

The SECI knowledge creation model: A look through sociology

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Abstract

Understanding human behavior as a product of decisions, actions, and cognitions is key to the success in managing software development projects. The SECI knowledge creation model provides the sequence for the creation of social space. The tools of sociology allow us to identify the characteristics of the objective and subjective elements in the exercise of praxis. Reality exists twice, in things and in minds, in fields and in habitus, outside and inside agents. Communicative action allows thought to be made visible through routines and co-creates solutions in a given context, with agents who occupy a position in the field, who have habitus and are capable of exchanging their capital under certain institutions. An imperfect management model offers the possibility to learn and try solutions. The representation of knowledge, as an objective and subjective reality, allows the monitoring of the project, anticipating the possible result before it enters into crisis.

Keywords

Knowledge management, Co-creation, Project management, Software development

1. Introduction

The goal of this article is to describe the elements and relationships that make up the field of project management in the exercise of practice and decision making. From a sociological look at the SECI (socialization, externalization, combination and internalization) model, it is intended to formalize the necessary elements for the creation of knowledge through the use of prior knowledge, identifying the problem, the context, the solution and the result in terms of success and failure, but also describing the characteristics of the people and the social space. The registration of these data provides a more complete understanding of the lessons learned, making it possible to infer the probabilities of success of the new team and make decisions and actions to change the result if it is not the expected one.

2. State of the art

Project management is a social construction [1] motivated by the need to carry out specific actions to achieve immediate goals [2], its big challenge being knowledge conservation [3]. The instability and unpredictability of changes in the system make the traditional approach of planning, execution and control ineffective [4]. The temporary organization [2] contains interconnected elements that need to continuously work and coordinate with each other to produce changes and desirable results [5]. It is necessary to integrate the subjective aspects of lived experiences [6] into the analysis of complexity [6], making an imperfect management model. Through the modeling, experimentation and learning sequence, knowledge can be built in an organic way [7].

The information is incomplete and ambiguous and there is a lack of time to gather knowledge, which makes it difficult to decide whether a project is in crisis [8]. Researchers have identified the symptoms and risks associated with failure [9], but when interpreting the world in simple and obvious terms, verbal

¹ICAIW 2022: Workshops at the Fifth International Conference on Applied Informatics 2022, October 27–29, 2022, Arequipa, Perú

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CEUR Workshop Proceedings (CEUR-WS.org)

language tends to extract linear concatenations of cause and effect [10] that do not always represent reality.

In systematic literature reviews published in [11], the low variability of success and failure factors over time is shown. The lessons learned in terms of cause and effect are not enough to address the problem from the viewpoint of the objective and institutionalized word. It is important to see the social world as meaningful. The structures of the institutions are created by the action of human beings, they reproduce or change and are at the same time structuring [12]. Whether it is a structure or a system processing information, organized work depends on tacit knowledge [12]. The creation of knowledge does not only imply the processing of information, but also takes advantage of tacit and subjective perceptions to make ideas available, tested and used [13].

Knowledge is a dynamic process of justification of beliefs [14] that arises from the interaction with the world [15]. At the end of the continuum line is the tacit knowledge rooted in mental models [13]. At the other end, the explicit or codified knowledge formally transmitted through language [15]. People relies on the observation of objects, events, and relationships [16] to make knowledge more explicit. Knowledge creation is an individual and social process [15] that moves through four modes of conversion known as the SECI [13,14,17].

Decision, action and cognition are the key elements to create knowledge when solving a problem during praxis. Cognitive operations depend on supporting processes such as perception, working memory and emotion, while reasoning and decision making depend on the availability of knowledge about situations, options for action and outcomes [18]. The nature of the knowledge, value and vision of perceived power and the different mentalities form barriers that prevent the exchange [19]. The choices that are made are not inherent to the situations that arise, but complex exchanges between the properties of the context and those of the people, with their doubts and their history [20]. In order to have a true understanding of the problem to be solved, it is important to identify the mental representations, recognize their power, face them directly and build new ones that also becomes solid and lasting [21]. Exposing mental models and making them increasingly explicit allows us to understand the world, to be able to explain it and make sense of it.

