what it is about.

4.4 Rank the scenarios

During this final part of the process, the stakeholders rank the different scenarios. This ranking can be used to purge low-value or incorrect scenarios of the repository or to select scenarios for innovation initiatives. The set of Scenarios will be used as input; the output will be the ranked set of scenarios.

The ranking will be determined by considering some criteria. The participants will first decide the criteria to be used. Obtaining the set of criteria is a co-design process done by the group. Considering the two scenarios described in Table 2 and Table 3, one criterion to determine which scenario should be used could be scenario precision. The scenario described in Table 2 is more precise because it specifies the irrigation mode: using an operations room. Another criterion could be the resources used for each scenario. The scenario described in Table 3 uses fewer resources than the one described in Table 2. The design of the set of criteria depends on the context of the decision to be made and on the involved stakeholders.

The group of stakeholders, having built a coherent family of criteria, will define the different alternatives to be ranked. The set of scenarios will form the set of alternatives. Some stakeholders could be attracted by a part of one scenario to be considered as an alternative. In that case, the considered part of the scenario will constitute a new scenario and, consequently, a new alternative.

When the set of criteria and the set of alternatives are defined in a consensus mode, each decision maker will give his own preferences for each alternative and on the importance of criteria. Each stakeholder can consider one criterion, i.e., the precision in the previous example, as more important than the others. Finally, each decision maker will give his own preferences depending on each criterion, i.e., this scenario (Table 2) is better for me than the other (Table 3) on the criterion of resource usage.

If the stakeholders disagree on a scenario to choose, their preferences are considered, and the best consensus will be calculated by a Group Decision Support System (GDSS). In this work, we propose using the GRUS system for group decision support [10] that adheres to the previously described decision-making process. In this system, multi-criteria Decision-Making Methodologies are embedded.

5 Preliminary evaluation

This proposal aims to support knowledge mobilization and learning in networked innovation projects. It builds upon a rich body of literature on knowledge mobilization across knowledge boundaries (as summarized in [24], Chapter 8). As boundary objects, it proposes scenarios (and a repository of scenarios) and Group Support System (GSS). As boundary processes, it proposes collaborative scenario writing, shared understanding, and collaborative multi-criteria ranking of scenarios. A complete evaluation of the whole approach is currently out of reach for the project. However, each of the constituting parts has been evaluated in comparable situations. Following, we discuss each of these evaluations.

The iterative approach described in this manuscript to capture the knowledge of the domain using Scenarios is based on a previous proposal [3]. That publication reports the evaluation of using Scenarios with an iterative and collaborative approach. The System Usability Scale (SUS) [9] was used to evaluate the usability and applicability of the approach. Although SUS is mainly used to assess the usability of software systems, it proved to be effective in assessing products and processes as well [4]. The score obtained in the evaluation was 70,53 which is considered above average (in a range from 0 to 100) according to common practice.

The approach to shared understanding presented in Section 4.3 is based on a previous proposal shown in [1]. This previous proposal mainly focuses on achieving shared understanding in collaborative problem-solving activities. It focuses on the ability of an individual to participate effectively in a process by which two or more agents attempt to solve a problem by sharing the understanding and effort needed to reach a solution and pooling their knowledge, skills, and efforts to reach that solution [28]. Networked innovation can be classified as a problem-solving activity where the aim is to solve a problem in the field of agriculture. Therefore, we consider that the principles of the shared understanding process presented in section 4.3, evaluated [2], can be generalized to this work.

Group decision support systems support a group of decision-makers to decide collaboratively. The approach considered in this work and reported in [10] is based on Multi-Criteria Analysis. In [39], it has been shown that evaluating such systems is possible. This evaluation is based on several experiments involving students in several countries. Several sessions of decision-making problems have been conducted. In these experimental studies, the alternatives were the items to be chosen.

6 Discussion and conclusions

In this work, we proposed an approach to support knowledge mobilization and learning in networked innovation projects. It focused primarily on the need to capture and mobilize knowledge about the potential opportunities for innovation. Scenarios, stored in a shared repository, are used to capture and share information about application and solution domains. A collaborative process guides participants to reach a shared understanding and construct shared meaning. Stakeholders engage in a collaborative decision-making process of scenario ranking that includes identifying and negotiating comparison criteria, using a GDSS. Scenarios, the shared repository of scenarios, and the GDSS act as boundary objects that keep collaboration focused and mainly serve to cross syntactic boundaries. Collaboration to reach a shared understanding and to rank scenarios constitute boundary practices that help identify and cross semantic boundaries. In addition, these two boundary practices help identify the nature and assess the magnitude of the existing pragmatic boundaries.