Project management and knowledge creation are systems that must evolve together and integrate. But, in order for this to happen, it is necessary to understand the link between projects and institutions and predict the effects that trigger change and establish long-term stabilizing mechanisms of social interaction [22]. The theory of action can be useful in understanding aspects of human behavior [23]. Identifying the properties of the actors that constitute a social space provides valuable tools in the effort to foresee what will happen in the future [24]. Social changes and power relations build the meanings of success and failure of projects over time [25]. Identifying the sociological profile of the field of project management provides objective and subjective tools from which to build.

The concept of wisdom refers to how people correctly use their knowledge through their practical actions, judgments and decisions [26]. It is recognized as the highest hierarchy of the DIKW model [27]. Achieving it requires integrating multiple perspectives, internal and external awareness, emotional cognitive domain, and internal-external reflection as the ability to step back, think, analyze, evaluate, and learn [28]. Intelligence is the bio psychological potential to process information that is activated in a framework to solve problems, but can only be activated or not, depending on the values, the available opportunities and the decisions made by the person or their environment [29]. The multiple intelligences theory makes it possible to identify the cognitive profile of the people who make up the social space, providing a framework for personal development and thus achieving wisdom. But participating in the exchange largely depends on the quality of the communication [30]. Communication barriers are an important part of human perception. Communicative action allows information to be transferred through the use of instruments to sustain and review consensus through human potential [31].

Thanks to knowledge, the world can be read and interpreted [32]. It is necessary to explain the sociology tools to identify the elements put into play when finding solutions to the problems that arise in software development projects.

3. Methodology

The snowballing technique [33] is used in order to describe the state of knowledge about the emerging elements proposed in the systematic review on success and failure in software development projects [11]. Snowballing refers to the use of the reference or citation list to identify additional articles by searching backwards or forwards, thus establishing a timeline that allows visualization of evolution [33]. An effective review creates a firm foundation for the advancement of knowledge and facilitates the development of the necessary theory for those who want to propose and justify a model [34]. In this sense, systematic reviews of the literature or the snowballing technique, by themselves, may not be enough to achieve a high result, which leads to the use of hybrid strategies [35]. A threat in the snowballing technique is that several articles from the same group of authors could be found since their previous research is usually relevant and cited [36]. However, it does not represent an obstacle to fulfill the objective of describing the appropriate toolbox that can justify the model [36]. The initial set of relevant and seminal articles [37] are those considered in [11] as emerging elements for success and failure in software development projects.

4. Results

In [11], the need for a framework that allows content to be co-created and then represented in decision-making is identified. The Theory of Action (Bourdieu), Communicative Action (Habermas) and the Knowledge Creation Spiral constitute a solid structure to understand the social dynamics in the administration field. The use of thought routines produces practices that allow the co-creation of intelligent temporary organizations. The Multiple intelligences theory (Gardner) suggests a framework for cognitive growth. The papers identified in [11] provide the initial seedbed to apply the snowballing technique and complete this review, yielding the following results:

4.1. Nonaka and Takeuchi's knowledge creation model (SECI)

The creation of knowledge moves through four SECI conversion modes [13,16,17,38,39,40] promoting the evolution of social practices and the necessary conditions of stability [15]. This human activity that exists in a coherent, complex and coordinated way allows the use of technology, significantly influencing the conversion process [41]. Knowledge is created through the dynamic interaction between individuals and the environment [42]. By defining a problem and experimenting with new solutions [15], the limits of the old knowledge are transcended and a new vision of the world is acquired [43].

Socialization allows the sharing of tacit knowledge through observation, imitation, practice and participation in a community [14]. People interact using technology to formalize meetings [41]. There are practices that contribute to the process such as the tacit accumulation of knowledge through experiences with customers or suppliers and competitors, the collection of extra-firm and intra-firm social information, and the transfer of knowledge, building environments that allow crafts to be understood [43]. *Externalization* occurs through dialogue and reflection [14]. Process capture methods, expert systems, and decision support systems are used as the basis for lessons learned, blogs, wikis and intuitive mapping tools, as a practice that contributes to the process is the facilitation of creative dialogue with abductive thinking and the use of metaphors [43]. In the *Combination phase*, the integration of concepts into knowledge occurs [14]. Web pages, forums, best practices are accessible to all teams, which facilitates the acquisition of knowledge [41]. The tools used include content management, statistical analyses, neural networks, intelligent agents, case-based reasoning systems, knowledge maps, dashboards, intranet, web portals [41]. Activities that contribute to the process include the acquisition and integration (exercise of strategic planning through the use of data, literature, simulation and forecast), synthesis and processing (construction of manuals, documents, databases) and dissemination. [43]. *Internalization* consists of the incorporation of knowledge [14]. Mining systems help to search for codified knowledge in large data repositories [41]. The factors that contribute to the process are personal experience and simulation and experimentation [43].

A director must take into account the view that the past makes sense only as a projection of the future [42]. He must consider the objectives as drivers of dialogue and practices [44]. Insist on dialogue to

create a flow of ideas based on the empathy, reciprocity, participation and openness that allows going further [42]. Promise shared and systematized practices, leadership to promote culture to create knowledge in a continuous and dynamic way. Propose economic or symbolic incentives such as self-satisfaction of being able to create, peer recognition and sense of belonging to sustain motivation and social context “Ba” (shared space of cognition and action) [42]. To promote the spiral of knowledge, intention, autonomy, fluctuation, creative chaos, redundancy and variety are necessary. The social context "ba" must positively influence the outcome of the process so that the assets of experiential, conceptual, systemic and routine knowledge are mobilized and shared [43]. Despite the criticism that the model has received, it is still widely accepted and applicable, and a new interest has arisen in the incorporation of the ba concept [45]. However, the elements to be incorporated into the knowledge base have not been characterized.

4.2. Bourdieu's theory of action and Habermas's theory of communicative action

Bourdieu proposes to integrate the subjective sense of the agent with the objective distributions of their practices [46]. The social world is something that the agents have to build individually and collectively, in cooperation and conflict, without ignoring the contradictions that may be their principle of transformation [47]. It is a multidimensional construction of positions, which defines approaches and social distances [48]. The different elements cannot be thought apart from their position [49]. It is constructed in such a way that agents are distributed according to the principles of differentiation such as economic and cultural capital [47]. Capital makes it possible for those who own it to obtain a differential return, it allows them to play cards better [48]. Cultural capital is found in an incorporated state (durable and permanent provisions of the organization), in an objectified state (books, computer programs, forming the product of human labor from the previous state) and in an institutionalized state (objectified and legally guaranteed) [49]. To know how a social space differs, it is necessary to observe the achievements that are legally recognized or not, explicit, rationalized and codified [49]. The field is centered on the objective, structured according to the position occupied by people influenced by the specific capital they possess. The greater the capital, the more benefits, more influence and more power. Such distribution may vary over time [51]. Capital is social energy, which can be disputed and accumulated, around which an exchange market arises, there are institutions that regulate it and agents that dispute it [51].

Strategies constitute practices aimed at obtaining some type of capital, thus shaping the observed behavior of agents in the various fields [46]. To understand the practices, it is necessary to construct things that are the truth of the practice but that the practice does not have as truth [50]. The social world is objectified in the habitus, permanent dispositions that are the product of a learning incorporation work [50]. Together with the field, the habitus forms a system of relationships [49]. The practical sense forms a system of cognitive and motivating structures in a world of ends already achieved, modes of employment and procedures to follow [51]. As a result of history, individual and collective practices originate, registered in each organism under the scheme of perception, thought and action with more security than all the formal and explicit rules [52]. The habitus are differentiated, but they are also differentiating, different and distinguished, they bring into play various principles of differentiation, they are structuring structures, classificatory schemes, as well as distinctions of what is good and what is bad, the distinguished and the vulgar [47]. The habitus are an open system of dispositions constantly subjected to experiences that either reinforce or modify its structures [53]. They are continually changing due to new experiences; it creates practices from the internal point of view while also creating them from the external point of view [24]. They are only in relation to certain structures that certain discourses or practices are produced, depending on the stimuli or the structures of the field. The same habitus can generate different and even opposite results [53]. They are systematic, it only makes sense if the different habits are related to each other [46]. They are socialized subjectivity [46] and it originates individual and collective practices [54], the tacit rules that are registered in the organism as perception, thought and action [51]. The habitus are limited by the social conditions that support them, recording them in the body and mind, forming subjective structures available to act, think and feel in a certain