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References

1. Agredo-Delgado, V., Ruiz, P.H., Mon, A., Collazos, C.A., Moreira, F., Fardoun, H.M.: Validating the shared understanding construction in computer supported collaborative work in a problem-solving activity. In: Trends and Innovations in Information Systems and Technologies: Volume 3 8. pp. 203–214. Springer (2020)
2. Agredo-Delgado, V., Ruiz, P.H., Mon, A., Collazos, C.A., Moreira, F., Fardoun, H.M.: Applying a process for the shared understanding construction in computer-supported collaborative work: an experiment. Computational and Mathematical Organization Theory pp. 1–24 (2021)
3. Antonelli, L., Ville, J.D., Dioguardi, F., Fernández, A., Tanevitch, L., Torres, D.: An iterative and collaborative approach to specify scenarios using natural language. In: Anais do WER22 - Workshop em Engenharia de Requisitos, Natal - RN, Brazil, August 23-26, 2022. WERpapers (2022)
4. Bangor, A., Kortum, P.T., Miller, J.T.: An empirical evaluation of the system usability scale. International Journal of Human–Computer Interaction **24**, 574 – 594 (2008)
5. Bittner, E., Leimeister, J.: Why shared understanding matters – engineering a collaboration process for shared understanding to improve collaboration effectiveness in heterogeneous teams. In: 2014 47th Hawaii International Conference on System Sciences. pp. 106–114. IEEE Computer Society, Los Alamitos, CA, USA (jan 2013). https://doi.org/10.1109/HICSS.2013.608, https://doi.ieeecomputersociety.org/10.1109/HICSS.2013.608
6. Bittner, E.A.C., Leimeister, J.M.: Creating shared understanding in heterogeneous work groups: Why it matters and how to achieve it. Journal of management information systems **31**(1), 111–144 (2014)
7. Bommert, B.: Collaborative innovation in the public sector. International Public Management Review **11**(1), 15–33 (Mar 2014), https://ipmr.net/index.php/ipmr/article/view/73
8. Van den Bossche, P., Gijselaers, W., Segers, M., Woltjer, G., Kirschner, P.: Team learning: building shared mental models. Instructional science **39**, 283–301 (2011)
9. Brooke, J.: "SUS-A quick and dirty usability scale." Usability evaluation in industry. CRC Press (June 1996), https://www.crcpress.com/product/isbn/9780748404605, iSBN: 9780748404605
10. Camilleri, G., Zaraté, P.: A group multicriteria approach. Handbook of Group Decision and Negotiation pp. 1023–1048 (2021)
11. Carlile, P.R.: A Pragmatic View of Knowledge and Boundaries: Boundary Objects in New Product Development. Organization Science **13**(4), 442–455 (Aug 2002). https://doi.org/10.1287/orsc.13.4.442.2953

12. Carlile, P.R.: Transferring, Translating, and Transforming: An Integrative Framework for Managing Knowledge Across Boundaries. Organization Science **15**(5), 555–568 (Oct 2004). https://doi.org/10.1287/orsc.1040.0094
13. Carrol, J.: Five reasons for scenario-based design. In: Proceedings of the 32nd Annual Hawaii International Conference on Systems Sciences. 1999. HICSS-32. Abstracts and CD-ROM of Full Papers. vol. Track3, pp. 11 pp.– (1999). https://doi.org/10.1109/HICSS.1999.772890
14. Castañer, X., Oliveira, N.: Collaboration, coordination, and cooperation among organizations: Establishing the distinctive meanings of these terms through a systematic literature review. Journal of Management **46**(6), 965–1001 (2020). https://doi.org/10.1177/0149206320901565, https://doi.org/10.1177/0149206320901565
15. Duin, H., Jaskov, J., Hesmer, A., Thoben, K.D.: Towards a Framework for Collaborative Innovation. In: Cascini, G. (ed.) Computer-Aided Innovation (CAI), vol. 277, pp. 193–204. Springer US, Boston, MA (2008). https://doi.org/10.1007/978-0-387-09697-1_16
16. Dutta, S., Lanvin, B., Wunsch-Vincent, S., León, L.R., Organization, W.I.P.: Global innovation index 2022. Unknown (0). https://doi.org/10.34667/TIND.46596
17. Óscar González-Benito, Muñoz-Gallego, P.A., García-Zamora, E.: Role of collaboration in innovation success: differences for large and small businesses. Journal of Business Economics and Management **17**(4), 645–662 (2016). https://doi.org/10.3846/16111699.2013.823103
18. Greer, C.R., Lei, D.: Collaborative Innovation with Customers: A Review of the Literature and Suggestions for Future Research*: Collaborative Innovation with Customers. International Journal of Management Reviews **14**(1), 63–84 (Mar 2012). https://doi.org/10.1111/j.1468-2370.2011.00310.x
19. Hawkins, M.A., Rezazade M., M.H.: Knowledge boundary spanning process: synthesizing four spanning mechanisms. Management Decision **50**(10), 1800–1815 (Jan 2012). https://doi.org/10.1108/00251741211279611, publisher: Emerald Group Publishing Limited
20. Jonker, C.M., Treur, J.: Compositional verification of multi-agent systems: a formal analysis of pro-activeness and reactiveness. In: de Roever, W.P., Langmaack, H., Pnueli, A. (eds.) Compositionality: The Significant Difference. pp. 350–380. Springer Berlin Heidelberg, Berlin, Heidelberg (1998)
21. Khan, I.S., Kauppila, O., Fatima, N., Majava, J.: Stakeholder interdependencies in a collaborative innovation project. Journal of Innovation and Entrepreneurship **11**(1), 38 (Apr 2022). https://doi.org/10.1186/s13731-022-00229-0, https://doi.org/10.1186/s13731-022-00229-0
22. Kleinsmann, M., Buijs, J., Valkenburg, R.: Understanding the complexity of knowledge integration in collaborative new product development teams: A case study. Journal of Engineering and Technology Management **27**(1), 20–32 (2010). https://doi.org/https://doi.org/10.1016/j.jengtecman.2010.03.003, https://www.sciencedirect.com/science/article/pii/S0923474810000044
23. Langan-Fox, J., Anglim, J., Wilson, J.R.: Mental models, team mental models, and performance: Process, development, and future directions. Human Factors and Ergonomics in Manufacturing & Service Industries **14**(4), 331–352 (2004). https://doi.org/https://doi.org/10.1002/hfm.20004, https://onlinelibrary.wiley.com/doi/abs/10.1002/hfm.20004