way throughout history [46]. They are the pillar that makes up the set of behaviors, preferences, language and judgments learned throughout the history of their performance in various social spaces. They contribute to building the field as a significant world, endowed with meaning and value where it is worth investing energy, guaranteeing the homogeneity and firmness of practices over time [53]. If the habitus highlights the subjective end, the field focuses on the objective. The field predetermines and structures the social space leaving room for improvisation [52]. The field concept allows us to know the objective relations of the agents, it allows us to know their position and to know the degree of inequality [53].

Social reality exists in two poles; in things and in minds; in fields and in habitus; outside and inside agents [53]. The behaviors produced by the habitus depend on the functioning of the field, making it possible for *the field not to vary* (a reproduction situation) [54], *for the field to vary, but not the practice* (situation of hysteresis) [53], or for both the *habitus and the practice to vary*, producing new practices of innovation [46].

In [55], the underlying forces that shape the practice of agile software development projects are theoretically explored, postulating that teams must have different past experiences, goals, interests, and power levels, which have repercussions on the way in which they collaborate thus impacting in practice. In [24], the sociological profile of the project manager is determined by identifying common characteristics that lead to success.

The sociological explanation must be made considering the relationships between capital, habitus and field that generate social practices and interpretation by reading the action in the different social positions of the actors and not so much in terms of the explicit meaning that they give to their own behavior [46].

In the social world, action is divided into two categories: strategic action, where language is used with the intention of influencing others, exercising informal power, and communicative action, where there is awareness of the social world and reasoning is adopted. logical rather than dominance to resolve disagreements [30]. The world of life is the work of interpretations carried out by past generations [56] in which speaker and listener can claim that their emissions are in accordance with the world and in which they can criticize and exhibit the foundations of those validity claims and resolve their dissent and reach an agreement [57]. Speakers and listeners use the reference system as a framework of interpretation within which they elaborate common definitions of their action situation [57].

Communicative action, under the functional aspect, serves the tradition and the renewal of cultural knowledge; under the aspect of action coordination, it serves social integration and the creation of solidarity; and under the aspect of socialization, it serves training of personal identities, giving rise to the structural components; *culture* (supply of interpretations to understand something in the world), *society* (legitimate ordinances of regulation the belonging to groups) and *personality* (competencies that make the subject capable of language and action) [58]. The communicative action forms a determining factor in the socialization process, defines cultural reception and reproduction, social integration, and personality development, they are measured by symbols and responds to the idea of shared recognition [59]. In the learning process, argumentation is systematically connected with the validity claim [56]. It is important to learn from social reality as a situated historical construction of individual and collective actors, keeping in mind the concept of a constructed world, which can be reproduced, but has the capacity for transformation [60]. Bourdieu's theory brings conflict, power, and inequality in the exercise of practice to the surface. Habermas provides, through communicative action, the consensus and harmony necessary for collective development [61] through self-knowledge for cognitive, affective, and practical transformation [62].

4.3. Gardner's theory of multiple intelligences and Perkins's thinking routines

An intelligent collaborative system applies artificial intelligence methods to provide better support to users and is based on interconnection, instrumentation (accumulation of necessary data), intelligence (making decisions that improve the learning process) and shared activity [63]. There are intelligences that make up the profile of a person, and the combination of these is what gives them unique abilities

[64] such as linguistic intelligence (ability to learn languages and use it to achieve certain goals), logical-mathematical (ability to analyze problems, perform mathematical operations and scientific investigations), musical, kinesthetic (ability to use parts of one's own body to solve problems), spatial (ability to recognize and manipulate patterns in large and small spaces), interpersonal (ability of a person to understand the intentions, motivations and desires of others), intrapersonal (ability to understand oneself) and naturalistic (ability to distinguish and classify elements of the environment) [65]. There is strong evidence that each intelligence possesses neural coherence [66], a unique neural system [67]. An intelligence differs from a skill in its depth, scope, and complexity. [68]. The neural bases for each intelligence are described in terms of primary regions, sub regions, and particular structures [69]. These frameworks have cognitive correlates that are generally well aligned with the skill sets associated with each intelligence, which makes it possible to personalize learning [67]. Multiple intelligences are cognitive abilities defining the learning style that can be assessed to help people develop thinking strategy [70]. The scientific evidence and the naturalized use for the creation of personalized academic content, considering the specific cognitive profiles, makes the use of this theory an important tool to identify the best strategies for knowledge management in organizations.

A distinctive feature of wisdom is the breadth of considerations that are considered when making a judgment or recommending a course of action [71]. A person who can employ multiple intelligences appropriately is more likely to be wise because they bring more faculties and factors into the equation [71]. Comprehension is a process of mental representation underlying the assimilation and transformation of knowledge [72]. It is important to know the different minds and design schemes that consider their differences by identifying the previous representations and the obstacles that must be eliminated [73].

Thought is invisible and remains hidden within the mind, but when it becomes visible it offers the opportunity from which to build and learn [74]. Thought visualization refers to any type of observable representation that documents and supports the development of an individual or group's developing ideas, questions, reasons, and reflections [75]. Understanding is the result of application, analysis, evaluation, and creation [76]. To create knowledge, it is necessary to collect associated activities and thoughts using methods and tools [77]. The process can be tackled with thinking routines [78]. It consists of patterns [74] that can be used repeatedly helping to internalize the message about what learning is and how it occurs, laying the foundations of teamwork [77].

4.4. Representation of knowledge and co-creation

Knowledge representation is a method to infer reasoning about information in order to achieve intelligent behavior [79]. It involves five roles; *surrogate* (allow reasoning about the world instead of acting on it); *ontological* (providing an answer to the question), *fragmentation of intelligence* (expressed as mental representation of reasoning); , *pragmatic medium* (for efficient computation), and *human expression medium* (language that says things) [80]. The frame conforms to the habits of human thought, it is good at representing structural knowledge, it can express the internal structure relationship and the connection between knowledge, describe the detail of things, but also can detect conflicts and achieve efficient reasoning. The scripts make it possible to encapsulate the action, the person and the thing that can be related in a given context [81].

There is little consensus on what is considered co-creation [82]. For [83], it consists of learning collaboratively using and actively combining the knowledge of others, considering previous knowledge. It involves the collective modification and evaluation of the ideas of others, which lead to improving one's own [84]. Enabling active participation in co-creation can lead to high-quality learning outcomes [85]. One way to promote it is the use of a script that explicitly guides participants through the process [85] so they can focus on cognitive activities without feeling pressure to plan or monitor on their own [86].

4.5. Knowledge co-creation model for project management

A project can be seen as an asset (technical characteristics), as a system (asset with its context focusing on the equipment, resources, and specifications to build the asset) and as a conversation (meaning and interactions with stakeholders) [87]. The different perspectives are complementary and come together through human action that transforms and creates a unique reality for each software development project. Managing teams requires a careful understanding of complex human interactions [55]. The planning, execution and control sequence fails in unpredictable, ambiguous and uncertain conditions, requiring an imperfect management model that allows modeling, experimenting and learning. The SECI model under the socialization, externalization, combination, and internalization sequence [13,16,17,38,39,40] provides a tool that allows creating knowledge in the exercise of practice. However, this knowledge stored in a database, as lessons learned, is incomplete when it comes to being represented as similar cases. It is important to characterize the subjective and objective elements of the social space in the development of the practice. The project must be seen as a system and a conversation at the same time. Is important to identify the asset with its context, with people who were part of the co-creation, the habitus, the motivations, the position they occupy in the field, the capital they hold, with their mental models and their way of learning. Mental models organize knowledge, help people describe, explain and predict events in context, and take only what is believed to be important and eliminate what is believed to be unimportant [6]. The decisions, actions and cognitions of the team must be aware of what subjective meaning, knowledge and practice play in the production of the asset [53]. Decision making, as an integral part of the project, is complex and multifactorial, which leads to work integrating several paradigms in a systematic way and analyzing interactions [88]. Teams need multifaceted approaches to be able to deal with new or unforeseen situations during software development processes and thus manage projects more effectively [89].