24. Liu, S.: Knowledge Management: An Interdisciplinary Approach for Business Decisions. Kogan Page, London, United Kingdom ; New York, NY, 1st edition edn. (Jan 2020)
25. Marks, L., Dunn, E., Keller, J., Godsey, L.: Multiple criteria decision making (mcdm) using fuzzy logic: an innovative approach to sustainable agriculture. In: Proceedings of 3rd International Symposium on Uncertainty Modeling and Analysis and Annual Conference of the North American Fuzzy Information Processing Society. pp. 503–508. IEEE (1995)
26. Meyer, P.: Contributions au processus d'Aide Multicritère à la Décision: Méthodes, Outils et Applications. Ph.D. thesis, Dauphine recherche en Management (2013)
27. Ojasalo, J., Kauppinen, H.: Collaborative innovation with external actors: An empirical study on open innovation platforms in smart cities. Technology Innovation Management Review **6**, 49–60 (12/2016 2016). https://doi.org/http://doi.org/10.22215/timreview/1041
28. O'Neil, H.F., Chuang, S.h., Chung, G.K.: Issues in the computer-based assessment of collaborative problem solving. Assessment in Education: Principles, Policy & Practice **10**(3), 361–373 (2003)
29. Oppl, S.: Supporting the collaborative construction of a shared understanding about work with a guided conceptual modeling technique. Group Decision and Negotiation **26**, 247–283 (2017)
30. Ozcan, S., Islam, N.: Analyses of collaborative innovation activities throughout the stages of innovation process. In: 2016 Portland International Conference on Management of Engineering and Technology (PICMET). pp. 446–452 (2016). https://doi.org/10.1109/PICMET.2016.7806550
31. do Prado Leite, J.C.S., Hadad, G.D.S., Doorn, J.H., Kaplan, G.N.: A scenario construction process. Requirements Engineering **5**, 38–61 (2000)
32. Senano, V., Fischer, T.: Contribution of Pervasine Intelligence to Collaborative Innovation Processes. In: Network-Centric Collaboration and Supporting Frameworks, vol. 224, pp. 93–100. Springer US, Boston, MA (2006). https://doi.org/10.1007/978-0-387-38269-2_10, series Title: IFIP International Federation for Information Processing
33. Stahl, G.: Group cognition in computer-assisted collaborative learning. Journal of Computer Assisted Learning **21**(2), 79–90 (2005)
34. Swink, M.: Building Collaborative Innovation Capability. Research-Technology Management **49**(2), 37–47 (Mar 2006). https://doi.org/10.1080/08956308.2006.11657367
35. Webb, N.M., Palincsar, A.S.: Group processes in the classroom. Prentice Hall International (1996)
36. Xie, X., Fang, L., Zeng, S.: Collaborative innovation network and knowledge transfer performance: A fsqca approach. Journal of Business Research **69**(11), 5210–5215 (2016). https://doi.org/https://doi.org/10.1016/j.jbusres.2016.04.114, https://www.sciencedirect.com/science/article/pii/S0148296316302946
37. Yoon, K.P., Hwang, C.L.: Multiple attribute decision making: an introduction. Sage publications (1995)
38. Zaraté, P.: Tools for collaborative decision-making. John Wiley & Sons (2013)
39. Zaraté, P.: Multi-criteria group decision support system: Multi cultural experiments. In: Innovation for Systems Information and Decision: Second International Meeting, INSID 2020, Recife, Brazil, December 2–4, 2020, Proceedings 2. pp. 47–61. Springer (2020)