A problem, with its solution and implementation, is part of the project asset. It has technical characteristics and results in terms of success and failure, which constitute the lessons learned that are part of the knowledge base. But the features are incomplete. It is important to describe the social space with the institutions that regulate the exchange market, the people that make it up and the capital (economic, cultural and symbolic) delimiting the position it occupies in the "ba" formed. Identifying people with habitus (history embodied in the body and mind), and a cognitive profile (unique combination of multiple intelligences) is important to establishing where to start to co-create and learn. It is important to keep the complete characteristics of the social space, ba, during the exercise of the practice that led to the resolution of a problem using certain thought routines around the creation spiral under the SECI sequence. These characteristics must be structured around a sociological profile and a cognitive profile. The sociological profile is composed of an objective structure such as the position occupied by the described agents around capital and the position they occupy in the field and a subjective one, the history embodied in the body and the mind (habitus). The cognitive profile, as a unique combination of multiple intelligences, predefines the way agents learn and is constantly changing habitus and practice, tracing the path to success of the solution in an innovative way.

Figure 1 represents the knowledge co-creation model. In the past, a problem, solution, implementation and result were recorded in the knowledge base characterized by the sociological and cognitive profile of the field ba institutionalized under the SECI spiral of knowledge creation using some proposed routine to make thought visible. All interaction was recorded on a virtual video conference platform. In the present, the social space ba is formed with the members of the team to solve the problem, and their current sociological and cognitive profile. The co-creation practices are carried out under the sequence of the SECI model. With the current characteristics, the knowledge base is inferred, which describes similar problems, implemented solutions, results obtained, profiles that intervened, and thought routines used. With the current profiles, it proposes the best routines to create the necessary knowledge and establishes the probability of success of finding a solution.

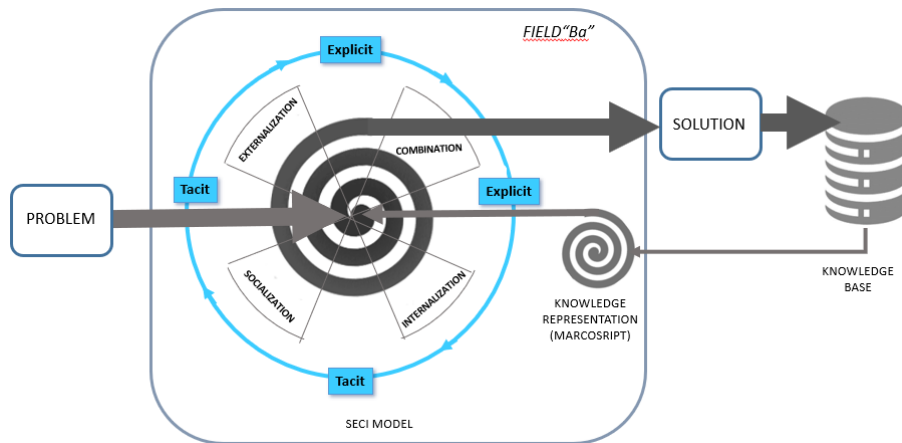


Figure 1: Knowledge co-creation model based on the SECI model [17]- Own source

The agents that make up the social field *ba* have a cognitive and sociological profile and play a role. The role can be manager, developer, client, or deployer. The cognitive profile is made up of a combination of multiple intelligences (logical, mathematical, linguistic, interpersonal, etc.) that could historically change and be modified by the habitus, giving the field significant meaning. Habitus implies knowing how to be and knowing how to do and modify both the cognitive and sociological profiles. The sociological profile is subjectively structured by habitus and objectively by capital. Capital can be cultural, economic, social and symbolic and allows agents to play cards better. It is the material of exchange in the *ba* social field.

The team dedicated to solving a problem in software development projects forms the social space and structures objectively around its capital and subjectively around habitus. Using different routines makes thinking visible to co-created and learned. This modifies the cognitive profile, the habitus and the capital of those who participated in the process. Co-creations produce assets (objects) and recordings. The assets are classified in terms of success and failure, they are the problems, their solutions and the characteristics of the people who co-create and implement them. The recordings are reviewed by agent behavior experts, identifying and recording changes in habitus and capital, allowing the cognitive and sociological profiles to be modified, which will then allow the creation of a new social space, unique in future co-creations. The relationship between the different concepts can be seen in Figure 2.

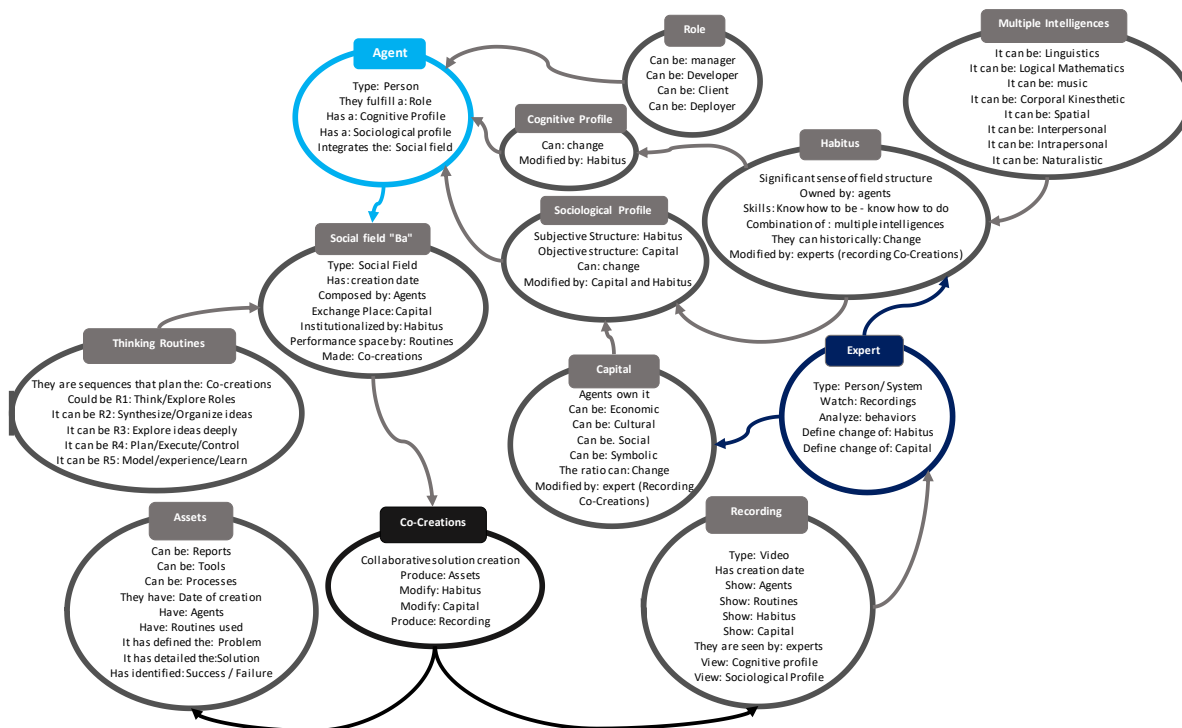


Figure 2: Relations of the concepts in the knowledge base- Own source

5. Conclusions and future lines of research

Project management is a social construction and as such must be analyzed with the tools provided by sociology in order to build successful software development projects. This construction requires an imperfect model that allows modeling, experimenting and learning in conditions of ambiguity and uncertainty. For this, tacit and explicit knowledge must be managed, co-creating knowledge that allows modifying the conditions of the social field *ba* to achieve success. The description of the problem may be objectively in the past, but the solution is subjectively co-created in the present, making it necessary to modify practices and habits to innovate because otherwise the same practices will be used and the same errors reproduced year after year. As future lines of research, it is proposed to describe the different stages of the process, the architecture and the knowledge representation models to validate them through expert judgment in the environment of technological developments.

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